ABBOTT LABORATORIES - HPD

TECHNICAL SUPPORT OPERATIONS

ELECTRONIC TECHNICAL SERVICE MANUAL

LIFECARE 5000 PLUM

Infusion Systems With Concurrent Flow

EPS-03714-004 (Rev. 8/96)

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TO CONTINUE

LifeCare® 5000

plum®

Infusion Systems With Concurrent Flow

For use with the following list numbers:

2507-04	2507-18	2507-29	2507-46
2507-13	2507-22	2507-36	2507-54
2507-15	2507-27	2507-42	2507-88

Technical Service Manual

VERSION 1.5 SERIES

VERSION 1.6 SERIES

Abbott Laboratories
North Chicago, IL 60064
USA

430-03714-004 (Rev. 8/96)

Change History

Part Number	Description of Change	Remove and Destroy Pages	Insert Change Pages
430-03714-001(Rev. 4/92)	Original issue		
430-03714-A01(Rev. 1/93)	Revised part number and title	All pages	All pages
	Section 1.1: Deleted obsoleted information pertaining to Level 1 and Level 2 repairs		
	Section 2: Revised warranty		
	Section 7: Deleted obsolete information pertaining to servicing qualifications		
	Section 7.2.1: Correct battery pack and minipole assembly part numbers		
430-03714-002 (Rev. 1/93)	Second Issue		
430-03714-A02 (Rev. 4/93)	Updated cover and added copyright information to the reverse side	cover	cover
	Updated Change History	i, ii	i, ii
	Updated Contents	iii to x	iii to x
	Added Section 1.2, Conventions	1-3 to 1-4	1-3 to 1-4
	Section 1.6.1: Removed Table 1-4	1-5 to 1-10	1-5 to 1-8

Note: Change page packages assembled by Abbott Laboratories include a change page package identifier on the cover page in the part number. This change page package is identified on the cover page as 430-03714-A02.

Part Number	Description of Change	Remove and Destroy Pages	Insert Change Pages
430-03714-B02 (Rev. 12/93)	Not Issued		
430-03714-C02 (Rev. 1/94)	Updated cover and copyright	cover and copyright page	cover and copyright page
	Updated Change History	i, ii	i, ii

Part Number	Description of Change	Remove and Destroy Pages	Insert Change Pages
	Updated Contents	iii to x	iii to x
	Updated Table 5-1, Cleaning Solutions	5-1, 5-2	5-1, 5-2
	Updated Section 5.2, Performance Verification Test (1.5 Series)	5-3 to 5-6	5-3 to 5-6
	Updated Section 5.2.9, Bubble Sensor Location Test	5-9, 5-10	5-9, 5-10
	Updated Section 5.3, Performance Verification Test (1.6 Series)	5-13 to 5-16	5-13 to 5-16
	Updated Section 5.3.7, Bubble Sensor Location Test	5-17, 5-18	5-17, 5-18
	Updated Section 6.2, Audible Alarms, Table 6-1, Alarm Codes and Corrective Actions	6-9 to 6-12	6-9 to 6-12
	Updated Section 7.2, Repair and Replacement, Section 7.2.1.2, Materials	7-3, 7-4	7-3, 7-4
	Removed reference to "white lithium" grease: Sections 7.2.7; 7.2.7.2; 7.2.23; 7.2.23.2; 7.2.23.3; 7.2.23.4	7-9 to 7-12 7-29 to 7-36	7-9 to 7-12 7-29 to 7-36
	Added Section 7.2.29, Plunger Motor Shaft Lubrication, and Figure 7-14, Plunger Motor Shaft Lubrication Points	7-41 to 7-44	7-41 to 7-44
	Updated back cover	Back cover	Back cover

Note: Change page packages assembled by Abbott Laboratories include a change page package identifier on the cover page in the part number. This change page package is identified on the cover page as 430-03714-C02.

430-03714-003 (Rev. 8/94)	Third issue		

Part Number	Description of Change	Remove and Destroy Pages	Insert Change Pages
430-03714-A03 (Rev. 3/95)	Updated Cover and Copyright	Cover and Copyright	Cover and Copyright
	Updated Change History and Contents	iii to x	iii to xii
	Updated Section 1.1	1-3, 1-4	1-3, 1-4
	Updated Section 1.6	1-7 to 1-10	1-7 to 1-10
	Updated Section 4.1.2.1	4-3, 4-4	4-3, 4-4
	Updated Section 4.8	4-19, 4-20	4-19, 4-20
	Updated Table 5-1, reordered Sections 5.2 and 5.3, and updated Section 5.5	5-1 to 5-28	5-1 to 5-26
	Updated Table 6-1, alarm code 24	6-9, 6-10	6-9, 6-10
	Added Tables 6-3 and 6-4		6-23 to 6-26
	Updated Sections 7.2, 7.2.1.1 and 7.2.1.2,	7-3, 7-4	7-3, 7-4
	Updated Figure 7-6	7-19, 7-20	7-19, 7-20
	Revised Section 7.2.17.2	7-21, 7-22	7-21, 7-22
	Revised Section 7.2.29 and added Section 7.2.31	7-41 to 7-44	7-41 to 7-46
	Updated Section 8	8-1 to 8-4 8-7 to 8-10	8-1 to 8-4 8-7 to 8-10
	Updated Section 9 note	9-1, 9-2	9-1, 9-2
	Updated Section 10	I-1 to I-6	10-1 to 10-6
	Updated back page	Back page	Back page

Note: Stand-alone change pages are identified as part number 450-03714-A03. Abbott-assembled manuals that contain change pages are identified on the cover page as part number 430-03714-A03.

430-03714-004 (Rev. 8/96)	Fourth issue

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Section 1
INTRODUCTION

The LifeCare® 5000 Drug Delivery System, herein referred to as the infusion system, is a microprocessor-based dual-channel drug delivery infusion system that provides consistent dual-channel delivery of two different fluids, at two different flow rates, from two containers, through the same cassette and into a common administration line.

The infusion system provides two methods of delivery: macro and micro. Each delivery method allows a choice of non-concurrent or concurrent rate and dose delivery selection. *Table 1-1, LifeCare 5000 Infusion Mode Configurations*, lists infusion system non-concurrent and concurrent delivery modes for macro, macro secondary, macro multidose, micro, micro secondary, and micro multidose delivery methods.

Through microprocessor-based firmware, the infusion system supports the following features: self-prompting for all setup and operating sequences, continual updates of operating and delivery status, nurse-selectable callback for secondary dose, and continual line pressure monitoring and read-out. Infusion system design also accommodates the following specifics: flow detector option on primary, 10 pounds per square inch (psi), 68.9 kPa (kilopascal) adjustable occlusion pressure, and syringe or vial delivery capability.

The infusion system administers a variety of medical fluids, from 5 percent dextrose injection, USP, to enteral feeding products and blood. Primary and secondary doses of compatible drugs may be delivered concurrently. The DataPort® 1.6 series infusion system allows continuous infusion system monitoring when connected to a properly configured host computer.

For additional information regarding the infusion system, refer to the appropriate system operating manual listed in *Table 1-2, LifeCare 5000 System Operating Manuals*.

Table 1-1. LifeCare 5000 Infusion Mode Configurations

	Non-Concurrent Rate	Non-Concurrent Dose	Concurrent (Combined) Rate	Concurrent (Combined) Dose	No. of Sec Doses	Dose Interval
Macro	1-999 ml/hr	1-9999 ml	N/A	N/A	N/A	N/A
Macro Secondary	1-999 ml/hr	1-9999 ml	2-800 ml/hr (1.5 series) 2-700 ml/hr (1.6 series)	2-19998 ml	1	N/A
Macro Multidose	1-999 ml/hr	1-9999 ml	2-800 ml/hr (1.5 series) 2-700 ml/hr (1.6 series)	2-19998 ml	2-24	15 minutes to 24 hours
Micro	0.1-99.9 ml/hr	0.1-999 ml	N/A	N/A	N/A	N/A
Micro Secondary	0.1-99.9 ml/hr	0.1-999 ml	1.0-99.9 ml/hr	0.2-1998 ml	1	N/A
Micro Multidose	0.1-99.9 ml/hr	0.1-999 ml	1.0-99.9 ml/hr	0.2-1998 ml	2-24	15 minutes to 24 hours
Variable Pressure Limit Selection	User selectable from 0.1 to 8.0 pounds per square inch gauge (psig) 6.9 to 55.1 (kPa) (1.5 series) User selectable from 0.1 to 10.0 psig (6.9 to 68.9 kPa) (1.6 series)					

Table 1-2. LifeCare 5000 System Operating Manuals

LifeCare 5000 Plum Infusion System With Concurrent Delivery Feature, 1.5 Series
LifeCare 5000 Plum Infusion System with Concurrent Flow, 1.6 Series
LifeCare 5000 Plum Concurrent Flow Infusion System With DataPort, 1.6 Series
LifeCare 5000 Infusion Pump System, 1.5 Series, International
LifeCare 5000 Infusion Pump System, 1.6 Series, International

1.1 SCOPE

The 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 infusion system operation cannot be resolved using the information in this manual, contact Abbott Laboratories *(see Section 6.1, Technical Assistance)*.

Specific instructions for infusion system operation are provided in the LifeCare 5000 system operating manuals.

Note: Figures are rendered as graphic representations to approximate the actual product; therefore, figures may not exactly reflect the product. Display screens and touchswitch labels may vary slightly from graphic representations, depending on the version of infusion system in use.

1.2 CONVENTIONS

Table 1-3, Conventions, lists the various conventions used within this manual.

Table 1-3. Conventions

Convention	Application	Example
Italic	Reference to a section, figure, table, or publication	*(see Section 6.1, Technical Assistance)*
[ALL CAPS]	Touchswitch labels on the infusion system are described in all caps and enclosed in brackets	[START]
ALL CAPS	Screen displays	CONCURRENT DELIVERY
Bold	Emphasis	**CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store PWA in an antistatic bag before placing it on any surface.**

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 in front of a procedure or statement and 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

ADCBAT	Battery voltage
ALMFLG	Alarm flag
AM	Amplitude modulator
AUDALMN	Audible alarm
BADBAT	Bad battery
Calibration block	Bubble sensor location calibration block
CMOS	Complementary metal-oxide semiconductor
COMM	Communication
CPU	Central processing unit
CTS	Clear to send
DC	Direct current
DGND	Digital ground
DIP	Dual in-line package
DMM	Digital multimeter
DPM	Digital pressure meter
DSPD	Display data
ECG	Electrocardiograph
EEG	Electroencephalogram
EIA	Electronics Industries Association
EMG	Electromyogram
EPROM	Erasable/programmable read-only memory
ESD	Electrostatic discharge
FET	Field-effect transistor
FLAGON	Flag on
HI-Z	High impedance
hr	Hour
IC	Integrated circuit
ID	Identification
INITBAT	Initiate battery
I/O	Inlet and outlet
I/O	Input/output
IPB	Illustrated parts breakdown
IV	Intravenous
kHz	Kilohertz
kPa	Kilopascal
KVO	Keep vein open
lbs	Pounds
LCD	Liquid crystal display

LED	Light emitting diode
mA	Milliampere
MHz	Megahertz
ml/hr	Milliliter per hour
MOS	Metal-oxide-semiconductor
MOSFET	Metal-oxide-semiconductor field-effect transistor
MOTPWR	Motor power
MPU	Microprocessor unit
ms	Millisecond
mV	Millivolt
N/A	Not applicable
NC	Normally closed
NO	Normally open
No.	Number
PIGBK	Piggyback
PLUNGR	Plunger
PSI	Pounds per square inch
PSIG	Pounds per square inch gauge
PVT	Performance verification test
PWA	Printed wiring assembly
RAM	Random-access memory
RAMSEL	RAM select
REGON	Regulator on
RF	Radio frequency
RMS	Root-mean-square
RN	Resistor network
ROM	Read-only memory
RTC	Real-time clock
RX	Receive
SCI	Serial communication interface
SOFTSW	Soft switch
SW	Switch
SWRDC	Switched raw DC
TP	Test point
TXEN	Transmit enable
V	Volt
VCO	Voltage-controlled oscillator
VMEM	Voltage memory

VREF2.5	2.5 V reference
WDTRAP	Watchdog trap
XMIT	Transmit
XOR	Exclusive OR
µA	Microampere
µL	Microliter
µV	Microvolt

1.4 USER QUALIFICATION

The infusion system is for use at the direction or under the supervision of licensed physicians or by licensed or certified healthcare professionals who are trained in the use of the infusion system and the administration of intravenous (IV) fluids.

1.5 ARTIFACTS

Nonhazardous, low-level electrical potentials are commonly observed when fluids are administered using infusion systems. 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 infusion system instead of some other source in the environment, set the infusion system so that it is temporarily not delivering fluid. Disappearance of the abnormality indicates that it was probably caused by electronic noise generated by the infusion system. 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 system damage may occur unless proper care is exercised during product unpacking, inspection, and self test. The battery may not be fully charged upon receipt of the infusion system. Do not place the infusion system in service if it fails the self test.

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

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

Note: Do not place the infusion system in service if the battery is not fully charged. To make certain the battery is fully charged, connect the infusion system to AC (mains) power for 16 hours.

1.6.1 UNPACKING

Inspect the infusion system shipping container as detailed in *Section 1.6.2, Inspection*. Use care when unpacking the infusion system. Retain the packing slip and save all packing material in the event it is necessary to return the 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 system shipping container for damage prior to opening. Should any damage be found, contact the delivering carrier immediately.

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

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

1.6.3 SELF TEST

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

To conduct the self test, proceed as follows:

1. Connect the AC (mains) power cord to a grounded, hospital-grade receptacle and confirm that the AC (mains) power symbol on the front panel is illuminated.
2. Lift the door latch. Hold a primed cassette by its finger grip and insert the set into the door guides. Do not force the cassette; it should slide into the guides easily.
3. Close the door latch to lock the cassette in place.
4. If a flow detector is used, confirm that it is securely connected to the accessory jack (labeled ACC) on the back of the infusion system.

5. The infusion system automatically initiates a self test to check internal systems. If the self test is completed satisfactorily, the following screen appears:

```
LIFECARE          5000

(MODE IDENTIFICATION)
SELF    TEST    :    OK
```

9210D011

Note: The SELF TEST: OK screen indicates that the infusion system is ready for use. This display changes after a few seconds and the following screen appears:

```
RATE                  0 ML/HR
   (MODE IDENTIFICATION)
         PRESS  ↑↓
         AND ENTER
```

9222B050

Note: If any malfunction is detected by the self test, an alarm sounds and the liquid crystal display (LCD) screen shows a malfunction code. If the alarm sounds, do not place the infusion system in service; note the malfunction code and contact Abbott Laboratories.

6. After the infusion system self test successfully completes, refer to *Section 1.9, Setting the Delivery Mode*, to set the delivery mode.

1.7 OBTAINING THE SOFTWARE VERSION NUMBER

To obtain the infusion system software version number, proceed as follows:

1. Connect the infusion system to AC (mains) power.
2. Lift the door latch and insert a primed cassette into the cassette door holder.
3. Close the door latch to lock the cassette in place.

Note: The infusion system automatically initiates a self test when the cassette is in place and the door latch is closed.

4. When the SELF TEST:OK screen appears on the LCD, press the [REVIEW/CHANGE] touchswitch. The LCD screen displays the software version number.

Note: The SELF TEST:OK screen appears for only three seconds.

1.8 SERIES SPECIFIC FEATURES

Features specific to the 1.5 and 1.6 series infusion systems are summarized in *Table 1-4, Series Specific Features*.

Table 1-4. Series Specific Features

Feature	1.5 Series	1.6 Series
Flow Detector (optional)	No	Yes
Proximal Pressure Sensor	No	Yes
Battery Charger PWA	Service effective change only	Yes
I/O PWA with DataPort	No	On selected infusion systems

1.9 SETTING THE DELIVERY MODE

The infusion system allows a selection of six delivery modes: macro (single channel); macro secondary (dual channel, single dose); macro multidose (dual channel, multidose); micro (single channel); micro secondary (dual channel, single dose); and micro multidose (dual channel, multidose). Delivery mode selection is determined by a dual in-line package (DIP) switch located under the DIP switch cover on the back of the infusion system. *Figure 1-1, DIP Switch Settings for Each Delivery Mode*, illustrates the settings. *Table 1-1, LifeCare 5000 Infusion Mode Configurations*, lists the infusion system flow parameters for each delivery mode.

To reset the infusion system delivery mode, refer to *Figure 1-1* and *Table 1-1*, then proceed as follows:

1. Open the cassette door and remove the cassette.
2. Using a small flat-blade screwdriver, remove the screw from the DIP switch cover. Remove the cover to expose the DIP switches.
3. Set the DIP switch to the appropriate position for the desired infusion system delivery mode.
4. Verify the new delivery mode by closing the cassette door with a primed cassette properly installed in the door.
5. Replace the DIP switch cover and secure it to the infusion system.

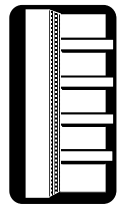
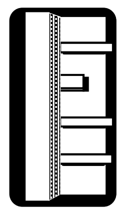
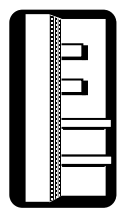
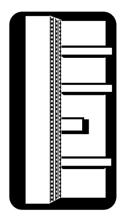
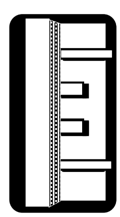
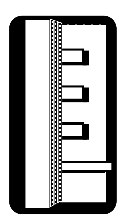
DELIVERY MODE	DIP SWITCH SETTING	DISPLAY LEGEND CONFIRMATION
MACRO (Single Channel)		LIFECARE 5000
MACRO SECONDARY (Dual Channel, Single Dose)		LIFECARE 5000 DUAL CHANNEL
MACRO MULTIDOSE (Dual Channel, Multidose)		LIFECARE 5000 MULTIDOSE
MICRO (Single Channel)		LIFECARE 5000 MICRO MODE
MICRO SECONDARY (Dual Channel, Single Dose)		LIFECARE 5000 MICRO MODE DUAL CHANNEL
MICRO MULTIDOSE (Dual Channel, Multidose)		LIFECARE 5000 MICRO MODE MULTIDOSE

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Figure 1-1. DIP Switch Settings for Each Delivery Mode

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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 a *LifeCare 5000 Infusion System System Operating Manual* is included with every system. For convenient reference, insert a copy of the appropriate system operating manual (or manuals).

If an operating manual is not available, contact Abbott Laboratories (*see Section 6.1, Technical Assistance*).

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Section 4

THEORY OF OPERATION

This section describes the theory of operation of the infusion system. Related drawings are provided in *Section 9, Drawings*. The theory of operation gives a general description of the infusion system and provides a brief overview of the electronics, infusion system alarms, battery, firmware, and mechanics.

Topics covered, in order of presentation, are as follows:

- Sequence of operations
- Alarm conditions
- Battery operation
- System malfunction detection
- Data retention
- Monitors and detectors
- System interface description
- Printed wiring assembly (PWA) functional description
- Mechanics functional description

Note: The flow detector is optional for use with the 1.6 series infusion system. The DataPort communication accessories, including the junction box, are optional for use with DataPort equipped 1.6 series infusion systems. These features are discussed in various subsections.

4.1 SEQUENCE OF OPERATIONS

This section describes OFF status and the sequence of operations associated with ON status of the infusion system.

4.1.1 OFF STATUS

The infusion system is off when the cassette door is open, or when the door is closed with no cassette in place. When the infusion system is off, the following occurs:

- Infusion system does not operate
- LCD and light emitting diode (LED) screen displays are deactivated
- Pumping mechanism valve and plunger motors are returned to home position. Home position is described as follows. Refer to *Figure 4-1, Fluid Path in the Cassette*.
    - Plunger is fully retracted
    - Inlet valve is open and outlet valve is closed

- Primary valve is open and the secondary valve is closed

❑ Nurse-call alarm circuit is disabled

Under normal conditions, critical data and setup data are retained in memory for four hours after the infusion system is turned off. Alarm history is retained for an extended time, and the distal occlusion pressure limit is retained for an extended time at user option, unless the battery pack is completely discharged or is disconnected.

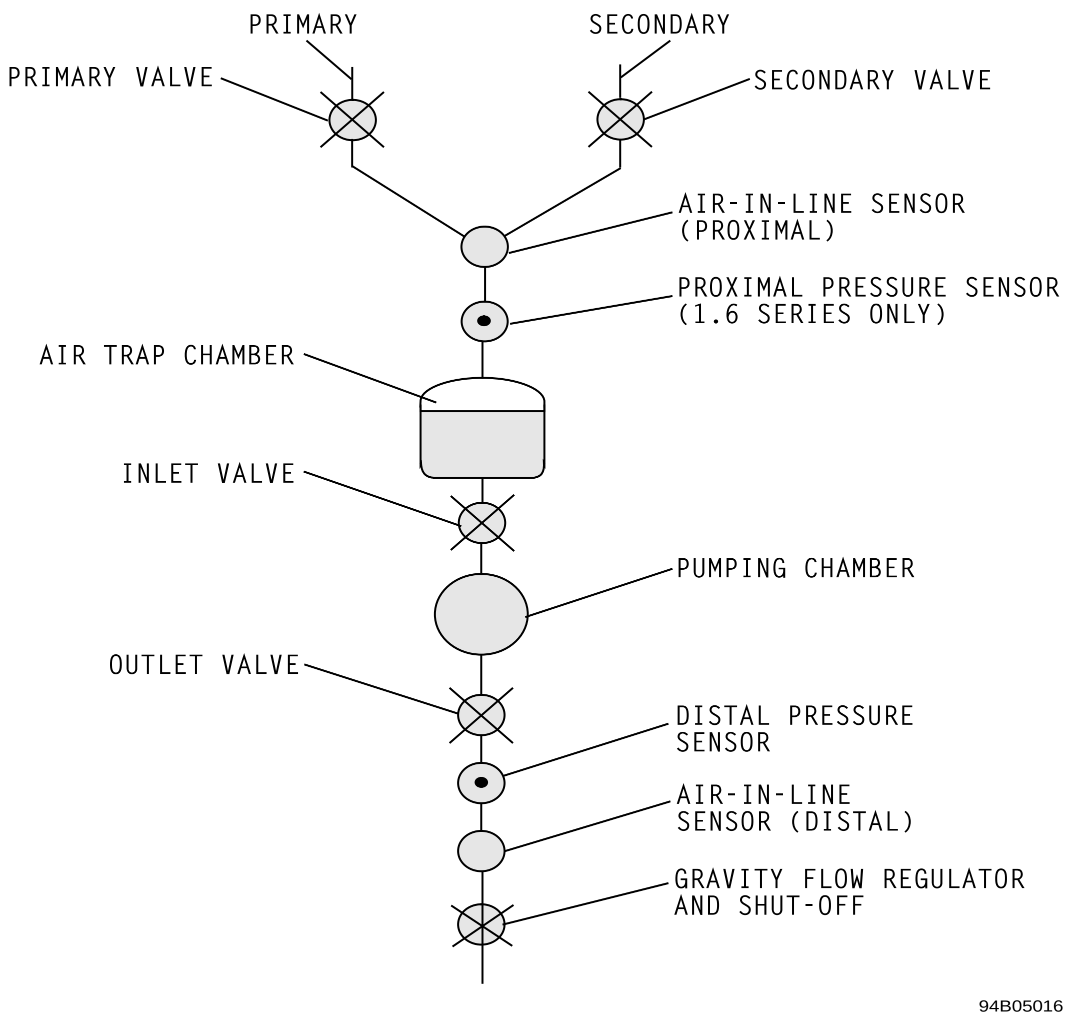

Figure 4-1. Fluid Path in the Cassette

4.1.2 ON STATUS

The infusion system is on when a cassette is installed and the door latch is closed. When the door is closed, the following occurs:

❑ +5 VDC power supply is turned on

❑ LCD and LED screen displays are activated

❑ Infusion system performs a self test, followed by a cassette leak test

- ❑ Upon successful completion of self test, the touchswitches are activated and the system is ready for setup and operation

The following sections describe the self test, cassette leak tests, main program software functions, and operational procedures that occur when the infusion system is turned on.

4.1.2.1 SELF TEST

The infusion system self test performs the following functions:

- ❑ Initializes all data except the following:
  - Alarm history data
  - User selected occlusion pressure limit setting (unless a data retention interval of greater than four hours has elapsed, at which time the default pressure setting is initialized)
- ❑ Tests random access memory (RAM) and read only memory (ROM)
- ❑ Checks failure monitor circuit status
- ❑ Tests LED and LCD screen displays
- ❑ Tests the audible alarm
- ❑ Checks critical data integrity

When the self test successfully completes, the LCD screen displays: SELF TEST: OK. The cassette leak tests follow immediately. If the self test or the cassette leak tests fail, the infusion system is in a system malfunction condition *(see Section 4.4, System Malfunction Detection)*.

4.1.2.2 CASSETTE LEAK TESTS (1.5 SERIES)

Note: If the [START] touchswitch is pressed during the cassette leak tests, the LCD screen displays: SELF TEST IN PROGRESS PLEASE WAIT.

In 1.5 series infusion systems, cassette valve integrity is tested by the leak tests which immediately follow the self test. The infusion system checks the inlet and outlet (I/O) valves (pumping chamber), the plunger draws fluid into the cassette, and both valves close. The plunger moves forward three steps, pressurizing the cassette. The microprocessor searches for a pressure spike when the outlet valve opens. If the pressure spike occurs, the inlet valve is considered good. If the pressure spike does not occur, this indicates that the inlet valve leaks, and the test fails.

The infusion system operates through one cycle of fluid delivery and refill. The bubble/air trap is tested for excess air by advancing the plunger four steps with the outlet valve closed and inlet valve open. The proximal air-in-line sensor indicates that air is present in the air trap. Depending on the outcome of the air detection test, one of two tests is performed as follows:

1. If no air is detected in the air trap, the primary and secondary valves are checked with the inlet valve open and the outlet valve closed. Both primary and secondary valves close, and the cassette is pressurized by advancing the plunger five to six

steps forward. The pumping chamber inlet valve is closed and the outlet valve opens. A pressure spike amplitude is measured. If the pressure spike is greater than 2 psig (14 kPa), no leakage is indicated, and the infusion system delivers a second fill cycle.

2. If air is detected in the air trap, both primary and secondary valves close, and the cassette is pressurized by advancing the plunger five to six steps forward. Any change in status at the proximal bubble sensor indicates a leak in the primary or secondary valve. The primary and secondary valves are considered good if no change is detected.

At the conclusion of the cassette leak tests, the infusion system is ready for touchswitch setup and operation *(see Section 4.1.2.5, Setup*, and *Section 4.1.2.6, Operation)*.

4.1.2.3
CASSETTE LEAK TESTS (1.6 SERIES)

Note: If the [START] touchswitch is pressed during the cassette leak tests, the LCD screen displays: SELF TEST IN PROGRESS PLEASE WAIT.

In 1.6 series infusion systems, cassette valve integrity is tested by the leak tests. Leak tests immediately follow the infusion system self test. The cassette leak tests consist of three stages, as follows:

1. The primary and secondary valves and the outlet valve close. The plunger moves forward until proximal pressure increases by approximately 2.0 psig (13.8 kPa). If proximal pressure does not reach 2.0 psig (13.8 kPa) within 40 steps, the test fails. The plunger again moves forward 110 steps or until proximal pressure reaches 8.0 psig (55.1 kPa). If proximal pressure does not increase to the proper level, the test fails.

   Note: Failure of proximal pressure to reach 8.0 psig (55.1 kPa) may be caused by excessive air in the air trap chamber.

   After five seconds, the pressure drop is measured. If the pressure drops more than 2.0 psig (13.8 kPa), the test fails. At this point, the primary and secondary valves and the outlet valve have been tested.

2. All four valves close. The plunger is retracted, creating a vacuum in the pumping chamber. Proximal pressure drop is checked, and then verified again in five seconds. A drop in pressure during this time indicates a failed inlet valve.
3. The inlet valve opens and the plunger retracts to the home position, relieving pressure within the cassette. The primary valve opens and the plunger advances 78 steps. The amount of air flowing past the proximal air detector is monitored, and the value is used to compute the delivery compensation for concurrent fluid delivery. The plunger again retracts to the home position. The motors are initialized, the outlet valve closes, and the inlet and primary valves open.

If any of the leak tests fail, the LCD screen displays: STOPPED SYSTEM RETEST REQUIRED PRESS RESET. After the [RESET] touchswitch is pressed, the LCD screen displays: STOPPED OPEN DOOR AND REPRIME SET. The cassette should be reprimed and the door closed, which starts a new self-test routine. If the leak test fails again, replace the cassette. If the leak test fails with a new cassette, remove the infusion system from service and contact Abbott Laboratories.

Note: An alarm code is stored in the alarm history for any leak test failure.

At the successful conclusion of cassette leak tests, the infusion system is ready for setup and operation.

4.1.2.4
MAIN PROGRAM SOFTWARE FUNCTIONS

Upon successful completion of the infusion system self test and the cassette leak tests, the touchswitches become active and the main program software performs the following functions:

- Activates the 10 millisecond (ms) clock and other timers
- Activates the watchdog monitor
- Updates I/O flag information
- Activates the audio processor
- Monitors the cassette sensor
- Monitors dose delivery against dose limit
- Monitors the system for alarm conditions; generates audible alarm if condition exists
- Activates the three motors for pumping
- Activates the keyboard
- Activates message and numeric displays
- Checks motor rate against selected rate
- Activates the nurse call relay
- Activates rolling data routine
- Checks microprocessor operation
- Performs RAM memory test
- Performs ROM checksum test
- Monitors accumulated volume data
- Monitors DataPort functions

4.1.2.5
SETUP

If a flow detector is attached, refer to *Section 4.6.4, Flow Detector (1.6 Series)*.

During the operational sequence, pressing the [RESET] touchswitch returns the infusion system to setup.

When the touchswitches are active, the infusion system is ready for setup. During setup, the following occurs:

- Pumping mechanism is inactive and the plunger retracts from the cassette to home position
- LCD message panel prompts the user to enter therapy settings through a sequence of menus *(see system operating manual for more detailed instructions)*. When infusion system setup is complete, the LCD screen displays: SETTING COMPLETE PRESS START OR REVIEW/CHANGE**.**
- Audible alarm beeps once per minute if there is no touchswitch activity

- Cassette door can be opened without an audible alarm
- If setup activity exceeds five minutes, the infusion system sounds an alarm
- All alarms are prevented during setup, except the following:
  - STOPPED, DEAD BATTERY
  - CHECK SET
  - Malfunction alarms

Upon infusion system setup completion, previous settings may be changed and current settings and delivery mode can be reviewed.

4.1.2.6 OPERATION

The normal operating cycle can begin only after appropriate therapy settings have been entered and the [START] touchswitch is pressed. Pressing the [START] touchswitch initiates the following:

- Pumping mechanism drives the cassette at the user-set delivery rate
- User-set delivery rate and total volume are displayed continuously
- Front panel touchswitch controls are inhibited, except the following:
  - [REVIEW/CHANGE]
  - [RESET]
  - [SILENCE]
  - Titration function

  Note: See the appropriate system operating manual for additional information.

- Alarm circuits are active

Infusion system operation is interrupted whenever the system detects an alarm, malfunction, or open door. Opening the door during setup, normal operation, or after completion of operation initiates a wait period (sleep mode). At the end of the wait period, the +5 VDC power supply is turned off and the LCD displays are deactivated.

Note: The wait period is 4 hours for 1.5 series infusion systems, and 10 seconds for 1.6 series infusion systems.

4.2 ALARM CONDITIONS

When the infusion system detects an alarm condition, the following occurs:

- Pumping mechanism either drives the cassette at the keep vein open (KVO) rate or it stops, depending on the alarm type *(see Table 6-1, Alarm Codes and Corrective Actions)*.

Note: The KVO rate is the lesser of 1 milliliter per hour (ml/hr) or the user-set primary delivery rate when operating in primary mode. When operating in secondary or concurrent mode, the infusion system reverts to the KVO rate if primary dose end is reached prior to secondary dose end. If secondary dose end is reached prior to primary dose end, the infusion system reverts to primary rate and continues to primary dose end, then reverts to KVO rate. If the callback feature is enabled, an alarm sounds when delivery of the secondary dose ends. The alarm condition allows the user to change the secondary container, if required *(see system operating manual).*

- LCD screen displays the appropriate alarm message *(see Table 6-1)*
- If active, the nurse-call circuit signals that an alarm condition exists for all alarms except the POWER FAILURE alarm
- Alarm sounds
- If the audible alarm can be silenced, the [SILENCE/NO] touchswitch is activated

An alarm condition can be exited by pressing the [RESET] touchswitch or opening the cassette door. Refer to *Section 6, Troubleshooting*, for alarm and malfunction code information.

4.3 BATTERY OVERVIEW

Proper battery use and maintenance are essential for optimum infusion system operation. Should the battery pack require replacement, refer to *Section 7.2.2, Battery Pack Replacement*.

Factors that most commonly affect battery life are the depth and frequency of discharge and the length of the recharge period. Storage time and room temperature may also affect battery life. When the infusion system is neither connected to AC (mains) power, nor operating, the battery pack retains 50 percent of a full charge for at least one month.

The sealed battery pack can be damaged by misuse. The primary cause of damage is leaving the battery pack in a less than fully charged state. Battery damage can occur in a matter of hours. Damage results in 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.

4.3.1 DEPTH OF DISCHARGE

When the battery pack is discharged below 7.4 VDC while the infusion system is operating, the alarm sounds and the LOW BATTERY message displays on the LCD screen. Although continuing to operate the infusion system is not recommended, the battery pack provides power until discharged to approximately 7 VDC. At approximately 7 VDC, the DEAD BATTERY alarm activates and infusion system operation ceases.

CAUTION: When the LOW BATTERY alarm sounds, connect the infusion system to AC (mains) power.

If the battery pack is frequently discharged to the DEAD BATTERY threshold, battery life is compromised due to sulfation, a reduction in charge carrying ability, and the formation of a lead precipitate.

4.3.2 BATTERY RECHARGE

Battery recharge occurs any time the infusion system is connected to AC (mains) power. It is recommended that the infusion system be connected to AC (mains) power whenever practicable to maximize available battery charge during patient transport or ambulation. The power switch does not have to be on for the battery to recharge.

A discharged battery pack may be recharged to 80 percent of its previous capacity during a 16 hour recharging period while the infusion system operates at a delivery rate of 125 ml/hr or lower.

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

4.3.3 OPERATIONAL REQUIREMENTS

The infusion system is intended to operate on battery power on an exception basis only. The battery pack provides emergency backup power during AC (mains) power failure, or inadvertent disconnection of the AC (mains) power cord. The battery pack also allows temporary portable operation during short periods while a patient is moved from one location to another.

If the infusion system is used frequently on battery power, battery life may be significantly reduced. As a general rule, the more often the battery pack is discharged and recharged, the sooner it needs replacement.

The infusion system should be connected to AC (mains) power whenever possible to ensure the battery pack is always in a charging condition. To prolong battery life, keep the infusion system connected to AC (mains) power when available.

If the infusion system operates on battery power until the LOW BATTERY message appears, the battery pack may be permanently damaged. If the LOW BATTERY message appears, connect the infusion system to AC (mains) power immediately to minimize the risk of battery damage.

Note: The battery pack quickly degrades if repeatedly cycled from a charged state to a deeply discharged state.

4.3.3.1 BATTERY OPERATION

When the infusion system operates on battery power, the red LED battery symbol on the front panel is illuminated. The microprocessor monitors battery voltage to prevent excessive battery discharge. The infusion system alerts the user to any battery alarm condition.

If the infusion system operates on continuous battery power, the following sequence of alarm conditions can occur:

- Upon detecting a low battery threshold, the LCD screen displays: LOW BATTERY. This message alternates with routine status messages. An intermittent alarm sounds. The infusion system continues pumping.

  Note: The low battery alarm stops if the infusion system is connected to AC (mains) power. The battery pack is in a discharged state, but is being recharged.

- If the infusion system is not connected to AC (mains) power, approximately 30 minutes after the LOW BATTERY message appears (for a new, fully charged battery), the LCD screen displays: STOPPED - DEAD BATTERY. The audible alarm sounds. In addition, the following occurs:

  - Infusion system stops pumping
  - Plunger retracts to the home position
  - Primary valve opens and secondary valve closes
  - Outlet valve closes
  - Inlet valve opens
  - LCD backlight is deactivated

  Note: If the infusion system is connected to AC (mains) power, the STOPPED - DEAD BATTERY alarm ceases. The battery pack is in a discharged state, but is being recharged.

- If the infusion system is not connected to AC (mains) power, the LCD screen goes blank approximately 10 minutes after displaying the message: STOPPED - DEAD BATTERY. The audible alarm sounds.

  Note: When the continuous audible alarm sounds, the infusion system is in hardware shutdown. Critical data in infusion system memory is lost. If the infusion system door is opened, the alarm stops immediately.

CAUTION: Minimize the time the infusion system operates on battery power. Recharge the battery pack as soon as possible after battery operation.

4.3.3.2
BATTERY CHARGER OPERATION

A Battery Charger PWA is standard in 1.6 series infusion systems. Certain 1.5 series infusion systems also have the battery charger PWA installed *(see Section 1.8, Series Specific Features)*. Other infusion systems contain battery charging circuitry on the Power Supply PWA. This section describes the battery charging function for infusion systems with the battery charger PWA.

When the battery pack is discharged (terminal voltage falls below +8 VDC), charging occurs at the 1 ampere (A) limit for as long as required. As the terminal voltage increases to +9.4 VDC, the current decreases until a current of 220 milliamperes (mA) is reached. The charge current is maintained at a constant 220 mA level and the terminal voltage again continues to increase toward +10 VDC. Upon reaching the +10 VDC level, a 60-minute timer is activated. The 220 mA charging rate is maintained during the 60-minute period, and then shuts off. The terminal voltage immediately moves towards the voltage of a fully charged battery (approximately 8.6 V). Because less than 20 mA charging current is now required, the float charger remains off. If AC (mains) power is disconnected during the 60-minute, 220 mA charge period, charging continues for the balance of this time after reconnecting AC (mains) power.

When the battery pack is partially discharged (terminal voltage is greater than +8 VDC), charging occurs at the constant voltage of +9.4 VDC. When the charging current reduces to between 20 and 25 mA, the charger shuts off.

When battery charging is interrupted prior to full charge, the charger continues to charge the battery pack upon reconnection to AC (mains) power.

4.4 SYSTEM MALFUNCTION DETECTION

Two failure states can occur when the system detects a malfunction: the core failure state, and the peripheral failure state.

4.4.1 CORE FAILURE STATE

A core failure state occurs when the failure monitor detects a malfunction that causes a system failure. During the core failure state, the following occurs:

- Pumping mechanism stops
- Continuous alarm sounds
- System-prompting function is inhibited

4.4.2 PERIPHERAL FAILURE STATE

A peripheral failure state occurs when any one of the following malfunctions are detected:

- Monitor circuit failure
- Mechanical malfunction
- Noncritical electronic circuitry malfunction
- Short duration, nonpermanent memory failure
- Control override by the failure monitor circuit

During the peripheral failure state, the following occurs:

- Pumping mechanism stops
- An alarm code is displayed and the LCD screen flashes: MALFUNCTION *(see Table 6-1, Alarm Codes and Corrective Actions)*

- Alarm sounds
- Nurse-call circuit is activated

4.4.3 EXITING FROM FAILURE STATE

Exit from failure state is accomplished by opening the cassette door, or discharging the battery pack.

Note: If the alarm is not silenced by opening the cassette door, remove and replace the battery pack *(see Section 7.2.2, Battery Pack Replacement)*.

4.5 DATA RETENTION

The following sections describe critical data and alarm history data, and how they are retained in memory.

4.5.1 CRITICAL DATA RETENTION

Critical data is held in infusion system memory for four hours after the infusion system enters the off status condition. Critical data includes the following:

- Status condition
- Activity state
- Dose functions
- Volume delivered
- Delivery rates
- Dose limits
- Doses delivered

Memory hold time is restored by returning the infusion system to the setup/operating status condition *(see Section 4.1.2, On Status)*.

Any of the following result in critical data loss:

- Four hours elapse after the infusion system is shut off
- Battery pack is completely discharged or is disconnected
- System malfunction occurs

A user-selected occlusion pressure limit setting is retained in memory unless the battery pack discharges or is disconnected.

Once critical data has been lost, the infusion system reverts to default values in the setup/operating mode.

4.5.2
ALARM HISTORY ERROR CODES

Alarm history is a rolling history of alarms and malfunctions. To display alarm history, press the [REVIEW/CHANGE] touchswitch twice during the first three-to-five seconds after the LCD screen displays: SELF TEST : OK.

The alarm history screen displays up to 15 alarm and malfunction codes, with the most recent appearing in the lower right corner of the screen. Alarm history is retained in memory until any one of the following occurs:

- Infusion system is disconnected from AC (mains) power and the battery pack is disconnected
- Infusion system is not connected to AC (mains) power and the battery pack reaches the DEAD BATTERY alarm condition
- An AC (mains) power failure occurs, and the infusion system operates on battery power until the DEAD BATTERY alarm condition is reached

4.6
MONITORS AND DETECTORS

The monitoring and detection system consists of fluid sensors in the mechanism assembly, two bubble sensors in the cassette, microprocessor-controlled flow alarm algorithms, and associated electronics. The ultrasonic bubble sensors detect air at the inlet and outlet of the cassette pumping chamber.

4.6.1
PRESSURE SENSING SYSTEM

The pressure sensing system senses occlusions from the distal pressure sensor (1.5 series) or from the distal and the proximal pressure sensors (1.6 series), as described in the following sections.

4.6.1.1
DISTAL OCCLUSION

Distal occlusion is defined as an occlusion in the administration set distal to the cassette. Pressure within the cassette is measured by sensing the strain in a four element strain gauge bridge that is bonded to a steel leaf spring. The microprocessor monitors absolute pressure. If the absolute pressure limit is exceeded, a DISTAL OCCLUSION alarm occurs and pumping ceases.

The distal occlusion alarm is triggered by any one of the following conditions:

- Measured pressure exceeds 10 psig (68.9 kPa) for approximately 1.2 seconds
- Measured pressure exceeds the user-selected pressure limit for approximately 12 seconds
- Instantaneous pressure exceeds 10 psig (68.9 kPa) and the plunger motor slips

- ❑ Measured pressure exceeds user selected pressure limit at the time the [START] touchswitch is pressed

4.6.1.2
PROXIMAL OCCLUSION (1.5 SERIES)

Note: 1.5 series infusion systems do not have a proximal pressure sensor. Proximal occlusion is measured by a negative pressure spike at the distal pressure sensor.

Proximal occlusion is defined as an occluded primary or secondary administration set proximal to the cassette. Proximal occlusion is sensed by measuring the output of the distal sensor during pumping. If the proximal line is occluded, a vacuum forms in the air trap chamber, which is sensed by the distal sensor. If the proximal occlusion is present after three cycles, the proximal occlusion alarm sounds.

4.6.1.3
PROXIMAL OCCLUSION (1.6 SERIES)

Proximal occlusion is defined as an occluded primary or secondary administration set proximal to the cassette. Proximal occlusion is sensed by measuring the output of the proximal sensor. If the proximal line is occluded, a vacuum forms in the air trap chamber, which is sensed by the proximal sensor. If the proximal occlusion is present after three cycles, the proximal occlusion alarm sounds.

4.6.2
AIR-IN-LINE DETECTION

Air-in-line detection takes place both proximal and distal to the cassette, as described in the following sections.

4.6.2.1
PROXIMAL AIR-IN-LINE DETECTION

A proximal air-in-line alarm is triggered if air is detected by the proximal air sensor for a continuing bolus of air equivalent to approximately 600 microliters (µL), or if air is sensed for intermittent cumulative boluses of air equivalent to approximately 1.2 ml.

When cumulative air boluses equivalent to approximately 600 µL are registered, and the infusion system is programmed for secondary delivery, autobackpriming is triggered in order to backprime excess accumulated air into the secondary container.

4.6.2.2
DISTAL AIR-IN-LINE DETECTION

A distal air-in-line alarm is triggered if air is detected by the distal air sensor for a continuing bolus of air equivalent to approximately 100 µL, or if air is sensed for intermittent cumulative boluses of air equivalent to approximately 240 µL out of 2 ml total volume. When the cassette door is opened, the sensor is reset.

Before the distal air-in-line alarm is activated, the infusion system pushes the air bubble approximately 20 motor steps forward to a position where it is visible in the tubing.

4.6.3 MALFUNCTION DETECTION

The infusion system diagnoses two types of hardware malfunctions: those detected during self test, and those that occur during normal operation.

Refer to the tables in *Section 6, Troubleshooting*, for a list of alarm and malfunction codes. Refer to *Table 6-1, Alarm Codes and Corrective Actions*, for LCD messages, possible causes, and recommended corrective actions where applicable.

Malfunction codes can be reviewed by pressing the [REVIEW/CHANGE] touchswitch twice during the first three-to-five seconds after closing the door. The LCD screen displays the last 15 alarm or malfunction codes, with the most recent appearing in the lower right-hand corner of the screen.

4.6.4 FLOW DETECTOR (1.6 SERIES)

Use of a flow detector is optional for 1.6 series infusion systems.

The flow detector clips around the drip chamber and optically senses drops falling within the chamber. The device consists of a set of three phototransistors and two infrared LEDs, together with infrared and limited acceptance angle filters, all of which are contained in a plastic housing.

4.6.4.1 FLOW DETECTOR CONNECTED DURING RESET

If a flow detector is connected to the infusion system during reset or setup, no dose limit setting is required. If no dose limit is set, the infusion system runs until the primary container empties. The flow detector then senses the absence of flow, generates an audible alarm, and the LCD screen displays: EMPTY CONTAINER PRIMARY. The pumping rate is decreased to KVO.

4.6.4.2 FLOW DETECTOR NOT USED

If a flow detector is not connected to the infusion system, a dose limit must be set for primary delivery during reset; otherwise, the infusion system will not leave setup when the [START] touchswitch is pressed.

4.6.4.3
FLOW DETECTOR DISCONNECTED WHILE INFUSION SYSTEM IS OPERATING

If the flow detector is disconnected while the infusion system is operating, a FLOW DETECTOR DISCONNECTED alarm is generated and the infusion system stops pumping. To silence the alarm, press the [RESET] touchswitch. Follow the screen prompts to set a dose limit for primary delivery. Press [START] to continue delivery.

4.7
SYSTEM INTERFACE DESCRIPTION

The interfaces between the principal hardware subassemblies in the infusion system are shown in *Figure 4-2, LifeCare 5000 System Interface Block Diagram*. See *Section 9, Drawings*, for the system interconnect schematic shown in *Figure 9-7, 1.5 Series Interconnect Schematic*, or *Figure 9-8, 1.6 Series Interconnect Schematic*. The interfaces are categorized as follows:

- ❑ Power interface
- ❑ User interface
- ❑ Motors and valve interface
- ❑ Sensor interface
- ❑ Display interface
- ❑ Main and I/O interface

A description of the interfaces and the signal flow between them follows.

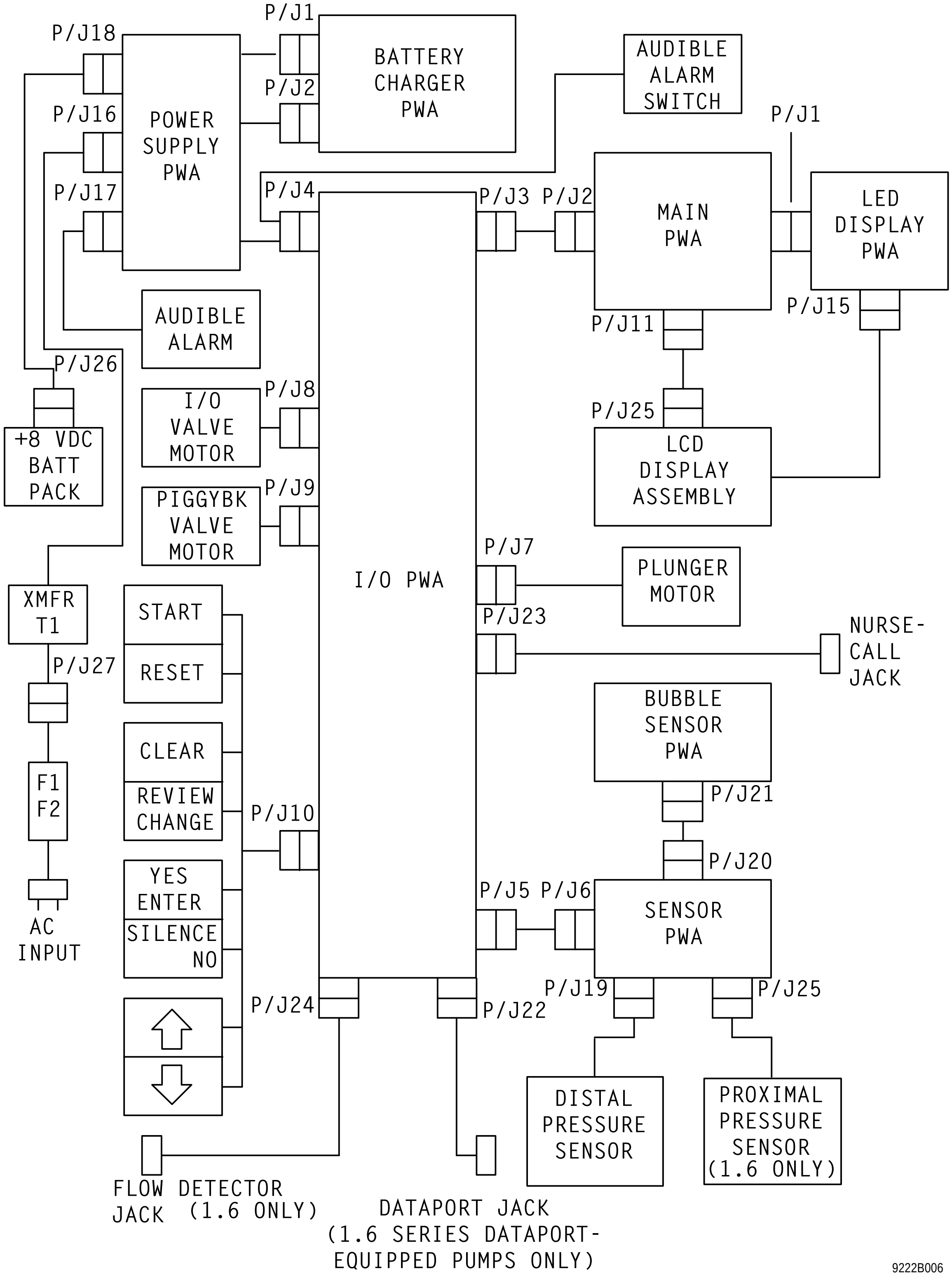

Figure 4-2. LifeCare 5000 System Interface Block Diagram

4.7.1 POWER INTERFACE

Both AC (mains) input power and +8 VDC battery power are inputs to the power supply PWA *(see Figure 4-2, LifeCare 5000 System Interface Block Diagram)*. The power supply PWA provides audio signal power to the audible alarm and DC power levels, in addition to supplying various control signals to the I/O PWA. These interfaces are described in the following sections.

4.7.1.1 AC POWER INTERFACE

The infusion system is connected to AC (mains) power through the power cord, which connects into the back of the infusion system. The AC (mains) input is routed to F1 and F2 and then to a power transformer (T1) through connector P/J27. From the output of T1, AC (mains) power is connected to the power supply PWA through connector P/J16.

4.7.1.2 DC POWER INTERFACE

The +8 VDC rechargeable battery pack is connected to the power supply PWA through the connector P/J26, which routes battery power to P/J18 on the power supply PWA. When the infusion system operates on AC (mains) power, output of the charging circuitry on the power supply PWA recharges the battery pack. When the infusion system operates on battery power, the battery pack supplies the infusion system with +8 VDC power through the same interface.

4.7.1.3 POWER SUPPLY PWA INTERFACE

The power supply PWA provides an audio drive signal to the audible alarm assembly through P/J17. The power supply PWA also provides power and signal interfaces with the I/O PWA through P/J4.

4.7.1.4 BATTERY CHARGER PWA INTERFACE

The battery charger PWA is used in 1.6 series infusion systems and in certain factory serviced 1.5 series infusion systems.

The battery charger PWA connects to two cables, and is routed to the power supply PWA through connectors P/J1 and P/J2. Connector P/J1 connects the power supply PWA to the voltage detector and current limiter circuitry on the battery charger PWA. Connector P/J2 connects the power supply PWA to the current sensing circuitry on the battery charger PWA.

4.7.2 USER INTERFACE

The user interface consists of the front panel touchswitches, the nurse-call jack interface on the infusion system back panel, and the DataPort interface on the infusion system back panel. These interfaces, illustrated in *Figure 4-2, LifeCare 5000 System Interface Block Diagram*, are described in the following sections.

4.7.2.1 FRONT PANEL INTERFACE

The front panel interface consists of inputs to the I/O PWA from the eight front panel touchswitches through P/J10.

4.7.2.2 NURSE-CALL INTERFACE

The nurse-call jack on the infusion system back panel (labeled NURSE CALL) interfaces with the I/O PWA through P/J23.

4.7.2.3 DATAPORT INTERFACE

The DataPort interface makes it possible to connect from 1 to 15 DataPort equipped infusion systems to a host computer through a system of communication cables. A separate junction box attaches to the back I/O port panel on the infusion system through a DB-15 connector, P/J22. Two six-pin modular jacks (J1 and J2) on the junction box connect to the communication bus and to another infusion system.

An infusion system may be removed from the communication bus without breaking the bus connection by disconnecting the junction box from the infusion system.

DIP switches in the junction box create a hard identification (ID), or location, for each infusion system. Hard ID values between 1 and 15 are supplied by the attached junction box. The hard ID may be written on a label on the exterior of the junction box. The host computer identifies the location of the infusion system using this hard ID.

Note: DIP switch setup instructions are described on the insert accompanying the junction box.

4.7.3 MOTORS AND VALVE INTERFACE

The motors and valves in the infusion system are powered and controlled by the I/O PWA. The plunger motor receives +6.5 VDC power and motor drive signals through P/J7. The I/O valve motor receives +6.5 VDC power and motor drive signals through P/J8. The primary/secondary valve motor receives +6.5 VDC power and motor drive signals through P/J9.

4.7.4 SENSOR INTERFACE

The sensor interface includes the following interfaces:

- Distal pressure sensor interface with sensor PWA (includes proximal pressure sensor on 1.6 series infusion systems)
- Bubble sensor PWA interface with sensor PWA
- Flow detector interface with I/O PWA (1.6 series)
- I/O PWA interface with sensor PWA

4.7.4.1 PRESSURE SENSOR INTERFACE

Note: Only 1.6 series infusion systems have a proximal pressure sensor. On 1.5 series infusion systems, the connector J/P25 is not installed.

The distal, proximal, and bubble sensors connect to the sensor PWA which connects to the I/O PWA. Bubble sensing is performed by the bubble sensor PWA which interfaces with the sensor PWA through connectors P/J21 on the bubble sensor PWA and P/J20 on the sensor PWA. Distal and proximal pressure sensor signals are routed directly to the sensor PWA through P/J19 and P/J25, respectively, on the sensor PWA. The sensor PWA interfaces with the I/O PWA through connector P/J6 on the sensor PWA and connector P/J5 on the I/O PWA.

4.7.4.2 FLOW DETECTOR INTERFACE (1.6 SERIES)

The flow detector connector P/J24 is installed only on 1.6 series infusion systems. Refer to *Section 4.6.4, Flow Detector (1.6 Series)*, for flow detector information. The flow detector connector on the back of the infusion system interfaces with the I/O PWA connector P/J24, as shown in *Figure 4-2, LifeCare 5000 System Interface Block Diagram*.

4.7.5 DISPLAY INTERFACE

The display interface consists of the LED display and the LCD screen display on the infusion system front panel. The display interface involves the main PWA which connects directly to the LED PWA through P/J1 and to the LCD screen display through P/J11 on the main PWA and P/J25 on the LCD screen display. The LED display PWA provides power to the LCD screen display PWA through connector P/J15.

4.7.6 MAIN AND I/O INTERFACE

The main PWA receives power through the I/O PWA, through connector P/J3 on the I/O PWA, directly into connector P/J2 on the main PWA.

4.8 PWA FUNCTIONAL DESCRIPTION

This section provides a functional description and a functional block diagram of the infusion system PWAs. For circuit details, refer to the schematics for each PWA in *Section 9, Drawings*. International schematics are also located in *Section 9* and should be referred to accordingly.

4.8.1 MAIN PWA

As shown in *Figure 4-3, Main PWA Functional Block Diagram*, the main PWA provides microprocessor control for the infusion system. For main PWA schematics, refer to *Figure 9-14, 1.5 Series Main PWA Schematic*, and *Figure 9-15, 1.6 Series Main PWA Schematic*. Basic circuitry on the main PWA is as follows:

- Microprocessor unit (MPU) and 8 megahertz (MHz) clock
- 455 kilohertz (kHz) second clock source
- 48K bytes of erasable/programmable read only memory (EPROM)
- 2K bytes of RAM
- Custom integrated circuit (IC) logic for selection of various memory functions
- Analog-to-digital (A/D) converter
- DC-to-DC converter

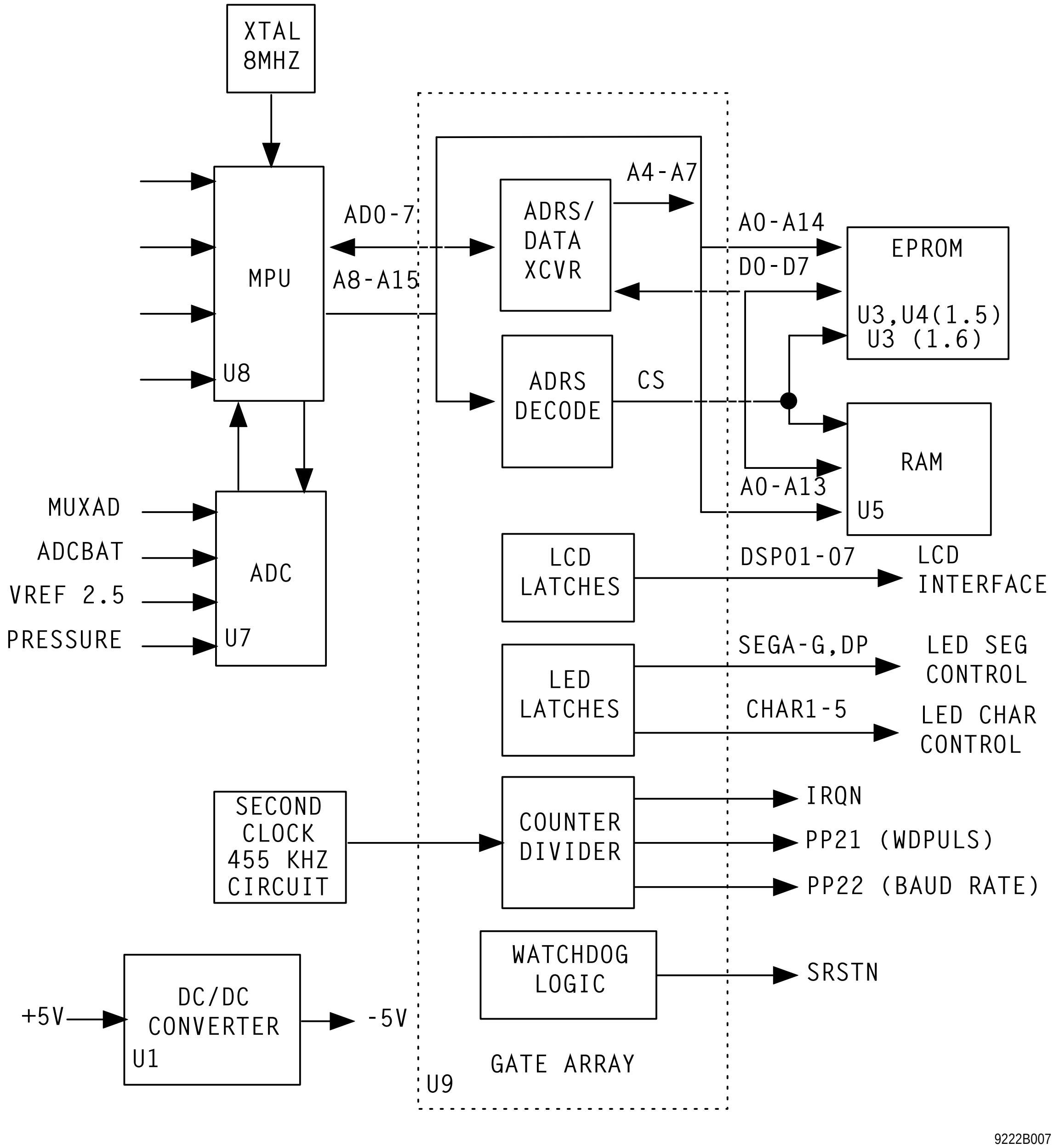

Figure 4-3. Main PWA Functional Block Diagram

4.8.1.1 MPU AND CLOCK

The 40-pin Hitachi HD63B03R complementary metal-oxide-semiconductor (CMOS) MPU on the main PWA is the central processing unit (CPU). The CPU contains 128 bytes of RAM, the serial communication interface (SCI), the parallel input/output (I/O) ports, and a multifunction timer. The CPU is address and data bus compatible with the Motorola MC6800 family of microprocessors. In addition, RAM can be expanded to 64K bytes.

The MPU clock consists of the 8 MHz crystal Y2 and capacitors C10 and C11. Y2 is internally divided by four to give a 2 MHz system cycle frequency.

4.8.1.2 SECOND CLOCK SOURCE

The second clock source contains the 455 kHz resonator Y1, the inverter U2, and capacitors C8 and C9. The second clock source performs the following functions:

- Watchdog pulse source
- LED refresh interrupt timer
- Baud rate generator

4.8.1.3 EPROM, RAM, AND MEMORY PROTECTION (1.5 SERIES)

Program memory resides in two chips, U3 and U4, with 48K bytes of program memory available. The EPROMs are one 27C256 and one 27C128.

2K bytes of system RAM are provided by the HM6116 static RAM, U5. The system RAM is powered by the voltage memory (VMEM) line. This line is held at 5 volts when the system is on, and drops to 2.3 volts when the system 5 V supply is off.

Memory block decoding is performed by the custom IC U9. RAM memory is decoded from $20_{(16)}$ to $7FF_{(16)}$. I/O space is decoded between $1000_{(16)}$ and $1FFF_{(16)}$. EPROM space is decoded from $4000_{(16)}$ to $FFFF_{(16)}$.

RAM memory is protected from spurious writes by NAND gate U6A during system power down. The RAM select (RAMSEL) signal from U9 is AND gated with regulators on (REGON). This allows writes to the RAM only when +5 V is available. REGON, provided by the power supply, is brought low immediately when the infusion system is turned off. RAMSEL is forced low by a system reset and during power up.

4.8.1.4 EPROM, RAM, AND MEMORY PROTECTION (1.6 SERIES)

Program memory resides in the 27C512 EPROM, U3. U3 has 64K byte capacity of which 56K is used. The remaining address space is used for RAM and I/O mapping.

2K bytes of system RAM are provided by the MK48T128 U5, which also provides real-time clock (RTC) capability. The 48T128 contains an internal battery which provides power for memory retention and clock functions when the system 5 V supply is off.

Memory block decoding is performed by the custom logic IC U9, and by NOR gate U4A.

RAM memory is decoded from $20_{(16)}$ to $7FF_{(16)}$. I/O space is decoded between $1000_{(16)}$ and $1FFF_{(16)}$. EPROM space is decoded from $2000_{(16)}$ to $FFFF_{(16)}$.

RAM memory is protected from spurious writes by NAND gate U6A during system power down. The RAMSEL signal from U9 is AND gated with REGON. This allows writes to the RAM only when +5 V is available. REGON, provided by the power supply, is brought low immediately when the infusion system is turned off. RAMSEL is forced low by a system reset and during power up.

4.8.1.5
CUSTOM LOGIC IC

The custom IC, U9, is a HCMOS 84-pin gate array that provides the following functions:

- Address decoding
- Bus interfacing
- Timing control
- LED/LCD interfacing
- Power up/system reset control

4.8.1.6
A/D CONVERSION (1.5 SERIES)

IC U7 is an 8 bit A/D converter with four multiplexed inputs. Channel 0 (pin 3) converts the distal pressure amplifier output. Channel 1 (pin 4) measures the battery voltage (ADCBAT). Channel 2 (pin 5) converts the 2.5 V reference (VREF2.5).

Channel 3 converts the output voltage from the analog multiplexer on the display PWA. The multiplexer switches between the LED test voltage or current, the OVPREF signal from the power supply, and the signal DROPFB (unused).

4.8.1.7
A/D CONVERSION (1.6 SERIES)

IC U7 is an 8 bit A/D converter with four multiplexed inputs. Channel 0 (pin 3) converts the distal pressure amplifier output. Channel 1 (pin 4) converts the proximal pressure amplifier output.

Channel 2 (pin 5) measures the ADCBAT and the 2.5 V reference (VREF2.5). Signal switching is performed by U4 on the I/O PWA. The reference voltage is tested at power up self test only.

Channel 3 converts the output voltage from the analog multiplexer on the display PWA. The multiplexer switches between the LED test voltage or current, the OVPREF signal from the power supply, and the output of the flow detector (DROPFB).

4.8.1.8
-5 VOLT GENERATION

Voltage converter U1 and associated components generate -5 VDC from the 5 V supply. A negative voltage set by potentiometer R1 is used to adjust the LCD screen viewing angle.

4.8.2
I/O PWA

The I/O PWA provides interface between the MPU and infusion system hardware such as the front panel, motors, alarms, sensors, and nurse-call relay *(see Figure 4-4, I/O PWA with DataPort Option Functional Block Diagram)*. The I/O PWA contains the following circuitry:

- Custom I/O IC
- Motor drivers
- Nurse-call relay and control circuits
- Communications port (on selected units)
- Configuration switches

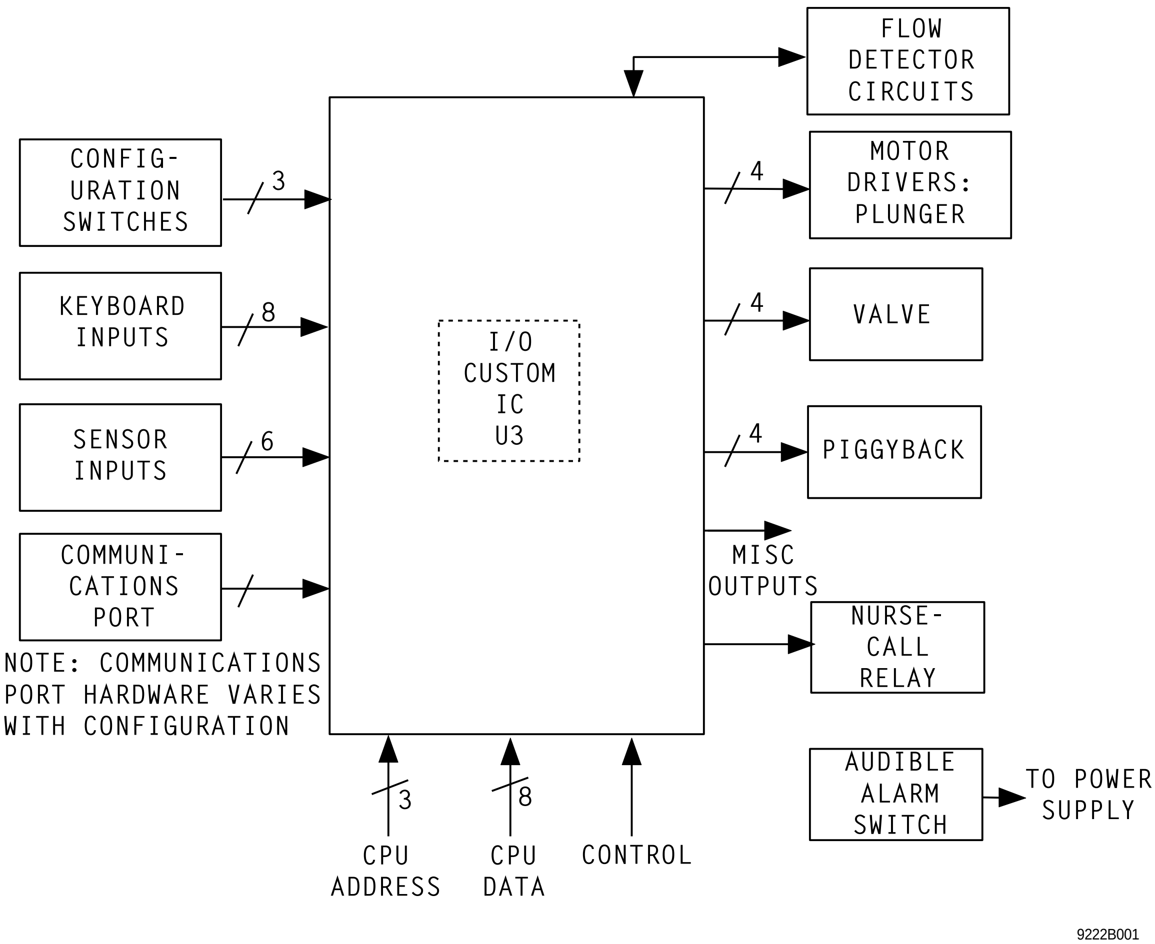

Figure 4-4. I/O PWA with DataPort Option Functional Block Diagram

4.8.2.1
CUSTOM I/O IC

U3 is a custom CMOS IC which provides I/O expansion for the MPU. Addresses from $1030_{(16)}$ through $1033_{(16)}$ are decoded into output latches or input buffers in this IC. The custom I/O IC contains the following circuitry:

- Bus interface
- Hardware watchdog
- Reset and power control logic
- Sensor interface
- Touchswitch interface
- Motor control latches
- Communication port interface

The hardware watchdog monitors the software integrity by posting a message to the CPU and then waiting for the CPU to respond. If the CPU fails to respond intelligently, a system reset occurs.

During run-time, the CPU monitors the watchdog clock input (6303, pin 9, P21) and matches it with the watchdog bit (6303, pin 8, P29) when the watchdog clock changes its state from high to low. The CPU generates the matching bit within 27 ms after transition has occurred. The matching pattern consists of 8 bits, as $10110100_{(2)}$ after power up reset.

The watchdog circuit triggers the system reset within 81 ms after power up if the CPU fails to match the watchdog pattern.

4.8.2.2 MOTOR DRIVERS

N-channel metal oxide semiconductor field-effect transistor (MOSFET) Q1 through MOSFET Q12, along with resistor network (RN) 2 through RN4, comprise the driver circuits for the plunger motor, valve motor, and primary/secondary motor. When turned on, these transistors sink current from the stepper motor windings. Gate drive for these transistors is provided by the outputs M1D0 through M3D3, through the resistor networks.

Figure 9-13, 1.6 Series with DataPort I/O PWA Schematic and *Figure 9-14, 1.5 Series Main PWA Schematic* show two sets of motor driver transistors: Q1 through Q12 and Q1A through Q12A. Only one set of transistors is installed in any board; the two sets of holes allow a choice of transistor packages.

4.8.2.3 NURSE-CALL RELAY CONTROL (1.5 SERIES)

Q15 controls the on/off state of nurse-call relay K1. JP3 is a jumper which selects normally open (NO) or normally closed (NC) operation of the nurse-call circuit. JP3 is configured at the factory for NO operation. J23 is the back panel connector for the nurse-call system.

4.8.2.4 NURSE-CALL RELAY CONTROL (1.6 SERIES)

Operation of nurse-call relay K1 is controlled by Q15 and Q16. Q15 is turned on under processor control during any alarm condition. Q16 is turned off by the soft switch (SOFTSW) line during the power-on self test to prevent unwanted relay activation.

JP3 is a jumper which selects NO or NC operation of the nurse-call circuit. JP3 is configured at the factory for NO operation. J23 is the back panel connector for the nurse-call system.

4.8.2.5 DELIVERY MODE SELECTION

Switch (SW)2 is a DIP switch used to set infusion system delivery modes. For DIP switch configurations, refer to *Section 1.9, Setting the Delivery Mode*, and *Figure 1-1, DIP Switch Settings for Each Delivery Mode*.

4.8.2.6 DATAPORT OPTION

The DataPort is a computer interface port similar to an RS-232 port, with significant changes: a hardware address is provided for each infusion system, and the receive (RX) line is modified to allow multiple infusion systems on a single channel.

The DataPort circuitry on the I/O PWA performs three functions:

1. The DataPort power supply circuit generates ±10 V from the +5 V supply. The IC, U6, (MAX680) is a power supply converter, with capacitors C18, C19, C21 and C22 converting the +5 V to the ±10 V. Capacitor C20 decouples the 5 V line.
2. The driver/receiver circuit inverts signals from CMOS levels to EIA standard RS-232-D levels, and from RS-232-D levels to CMOS levels, respectively. The driver IC, U5, (LT1039) enables RX line when transmit enable (TXEN) is high, and permits data transmission. When TXEN is low, the U5 driver is in a high impedance (HI-Z) state. The receiver portion of IC U5 is turned on at all times. The receiver input impedance is 30K ohms. (When 15 devices are on line, line impedance is lowered to 2K ohms, which is high enough to be driven by the host computer.)
3. The clear to send (CTS) circuit raises the line high when it is connected to the communication bus and the infusion system is turned on. Diode CR7 creates an OR signal with the rest of the infusion systems on the line. Transistors Q17, Q18, and resistors R17 and R18 provide a current limit circuit.

4.8.2.7 FLOW DETECTOR (1.6 SERIES)

The flow detector circuit consists of a switchable LED driver (R5, R6, and Q13) and load/sensing circuitry (R3, R4, C1, CR1, and CR2) for the phototransistors in the flow sensor.

DROPFB is an input to the A/D converter on the main PWA.

Refer to *Section 4.8.8, Flow Detector PWA (1.6 Series)*, for a complete description of the flow detector.

4.8.2.8
MISCELLANEOUS I/O CIRCUITRY (1.5 SERIES)

SW1 is a back panel switch which selects low, medium, or high alarm volume.

RN5 and RN8 perform pull-up and input protection for the eight front panel touchswitches.

Inputs from the sensor PWA include the following:

- ❑ EMPTY and BUBBLE: Signals from the bubble sensor PWA which indicate the presence of air/fluid in the inlet and outlet air sensors, respectively
- ❑ Piggyback (PIGBK)1, VALVE, plunger (PLUNGR), and PIGBK2: Outputs of sensor PWA optical interrupters used to detect the location of the three motors
- ❑ Switched raw DC (SWRDC): Output from the cassette sensor switch; it is high (up to 15 V) when the cassette is in place with the door closed

Outputs to the sensor PWA include the following:

- ❑ Flag on (FLAGON): Controls power to the optical interrupters
- ❑ Transmit (XMIT): When low, enables the ultrasonic oscillator
- ❑ PRESSCK: Not used
- ❑ SOFTSW: Held high during power-on self test and during audible alarm activation; it bypasses the cassette door switch, preventing unwanted infusion system shutoff

Inputs from the supply PWA include the following:

- ❑ Bad battery (BADBAT): Asserted (high) if the battery voltage falls below 6.8 V, causing the system to shut down completely
- ❑ ADCBAT: Scaled battery voltage for A/D conversion
- ❑ Audible alarm (AUDALMN): Asserted (low) when an alarm sounds; used during self test
- ❑ Motor power (MOTPWR): Used to sense whether the motor power is off during overvoltage self test

Outputs to the supply PWA include the following:

- ❑ VMOFF: Asserted (high) to shut off the motor power supply
- ❑ OVPTST: Asserted (high) during self test to simulate an overvoltage condition; this should cause the MOTPWR to be off
- ❑ Initiate battery (INITBAT): During power up self test, this line is asserted high to prevent a dead battery shutdown
- ❑ WAKEUP: Main power supply enable signal
- ❑ Watchdog trap (WDTRAP): Asserted (high) if a watchdog-detected processor failure occurs, causing the alarm to sound

4.8.2.9
MISCELLANEOUS I/O CIRCUITRY (1.6 SERIES)

Analog switches U4A and U4B select the scaled ADCBAT or the VREF 2.5 as inputs to the A/D converter on the main PWA. VREF 2.5 is tested during power up. At all other times, the A/C channel is used to measure the battery state of charge.

4.8.3
POWER SUPPLY PWA

Certain 1.5 series infusion systems do not have the battery charger PWA installed in the as-built configuration. For schematics of the power supply PWA, refer to *Section 9, Drawings, Figure 9-16, 1.5 Series Power Supply PWA Schematic*, and *Figure 9-17, 1.6 Series Power Supply PWA Schematic*.

The power supply PWA converts AC voltage to DC voltage and provides power control circuitry for AC (mains) power or battery operation of the infusion system *(see Figure 4-5, Power Supply PWA Functional Block Diagram)*. The power supply PWA circuitry includes the following:

- ❑ Unregulated DC power supply
- ❑ AC (mains) line and battery power indication
- ❑ Power control
- ❑ +5 VDC supply
- ❑ VMEM supply
- ❑ Motor power supply
- ❑ Overvoltage protection
- ❑ Audible alarm backup
- ❑ Audible alarm control
- ❑ Audible alarm self test
- ❑ Battery pack charging
- ❑ Battery voltage detection

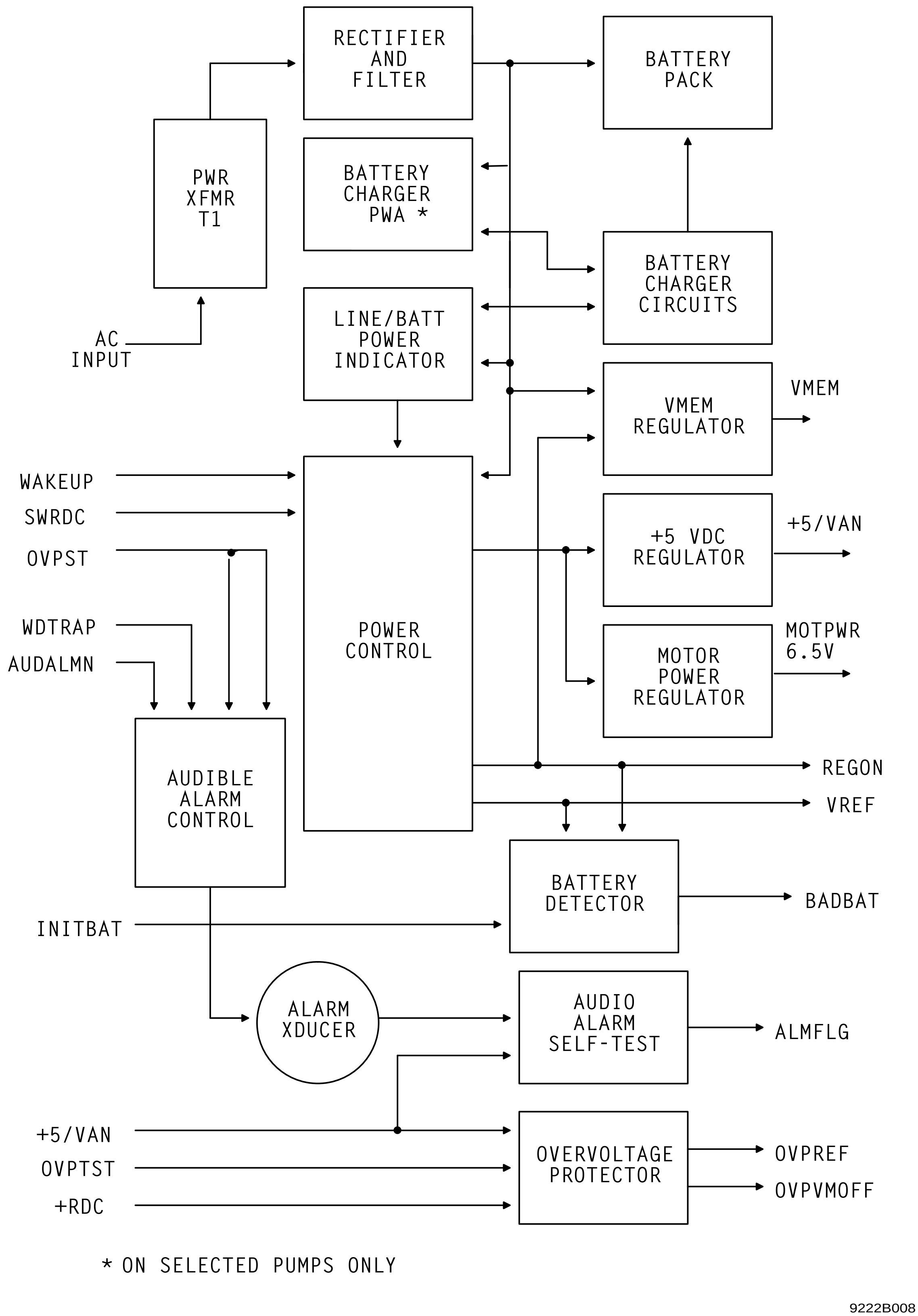

Figure 4-5. Power Supply PWA Functional Block Diagram

4.8.3.1 UNREGULATED DC POWER SUPPLY

As shown in *Figure 4-5, Power Supply PWA Functional Block Diagram*, the unregulated DC power supply is composed of the power transformer T1, in conjunction with the rectifier and filter.

The AC (mains) power voltage is supplied to T1 through the power cord and fuses F1 and F2, located on the back panel, *(see Section 9, Drawings, Figure 9-7, 1.5 Series Interconnect Schematic*, and *Figure 9-8, 1.6 Series Interconnect Schematic)*. The secondary of T1 is center tapped for full wave rectifying by diodes CR7 and CR8. Under no-load conditions, the T1 secondary delivers 22 VAC root-mean-square (RMS). Capacitor C11 filters ripple voltage that appears between +RDC and -RDC.

4.8.3.2 AC (MAINS) LINE AND BATTERY POWER INDICATION

Operating the infusion system on battery power causes the green LED (AC power indicator on the display PWA) to deactivate and the red LED (battery power indicator) to activate.

The line/battery indicator circuit consists of Q17, CR11, and resistors RN10 (1,2), R21, and R23.

The BPLEDA signal at P4, pin 37, sources current to the battery power LED indicator anode on the display PWA through the parallel combination of resistor network RN10 [1,2] and resistor R21.

When operating on AC (mains) power, Q17 is turned on and shunts current around the red LED through diode CR11 to turn off the battery power LED indicator. The +RDC supply sources current through resistor R23 and LPLEDA at P4, pin 38, to the anode of the AC (mains) power green LED; the cathode of this LED returns to -RDC through P4, pin 40.

4.8.3.3 POWER CONTROL

When the infusion system is on, the cassette switch on the sensor PWA is actuated, causing SWRDC at P4, pin 1, to go high. When SWRDC goes high, a positive pulse is placed on the base of Q9, through C19 and resistor networks RN7 (1,2) and RN10 (4,5). The base of Q18 is pulled low by Q9; the Q18 collector brings the REGON line (P4, pin 32) high.

The REGON line enables both the +5 VDC and motor regulators. REGON is also used as a RAM enable signal (U6, pin 1) on the main PWA. After the processor is started, the WAKEUP line is held high, which holds REGON high, for as long as the infusion system is in operation.

If the battery is completely discharged, the BADBAT signal causes the custom IC on the main PWA to bring WAKEUP low, which causes the infusion system to go into shutdown.

CR12 prevents the base of Q9 from being driven below ground.

4.8.3.4
+5 VDC SUPPLY CONTROL

For the +5 VDC power supply, reference diode U2 adjusts precisely to +2.5 VDC through potentiometer R2, and connects to the noninverting input at U3-A, through R10 and RN7 (9,10). U2 also sets the +2.5 VDC reference for the +6.5 VDC motor power regular power supply. U2 receives power from REGON.

The voltage divider, consisting of RN4 (6,7) and RN4 (5,6), feeds back one half of the +5/VAN output to the inverting input of U3. This input is amplified to drive the base of Q10.

If the +5/VAN output is too low, U3A output (pin 1) goes higher, providing more base drive to Q10. Q10 then draws more base current from series pass transistor Q13, raising the output voltage.

U3-B operates as a voltage comparator to limit current. The dividers, consisting of RN4 (8,9) RN4 (9,10), and RN4 (9,11), provide a +135 mV reference to the inverting input of U3-B. Should the load return current through R6 exceed 1.35 A, the output of U3-B will go high to turn on Q7 through R11. The collector of Q7 clamps the noninverting input of U3-B to ground, removes the +2.5 VDC reference, and disables the +5/VAN supply.

4.8.3.5
VMEM SUPPLY CONTROL

The VMEM supply (P4, pin 19) is the +2.3 VDC memory backup supply for RAM U5 on the main PWA. When the infusion system is on, REGON is high and turns on Q14 through RN8 (1,8). Q14 supplies the VMEM line with +5 VDC. Schottky diode CR17 blocks this +5 VDC from the +2.5 VDC reference produced by the voltage comparator U6.

When the infusion system is off, the REGON line goes low to turn off Q14. +RDC is regulated to 2.5 V by U6 and RN9 (5,6) which flows through CR17 to become VMEM.

4.8.3.6
MOTOR POWER SUPPLY CONTROL

The +6.5 VDC motor supply is regulated similarly to the +5 VDC supply. U2 supplies +2.5 VDC to the noninverting input of U3C. The dividers, consisting of RN3 (3,4), RN3 (4,5), and R9, apply a fraction of the MOTPWR voltage to the inverting input of U3-C. When the MOTPWR line is +6.5 VDC, U3-C provides the necessary reference voltage as shown in the following equation: (0.385) X (6.5) = 2.5.

Any variance from the +2.5 VDC reference is continuously corrected as U3-C varies the current through transistor Q6 through Q4.

U3-D operates as a voltage comparator to limit current. The dividers, consisting of RN3 (8,9), RN3 (9,10), and RN3 (9,11) source a 293 mV reference to the inverting input of U3D. Should the motor return current through R4 exceed 2.93 A, U3-D output will go high to turn on transistor Q12. The collector of Q12 clamps the noninverting input of U3-D to ground, removes the +2.5 VDC reference, and disables the +6.5 VDC motor supply.

The VMOFF line at P4, pin 4, is a control signal from the I/O PWA. Operating under software control, a logic high at P4, pin 4, turns on transistor Q12 and disables the +6.5 VDC motor supply, the same as the current limit.

Note: The motor supply can also be disabled by the OVPVMOFF signal from the overvoltage protector through transistor Q12.

4.8.3.7
OVERVOLTAGE PROTECTION

A faulty +5 VDC power supply can damage the MPU on the main PWA. When a +5 VDC supply malfunction occurs, the pumping mechanism motors cease operation.

Pumping ceases as follows: operational amplifier U5-B senses the +5/VAN supply line through the divider, consisting of RN9 (8,9) and RN9 (7,9). These resistors divide the +5/VAN level by a factor of 0.452 for comparison with the +2.5 VDC reference from U6. Should the +5/VAN level exceed +5.5 VDC, (e.g., +2.5 VDC divided by 0.452), the output of U5-B will go high to activate the OVPVMOFF line through CR16 and RN9 (3,4), shutting off the +6.5 VDC motor supply. The OVPALM signal from U5-B output also triggers the audible alarm, indicating an overvoltage situation.

Signals OVPREF (P4, pin 16) and OVPTST (P4, pin 13) are available for monitoring and testing by the I/O PWA.

4.8.3.8
AUDIBLE ALARM BACKUP

Capacitor C3 serves as a temporary audible alarm backup power source. Should the supply voltage drop to zero due to a complete battery discharge, or should a catastrophic failure of logic circuitry occur during on status, the capacitor C3 automatically provides backup power for several minutes to enable the audible alarm.

Capacitor C3 is charged from the +5 VDC supply through diode CR5. Diodes CR3 and CR4 isolate the charged capacitor unless the cassette switch SW1 is activated.

4.8.3.9
AUDIBLE ALARM CONTROL

The audible alarm is a self contained piezoelectric crystal and oscillator circuit which emits sound when a DC voltage is applied. The alarm can be triggered by the following signals:

- ❑ AUDALM line from the I/O PWA custom IC (under processor control)
- ❑ OVPALM signal from the over-voltage protect circuit
- ❑ WDTRAP signal from the I/O PWA custom IC
- ❑ Absence of -5 V supply from the main PWA

Positive voltage for the beeper is supplied by SWRDC, through RN10 (6,7). The level of drive current is set by the volume switch (S1 on the I/O PWA), which switches additional resistance, as necessary. In the high position, the total resistance is 200 ohms (RN10 (6,7)). In the medium position, S1 is open and the resistance is 2500 ohms (RN10 (6,7) + RN10 (7,8) + R30). In the low position, the beeper is shunted by 480 ohms (R31 + RN 10 (9,10)).

AUDALMN is the normal means for the processor to sound an alarm. AUDALMN goes low, turning off Q3, which allows Q2 to be turned on. Q2 provides a current path to ground from the beeper.

OVPALM goes high if the over-voltage protection circuit trips; this turns Q1 on, providing a current path.

WDTRAP is wire-ORed with the OVPALM signal.

If the 5 V supply goes to zero due to a flat-battery shutdown or circuit failure, the -5 V supply also goes to zero. This allows enhancement-mode field-effect transistor (FET) Q19 to turn on, providing a path from SWRDC through RN10 (6,7) to the beeper.

4.8.3.10 AUDIBLE ALARM SELF TEST

Audible alarm operation is tested by comparator U5, transistor Q11, and associated passive components. A low on alarm flag (ALMFLG)* (P4, pin 7) informs the MPU of proper alarm operation.

The audible alarm self test is performed by bringing OVPTST (P4, pin 13) high, and turning on transistor Q21, which turns off transistor Q5. This controlling action removes the shunt across the piezoelectric alarm during a low volume setting of SW1.

With sufficient piezoelectric alarm output, the AC voltage produced by the piezoelectric alarm transducer is verified. The AC frequencies above 1.5 kHz are extracted by the high-pass filter consisting of capacitors C1, C2, resistor R7, and resistor network RN1 (9,10). Such signals are applied to the noninverting input of U5-C with diode CR1 clamping the negative excursion to -0.7 VDC. A reference of +0.1 VDC is provided by resistor networks RN5 (5,6) and RN5 (6,7) at the inverting input of U5-C. If the output is greater than the reference, the output of U5-C goes high to turn on Q11. The ALMFLG line (P4, pin 7) is clamped low by Q11 to indicate normal piezoelectric alarm operation.

4.8.3.11 BATTERY PACK CHARGING

On certain 1.5 series infusion systems, and on 1.6 series infusion systems, a battery charger PWA is installed and connected to the power supply PWA. The interface consists of nine wires that connect the battery charger PWA through P/J1 and P/J2 to the power supply PWA *(see Figure 4-2, LifeCare 5000 System Interface Block Diagram*, and *Figure 9-7, 1.5 Series Interconnect Schematic*, or *Figure 9-8, 1.6 Series Interconnect Schematic)*. The nine wires connect to the battery charger circuitry on the power supply PWA *(see Figure 9-16, 1.5 Series Power Supply PWA Schematic* or *Figure 9-17, 1.6 Series Power Supply PWA Schematic)*. The circuitry functions the same for either 1.5 series infusion systems or 1.6 series infusion systems.

The battery charger circuit consists of the following components:

- Transistors Q8, Q15, Q16, and Q20
- Diodes CR6, CR9, CR26, and CR27
- Reference U1

- Operational amplifiers U4-A and U4-B
- Associated passive components

Since battery terminal voltage is a function of both state of charge and temperature, the end-of-charge reference voltage is temperature compensated. A trickle charge current is also supplied to maintain the battery between normal charge and discharge cycles.

The positive battery terminal J18, pin 1, is the common line (+RDC) for the charger, the battery, and the raw DC supply. The inverting input of comparator U4-A is supplied with -2.32 VDC reference relative to +RDC; this reference derives from U1 through resistors R26 and R29, and potentiometer R28, with diodes CR26 and CR27, to lower the charging voltage -4 mVDC per degree centigrade.

The battery terminal voltage is sensed through diode CR6 and the divider network, consisting of resistors RN2 (1,2) and RN2 (2,3). The noninverting input of U4-A recognizes [-VBATT - 0.5(CR6 Vf)]/4.2 = 2.3 V relative to +RDC when the battery is fully charged. CR6 disables the charger during battery operation. Current sources Q15, Q16, and RN6 (1,2) keep the forward drop of CR6 constant. The U4-A output is high when VBATT is less than +9.2 VDC (+2.3 VDC per cell), turning on FET transistor Q20 through resistor network RN2 (8,9). Charging current flows through the diode CR10 and the 0.1 ohm sensing resistor R18 to -RDC.

The current loop uses IC U4-B to compare the voltage drop across sensing resistor R18 to approximately 0.1 V from the divider network, which consists of resistor networks RN5 (1,2), RN6 (2,3), RN6 (3,4), and resistor R8. Should the load current exceed (0.1 V/0.1 ohm) = 1.0 A, U4-7 goes high, turning on transistor Q8 through RN6 (6,7). Q8 clamps the noninverting input of U4-A to -RDC to send U4-1 low, turning off transistor Q20. The charger is protected against excessive load current.

When the battery pack is supplying power, the battery return current path of transistor Q20 is through the source to the drain. Resistor networks RN2 (7,8) and RN2 (8,9) forward bias the gate of transistor Q20 with respect to its drain, causing the FET to operate in the inverted mode. When battery voltage is not low enough to trigger charger operation, a trickle current (approximately 5 mA) is supplied by CR9 and R15.

Note: On infusion systems with the battery charger PWA, CR9, and R15 are removed.

4.8.3.12 BATTERY VOLTAGE DETECTION

The sealed battery may be damaged if it is drained to less than approximately +1.6 VDC per cell (a four cell battery pack equals +6.5 VDC). The battery detector circuit detects this state of discharge, terminates battery operation, and sounds an alarm. The battery detector consists of U5-A, diodes CR13 through 15, and associated passive components.

The REGON line equals the battery voltage minus the approximate +0.6 VDC drop across the source to drain of transistor Q20 and the collector to emitter drop of Q18. This voltage is divided by the resistor networks RN8 (1,2), RN8 (2,3), RN8 (3,4) and RN8 (4,5), to yield (0.388)(REGON) = (0.388)(6.50-0.6) = +2.5 VDC, at the inverting input of U5-A, when the battery is discharged. U5-A compares this to the +2.5 VDC reference at its noninverting input, so that its output goes high, signaling a discharged battery; this activates BADBAT (P4, pin 17), setting a latch on the custom I/O chip, which returns a low WAKEUP signal to the power control circuit, disabling both the +5 VDC (logic) and +6.5 VDC (motor) supplies.

CR13 clamps the inverting input of U5-A to +5.5 VDC with a fully charged battery. CR15 clamps the BADBAT line to +5.5 VDC, to be compatible with logic levels on the I/O PWA. R22 supplies a positive input bias for the inverting input of U3-A.

When the infusion system is turned on, INITBAT (P4, pin 30) is set high for approximately 50 ms by the resistor R14, capacitor C14, and the custom I/O chip on the I/O PWA. The signal charges C20 through CR14 to avoid a false bad battery indication before REGON is able to charge capacitor C20 through resistor network RN8 (1,2). INITBAT goes low and remains low during infusion system operation.

4.8.4
BATTERY CHARGER PWA

A battery charger PWA is installed in 1.6 series infusion systems. This PWA is also installed in certain 1.5 series infusion systems that have been returned to Abbott Laboratories *(see Section 1.8, Series Specific Features)*. The battery charger PWA contains the following circuitry *(see Figure 4-6, Battery Charger PWA Functional Block Diagram)*:

- Differential amplifier (U3) and 20 mA shut-off circuitry
- (Q8)
- Window comparator with hysteresis (U1)
- 60 minute battery charger timer (U2)
- 200 mA constant current source (transistors Q6 and Q7) and associated logic (transistors Q3, Q4, Q5, Q9)
- AC (mains) detector (transistor Q1)

For a schematic of the battery charger PWA, refer to *Section 9, Drawings, Figure 9-9, 1.6 Series Battery Charger PWA Schematic*. The battery charger PWA functions during infusion system AC (mains) power and battery power operation, as described in the following sections.

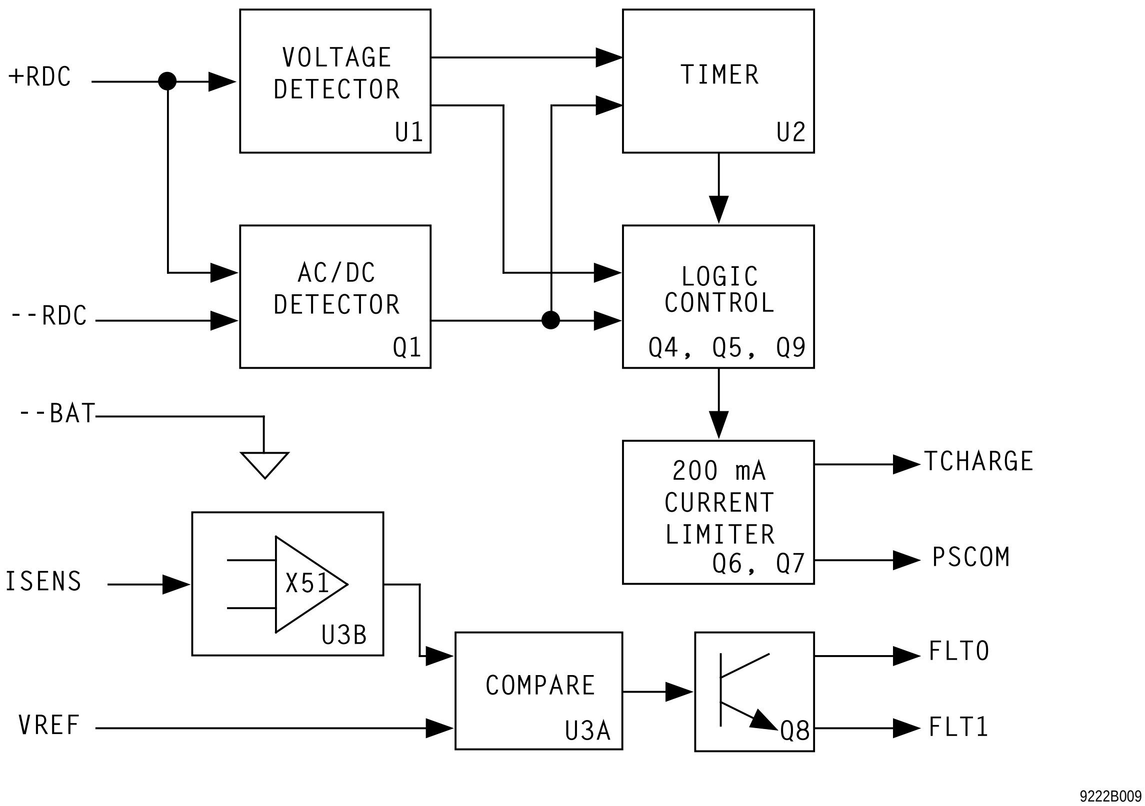

Figure 4-6. Battery Charger PWA Functional Block Diagram

4.8.4.1
AC (MAINS) OPERATION

Voltage detector U1, with associated capacitors and resistors, functions as a window comparator with hysteresis. When the battery is initially connected, the output of U1 is at logic high. After the battery voltage reaches 10 VDC, this output goes low, disabling transistors Q3 and Q4 and triggering the timer, U2.

The clock frequency of timer U2 is determined by C5 and R9; time-out is pending the biasing of the U2 program inputs A, B, C, and D. Upon time-out, the DECODE signal on output pin 13 of U2 goes high; this disables Q5, since Q4 is already disabled, removing the supply to Q9 and causing battery charging to stop. The DECODE signal also locks in the timer, U2, preventing operation by placing a logic high on the SET input, pin 1, of U2.

The AC/DC detector consists of transistor Q1 and associated resistors. When the infusion system operates on AC (mains) power, the collector of Q1 is at logic low, enabling the timer U2 and transistors Q2 and Q9. During DC operation, the -RDC signal goes positive, and the collector of Q1 goes logic high.

Current is limited to 200 mA by the quotient of the VBE of transistor Q6 divided by R14. Transistor Q7 acts as a power switch that is enabled and disabled by transistor Q9. Q7 functions in parallel with Q20 in the battery charging circuitry of the power supply PWA.

IC U3-B acts as a noninverting amplifier with a gain of 51. Current is sensed across resistor R18 in the battery charging circuitry of the power supply PWA. When current drops below approximately 20 mA, the output of U3-B, pin 7 (which is also the input to comparator U3-A, pin 2) is at 100 mV or below. Pin 3 of U3-A is referenced at 100 mV from the battery charger circuitry on the power supply PWA. At this point, U3-A switches to a logic high and turns on transistor Q8. Q8 shorts the gain network to the voltage regulator on the battery charger circuitry in the power supply PWA. Resistor R19 and capacitor C6 act as a noise filter to Q8.

4.8.4.2 DC OPERATION

When the infusion system operates on battery power and the battery pack drains to approximately 8 VDC, pin 4 of the voltage detector U1 switches to logic high; this resets the timer U2, enabling transistors Q3, Q4, and Q5. Transistor Q9 remains disabled because Q1 is disabled. Transistor Q2 discharges capacitor C6 through diode CR2 and resistor R22 into PSCOM, which becomes circuit ground.

4.8.5 SENSOR PWA

For schematics of the sensor PWA, refer to *Section 9, Drawings, Figure 9-19, 1.5 Series Sensor PWA Schematic* and *Figure 9-20, 1.6 Series Sensor PWA Schematic*. Note that *Figure 9-20* shows both a distal and a proximal pressure amplifier channel. Only 1.6 series infusion systems utilize a proximal pressure sensor and proximal pressure amplifier channel. For a functional block diagram of the sensor PWA, refer to *Figure 4-7, Sensor PWA Functional Block Diagram*.

The sensor PWA supplies the following functions:

- ❑ Cassette installation recognition
- ❑ Air-in-line detection in the cassette sensing areas
- ❑ Pressure amplification for proximal and distal strain gauges
- ❑ Optical interrupters to sense the state of the pumping mechanism

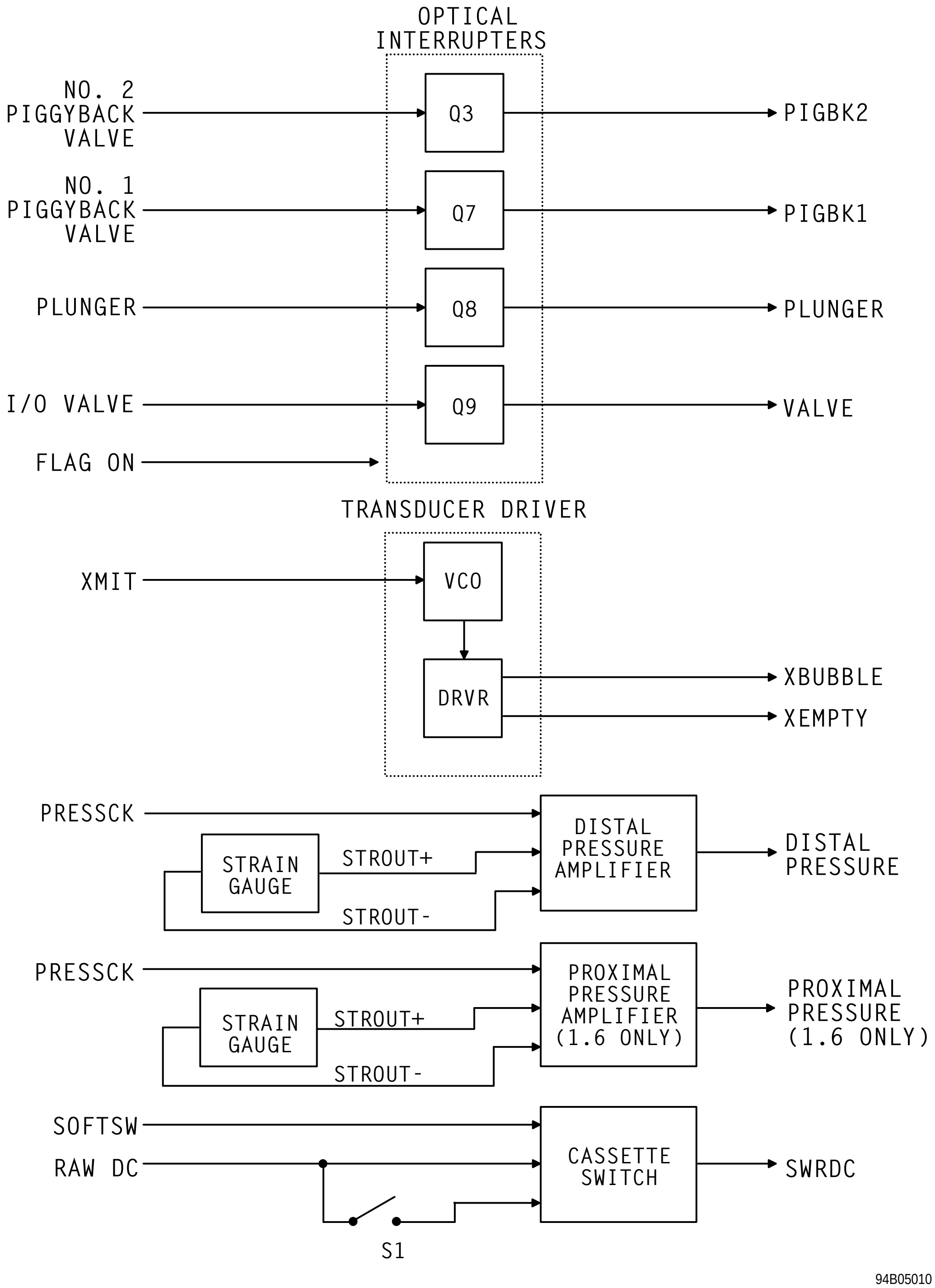

Figure 4-7. Sensor PWA Functional Block Diagram

4.8.5.1 CASSETTE INSTALLATION RECOGNITION

S1 is activated when the infusion system door is closed with a cassette installed; this raises the voltage on SWRDC (J6, pin 18) line to the level of RAWDC (J6, pin 20). RAWDC varies from minimum of +6.4 VDC (when operating from a low battery) to approximately +15 VDC (when operating from AC (mains) line voltage). SWRDC enables the main power regulator to start the infusion system from the off status. SWRDC is an input to the custom IC on the main PWA, signaling the processor that a cassette is installed in the receptacle of the door.

Transistors Q5 and Q6, with associated passive components, allow the processor to bypass switch S1. Bypass condition occurs when the door is opened without first pressing the [RESET] touchswitch (S1 is shunted to allow the audible alarm to sound). Bypass also occurs when the processor is performing power up self testing (S1 is shunted to prevent loss of +5 VDC power during the watchdog test).

4.8.5.2
AIR-IN-LINE DETECTION IN CASSETTE

Air may be detected in the cassette where fluid enters the cassette (proximal) and where fluid exits the cassette (distal).

The air-detection mechanism is similar in both locations. The presence of air in the sensing area of the cassette interrupts the signal paths of the ultrasonic piezoelectric transducer pairs (driven by circuitry on the sensor PWA).

The voltage-controlled oscillator (VCO) section of the 74HCT4046 (U1) phase-locked loop integrated circuit, and a single FET (Q1), drive both transmitting transducers through the XEMPTY (J20, pin 5) line. A 5 kHz triangle wave oscillator, formed by operational amplifier U3-B and an exclusive OR (XOR) gate inside U1, sweeps the VCO output at U1-4 between 4.5 Mhz and 6.5 Mhz to assure that this output passes through the resonant frequency of the transducers.

Sweeping the VCO output is accomplished as follows: the XOR U1-B works as an inverting buffer, charging C14 through R16 until the negative input of U3-B reaches the positive level established by the divider resistors R17 and R18. R2, along with this divider, provides +0.9 VDC of switching hysteresis for U3-B. When its negative input reaches the positive level, U3-7 and U1-2 (the XOR buffer output) go low to discharge C14 through R16 and start another charging cycle. The resulting input to VCO (U1-9) is a triangular waveform of amplitude +0.9 VDC centered at +2.5 VDC.

When the MPU enables the bubble detection system, the VCO center frequency is set by a circuitry network consisting of C7 and R1. U1-5 is then pulled low by the XMIT (J6-13) line from the I/O PWA. A high on this line shuts off the VCO and holds U1-4 high. The output is coupled through capacitor C5 and resistor R5 to the gate of driver FET Q1. R4 and CR1 prevent false turn-on of Q1 by discharging C6, when U1, pin 4 is held high or when the tank circuit (consisting of L1 and C4) rings. Ringing of the L1 and C4 tank circuit allows peak voltages of more than twice the +5 VDC supply developed at the XEMPTY (J20, pin 1) output.

4.8.5.3
PRESSURE AMPLIFICATION

Pressure sensing is accomplished with a four element strain gauge bridge, that is bonded to a steel leaf spring. Element resistance is 350 ohms and the bridge is excited by the +5 VDC supply. When pressure within the cassette causes the spring to be deflected by force, the voltage across the bridge output arms varies by a nominal 735 microvolts (µV) per psi (107 µV per kPa).

The bridge output is linked to the chopper-stabilized amplifier U4, which has a low and temperature-independent offset voltage. Resistor R19 sets the gain on U4-10 at 350. In combination with C10, R19 rolls off this gain at frequencies above 10 Hz for noise suppression; this yields a sensitivity of 260 mV/psi (38 mV/kPa) at U4-10, which is attenuated by a nominal factor of 0.6 through resistor R14 and resistor network RN3 (7,8). Amplifier U3-A further amplifies and filters this output with a DC gain of 1.5, set by resistor networks RN1 (7,8) and RN3 (8,9). The resulting sensitivity at test point (TP) 1 is 195 millivolts (mV)/psi (28 mV/kPa).

The system gain adjustment by R14 allows correction for gauge-to-gauge sensitivity variation. Resistor R15 is adjusted to balance the bridge offset, with R13 setting the range of adjustment. The bridge is balanced for an output of 1.400 V at TP1 using a cassette with zero pressure. The A/D converter on the main PWA reads the pressure (J6, pin 4) output signal.

Proximal pressure sensing is performed by a system similar to that described above. The proximal strain gauge is extended by increasing proximal pressure so that the sense of the gauge outputs must be reversed. The mechanical sensitivity of the proximal pressure system is approximately half that of the distal sensor, so that the resulting pressure signal (at TP4) is about 110 mV/psi (16 mV/kPa).

The offset is different for the proximal sensor; at 0 psi (kPa), the voltage at TP4 is approximately 2 V.

4.8.5.4 OPTICAL INTERRUPTERS

Transistors Q3, Q7, Q8, and Q9 act as optical interrupters, sensing the position of the three stepper motors that actuate the valves and the plunger. Attached to each motor shaft is an opaque flag. The flag breaks the light path of the interrupter at specific motor positions. Transistor Q4 sinks the load current of the interrupters when the FLAGON (J6, pin 2) enabling signal is applied to its gate through the I/O PWA.

4.8.6 BUBBLE SENSOR PWA

The bubble sensor PWA contains circuitry for the preamplifier (transducer preamplifier and piezoelectric transducer transmit/receive channels) as well as circuitry for the amplitude modulator (AM) and threshold detectors. Refer to *Figure 4-8, Bubble Sensor PWA Functional Block Diagram* and *Section 9, Drawings, Figure 9-18, Bubble Sensor PWA Schematic*.

The two sensor bulbs in the cassette fluid path are shown in *Figure 4-9, Major Elements of the Dual-Channel Cassette* and *Figure 4-1, Fluid Path in the Cassette*. With a cassette installed and the door closed, these sensors are straddled by the transducer pairs. The presence of fluid permits passage of an ultrasonic sound wave (approximately 5 Mhz) from the transmit crystal to the receive crystal (X1 for empty and X2 for bubble). This ultrasonic coupling is prevented by the presence of air in the path. Either the absence of a cassette or the presence of air in the cassette is detected through the loss of a signal at the receive crystal.

With the exception of the threshold-detection reference level, bubble sensing is identical for proximal and distal lines. The following sections describe only the X1 channel.

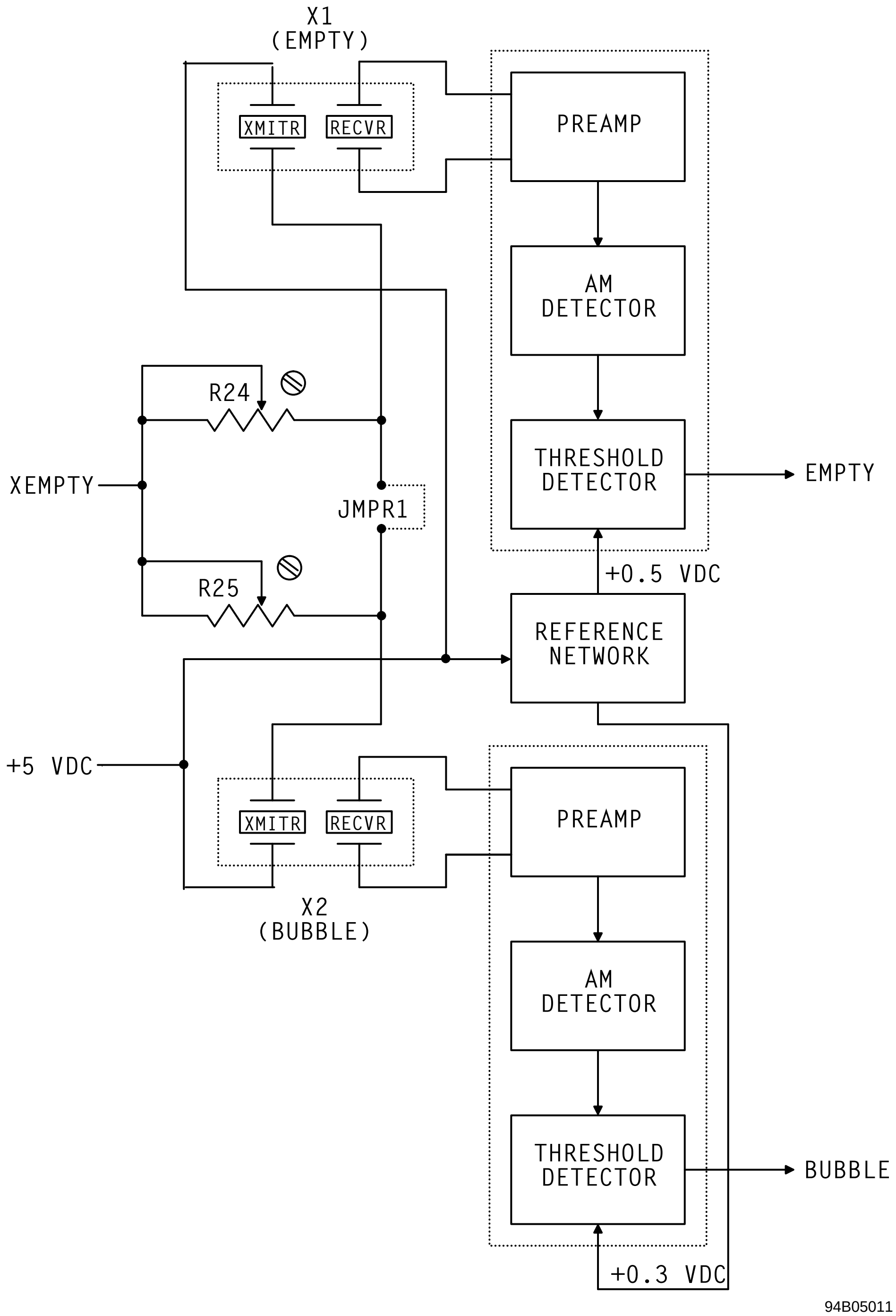

Figure 4-8. Bubble Sensor PWA Functional Block Diagram

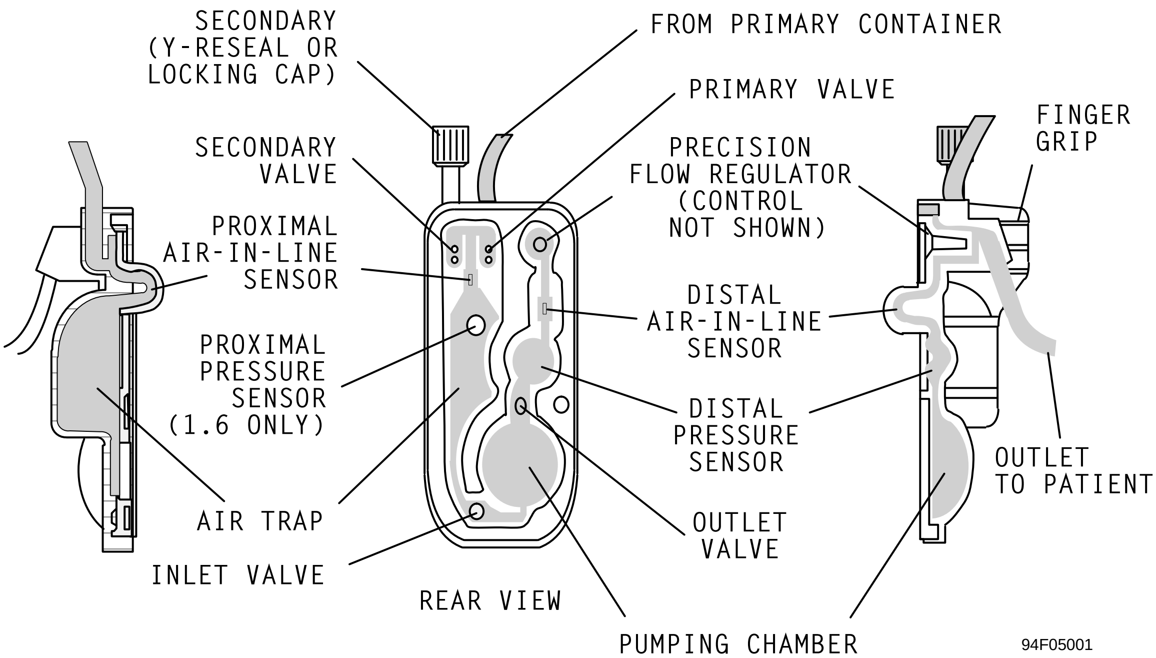

Figure 4-9. Major Elements of the Dual-Channel Cassette

4.8.6.1
PREAMPLIFIER

Potentiometer R24 sets the power level driving the empty X1 crystal, allowing correction for variations in transducer pair sensitivity. A swept radio frequency (RF) signal (J21, pin 1) from the sensor PWA excites the crystal at its resonant frequency for maximum ultrasonic output.

The receive crystal is coupled to the common emitter amplifier Q4. Resistors R18, R22, and R23 bias the collector of Q4 at approximately +2.6 VDC, for maximum linear swing. Resistors R14, R19, and the emitter resistance of Q4 set the gain to approximately -22.

4.8.6.2
AM AND THRESHOLD DETECTORS

The RF output of the preamplifier is amplitude modulated by the fluid or air in the ultrasonic path. This signal must be converted to a DC level to permit threshold detection. Resistors R13 and R15 bias transistor Q2 on the edge of conduction, rectifying the output of Q4 with only a small voltage drop. The 4.7 ms time constant of resistor R9 and capacitor C4 hold the peak DC level between RF sweeps for the threshold detector input. Resistors R24 and R25 are adjusted to give +1.5 VDC in both the proximal and distal channels using an installed water-filled cassette.

The comparator U1-A compares the DC level from transistor Q2 to a +0.5 VDC reference, to signal the presence of air by sending the EMPTY (J21, pin 5) line high. If fluid is present, the input of U1-A is higher than the reference, and the output is low. Resistors R1 and R2 provide about 20 mV of switching hysteresis for noise immunity. The EMPTY (J21, pin 5) and BUBBLE (J21, pin 6) lines are routed through the sensor PWA to the I/O PWA.

Resistors R3, R6, and R7 provide the threshold reference network for both the proximal and the distal channels. The empty reference is +0.5 VDC and the bubble level reference is +0.3 VDC.

4.8.7 LED DISPLAY PWA

The LED display PWA consists of the following circuitry *(see Figure 4-10, LED Display PWA Functional Block Diagram)*:

- Character LEDs and drivers
  - Segment and character control
  - Display drivers
  - Five seven-segment common cathode LEDs
  - Three LEDs (AC, battery, and decimal point)
- Current sensing amplifier
- Analog multiplexer

For a schematic of the LED display PWA, refer to *Section 9, Drawings, Figure 9-10, LED Display PWA Schematic*.

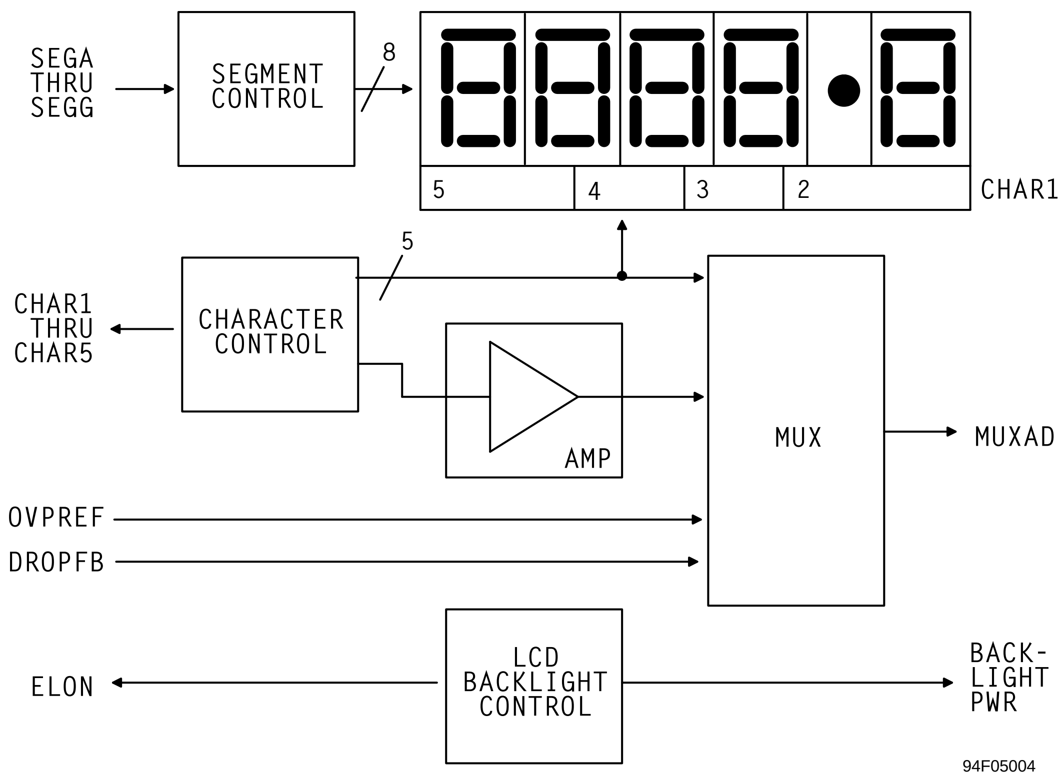

Figure 4-10. LED Display PWA Functional Block Diagram

4.8.7.1
CHARACTER LEDS AND DRIVERS

The LED characters U1 through U5 are driven by transistor arrays U7, U8, and U9. Digit drivers are multiplexed through U9, with the MPU refreshing a new digit every three ms. A custom IC on the main PWA provides the segment drive signals (SEGDA through SEGDP, P1, pins 1 through 8) and character drive signals (CHAR1 through CHAR5, P1, pins 12 through 16).

When SEGDA through SEGDP goes low, U7 and U8 source current through the resistor networks RN1 and RN2 to energize the segments of the active character LED. The active character is selected by the CHAR1 through CHAR5 line that is low, sinking the segment currents through one of the transistors in U9.

LED 1 and LED 2 are driven by the power supply PWA through LPLEDA (P1, pin 23) and BPLEDA (P1, pin 24) to indicate AC (mains) line or battery power.

4.8.7.2
CURRENT SENSING AMPLIFIER

Total display current flows to ground through the 1 ohm, current-sensing resistor R3. The operational amplifier U6-A is configured as an amplifier with a noninverting gain of 11, through resistor networks RN3 (7,8) and RN3 (8,9) with input dividers RN3 (4,5) and RN3 (5,6) giving 10 times the voltage drop across R3. The output of U6-A is a 10 mV/mA representation of the current flowing through the active LED character.

4.8.7.3
ANALOG MULTIPLEXER

The collector voltages of U9 and the current sense amplifier output comprise six out of the eight inputs to multiplexer U10. The remaining inputs are the flow monitor circuit (used in 1.6 series infusion systems only), and the OVPREF (P1, pin 22) line from the power supply PWA.

The multiplex signals MUX0 through MUX2 (P1, pins 9 through 11), are outputs from the custom IC on the main PWA. Output MUXAD (P1, pin 20) is delivered to the A/D converter on the main PWA, allowing the display devices to be tested when the infusion system is turned on.

Module T1 is a 90 V power supply which generates drive voltage for the LCD screen module backlight. T1 is energized when the ELON line from the main PWA is high.

4.8.8
FLOW DETECTOR PWA (1.6 SERIES)

The flow detector contains two PWAs: a photo emitter PWA, and a photo sensor PWA. As shown in *Figure 4-11, Flow Detector PWAs Schematic Diagram*, the flow detector diodes DS1 and DS2 on the photo emitter PWA emit narrow beams of infrared light toward the phototransistors on the photo sensor PWA. The resulting currents are summed at the sensor output and represent the total infrared energy incident on the transistors Q1, Q2, and Q3. When a drop falls through the infrared beam, the amount of light incident on the transistors is reduced, resulting in a corresponding reduction in output current, which forms the drop signal.

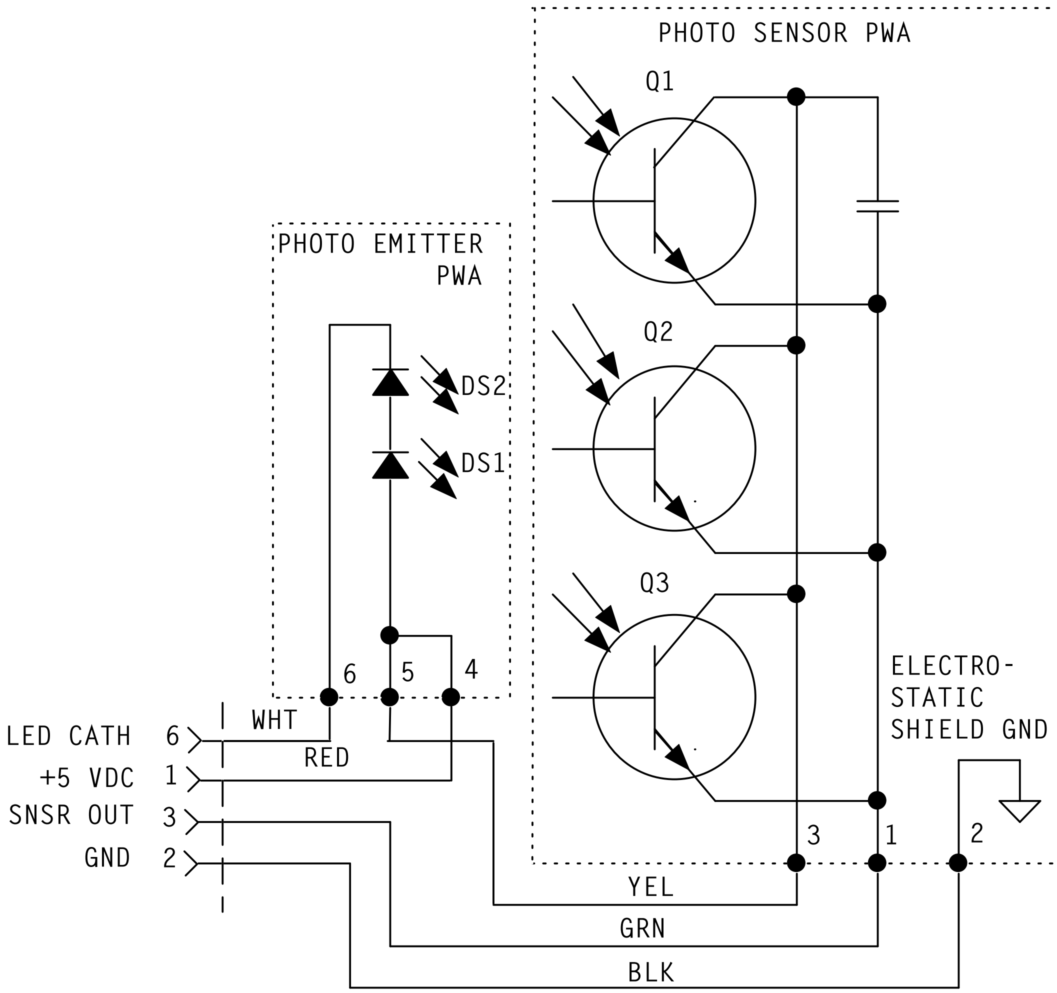

Figure 4-11. Flow Detector PWAs Schematic Diagram

4.8.9
LCD ASSEMBLY

The LCD assembly is mounted directly behind the LCD window on the infusion system front panel. The LCD assembly provides a 4-line-by-16-character display for alarm and status messages. Since the LCD display PWA is an integrated module, no functional block diagram or schematic is furnished.

The LCD assembly module consists of the 4-line-by-16-character dot matrix display, an electroluminescent backlight panel, and a PWA containing SMD-integrated circuitry that performs display interfacing and drive functions. Support circuits on the main PWA and the display PWA provide contrast control and backlight power, respectively.

Characters are written to and read back from the LCD through line display data (DSPD)0 through DSPD7. LCDRS and LCDWR provide read and write control, respectively. The read capability allows the system to confirm that data latches in the LCD module are functioning correctly.

4.8.10
JUNCTION BOX ASSEMBLY (DATAPORT OPTION)

The junction box assembly permits interconnection and communication between a host computer and up to 15 DataPort-equipped infusion systems on one channel. See *Section 4.7.2.3, DataPort Interface*. The junction box PWA consists of the following circuitry *(see Figure 4-12, Junction Box PWA Functional Block Diagram*, *and Figure 9-21, 1.6 Series Junction Box PWA Schematic)*:

- The main communication lines entering the junction box are TX, communication (COMM), RX, and CTS. Signals are routed through six-pin modular jacks J1 and J2 and the DB-15 connector P22 in the junction box.
- Connectors J1 and J2 are identical and interchangeable. Connector P22 interfaces with J22 on the I/0 PWA on the back of the infusion system.
- Diodes CR1 through CR6 are low-capacity, unidirectional transient voltage suppressors, two of which perform a bidirectional protection function. The diodes protect the TX, RX, and CTS signal lines, relative to the COMM signal, from static discharge. A maximum voltage of 23.6 V is allowed on the transient suppressors before they conduct. The driver/receiver IC, U5, located on the I/O PWA, tolerates 30 V without sustaining damage.
- When properly configured, the DIP switch SW1 assigns a hard ID to each infusion system. Poles 1 through 4 assign the binary code, and pole 5 is the parity function. The hard ID circuit is isolated from the COMM lines through digital ground (DGND).

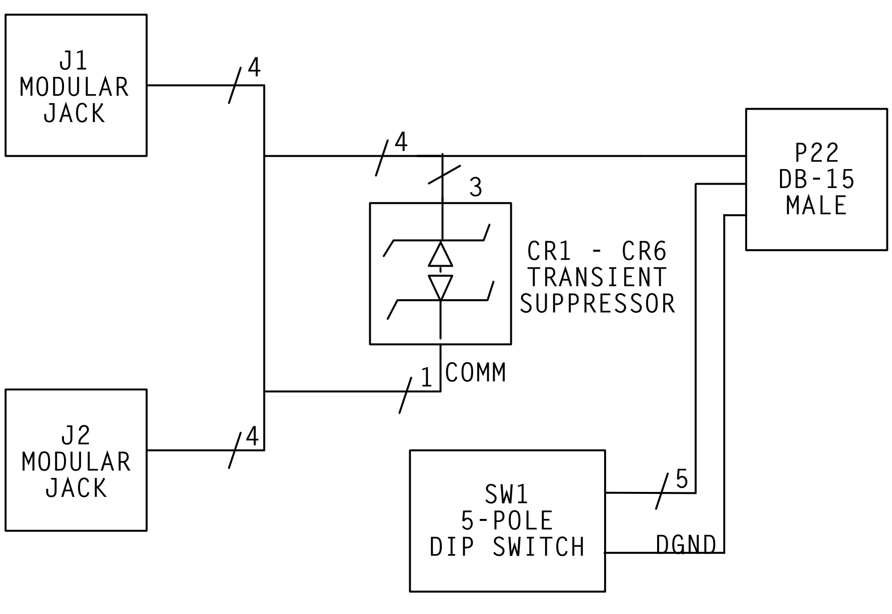

Figure 4-12. Junction Box PWA Functional Block Diagram

4.9 MECHANICS FUNCTIONAL DESCRIPTION

Principal mechanical elements of the infusion system include the following:

- Cassette
- Three-motor pumping mechanism
- Cassette sensor switch
- Fluid sensors
- Regulator
- Interconnect/interface electronics

The following sections detail the cassette and the pumping mechanism. When a cassette is properly installed, the infusion system performs a 15-second self test to verify the integrity of internal systems. The properly-installed cassette and closed door activate the cassette sensor switch, which applies power to the infusion system.

4.9.1 CASSETTE

The infusion system cassette operates on a fluid displacement principle to deliver fluid volumetrically *(see Figure 4-9, Major Elements of the Dual-Channel Cassette*, and *Figure 4-1, Fluid Path in the Cassette)*. Refer to the system operating manual for a description of the major cassette functions.

The pumping cycle begins when the outlet valve is opened and the diaphragm is deflected by the plunger expelling the fluid. At the end of the pumping stroke, the outlet valve is closed, the inlet opens, and the plunger retracts, allowing fluid to refill the pumping chamber. After the pumping chamber is filled, the inlet and outlet valves are reversed and the cycle repeats.

Air detection operates as follows: The cassette contains two chambers separated by an inlet valve. The upper chamber is an air trap, which receives fluid from the IV container through either the primary or secondary valve. The upper chamber collects air bubbles from the IV line and container, and prevents them from entering the pumping chamber. The air-trap chamber can collect a substantial amount of air before the cassette needs to be reprimed. The MPU tracks the amount of air collected in the air-trap chamber; if the limit is reached, it calls for a backprime.

A proximal air-in-line sensor (bubble detector), located between the primary valves and the air trap, detects air entering the air trap. A proximal air-in-line alarm sounds when a predetermined amount of air is detected. Similarly, a second air-in-line sensor (bubble detector), located distal to the pumping chamber, initiates an alarm if a predetermined amount of air is detected. The distal air-in-line sensor prevents air from reaching the patient.

A pressure sensor located distal to the pumping chamber monitors pressure on the distal side of the cassette. In 1.6 series pumps, a proximal pressure sensor located above the air trap also monitors proximal pressure.

A flow regulator is incorporated in the cassette distal end. This flow regulator can be used to control flow manually when the cassette is not inserted in the pump.

When the cassette is properly inserted and the door is closed, a mechanism opens the regulator to allow flow to be controlled by the pump. When the door is opened, the same mechanism closes the regulator, assuring there is no flow to the patient.

The pumping chamber receives fluid from the air-trap chamber through the inlet valve. When the diaphragm covering the pumping chamber is deflected by the plunger, the pumping chamber expels fluid through the outlet valve.

4.9.2 MECHANISM ASSEMBLY

Refer to *Figure 4-13, Elements on the Mechanism Assembly*. When a cassette is properly installed and the door is closed, the mechanism assembly turns the cassette [ON/OFF] switch ON, which activates the plunger. The motors are phased and matched for proper operation.

During the pumping cycle, the plunger motor drives a nut coupled to a lead screw. The motor action and screw move the plunger forward, delivering 0.33 ml of fluid per cycle (0.17 ml for concurrent). The plunger motion synchronizes with the valve motor action to provide controlled fluid delivery.

The mechanism assembly is a self-contained assembly that consists of the following components:

- Motors and valves *(Section 4.9.2.1)*
  - Primary/secondary valve subassembly
  - Inlet/outlet valve subassembly
  - Plunger drive subassembly
- Cassette door subassembly *(Section 4.9.2.2)*
- Bubble sensor PWA *(Section 4.8.6)*
- Sensor PWA *(Section 4.8.5)*

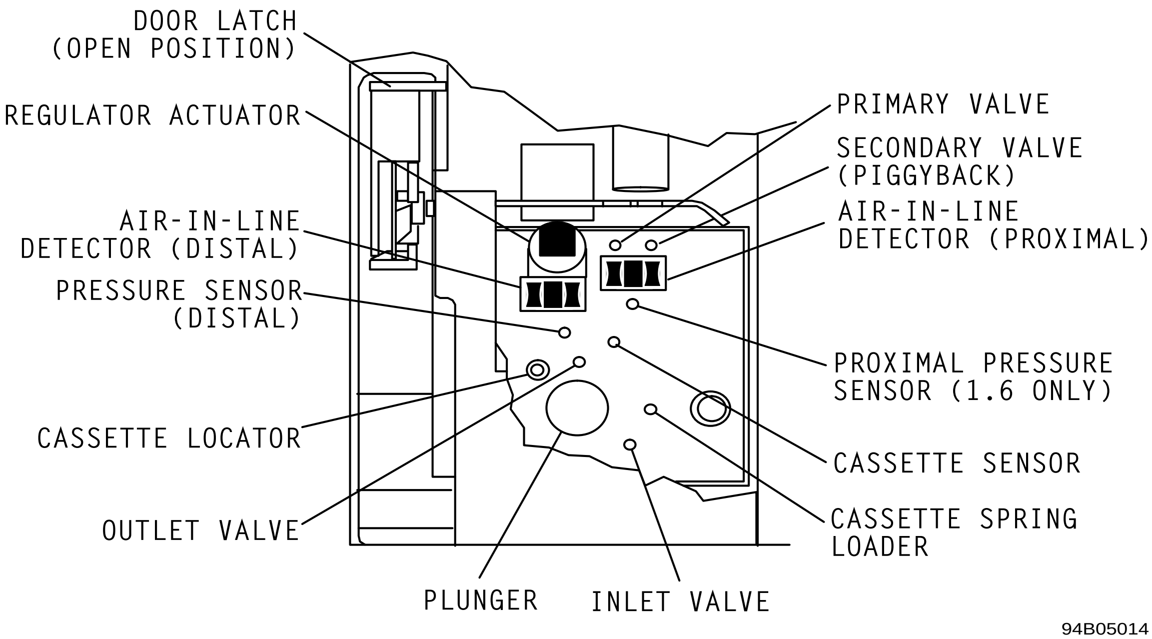

Figure 4-13. Elements on the Mechanism Assembly

4.9.2.1
MOTORS AND VALVES

Pumping action of the mechanism is controlled by three stepper motors. One motor and associated valve assembly activates either the primary or the secondary valves of the cassette, depending on command input. The second motor opens or closes the inlet or outlet valves to control fluid delivery into the cassette chamber. A third motor moves the plunger, which causes a pumping action that increases pressure to the cassette fluid pumping chamber.

4.9.2.2
CASSETTE DOOR SUBASSEMBLY

The cassette door subassembly consists of the door handle subassembly and the cassette door holder subassembly. The cassette door holder subassembly is activated by lifting the door handle, which opens the cassette door holder. The open cassette door holder permits the installation of a cassette. A mechanism in the mechanism assembly opens the regulator to allow controlled flow through the cassette. When the door is opened, the regulator closes to prevent flow to the patient.

4.9.2.3
PRIMARY/SECONDARY VALVE ASSEMBLY

Note: The inlet/outlet valve assembly is similar in design, but opposite in function to the primary/secondary valve assembly. Because the assemblies are similar, only the primary/secondary valve assembly description follows.

The primary/secondary valve assembly consists of a stepper motor with attached ball bearing, flag, two levers, and associated valve pins. The motor is designed to rotate an eccentrically mounted ball bearing. When positioned at top dead center (home position), this bearing can rotate 12 steps (90 degrees) left or right. Rotation causes one valve to open and the other to close. Rotation clockwise from the home position opens the primary valve and closes the secondary valve.

The flag passes through an interrupter module as it rotates with the shaft of the motor.

The lever is the connecting link between the eccentrically mounted ball bearing and the valve pin. The lever also serves as an actuator device in the event of a broken main valve loading spring. If the spring should break, a small-diameter spring mounted to the bottom of each lever acts as a safety spring. The safety spring positions the primary lever in the interrupter module, causing infusion system shutdown and activating alarm code 79 *(see Table 6-1, Alarm Codes and Corrective Actions)*.

To determine home position when the infusion system turns on, a pin on the motor eccentric (combination of shaft, bearing, and cam), comes in contact with a finger attached to the motor plate.

4.9.2.4
PLUNGER DRIVE ASSEMBLY

The plunger drive assembly consists of the following components:

- Stepper motor
- Thrust ball bearing
- Coupling assembly
- Lead screw
- Plunger and plunger guide leaf spring

The stepper motor is designed to rotate one and two-thirds revolutions per cycle. Each rotation of the motor displaces 0.333 ml of fluid. The motor reverses, the plunger returns to home position, and the cycle repeats for the duration of fluid administration.

The thrust ball bearing rests against the motor mounting base. As the cassette displaces fluid, the resulting load is absorbed axially by the bearing.

The coupling assembly provides the mechanical linkage for a fixed dead-center location of the plunger by holding the plunger in true position. A plastic nut is retained within the coupling assembly, and moves freely on its axis regardless of any misalignment between the motor and plunger. A wave washer applies a constant spring load against the nut, confirming the plunger’s fixed location, and allows the nut to move freely in any angular direction. The coupling assembly also contains a flag, which passes through an interrupter module, determining the plunger home position. The flag, passing through the interrupter module, also determines the number of pumping steps.

Each time the infusion system turns on, the motor automatically reverses until home position is determined. From home position, the pumping cycle starts. As the motor rotates, the flag passes twice through the interrupter module, the motor stops momentarily, returns to the home position, and repeats the pumping cycle.

The lead screw converts motor rotation into linear pumping motion. The lead screw is contained on one end by a nut, and on the other end by a plunger guide leaf spring. The plunger guide leaf spring and the plunger act as a single unit that cannot be separated. The plunger guide leaf spring operates in conjunction with the coupling assembly, so the plunger moves freely in a linear direction.

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Section 5

MAINTENANCE AND SERVICE TESTS

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

5.1 ROUTINE MAINTENANCE

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

5.1.1 INSPECTING THE INFUSION SYSTEM

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

5.1.2 CLEANING THE INFUSION SYSTEM

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

Follow hospital protocol for establishing the infusion system cleaning schedule.

WARNING

DISCONNECT THE INFUSION SYSTEM 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 system in liquids. Immersion could damage the instrument. Do not allow liquids to enter the infusion system electronics compartment.

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

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.

Clean the exposed surfaces of the infusion system 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 system 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
Vesphene® IIse	Calgon Vestal Laboratories	Per manufacturer's recommendation
Manu-Klenz®	Calgon Vestal Laboratories	Per manufacturer's recommendation
Formula C™	Diversey Corporation	Per manufacturer's recommendation
LifeCare® Germicidal Towelette	Manufactured for Abbott Laboratories	Per manufacturer's recommendation, use undiluted
Super Edisonite®	S. M. Edison Chemical Co.	Per manufacturer's recommendation
Household bleach	Various	Per hospital procedures; do not exceed one part bleach in ten parts water

Clean the cassette door with a soft, lint-free cloth dampened with one of the cleaning agents listed in *Table 5-1, Cleaning Solutions*, or a mild solution of soapy water. Use a small non-abrasive brush to aid in cleaning the infusion system housing and subsystem chassis components. To thoroughly clean the cassette receptacle, disengage the cassette door from the door latch by pressing the door release tab *(see Figure 5-1, Mechanical Elements Behind Cassette Door)*.

Clean the flow detector with a soft cloth dampened with with an approved cleaning solution or soapy water. Carefully clean the sensor windows with a cotton swab dipped in cleaning solution or soapy water. After cleaning, thoroughly dry the windows. Use cotton swabs dampened with an approved cleaning solution to clean the pins. No other routine maintenance is necessary, except as required by hospital policy.

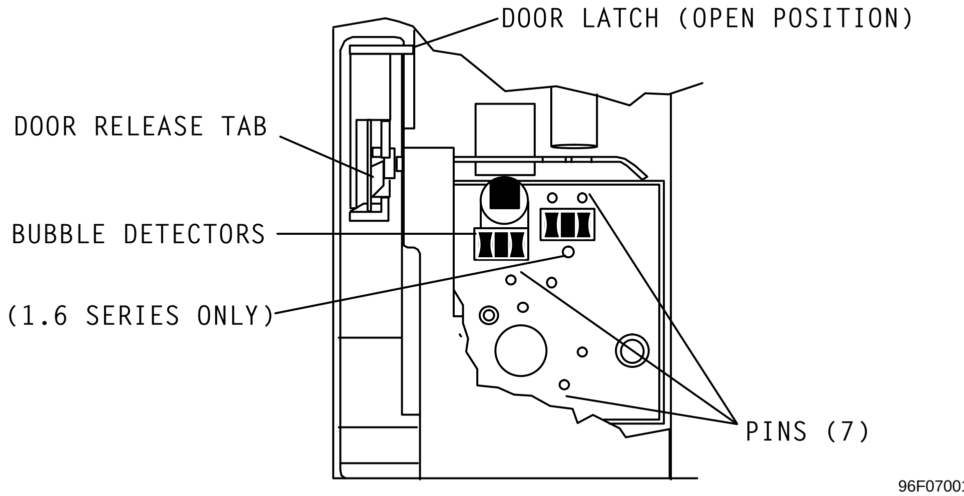

Figure 5-1. Mechanical Elements Behind Cassette Door

5.1.3
SANITIZING THE INFUSION SYSTEM

Sanitize the external surfaces of the infusion system using a cleaning solution listed in *Table 5-1, Cleaning Solutions*.

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

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

5.2
PERFORMANCE VERIFICATION TEST (1.5 SERIES)

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 system. The PVT should be used for performance verification before an infusion system 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 (1.5 Series)*.

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

This section consists of the PVT for 1.5 series infusion systems. For performance testing of 1.6 series infusion systems, use the PVT in *Section 5.3, Performance Verification Test (1.6 Series)*.

5.2.1 EQUIPMENT AND MATERIALS REQUIRED

The equipment and materials or equivalents required to perform the PVT for 1.5 series infusion systems follow:

- Safety analyzer, Dynatech Nevada® Model 231D
- Digital pressure meter (DPM), 0 to 50 psig (0 to 345 kPa), Bio-Tek® DPM II
- Blunt Cannula, List No. 11302 or 21-gauge needle, List No. 4492 (optional)
- Nurse-call test cable or equivalent 1/4 inch phone jack to banana plug, P/N 561-88416-001
- Three-way stopcock, List No. 3233
- Reflux valve, P/N 711-38272-001 (optional)
- 470 ohm/100 microfarad resistor/capacitor network, P/N 561-88419-001
- Digital multimeter (DMM), Fluke® Model 77
- Two containers of sterile water, List No. 7973-08, or tap water
- IV sets, List Nos. 6426-02 and 3047-01
- Primary macro set plus matching secondary macro set
- 25 ml cylinder graduate (0.2 graduations)
- No. 2 Phillips screwdriver
- Hex nutdriver set
- Stopwatch
- Special cassette, P/N 595-81670-001, with proximal bubble sensor tips removed from cassette, and marked EMPTY on the cassette
- Special cassette, P/N 595-81670-001, with distal bubble sensor tips removed, and marked AIR on the cassette
- Bubble sensor location fixture, P/N 561-81402-001*
- Bubble sensor location calibration block (calibration block), P/N 561-81402-006*

***Note:** The bubble sensor location fixture and calibration block are required only when performing the bubble sensor location test.

5.2.2 INSPECTING THE INFUSION SYSTEM

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

Inspect the following for missing or damaged parts and for cosmetic defects:

- All cords
- Case
- Pole clamp and pad
- All switches
- Accessory jacks

- ❑ Faceplate
- ❑ Pressure pads (feet)
- ❑ Velcro® strap
- ❑ Minipole and clutch
- ❑ Door assembly (open and unlatch door; check valve pins and air sensor behind door. Valve pins should move freely in the guide holes. Clean as necessary)
- ❑ Flow detector (1.6 series, as applicable)
- ❑ Junction box (1.6 series, as applicable)

5.2.3 START-UP TEST

WARNING

DO NOT CONNECT A PATIENT TO THE INFUSION SYSTEM DURING DEVICE TESTING.

The following tests are normally conducted with the infusion system in the MACRO SECONDARY MODE (dual channel, single dose). When the infusion system is in this mode, the LCD screen displays: LIFECARE 5000 DUAL CHANNEL. Prior to starting the PVT, note the configuration of the DIP switches and place the infusion system in the MACRO SECONDARY MODE as necessary. Refer to *Section 1.9, Setting the Delivery Mode*, for information on DIP switch settings for the desired mode. See also *Figure 1-1, DIP Switch Settings for Each Delivery Mode*. At the conclusion of the PVT, reset DIP switches to the previous settings.

Note: If testing in MICRO SECONDARY MODE, the maximum delivery rate is 99.9 ml/hr.

Note: For all testing, the vertical distance from the top of the fluid in the flexible container to midline of the cassette must be 18 ± 6 inches (46 ± 15 cm) as shown in *Figure 5-2, Test Setup*.

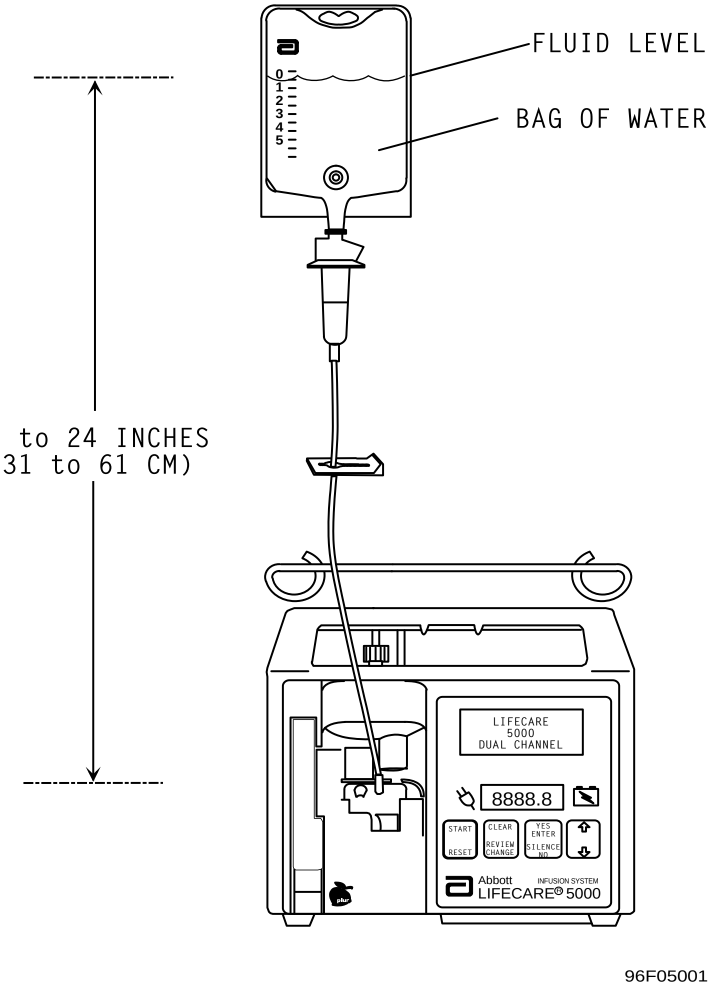

Figure 5-2.   Test Setup

To perform the start-up test, proceed as follows:

1. Insert the primed IV set, with 21-gauge needle attached to the distal line end, into the door. Close the door and verify that the red battery power symbol illuminates.
2. Connect the infusion system to an AC (mains) outlet and verify that the green AC (mains) power symbol illuminates.

   Note: Complete the remainder of the PVT with the infusion system connected to AC (mains) power, except as specified.

3. To verify that all touchswitches emit one short tone or flutter, press each touchswitch in sequence, as follows:

   [START]

   [RESET]

   [REVIEW/CHANGE]

   [SILENCE/NO]

   Down Arrow

   Up Arrow

   [YES/ENTER]

   [CLEAR]

4. Press all touchswitches again except [START] and [CLEAR] in same sequence as described in Step 3; verify that no tones sound. Press [CLEAR] and listen for flutter.
5. Press all touchswitches again as described in Step 3; listen for tone or flutter.
6. Optional. Open and reclose door. When the SELF TEST:OK prompt appears for three seconds, press the [REVIEW] touchswitch to display the software version. Press [REVIEW] again to view the alarm history.

Note: Throughout this manual, a touchswitch, such as [REVIEW/CHANGE], may be referred to by the name that most closely describes its function in a particular procedure. For example, the [REVIEW/CHANGE] touchswitch is referred to as the [REVIEW] touchswitch in Step 6.

5.2.4 BUBBLE SENSOR LOCATION TEST

To perform the bubble sensor location test, refer to *Figure 5-3, Gauge Dial Indicator*. Standardize the gauge of the bubble sensor location fixture, as follows:

1. Place calibration block (boss end) of bubble sensor location fixture over each contact pin, holding the block flush to the base of fixture.
2. Check gauge dial indicators for 0 reading on outer scale and 1 inner revolution indicator. Adjust bezel to 0 as necessary by loosening bezel clamp. Retighten after adjustment is made.

After standardizing the fixture, perform the bubble sensor location test, as follows:

1. Insert bubble sensor location fixture in cassette door and close door.
2. Verify that both dial indicators read 1 revolution ± 0.010.
3. Open cassette door and remove fixture.

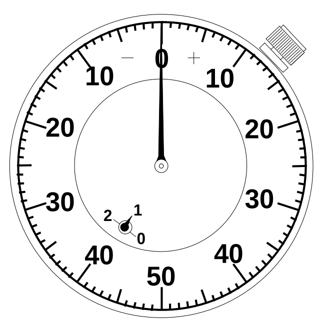

Figure 5-3. Gauge Dial Indicator

5.2.5 NURSE-CALL TEST

Note: The following test may be bypassed if the nurse-call function is not used.

To perform the nurse-call test, attach the nurse-call cable, then proceed as follows:

1. Set primary delivery rate to 400 ml/hr and primary dose limit to 1 ml.
2. Connect DMM to nurse-call cable.

3. Press [START] and verify pumping action.
4. After DOSE END and KVO appear on the LCD screen, observe short circuit on DMM (approximately 1 ohm on 0 to 100 ohms scale).

5.2.6
EMPTY CONTAINER TEST

To perform the empty container test, refer to *Figure 5-4, Dry Cassette*, then proceed as follows:

1. Insert the special cassette marked EMPTY, with the proximal bubble sensor bulb tips removed *(see Figure 5-5, Infusion System Cassettes with Bubble Sensor Tips Removed)*.
2. Attach starter and close door.
3. Set RATE to 400 ml/hr and press [ENTER].
4. Set DOSE LIMIT to 10 ml and press [ENTER].
5. Press [NO] in response to SET SECONDARY.
6. Press [START] and verify that pumping occurs. Within three pumping cycles, verify that one of the following messages appears on the LCD screen: STOPPED AIR IN PROXIMAL LINE PRESS RESET or STOPPED CHECK SET REPRIME SET.
7. Open door and remove cassette.

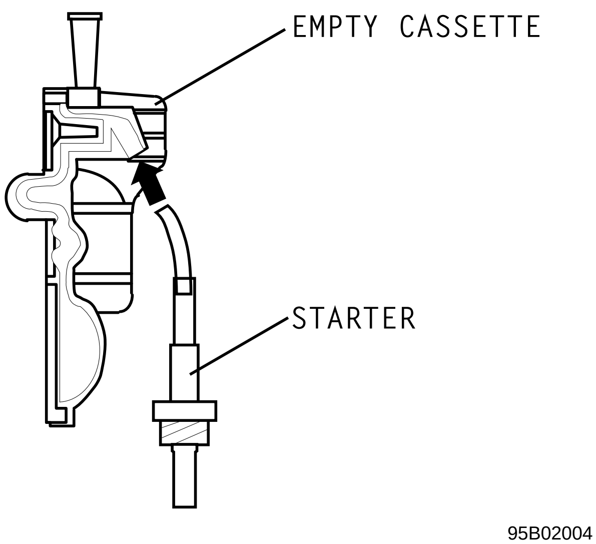

Figure 5-4. Dry Cassette

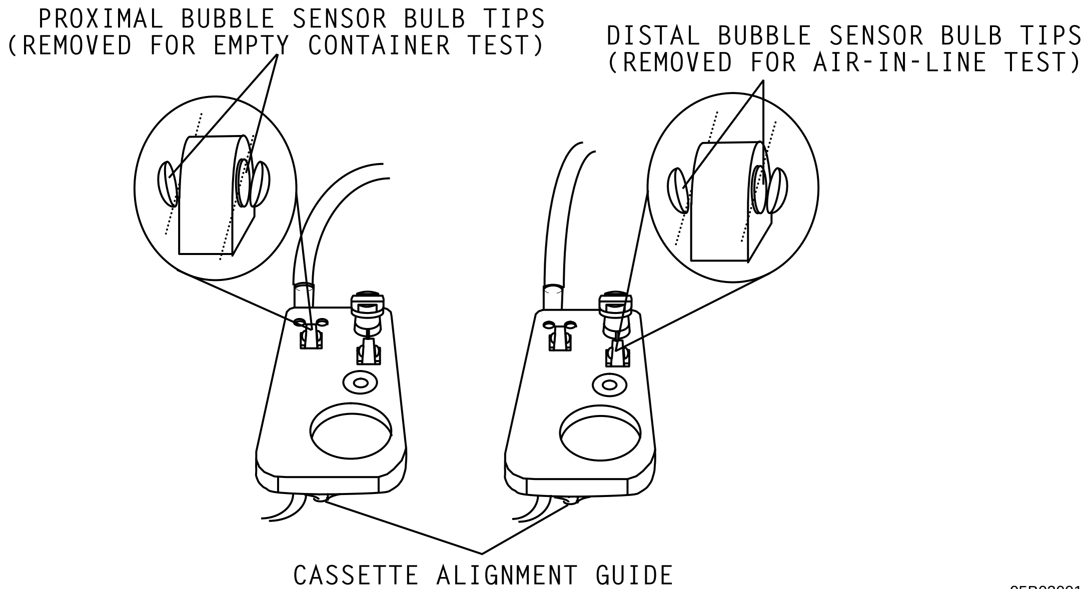

Figure 5-5. Infusion System Cassettes with Bubble Sensor Tips Removed

5.2.7 AIR-IN-LINE TEST

To perform the air-in-line test, proceed as follows:

1. Insert special cassette marked AIR, with the distal bubble sensor tips removed *(see Figure 5-5, Infusion System Cassettes with Bubble Sensor Tips Removed)*.
2. Attach starter and close door.
3. Press [YES] in response to SAVE SETTINGS.
4. Press [YES] in response to FINISH PRIMARY DOSE. Press [START].
5. Before delivery of 6 ml, verify the alarm sounds and that one of the following messages appears on the LCD screen: STOPPED CHECK SET REPRIME SET or STOPPED AIR IN DISTAL LINE PRESS RESET.
6. Press [RESET] to silence alarm. Verify the LCD screen displays: IN RESET OPEN DOOR AND REPRIME SET.
7. Open and close door. Press [NO] in response to SAVE SETTINGS; press [YES] in response to CLEAR VOLUME.

5.2.8 CONCURRENT DELIVERY TEST

To perform the concurrent delivery test, proceed as follows:

1. Set operating parameters as follows:

   Primary delivery rate: 400 ml/hr

   Primary dose limit: 100 ml

   Press [YES] in response to SET SECONDARY

   Press [YES] in response to SET CONCURRENT DELIVERY

   Secondary delivery rate: 200 ml/hr

Secondary dose limit: 50 ml

2. Press [START] and verify the LCD screen displays: PUMPING-CONCURRENT.
3. Verify that pumping occurs alarm-free for one minute.

5.2.9 DELIVERY ACCURACY TESTING

Accuracy testing is for informational purposes only, and is not to be used as a re-release test. If there is any concern regarding infusion system accuracy, return the infusion system to Abbott Laboratories.

5.2.9.1 DELIVERY ACCURACY TEST (MACRO)

To perform the delivery accuracy test in macro secondary mode, proceed as follows:

1. Insert needle or adapter of primed secondary set into cassette secondary inlet.
2. Verify that the infusion system DIP switches are set for MACRO SECONDARY MODE (dual channel, single dose), as described in *Section 5.2.3, Start-Up Test*. (If the DIP switches are in MICRO mode proceed to *Section 5.2.9.2, Delivery Accuracy Test (Micro)*). Set the remaining operating parameters as follows:

   Primary delivery rate: 400 ml/hr

   Primary dose limit: 10 ml. Press [YES] in response to SET SECONDARY.
   Press [NO] in response to CONCURRENT DELIVERY

   Secondary delivery rate: 400 ml/hr

   Secondary dose limit: 10 ml
3. Press [NO] in response to SECONDARY OVERFILL.
4. Place distal Cannula or needle into cylinder graduate and press [START].
5. Verify pumping action.
6. After DOSE END and KVO appear on the LCD screen display, a flashing 1 appears on the LED display and an alarm sounds. Press [RESET].
7. To observe total volume, press [YES] in response to REPEAT PRIMARY, then press [CLEAR] and observe total volume of 20 ml. Press [YES] to clear. The volume in the graduated cylinder should be between 19 and 21 ml.
8. Disconnect infusion system from AC (mains) power.
9. Open door and start stopwatch; if battery symbol remains illuminated for more than 10 seconds, memory reserve is functional.
10. Reconnect infusion system to AC (mains) power.
11. Close door. At end of self test, clear all operating parameters by pressing [SILENCE/NO] and [YES/ENTER].

Note: If the infusion system fails to deliver properly, reprime cassette and repeat test. If the infusion system again fails to deliver properly, contact Abbott Laboratories *(see Section 6.1, Technical Assistance)*.

5.2.9.2 DELIVERY ACCURACY TEST (MICRO)

Note: This test need only be performed if the DIP switches were set to MICRO SECONDARY MODE on the device when it was received.

To perform the delivery accuracy test in micro secondary mode, proceed as follows:

1. Insert needle or adapter of primed secondary set into cassette secondary inlet.
2. Set the infusion system DIP switches to MICRO SECONDARY MODE (dual channel, single dose). Set the remaining operating parameters as follows:

   Primary delivery rate: 99.9 ml/hr

   Primary dose limit: 10 ml. Press [YES] in response to SET SECONDARY. Press [NO] in response to CONCURRENT DELIVERY

   Secondary delivery rate: 99.9 ml/hr

   Secondary dose limit: 10 ml
3. Press [NO] in response to SECONDARY OVERFILL.
4. Place distal Cannula or needle into cylinder graduate and press [START].
5. Verify pumping action.
6. After DOSE END and KVO appear on the LCD screen display, a flashing 1 appears on the LED display and an alarm sounds. Press [RESET].
7. To observe total volume, press [YES] in response to REPEAT PRIMARY, then press [CLEAR] and observe total volume of 20 ml. Press [YES] to clear. The volume in the graduated cylinder should be between 19 and 21 ml.
8. Disconnect infusion system from AC (mains) power.
9. Open door and start stopwatch; if battery symbol remains illuminated for more than 10 seconds, memory reserve is functional.
10. Reconnect infusion system to AC (mains) power.
11. Close door. At end of self test, clear all operating parameters by pressing [SILENCE/NO] and [YES/ENTER].
12. Set the infusion system DIP switches to MACRO SECONDARY MODE (dual channel single dose), as described in *Section 5.2.3, Start-up Test*.

Note: If the infusion system fails to deliver properly, reprime cassette and repeat test. If the infusion system again fails to deliver properly, contact Abbott Laboratories *(see Section 6.1, Technical Assistance)*.

5.2.10 PRESSURE SENSOR TEST

To perform the pressure sensor test, proceed as follows:

1. Set the operating parameters as follows:

   Primary delivery rate: 40 ml/hr

   Primary dose limit: 50 ml

   Secondary delivery: 400 ml/hr

   Secondary dose limit: 4 ml

Occlusion pressure: 4 psig (28 kPa) (accessed through the [REVIEW/CHANGE] touchswitch)

2. Clamp secondary line near inlet site. Within five infusion system strokes, an alarm sounds, and the LCD screen displays: PROXIMAL OCCLUSION SECONDARY.
3. Press [RESET] and unclamp tubing.
4. Press [START]. The infusion system delivers the remaining secondary dose and begins primary delivery.
5. When primary section has pumped 1 ml of fluid, close upper slide clamp. Within five infusion system strokes, an alarm sounds, and the LCD screen displays: PROXIMAL OCCLUSION PRIMARY.
6. Press [RESET] and open the upper slide clamp.
7. Connect distal tubing to DPM through three-way stopcock as shown in *Figure 5-6, Pressure Sensor Test Setup*. A reflux valve between the stopcock and the meter may be used to prevent moisture from entering the meter.

   Note: Height of DPM must be 0 ± 6 inches (0 ± 15 cm) from the midline of the cassette.
8. Open stopcock to air.
9. Press [START] and allow the infusion system to stabilize for at least one minute.
10. Set the stopcock to measure pressure.
11. Press [REVIEW/CHANGE] four times to read pressure according to the infusion system.
12. Confirm an alarm sounds and the LCD screen displays: DISTAL LINE OCCLUSION. Confirm the pressure meter displays 4 ± 1 psig (27.6 ± 6.9 kPa).
13. While the infusion system is in occlusion, turn the audible alarm switch to all three positions; confirm all stages operate correctly.
14. Press [RESET].
15. Set infusion system pressure to 8 psig (55 kPa) and repeat Steps 9 through 14 (omitting Step 15). At occlusion, the pressure meter should display 8 ± 1.5 psig (55.1 ± 10.3 kPa).
16. Remove the distal tubing from the stopcock.

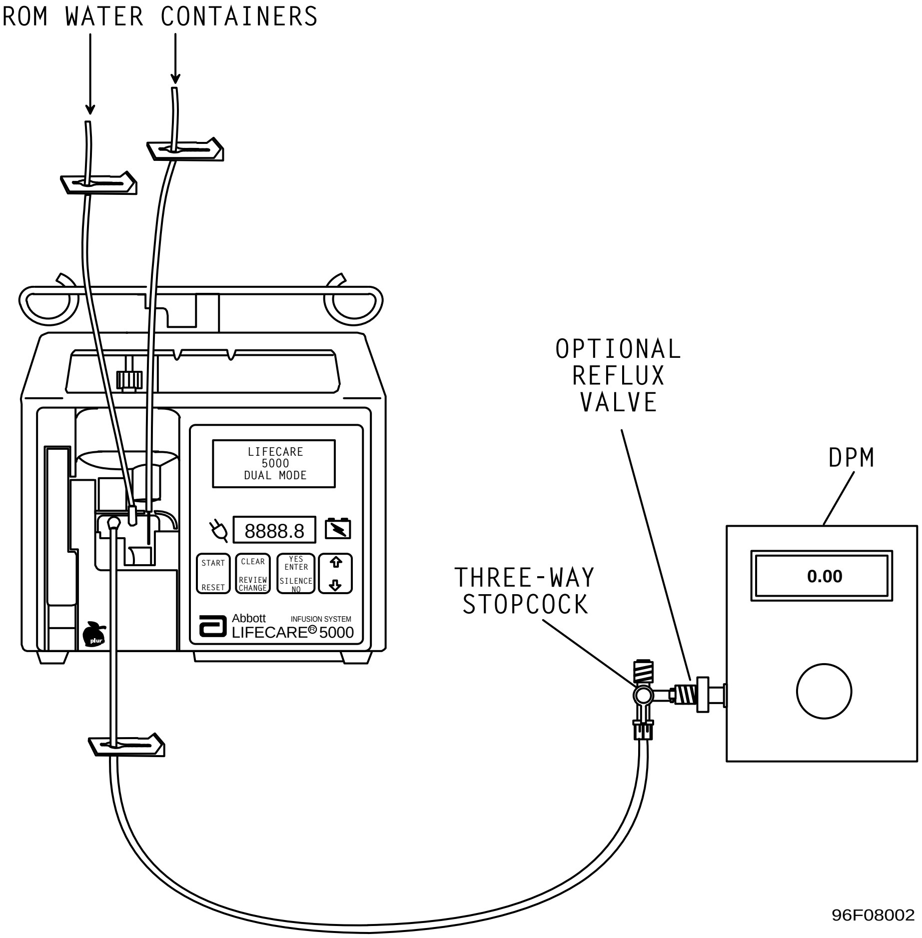

Figure 5-6. Pressure Sensor Test Setup

5.2.11 ELECTRICAL SAFETY TEST

To perform the electrical safety test, proceed as follows:

1. Connect the infusion system to a safety analyzer. Leakage current should be greater than 2 microamperes (open ground), but should not exceed 50 microamperes.
2. Using the safety analyzer, measure resistance of AC (mains) connector ground lug. Resistance should not exceed 0.1 ohm.

5.2.12 END OF PERFORMANCE VERIFICATION TEST (1.5 SERIES)

At completion of the PVT, proceed as follows:

1. Clear dose history. Open and close door. When SAVE SETTINGS appears on the LCD screen, press the [NO] touchswitch.
2. If all tests are successful, return infusion system to service. If any of the tests fail, refer to *Section 6, Troubleshooting*, or contact Abbott Laboratories.
3. Reset the mode DIP switches to previous configuration.

5.3 PERFORMANCE VERIFICATION TEST (1.6 SERIES)

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 system. The PVT should be used for performance verification before an infusion system is placed back in service after repair. If any malfunction is detected as a result of the PVT, refer to *Table 6-4, Troubleshooting with the PVT (1.6 Series)*.

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

This section consists of the PVT for 1.6 series infusion systems. For performance testing of 1.5 series infusion systems, use the PVT in *Section 5.2, Performance Verification Test (1.5 Series)*.

5.3.1 EQUIPMENT AND MATERIALS REQUIRED

The equipment and materials or equivalents required to perform the PVT for 1.6 series infusion systems follow:

- ❑ Safety analyzer, Dynatech Nevada Model 231D
- ❑ DPM, 0 to 50 psig (0 to 345 kPa), Bio-Tek DPM II
- ❑ Blunt Cannula, List No. 11302 or 21-gauge needle, List No. 4492 (optional)
- ❑ Nurse-call test cable or equivalent 1/4 inch phone jack to banana plug, P/N 561-88416-001
- ❑ Three-way stopcock, List No. 3233
- ❑ Reflux valve P/N 711-38272-001 (optional)
- ❑ 470 ohm/100 microfarad, resistor/capacitor parallel network, P/N 561-88419-001
- ❑ DMM, Fluke Model 77
- ❑ Two containers of sterile water, List No. 7973-08, or tap water
- ❑ IV sets, List Nos. 6426-02 and 3047-01 (optional)
- ❑ Primary macro set plus matching secondary macro set
- ❑ 25 ml graduated cylinder (0.2 graduations)
- ❑ No. 2 Phillips screwdriver
- ❑ Hex nutdriver set
- ❑ Stopwatch
- ❑ Recirculating set, List No. 6426-02, with proximal sensor bulb tips removed from cassette, and marked EMPTY on the cassette
- ❑ Recirculating set, List No. 6426-02, with distal sensor bulb tips removed from cassette, and marked AIR on the cassette
- ❑ PCXT or compatible computer (to perform PVT on infusion systems with DataPort)
- ❑ Infusion system DataPort to PC cable (to perform PVT on infusion systems with DataPort)

- ❑ Bubble sensor location fixture, P/N 561-81402-001*
- ❑ Bubble sensor location calibration block (calibration block), P/N 561-81402-006*

***Note**: The bubble sensor location fixture and calibration block are required only when performing the bubble sensor location test.

5.3.2 INSPECTION

Before starting the tests, thoroughly inspect the infusion system as detailed in *Section 5.2.2, Inspecting the Infusion System*.

5.3.3 START-UP TEST

WARNING

DO NOT CONNECT A PATIENT TO THE INFUSION SYSTEM DURING DEVICE TESTING.

The following tests are conducted with the infusion system in the MACRO SECONDARY MODE (dual channel, single dose). When the infusion system is in this mode, the LCD screen displays: LIFECARE 5000 DUAL CHANNEL. Before starting the PVT, note the configuration of the DIP switches and place the infusion system in the MACRO SECONDARY MODE as necessary. Refer to *Section 1.9, Setting the Delivery Mode*, for information on DIP switch settings for the desired mode. See also *Figure 1-1, DIP Switch Settings for Each Delivery Mode*. At the conclusion of the PVT, reset DIP switches to the previous settings.

Note: If testing in MICRO SECONDARY MODE, the maximum delivery rate is 99.9 ml/hr.

Note: For all testing, the vertical distance from the top of the fluid in the flexible container to midline of the cassette must be 18 ± 6 inches (46 ± 15 cm) as shown in *Figure 5-2, Test Setup*.

To perform the start-up test, proceed as follows:

1. Insert the primed IV set with 21-gauge needle attached to the distal line end, into the door. Close the door and verify the red battery power symbol illuminates.
2. Connect infusion system to an AC (mains) outlet and verify the green AC (mains) power symbol illuminates.

   Note: Complete the remainder of the PVT with the infusion system connected to AC (mains) power, except as specified.

3. To verify that all touchswitches emit one short tone or flutter, press each touchswitch in sequence as follows:

   [START]

   [RESET]

   [REVIEW/CHANGE]

[SILENCE/NO]

Down Arrow

Up Arrow

[YES/ENTER]

[CLEAR]

4. Press all touchswitches again except [START] and [CLEAR] in same sequence as described in Step 3; verify that no tones sound. Press [CLEAR] and listen for flutter.
5. Press all touchswitches again as described in Step 3; listen for tone or flutter.
6. Optional. Open and reclose door; observe that all LEDs and the LED decimal point illuminate immediately. When SELF TEST:OK prompt appears, press [REVIEW] to view software revision. Press [REVIEW] again to view alarm history.)

Note: Throughout this manual, a touchswitch, such as [REVIEW/CHANGE], may be referred to by the name that most closely describes its function in a particular procedure. For example, the [REVIEW/CHANGE] touchswitch is referred to as the [REVIEW] touchswitch in Step 6.

5.3.4 BUBBLE SENSOR LOCATION TEST

To perform the bubble sensor location test, refer to *Figure 5-7, Gauge Dial Indicator*. Standardize the gauge of the bubble sensor location fixture, as follows:

1. Place calibration block (boss end) of bubble sensor location fixture over each contact pin, holding the block flush to the base of fixture.
2. Check gauge dial indicators for 0 reading on outer scale and 1 inner revolution indicator. Adjust bezel to 0 as necessary by loosening bezel clamp. Retighten after adjustment is made.

After standardizing the fixture, perform the bubble sensor location test as follows:

1. Insert bubble sensor location fixture in cassette door and close door.
2. Verify that both dial indicators read 1 revolution ± 0.010.
3. Open cassette door and remove fixture.

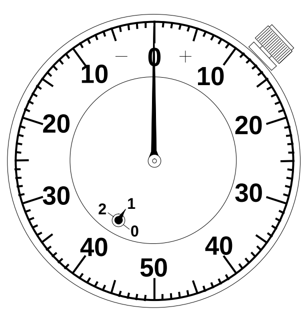

Figure 5-7. Gauge Dial Indicator

5.3.5 NURSE-CALL TEST

Note: The following test may be bypassed if the nurse-call function is not used.

To perform the nurse-call test, attach the nurse-call cable, then proceed as follows:

1. Set primary delivery rate to 400 ml/hr and primary dose limit to 1 ml.
2. Connect DMM to nurse-call cable.
3. Press [START] and verify pumping action.
4. After DOSE END and KVO appear on the LCD screen, observe a short circuit on DMM (approximately 1 ohm on 0 to 100 ohms scale).

5.3.6 EMPTY CONTAINER TEST

To perform the empty container test, proceed as follows:

1. Insert the recirculating set with cassette marked EMPTY, with the proximal bubble sensor bulb tips removed and close the door *(see Figure 5-8, Recirculating Set Test Setup, and Figure 5-9, Infusion System Cassettes with Bubble Sensor Tips Removed)*.
2. Set RATE to 400 ml/hr and press [ENTER].
3. Set DOSE LIMIT to 10 ml and press [ENTER].
4. Press [NO] in response to SET SECONDARY.
5. Press [START] and confirm that pumping occurs. Confirm that an alarm sounds. Within 30 seconds, confirm the following message appears on the LCD screen: STOPPED AIR IN PROXIMAL LINE PRESS RESET.
6. Open door and remove cassette.

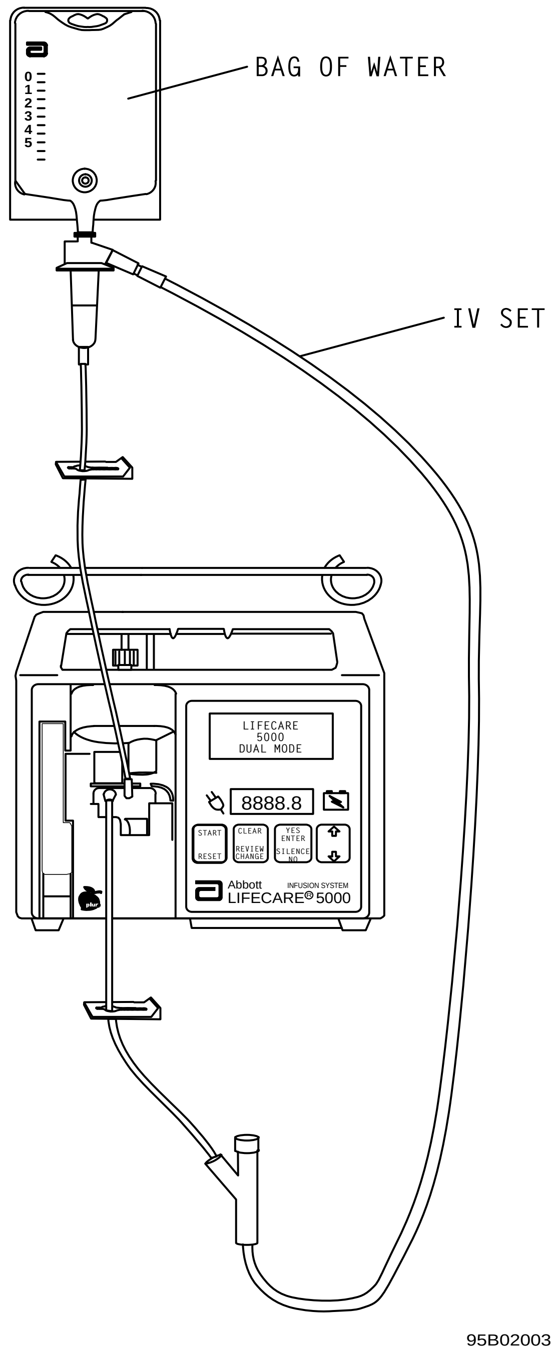

Figure 5-8.   Recirculating Set Test Setup

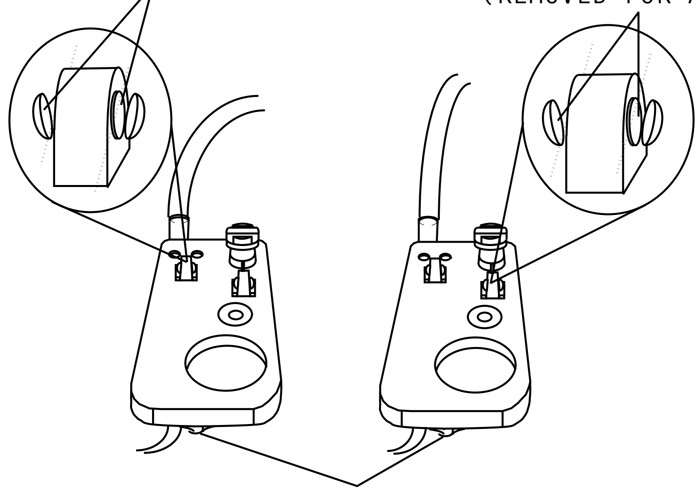

Figure 5-9. Infusion System Cassettes with Bubble Sensor Tips Removed

5.3.7 AIR-IN-LINE TEST

To perform the air-in-line test, proceed as follows:

1. Insert the recirculating set with cassette marked AIR, and with distal bubble sensor bulb tips removed *(see Figure 5-8, Recirculating Set Test Setup, and Figure 5-9, Infusion System Cassettes with Bubble Sensor Tips Removed)*.
2. Close the cassette door and press [YES] in response to SAVE SETTINGS.
3. Press [YES] in response to FINISH PRIMARY DOSE; press [START].
4. Verify that an alarm sounds. Within 30 seconds, verify the following message appears on the LCD screen: STOPPED AIR IN DISTAL LINE PRESS RESET.
5. Press [RESET]; open and close door. Press [NO] in response to SAVE SETTINGS. Press [NO] in response to RETAIN VOLUME.

5.3.8 CONCURRENT DELIVERY TEST

To perform the concurrent delivery test, proceed as follows:

1. Set operating parameters as follows:

   Primary delivery rate: 400 ml/hr

   Primary dose limit: 100 ml

   Press [YES] in response to SET SECONDARY

   Press [YES] in response to SET CONCURRENT DELIVERY

   Secondary delivery rate: 200 ml/hr

   Secondary dose limit: 50 ml
2. Press [START] and verify the LCD screen displays: PUMPING-CONCURRENT.

3. Verify that pumping occurs alarm-free for one minute.

5.3.9
DELIVERY ACCURACY TESTING

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 system accuracy, return the infusion system to Abbott Laboratories.

5.3.9.1
DELIVERY ACCURACY TEST (MACRO)

To perform the delivery accuracy test in macro secondary mode, proceed as follows:

1. Insert needle or adapter of primed secondary set into cassette secondary inlet.
2. Confirm the infusion system DIP switches are set for MACRO SECONDARY MODE (dual channel, single dose), as described in *Section 5.3.3, Start-Up Test*. Set operating parameters as follows:

   Primary delivery rate: 400 ml/hr

   Primary dose limit: 10 ml. Press [YES] in response to SET SECONDARY.
   Press [NO] in response to CONCURRENT DELIVERY

   Secondary delivery rate: 400 ml/hr

   Secondary dose limit: 10 ml
3. Press [YES] in response to CALL BACK AT SECONDARY DOSE END. Press [NO] in response to CONTINUE SECONDARY AT DOSE END. Press [NO] in response to DELIVER SECONDARY OVERFILL.
4. Place distal Cannula or needle into graduated cylinder and press [START].
5. If flow detector is used, attach to primary drip chamber and connect cable to port on back of infusion system.
6. Verify pumping action.
7. At end of secondary, verify the following message appears on the LCD screen: SEC DOSE END   PUMPING PRIMARY   PRESS SILENCE
8. Press [SILENCE]. In response to REPEAT SECONDARY, press [NO].
9. If testing flow detector, verify that infusion system operation is alarm free during primary delivery.
10. After DOSE END and KVO appear on the LCD screen, a flashing 1 appears on the LED display, and an alarm sounds, press [RESET].
11. To observe total volume, press [YES] in response to REPEAT PRIMARY. Press [CLEAR]; observe total volume of 20 ml. Press [YES] to clear. The volume in the graduated cylinder should be between 19 and 21 ml.

Note: If the infusion system fails to deliver properly, reprime cassette and repeat test. If the infusion system again fails to deliver properly, contact Abbott Laboratories.

5.3.9.2
DELIVERY ACCURACY TEST (MICRO)

Note: This test need only be performed if the DIP switches were set to MICRO SECONDARY MODE on the device when it was received.

To perform the delivery accuracy test in micro secondary mode, proceed as follows:

1. Insert needle or adapter of primed secondary set into cassette secondary inlet.
2. Set the infusion system DIP switches to MICRO SECONDARY MODE (dual channel, single dose), as described in *Section 5.3.3, Start-Up Test*. Set the remaining operating parameters as follows:

   Primary delivery rate: 99.9 ml/hr

   Primary dose limit: 10 ml. Press [YES] in response to SET SECONDARY. Press [NO] in response to CONCURRENT DELIVERY

   Secondary delivery rate: 99.9 ml/hr

   Secondary dose limit: 10 ml
3. Press [NO] in response to SECONDARY OVERFILL.
4. Place distal Cannula or needle into cylinder graduate and press [START].
5. Verify pumping action.
6. After DOSE END and KVO appear on the LCD screen display, a flashing 1 appears on the LED display and an alarm sounds. Press [RESET].
7. To observe total volume, press [YES] in response to REPEAT PRIMARY, then press [CLEAR] and observe total volume of 20 ml. Press [YES] to clear. The volume in the graduated cylinder should be between 19 and 21 ml.
8. Disconnect infusion system from AC (mains) power.
9. Open door and start stopwatch; if battery symbol remains illuminated for more than 10 seconds, memory reserve is functional.
10. Reconnect infusion system to AC (mains) power.
11. Close door. At end of self test, clear all operating parameters by pressing [SILENCE/NO] and [YES/ENTER].
12. Set the infusion system DIP switches to MACRO SECONDARY MODE (dual channel single dose), as described in *Section 5.3.3, Start-up Test*.

Note: If the infusion system fails to deliver properly, reprime cassette and repeat test. If the infusion system again fails to deliver properly, contact Abbott Laboratories *(see Section 6.1, Technical Assistance)*.

5.3.10
PRESSURE SENSOR TEST

To perform the pressure sensor test, proceed as follows:

1. Set operating parameters as follows:

   Primary delivery rate: 40 ml/hr

   Primary dose limit: 100 ml. Press [NO] in response to SET SECONDARY

   Occlusion pressure: 4 psig (27.6 kPa) (accessed by pressing the [REVIEW/CHANGE] touchswitch)

2. Connect distal tubing to DPM through a three-way stopcock, as shown in *Figure 5-6, Pressure Sensor Test Setup*. A reflux valve between the stopcock and the meter may be used to prevent moisture from entering the meter.

   Note: Height of DPM must be 0 ± 6 inches (0 ± 15 cm) from the midline of the cassette.

3. Open stopcock to air.
4. Press [START] and allow infusion system to stabilize for at least one minute.
5. Set the stopcock to measure pressure.
6. Press [REVIEW/CHANGE] until the LCD screen displays the pressure according to the infusion system under test.
7. Verify STOPPED DISTAL LINE OCCLUSION alarm status on LCD screen.
8. DPM should display 4.0 ± 1.0 psig (27.6 ± 6.9 kPa).
9. While the infusion system is in occlusion, turn the audible alarm switch to all three positions and make certain that audible levels operate correctly.
10. Press [RESET].
11. Set infusion system pressure to 8 psig (55 kPa) and repeat Step 4 through Step 10 (omitting Step 11). At occlusion, the DPM should display 8 ± 1.5 psig (55.1 ± 10.3 kPa).
12. Remove the distal tubing from the stopcock. Place distal tubing in waste receptacle or recirculate.
13. Open and close door; press [NO] to save settings.
14. Set operating parameters as follows:

    Primary delivery rate: 200 ml/hr

    Primary dose limit: 10 ml. Press [YES] in response to SET SECONDARY. Press [YES] in response to CONCURRENT.

    Secondary delivery rate: 200 ml/hr

    Secondary dose limit: 10 ml. Press [NO] in response to CALLBACK AT SECONDARY DOSE END. Press [NO] in response to DELIVER SECONDARY OVERFILL

15. Press [START] and allow system to stabilize for at least one minute.
16. After a minimum of two cycles, clamp proximal primary tubing just below drip chamber. Verify the LCD screen displays: STOPPED PROX. OCCLUSION PRIMARY, and an alarm sounds within three pumping cycles.
17. Press [RESET] and unclamp the tubing; open the door.

5.3.11 ELECTRICAL SAFETY TEST

To perform the electrical safety test, proceed as follows:

1. Connect the infusion system to the safety analyzer. Leakage current should be greater than 2 microamperes (open ground), but should not exceed 50 microamperes.
2. Using a safety analyzer, measure the resistance of AC (mains) connector ground lug. Resistance should not exceed 100 milliohms (0.1 ohm).

5.3.12
DATAPORT COMMUNICATION TEST

Note: The following procedure may be bypassed if the DataPort communications feature is not used.

The following program, written in BASIC, tests the DataPort communications hardware of the infusion system.

To perform the DataPort communication test, connect the DataPort host computer directly to the infusion system DataPort connector and run the following program. See *Figure 7-12, DataPort Accessory Cable Schematics*, and *Table 7-1, Accessories for 1.6 Series Infusion Systems*, for proper hardware connections.

```
 10 REM **********************************************************
 20 REM ***
 30 REM * Program:    LCTEST.BAS      REV:1.01
 40 REM * Description:
 50 REM     This program will test the hardware of the LC5000
 60 REM     DATAPORT system.  A single packet will be sent to the
 70 REM     pump and one will be expected in reply. The CRC is
 80 REM     pre-calculated.  This program will communicate with only
 90 REM     one pump—communication with multiple pumps on a single
100 REM     bus line will not function with this program.
110 REM * Interpreter : IBM BASIC Version 2.0
120 REM ***
130 REM **********************************************************
140 REM *** Beginning of program.
150 REM *** Clear computer screen.
160 CLS
170 REM *** Indicate “no packets received”.
180 LCSTR$ = “”
190 LCLEN = 0
200 REM *** If error then report failure of computer port.
210 ON ERROR GOTO 450
220 REM *** Activate communication port on the computer:
230 REM ***   port = 1, baud rate = 1200, parity = none,
240 REM ***   data bits = 8, stop bits = 1.
250 COM(1) ON
260 ON COM(1) GOSUB 530
270 OPEN “COM1:1200,N,8,1" AS #1
280 REM *** Send packet to pump:
290 REM ***   Flush and ask for status from Hard-ID 0.
300 PRINT #1,CHR$(3);
310 PRINT #1,"T@0;ISTA;2FAD"
320 REM *** Wait for a reply packet from pump.
321 REM *** To reduce the waiting period for the reply packet
322 REM *** to be sent from the pump to the PC, the loop
323 REM *** counter (25000) in line 330 may be reduced as
324 REM *** required to a minimum of 1500.
330 FOR I=1 TO 25000
340 NEXT
350 REM *** Test for a received packet. If received packet is empty
360 REM *** then test FAILS. Otherwise, test PASSes and the received
370 REM *** packet is printed.
```

```
380 REM ***
390 IF LCLEN = 1 THEN GOTO 400  ELSE GOTO 420
400 PRINT "** TEST PASSED, received packet:";LCSTR$
410 GOTO 500
420 PRINT "** TEST FAILED, no communication from pump."
430 GOTO 500
440 REM *** Communication port error.
450 PRINT CHR$(13);CHR$(13);CHR$(13)
460 PRINT "Communication ERROR on COM1 port—check cable connections."
470 GOTO 510
480 REM *** Close communication port.
490 COM(1) OFF
500 CLOSE
510 END
520 REM *** Receive the packet.
530 INPUT #1,LCSTR$
540 COM(1) OFF
550 LCLEN = 1
560 RETURN
570 REM *** End of program.
```

If TEST PASSED is displayed at the end of the program, the infusion system communication hardware and software are functioning properly. If TEST FAILED is displayed at the end of the program, re-enter program. If TEST FAILED is still displayed, refer to the DataPort malfunctions in *Table 6-2, Troubleshooting DataPort Systems (1.6 DataPort Only)*, or contact Abbott Laboratories.

5.3.13 END OF PERFORMANCE VERIFICATION TEST (1.6 SERIES)

At the completion of the PVT, proceed as follows:

1. Clear dose history. Open and close door. When SAVE SETTINGS appears on the LCD screen, press the [NO] touchswitch.
2. If all tests are successful, return infusion system to service. If any of the tests fail, refer to *Section 6, Troubleshooting*, or contact Abbott Laboratories.
3. Reset DIP switches to previous configuration.

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 system periodic maintenance inspection schedule. To perform the periodic maintenance inspection, complete the performance verification test *(see Section 5.2, Performance Verification Test (1.5 series)* or *Section 5.3, Performance Verification Test (1.6 series))*.

5.5 BATTERY OPERATION OVERVIEW

The infusion system 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 (mains) power failure or inadvertent disconnection of the AC (mains) power cord. An instance of temporary portable operation includes patient transfer from one location to another.

The infusion system should be connected to AC (mains) power whenever possible to allow the battery to remain fully charged. The infusion system line power indicator disappears and the BATTERY legend appears when the infusion system is operating 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 system is operating, the alarm sounds and the LOW BATTERY message displays. Although it is not recommended to continue operating the infusion system on battery power at this point, the battery will continue providing power until discharged. At this point, the infusion system enters the battery discharged mode and operation ceases.

CAUTION: As soon as the LOW BATTERY alarm occurs, connect the infusion system to AC (mains) power.

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

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

5.5.1 BATTERY CHARGER CURRENT TEST (1.5 SERIES)

To perform the battery charger test, proceed as follows:

1. Clear all rates and volumes, then disconnect the infusion system from AC (mains) power.
2. Open the door and confirm that in approximately 30 seconds, the LCD screen dims completely and the battery symbol deactivates.
3. Remove cassette and close door.

4. Remove the battery pack cover and disconnect the battery pack from the charger by disconnecting the battery cable *(see Section 7.2.2, Battery Pack Replacement)*.
5. Connect resistor-capacitor network to charger connector at one end and to DMM at other end.
6. Connect the infusion system to AC (mains) power and measure voltage across the network with DMM set to 0 to 100 voltage scale. DMM should read 9.4 ± 0.1 VDC. Voltage for infusion systems with Service Revision M and higher, or with a battery charger PWA, should read 13 ± 2 VDC.
7. Disconnect resistor-capacitor network and AC (mains) power.
8. Reconnect battery pack and replace battery pack cover.

5.5.2 BATTERY CHARGER CURRENT TEST (1.6 SERIES)

To perform the battery charger test, proceed as follows:

1. Clear all rates and volumes then disconnect the infusion system from AC (mains) power.
2. Open the door and confirm that in approximately 30 seconds, the LCD screen dims completely and the battery symbol deactivates.
3. Remove cassette and close door.
4. Remove battery pack cover and disconnect battery pack from charger by disconnecting battery cable *(see Section 7.2.2, Battery Pack Replacement)*.
5. Connect resistor-capacitor network to charger connector at one end and to DMM at other end.
6. Connect infusion system to AC (mains) power and measure voltage across network with DMM set to 0 to 100 voltage scale. DMM should display 13 ± 2 VDC.
7. Disconnect resistor-capacitor network and AC (mains) power.
8. Reconnect battery pack and replace battery pack cover.

Section 6
TROUBLESHOOTING

This section contains information on obtaining technical assistance from Abbott Laboratories. Also included is information on audible alarms, alarm and malfunction codes, and infusion system troubleshooting. For infusion systems operating with 1.6 series software, all alarm and malfunction codes detailed in this section can be monitored by a host computer connected to infusion systems with the DataPort communications feature.

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 at 1-800-241-4002.

Send all authorized, prepaid returns to the following address:

Through January 5, 1997	Effective January 6, 1997
Abbott Laboratories Technical Support Operations 960 Linda Vista Avenue Mountain View, California 94043	Abbott Laboratories Technical Support Operations 755 Jarvis Drive Morgan Hill, CA 95037

For technical assistance and services outside the United States, contact the nearest Abbott Laboratories representative.

6.2
AUDIBLE ALARMS

The infusion system alerts the user to an abnormal condition with an audible alarm. An audible alarm sounds either a continuous alarm tone, indicating a power failure, or a tone sequence of short-long-short-long. These short-long-short-long tones indicate the infusion system is in the alarm state *(see Section 4.2, Alarm Conditions)*. The infusion system automatically enters an alarm state whenever it detects an alarm condition. Infusion is prohibited during all audible alarm conditions unless otherwise indicated.

The following sections briefly describe alarm messages, alarm conditions, and obtaining an alarm history for 1.5 series and 1.6 series infusion systems.

6.2.1
ALARM MESSAGES

Under certain alarm conditions, the infusion system stops operating, generates an audible alarm, displays an alarm code, and an alarm message on the LCD screen. Alarm codes 06, 07, 08, 09, 0A, 12, 13, 14, and 15 display an initial alarm message on the LCD screen, followed by a secondary alarm message. There are two categories of alarm codes: codes that can be cleared by the operator and codes that require the assistance of qualified service personnel.

Table 6-1, Alarm Codes and Corrective Actions, lists alarm codes, LCD screen messages, possible causes, corrective actions, and DataPort codes. Alarm codes listed in *Table 6-1* are hexadecimal in value from $00_{(16)}$ to $FF_{(16)}$. The LCD screen message column differentiates alarm codes as operator-cleared messages or malfunction codes requiring the assistance of qualified service personnel. Operator alarm messages are corrected using corrective actions described in the system operating manual. DataPort codes apply only to 1.6 series infusion systems with DataPort.

CAUTION: If excessive alarms occur, contact Abbott Laboratories.

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
00	(No message, no alarm. Alarm code history displays all zeros)	New infusion system, no alarms recorded	None	OK
		System disconnected from AC (mains) power and battery pack removed	Replace battery pack	
01	STOPPED DISTAL LINE OCCLUSION PRESS RESET	Distal line occlusion: Excessive line pressure	Check clamps	OD1
		Distal line kinked; distal clamp closed; clotted IV site	Examine distal line for kinks in tubing or internal obstructions	
		Infusion system positioned incorrectly	Reposition infusion system at or above patient mid-axillary line	
		Pressure limit set too low	Raise pressure limit if therapy permits	
		Pressure sensor out of calibration	Replace mechanism assembly *(refer to Section 7.2.18.2 or Section 7.2.19.2)*	
02	(Code not used; no alarm)			

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
03	STOPPED PROX. OCCLUSION PRIMARY PRESS RESET	Primary proximal line occlusion	Check clamps and filters. Check for kinks in tubing, or internal obstructions. Verify 19-gauge or larger needle is used	OP1
		Defective administration set	Replace set	
04	STOPPED PROX. OCCLUSION SECONDARY PRESS RESET	Secondary proximal line occlusion	Check clamps and filters. Check for kinks in tubing and internal obstructions. Verify 19-gauge or larger needle is used	OP2
		Single channel administration set used for dual delivery	Replace with dual-channel administration set	
05	STOPPED PRESSURE OUT OF RANGE PRESS RESET	Distal line pressure outside of range	Position infusion system at patient mid-axillary line	PR1
		Distal line pressure too low	Reprime set	
		Defective administration set	Replace set. If problem recurs, discontinue infusion system use	
		Pressure sensor out of calibration	Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
06	STOPPED AIR IN PROXIMAL LINE PRESS RESET Secondary alarm message: BACKPRIME TO CLEAR AIR INTO SECONDARY YES OR NO?	Air-in-line, proximal sensor	Single channel administration set: reprime using standard techniques. If alarm repeats, replace set	AP1
		Empty container	Replace container and reprime set using standard techniques	
		Cumulative air-in-line volume exceeded due to outgassing or successive air segments introduced by underfilled secondaries	Dual channel administration set: use backpriming techniques or standard repriming techniques	
		Defective administration set or adapter	Replace set if defective and reprime	
		Defective bubble sensor(s)	Replace mechanism assembly *(refer to Section 7.2.18.2 or Section 7.2.19.2)*	
07	STOPPED AIR IN DISTAL LINE PRESS RESET Secondary alarm message: IN RESET OPEN DOOR CHECK SET AND RETEST	Air-in-line, distal sensor: excessive air in air trap; incomplete priming; outgassing	Reprime administration set using standard techniques. If alarm repeats, replace set	AD1
		Defective administration set or adapter	Replace set if defective and reprime	
		Defective bubble sensor(s)	Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
08 (1.5 series only)	STOPPED AIR IN PROXIMAL LINE PRESS RESET Secondary alarm message: BACK PRIME TO CLEAR AIR INTO SECONDARY YES OR NO? (If yes ↓) CONNECT SECONDARY PRESS & HOLD RESET and ENTER (If no ↓) IN RESET OPEN DOOR AND REPRIME SET	Air detected in administration set air-trap chamber	Single channel administration set: reprime set using standard techniques Dual channel administration set: use backpriming techniques or standard repriming techniques	N/A
09 (1.6 series only)	EMPTY CONTAINER PRIMARY KVO #### ML/HR PRESS RESET Secondary alarm message: REFILL/REPLACE PRI CONTAINER PRESS START OR REVIEW/CHANGE	No flow detected: Empty container on primary line	Replace with new container on primary line	FLF
		Occluded primary proximal	Clear alarm	
		Flow detector connected but not attached to the primary drip chamber	Attach flow detector to the primary drip chamber	
		Overfilled drip chamber	Adjust fluid level in drip chamber	

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
09 (AI EUK 1.6 series only)	EMPTY CONTAINER PRIMARY KVO #### ML/HR PRESS RESET Secondary alarm message: REFILL/REPLACE PRI CONTAINER PRESS START OR REVIEW	No flow detected: Empty container on primary line	Replace with new container on primary line	FLF
		Occluded primary proximal line	Clear alarm	
		Flow detector connected but not attached to the primary drip chamber	Attach flow detector to the primary drip chamber	
		Overfilled drip chamber	Adjust fluid level in drip chamber	
0A (1.6 series only)	CONNECT FLOW DETECTOR OR PRESS RESET TO SET DOSE LIMIT Secondary alarm message: DOSE LIM #### ML PRESS ↑↓ AND ENTER	Flow detector disconnected while infusion system is pumping	Press [RESET] Reconnect flow detector and press [START] or press [RESET] Enter a dose limit Press [START]	FDF
0B (1.6 series only)	FLOW DETECTOR CONNECTED PRESS RESET	Flow detector connected while infusion system is pumping	Press [RESET] Reconnect flow detector and press [START] or press [RESET] Enter a dose limit Press [START]	FDT
0C (1.6 series only)	MALFUNCTION CODE 0C	Defective flow detector	Press [RESET] Replace flow detector	MAL
		Defective I/O PWA	If problem repeats with new flow detector, replace I/O PWA	
0D to 10	(Code not used; no alarm)			

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
11	STOPPED FOR 5 MINUTES PRESS RESET OR REMOVE CASSETTE	Door has been closed for five minutes without further programming Infusion system in RESET longer than five minutes	Press [RESET]. Complete setup and press [START], or open door and remove set	RL
12	DOSE END KVO RATE #### ML/HR PRESS RESET Secondary alarm message: REPEAT PRIMARY RATE #### ML/HR DOSE LIM #### ML YES OR NO?	Dose end	Discontinue delivery or set another primary dose	DE1
13	STOPPED SYSTEM RETEST REQUIRED PRESS RESET Secondary alarm message: IN RESET OPEN DOOR CHECK SET AND RETEST	Cassette check failed: Occlusion or air in administration set detected at start up	Open all clamps. Prime out excess air. If alarm repeats, replace set. Close door to retest. If alarm repeats, discontinue use	CS1
		Defective administration set	Replace set. Close door to retest	
		Valve pins binding	Clean mechanism front	
		Pressure sensor out of calibration	Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
14	STOPPED SYSTEM RETEST REQUIRED PRESS RESET Secondary alarm message: IN RESET OPEN DOOR CHECK SET AND RETEST	Cassette check failed: Occlusion or air in administration set detected at start up	Open all clamps. Prime out excess air. If alarm repeats, replace set. Close door to retest If alarm repeats, discontinue use	CS1
		Defective administration set	Replace set. Close door to retest	
		Defective mechanism	Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	
15	STOPPED SYSTEM RETEST REQUIRED PRESS RESET Secondary alarm message: IN RESET OPEN DOOR CHECK SET AND RETEST	Cassette check failed: Occlusion or air in administration set detected at start up	Open all clamps. Prime out excess air. If alarm repeats, replace set. Close door to retest. If alarm repeats, discontinue use	CS1
		Defective administration set	Replace set. Close door to retest	
		Empty primary container	Replace container	
		Defective mechanism; administration set fails backprime check	Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	
16 (1.5 series only)	STOPPED CHECK CASSETTE REPRIME SET	Cassette check failed: Occlusion or air in administration set detected at start up	Open all clamps. Prime out excess air. If alarm repeats, replace set. Close door to retest. If alarm repeats, discontinue use	
		Defective administration set	Replace set. Close door to retest	

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
17	LOW BATTERY PLUG PUMP INTO AC CIRCUIT IMMEDIATELY	Low battery **Note:** LCD message alternates with current operating message	Connect infusion system to AC (mains) power	BLO
17 (AI EUK only)	LOW BATTERY PLUG PUMP INTO MAINS CIRCUIT IMMEDIATELY	Low battery **Note:** LCD message alternates with current operating message	Connect infusion system to AC (mains) power	BLO
18	STOPPED DEAD BATTERY	Battery is fully discharged	Connect infusion system to AC (mains) power Replace battery pack *(refer to Section 7.2.2)*	BLS
19	STOPPED DOOR OPENED WHILE PUMPING PRESS RESET	Door opened while infusion system is pumping	Close door. Press [RESET] and [START] to resume	DCO1
1A to 1F	(Code not used; no alarm)			
20	MALFUNCTION CODE 20	Stack runaway error: Defective ROM, RAM, processor, or custom logic	Replace main PWA *(refer to Section 7.2.17.1)*	MAL20
21	MALFUNCTION CODE 21	Critical data corrupted: Defective RAM Defective VMEM circuit	Replace main PWA *(refer to Section 7.2.17.1)* Replace power supply PWA *(refer to Section 7.2.18.1* or *Section 7.2.19.1)*	MAL21
22 23	MALFUNCTION CODE 22 MALFUNCTION CODE 23	Watchdog frequency too low Watchdog frequency too high Defective CPU or custom logic IC	Replace main PWA *(refer to Section 7.2.17.1)*	MAL22 MAL23

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
24	MALFUNCTION CODE 24	Watchdog detected processor failure	Replace battery *(refer to Section 7.2.2)*	MAL24
25	MALFUNCTION CODE 25	Watchdog does not reset processor Defective CPU or custom logic IC	 Replace main PWA *(refer to Section 7.2.17.1)*	MAL25
26	MALFUNCTION CODE 26	Processor internal malfunction: Defective CPU	 Replace main PWA *(refer to Section 7.2.17.1)*	MAL26
27	MALFUNCTION CODE 27	Illegal instruction trap: Defective CPU	 Replace main PWA *(refer to Section 7.2.17.1)*	MAL27
28	MALFUNCTION CODE 28	RAM check error: Defective RAM	 Replace main PWA *(refer to Section 7.2.17.1)*	MAL28
29	MALFUNCTION CODE 29	Low ROM checksum error: Defective EPROM	 Replace main PWA *(refer to Section 7.2.17.1)*	MAL29
2A to 2F	(Code not used; no alarm)			
30	MALFUNCTION CODE 30	High ROM checksum error: Defective EPROM	 Replace main PWA *(refer to Section 7.2.17.1)*	MAL30
31	MALFUNCTION CODE 31	Revision numbers do not match: Incorrect EPROM	 Replace main PWA *(refer to Section 7.2.17.1)*	MAL31

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
32 (1.6 series only)	MALFUNCTION CODE 32	RTC chip failure: Defective RTC chip in U5 socket	Replace main PWA *(refer to Section 7.2.17.1)*	MAL32
33	MALFUNCTION CODE 33	Serial I/O system failure: Defective I/O PWA	Replace I/O PWA *(refer to Section 7.2.17.2)*	MAL33
		Defective main PWA	Replace main PWA *(refer to Section 7.2.17.1)*	
34 to 40	(Code not used; no alarm)			
41	MALFUNCTION CODE 41	LCD message display read/write failure: Loose cable P/J11	Check cable connection	MAL41
		Defective LCD assembly	Replace LCD assembly *(refer to Section 7.2.16.2)*	
42	MALFUNCTION CODE 42	Message display RAM failure: Loose cable P/J11	Check cable connection	MAL42
		Defective LCD assembly	Replace LCD assembly *(refer to Section 7.2.16.2)*	
43	MALFUNCTION CODE 43	Numeric display digit driver failure: Loose cable P/J1	Check cable connection	MAL43
		Defective LED display PWA	Replace display PWA *(refer to Section 7.2.16.1)*	

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
44	MALFUNCTION CODE 44	Audible alarm failure:		MAL44
		Defective piezoelectric alarm	Replace piezoelectric alarm assembly *(refer to Section 7.2.25)*	
		Defective alarm driver or test circuit	Replace power supply PWA *(refer to Section 7.2.18.1* or *Section 7.2.19.1)*	
45	MALFUNCTION CODE 45	Touchswitch failure:		MAL45
		Touchswitch closed longer than 2 minutes and 40 seconds	Do not close touchswitch longer than specified limit	
		Defective front panel	Replace front panel *(refer to Section 7.2.16.3)*	
46 to 5F	(Code not used; no alarm)			
60	MALFUNCTION CODE 60	Plunger motor will not home	Lubricate plunger motor shaft *(refer to Section 7.2.29)*	MAL60
		Plunger motor jammed by cassette	Check administration set; replace if defective	
		No power to motor	Replace power supply PWA *(refer to Section 7.2.18.1* or *Section 7.2.19.1)*	
		Defective motor drivers	Replace I/O PWA *(refer to Section 7.2.17.2)*	
		Defective sensor PWA	Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
61	MALFUNCTION CODE 61	I/O valve motor will not home: Valve motor jammed by cassette	Check administration set; replace if defective	MAL61
		No power to motor	Replace power supply PWA *(refer to Section 7.2.18.1* or *Section 7.2.19.1)*	
		Defective motor drivers	Replace I/O PWA *(refer to Section 7.2.17.2)*	
		Defective sensor PWA	Replace mechanism assembly *(refer to Section 7.2.18.2 or Section 7.2.19.2)*	
62	MALFUNCTION CODE 62	Primary/secondary valve motor will not home: Valve motor jammed by cassette	Check administration set; replace if defective	MAL62
		No power to motor or faulty 2.5 VDC reference voltage	Replace power supply PWA *(refer to Section 7.2.18.1* or *Section 7.2.19.1)*	
		Defective motor drivers	Replace I/O PWA *(refer to Section 7.2.17.2)*	
		Defective sensor PWA	Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
63	MALFUNCTION CODE 63	Plunger motor slipping or stuck	Lubricate plunger motor shaft *(refer to Section 7.2.29)*	MAL63
		Plunger motor jammed by cassette	Check administration set; replace if defective	
		No power to motor	Replace power supply PWA *(refer to Section 7.2.18.1* or *Section 7.2.19.1)*	
		Defective motor drivers	Replace I/O PWA *(refer to Section 7.2.17.2)*	
		Defective sensor PWA	Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	
64	MALFUNCTION CODE 64	I/O valve motor slipping or stuck: Valve motor jammed by cassette	Check administration set; replace if defective	MAL64
		No power to motor	Replace power supply PWA *(refer to Section 7.2.18.1* or *Section 7.2.19.1)*	
		Defective motor drivers	Replace I/O PWA *(refer to Section 7.2.17.2)*	
		Defective sensor PWA	Replace mechanism assembly *(refer to Section 7.2.18.2 or Section 7.2.19.2)*	

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
65	MALFUNCTION CODE 65	Primary/secondary valve motor slipping or stuck:		MAL65
		Valve motor jammed by cassette	Check administration set; replace if defective	
		No power to motor or faulty 2.5 VDC reference voltage	Replace power supply PWA *(refer to Section 7.2.18.1* or *Section 7.2.19.1)*	
		Defective motor drivers	Replace I/O PWA *(refer to Section 7.2.17.2)*	
		Defective sensor PWA	Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	
66	MALFUNCTION CODE 66	Motor failure. Internal timers unsynchronized	Note circumstances. Contact Abbott Laboratories	MAL66
67	MALFUNCTION CODE 67	Software motor watchdog confused. Motor not running	Note circumstances. Contact Abbott Laboratories	MAL67
68 to 69	(Code not used; no alarm)			
6A	MALFUNCTION CODE 6A	Motor failure. Internal timers unsynchronized	Note circumstances. Contact Abbott Laboratories	MAL6A
6B	CODE 6B			MAL6B
6C	CODE 6C			MAL6C
6D	CODE 6D			MAL6D
6E	CODE 6E			MAL6E
6F to 70	(Code not used; no alarm)			
71	MALFUNCTION CODE 71	Software not executed in 10 ms period	Note circumstances. Contact Abbott Laboratories	MAL71

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
72	MALFUNCTION CODE 72	Defective pressure sensor or A/D converter	Replace mechanism *(refer to Section 7.2.18.2* or *Section 7.2.19.2)* or main PWA *(refer to Section 7.2.17.1)*	MAL72
73	MALFUNCTION CODE 73	A/D converter failure (0, 2.5 and 5 V tests): Defective A/D converter IC	Replace main PWA *(refer to Section 7.2.17.1)*	MAL73
		Defective custom logic IC	Replace I/O PWA *(refer to Section 7.2.17.2)*	
74	MALFUNCTION CODE 74	Ultrasound transmitter or receiver failure: Defective sensor or bubble PWA	Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	MAL74
75	MALFUNCTION CODE 75	Overvoltage protection failure: Defective overvoltage protection circuitry	Replace power supply PWA *(refer to Section 7.2.18.1* or *Section 7.2.19.1)*	MAL75
		Defective custom logic IC	Replace I/O PWA *(refer to Section 7.2.17.2)*	
76	MALFUNCTION CODE 76	Distal air sensor failed on-going check: Defective bubble sensor or sensor PWA	Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	MAL76
77	MALFUNCTION CODE 77	Proximal air sensor failed on-going check: Defective custom logic IC	Replace I/O PWA *(refer to Section 7.2.17.2)*	MAL77

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
78	MALFUNCTION CODE 78	Proximal air sensor is off when it should be on	Replace I/O PWA *(refer to Section 7.2.17.2)* or mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	MAL78
79	MALFUNCTION CODE 79	Primary/secondary valve safety spring broken: Defective mechanism assembly	 Replace mechanism assembly *(refer to Section 7.2.18.2* or *Section 7.2.19.2)*	MAL79
7A	MALFUNCTION CODE 7A	Proximal pressure sensor failed	Replace mechanism assembly *(refer to Section 7.2.18.2 or Section 7.2.19.2)*	MAL7A
7B 7C 7D 7E 7F	MALFUNCTION CODE 7B CODE 7C CODE 7D CODE 7E CODE 7F	Software motor watchdog is confused. Motor not running	Note circumstances. Contact Abbott Laboratories	MAL7B MAL7C MAL7D MAL7E MAL7F
80 to 89	(Code not used; no alarm)			
8A	MALFUNCTION CODE 8A	Software motor watchdog is confused. Motor not running	Note circumstances. Contact Abbott Laboratories	MAL8A
8B to 90	(Code not used; no alarm)			
91 (1.6 series only)	MALFUNCTION CODE 91	Overflow compensation table in PRI_OR_SEC_NXT	Note circumstances. Contact Abbott Laboratories	MAL91
92	MALFUNCTION CODE 92	RATEMATH calculation error from table overflow	Note circumstances. Contact Abbott Laboratories	MAL92
93	MALFUNCTION CODE 93	No synchronization, failed flag set after failing synchronization	Note circumstances. Contact Abbott Laboratories	MAL93
94 to 96	(Code not used; no alarm)			

Table 6-1. Alarm Codes and Corrective Actions

Alarm Code	LCD Screen Message	Possible Cause	Corrective Action	Data-Port Code
97	MALFUNCTION CODE 97	Rate checking failure within RATSEL routine	Note circumstances. Contact Abbott Laboratories	MAL97
98	MALFUNCTION CODE 98	Rate equals zero or division by zero	Note circumstances. Contact Abbott Laboratories	MAL98
99	MALFUNCTION CODE 99	Division by zero (used by S_DIV.)	Note circumstances. Contact Abbott Laboratories	MAL99
9A (1.6 series only)	MALFUNCTION CODE 9A	New alarm without setting alarm bit in ALMBRD	Note circumstances. Contact Abbott Laboratories	MAL9A
9B (1.6 series only)	MALFUNCTION CODE 9B	OCR timer interrupt error trap at IHANDR routine. Defective CPU	Replace main PWA *(refer to Section 7.2.17.1)*	MAL9B
9C to A1	(Code not used; no alarm)			
A2	MALFUNCTION CODE A2	Motor power up not detected	Replace power supply PWA *(refer to Section 7.2.18.1 or Section 7.2.19.1)*	MALA2
A3	MALFUNCTION CODE A3	Motor power down not detected	Replace power supply PWA *(refer to Section 7.2.18.1* or *Section 7.2.19.1)*	MALA3
A4	MALFUNCTION CODE A4	Illegal BCD digit in DRATE	Note circumstances. Contact Abbott Laboratories	MALA4
A5	MALFUNCTION CODE A5	Executive code in infinite loop	Note circumstances. Contact Abbott Laboratories	MALA5
A6	MALFUNCTION CODE A6	Unknown failure type, motor related	Note circumstances. Contact Abbott Laboratories	MALA6
A7	MALFUNCTION CODE A7	Potential PURGE runaway hazard detected	Note circumstances. Contact Abbott Laboratories	MALA7
A8 to FF	(Code not used; no alarm)			

6.2.2 OBTAINING AN ALARM HISTORY (1.5 SERIES)

A rolling history of alarm codes may be obtained by accessing the alarm history data screen. The alarm history screen appears on the LCD when the [REVIEW/CHANGE] touchswitch is pressed twice during the first three-to-five second interval after the door is closed and the SELF TEST:OK screen is displayed. The alarm history data screen displays 15 alarm codes, with the most recent code appearing at the lower right hand corner of the screen. Alarm code history data will be retained in memory unless both sources of primary power (AC (mains) and battery pack) are lost.

6.2.3 OBTAINING AN ALARM HISTORY (1.6 SERIES)

A rolling history of alarm codes may be obtained by accessing the alarm history data screen. The alarm history screen appears on the LCD when the [REVIEW/CHANGE] touchswitch is pressed twice during the first three-to-five second interval after the door is closed and the SELF TEST:OK screen is displayed. The alarm history data screen displays 15 alarm codes, with the most recent code appearing at the lower right hand corner of the screen.

6.3 ALARM AND MALFUNCTION CODES

Alarm and malfunction codes are listed in *Table 6-1, Alarm Codes and Corrective Actions*. For malfunction codes requiring corrective action beyond the scope of this manual, contact Abbott Laboratories.

6.3.1 ALARM CODES

Alarm codes 01 through 19 may typically be corrected by the system operator. Refer to *Table 6-1, Alarm Codes and Corrective Actions*, for a definition and appropriate corrective action for each of these codes.

6.3.2 MICROPROCESSOR OR SYSTEM ALARM CODES

Alarm codes are 20 through 33 are microprocessor or system alarm codes. Refer to *Table 6-1, Alarm Codes and Corrective Actions*, for a definition and appropriate corrective action for each of these codes.

6.3.3 DISPLAY, AUDIBLE, AND TOUCHSWITCH ALARM CODES

Alarm codes 41 through 45 are display, audible, and touchswitch alarm codes. Refer to *Table 6-1, Alarm Codes and Corrective Actions*, for a definition and appropriate corrective action for each of these codes.

6.3.4 INFUSION PUMPING MECHANISM ALARM CODES

Alarm codes 60 through 67 are infusion pumping mechanism alarm codes. Refer to *Table 6-1, Alarm Codes and Corrective Actions*, for a definition and appropriate corrective action for each of these codes.

6.3.5 MISCELLANEOUS ALARM CODES

Alarm codes 6A through A7 are miscellaneous alarm codes. Refer to *Table 6-1, Alarm Codes and Corrective Actions*, for a definition and appropriate corrective action for each of these codes.

6.4 INFUSION SYSTEM TROUBLESHOOTING

Before troubleshooting an alarm, open and close the infusion system door and allow the self test to complete. If an alarm persists, carefully inspect the infusion system for signs of damage as described in *Section 5.1.1, Inspecting the Infusion System*, and perform the corrective action specified in *Table 6-1, Alarm Codes and Corrective Actions*, or *Table 6-2, Troubleshooting DataPort Systems (1.6 DataPort Only)*.

Failures listed in *Table 6-2* that do not cause an alarm are detected by observation only when using the DataPort communications feature.

Note: Some corrective actions listed in *Table 6-1* and *Table 6-2* are beyond the scope of this manual. In such instances, contact Abbott Laboratories.

Table 6-2. Troubleshooting DataPort Systems (1.6 DataPort Only)

Code or Symptom	Possible Cause	Corrective Action
Infusion system does not reply to packet sent by host computer	Infusion system not connected to cable or DataPort bus	Check all cable and junction box connections
	Host computer defective	Run DataPort communication program in *Section 5.3.12*. If program passes, refer to *LifeCare 5000 Concurrent Flow Infusion System with DataPort Programmer's Guide* to check software
	Infusion system is turned off or is malfunctioning	Turn infusion system on. Run DataPort communication program in *Section 5.3.12*; if infusion system fails test, contact Abbott Laboratories
	Defective junction box	Bypass junction box and connect host computer directly to infusion system. If problem is corrected, replace junction box; if problem is not corrected, replace I/O PWA *(refer to Section 7.2.17.2)*
	Infusion system with incorrect software revision connected to DataPort bus	Check infusion system software revision *(refer to Section 1.7)*

Table 6-2. Troubleshooting DataPort Systems (1.6 DataPort Only)

Code or Symptom	Possible Cause	Corrective Action
Packets are received incorrectly by the infusion system or host computer	Junction box DIP switches not set correctly	Check DIP switch setting for hard ID
	Host computer defective	Run DataPort communication program in Section 5.3.12. If program passes, refer to *LifeCare 5000 Concurrent Flow Infusion System with DataPort Programmer's Guide* to check software
	Cable disconnected while transmission in progress	Check condition of connector and replace if necessary
	Electromagnetic interference from adjacent equipment	Remove or repair source of interference. If problem persists, contact Abbott Laboratories
	Bus traffic resulting from connection to a non-LifeCare 5000 1.6 Series infusion system with DataPort	Disconnect nonconforming equipment
	Bus wire length or electrical signals do not meet EIA-232D standards. Leads can be open or shorted	Use port that conforms to EIA-232D standard and DataPort cables
Host computer receives garbled responses to messages sent to infusion system	Host computer defective	Run DataPort communication program in Section 5.3.12. If program passes, refer to *LifeCare 5000 Concurrent Flow Infusion System with DataPort Programmer's Guide* to check software
Host computer detects infusion systems that are not present	Defective junction box	Bypass junction box and connect host computer directly to infusion system. If problem is corrected, replace junction box; if problem is not corrected, replace I/O PWA *(refer to Section 7.2.17.2)*

6.5 TROUBLESHOOTING WITH THE PVT

Table 6-3, Troubleshooting with the PVT (1.5 Series), and *Table 6-4, Troubleshooting with the PVT (1.6 Series)*, lists failures that may be detected during the PVT. If an error code displays, see *Section 6.2.1, Alarm Messages*.

Table 6-3. Troubleshooting with the PVT (1.5 Series)

Test Failure	Possible Cause	Corrective Action
Start-up test *Section 5.2.3*	Cassette not properly installed Faulty cassette Defective power supply PWA Defective touchswitch panel	Re-prime and re-insert cassette Replace administration set Replace power supply PWA Replace touchswitch panel
Bubble sensor location test *Section 5.2.4*	Bubble sensor location fixture not calibrated Calibration block not calibrated to required specifications	Calibrate bubble sensor location fixture calibration block Verify valid calibration date
Nurse-call test *Section 5.2.5*	Defective nurse call cable Defective I/O PWA	Replace nurse call cable Replace I/O PWA
Empty container test *Section 5.2.6*	Defective special cassette Dirty bubble sensors Defective bubble sensor PWA Proximal bubble sensor tips removed incorrectly Distal bubble sensor tips removed incorrectly	Replace special cassette Clean bubble sensors Replace mechanism assembly Re-cut proximal bubble sensor tips Re-cut distal bubble sensor tips
Air-in-line test *Section 5.2.7*	Defective special cassette Dirty bubble sensor Defective bubble sensor PWA	Replace special cassette Clean bubble sensors Replace mechanism assembly

Table 6-3. Troubleshooting with the PVT (1.5 Series)

Test Failure	Possible Cause	Corrective Action
Concurrent delivery test *Section 5.2.8*	Damaged or faulty administration set Defective mechanism assembly	Replace administration set and re-prime cassette Replace mechanism assembly
Delivery accuracy test *Section 5.2.9*	Cassette not properly primed Damaged or faulty administration set Defective mechanism assembly	Re-prime cassette Replace administration set and re-prime cassette Replace mechanism assembly
Pressure sensor test *Section 5.2.10*	Cassette not properly primed Defective cassette Dirty sensor pin Defective sensor PWA	Re-prime cassette Replace cassette Clean sensor pin Replace mechanism assembly
Electrical safety test *Section 5.2.11*	Insufficient ground connection Defective AC (mains) cordset Defective power supply PWA	Check electrical safety analyzer return line Replace AC (mains) cordset Replace power supply PWA

Table 6-4. Troubleshooting with the PVT (1.6 Series)

Test Failure	Possible Cause	Corrective Action
Start-up test *Section 5.3.3*	Cassette not properly installed Faulty cassette Defective power supply PWA Defective touchswitch panel	Re-prime and re-insert cassette Replace administration set Replace power supply PWA Replace touchswitch panel
Bubble sensor location test *Section 5.3.4*	Bubble sensor location fixture not calibrated Calibration block not calibrated to required specifications	Calibrate bubble sensor location fixture calibration block Verify valid calibration date
Nurse-call test *Section 5.3.5*	Defective nurse call cable Defective I/O PWA	Replace nurse call cable Replace I/O PWA
Empty container test *Section 5.3.6*	Defective special cassette Dirty bubble sensors Defective bubble sensor PWA Proximal bubble sensor tips removed incorrectly Distal bubble sensor tips removed incorrectly	Replace special cassette Clean bubble sensors Replace mechanism assembly Re-cut proximal bubble sensor tips Re-cut distal bubble sensor tips
Air-in-line test *Section 5.3.7*	Defective special cassette Dirty bubble sensor Defective bubble sensor PWA	Replace special cassette Clean bubble sensors Replace mechanism assembly
Concurrent delivery test *Section 5.3.8*	Damaged or faulty administration set Defective mechanism assembly	Replace administration set and re-prime cassette Replace mechanism assembly

Table 6-4.   Troubleshooting with the PVT (1.6 Series)

Test Failure	Possible Cause	Corrective Action
Delivery accuracy test *Section 5.3.9*	Cassette not properly primed Damaged or faulty administration set Defective mechanism assembly	Re-prime cassette Replace administration set and re-prime cassette Replace mechanism assembly
Pressure sensor test *Section 5.3.10*	Cassette not properly primed Defective cassette Dirty sensor pin Defective sensor PWA	Re-prime cassette Replace cassette Clean sensor pin Replace mechanism assembly
Electrical safety test *Section 5.3.11*	Insufficient ground connection Defective AC (mains) cordset Defective power supply PWA	Check electrical safety analyzer return line Replace AC (mains) cordset Replace power supply PWA
DataPort communication test *Section 5.3.12*	Damaged or faulty DataPort accessory cable Test program written incorrectly Defective I/O PWA	Replace DataPort accessory cable Verify correct program entry Replace I/O PWA

Section 7

REPLACEABLE PARTS AND REPAIRS

This section itemizes all parts and subassemblies of the infusion system that are repairable within the scope of this manual. In addition, this section describes replacement procedures for all listed parts.

WARNING

POSSIBLE EXPLOSION HAZARD IF PRODUCT IS SERVICED OR REPAIRED IN THE PRESENCE OF FLAMMABLE ANESTHETICS.

7.1 REPLACEABLE PARTS LIST

Replaceable parts for the infusion system are itemized in the spare parts price list and are identified in *Figure 9-1, IPB for the Infusion System*. *Table 9-2, IPB for the Infusion System*, identifies each infusion system 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)*. For convenient reference, insert a copy of the spare parts price list here.

Note: Certain part numbers are specific to 1.5 series infusion systems or 1.6 series infusion systems. Certain part numbers apply to all infusion systems.

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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 system. Before opening the infusion system enclosures, take all necessary precautions for working on high-voltage equipment.

WARNING

UNLESS OTHERWISE INDICATED, DISCONNECT THE INFUSION SYSTEM FROM AC (MAINS) POWER BEFORE PERFORMING ANY REPLACEMENT PROCEDURE.

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

CAUTION: Any repair or replacement must be followed by the appropriate PVT described in *Section 5.2, Performance Verification Test (1.5 Series)*, or *Section 5.3, Performance Verification Test (1.6 Series)*.

7.2.1 REQUIRED TOOLS AND MATERIALS

Standard handtools, special tools, and materials required for the repair and replacement procedures in this section are described in *Section 7.2.1.1, Standard Handtools*, and *Section 7.2.1.2, Materials*. Tools and materials required for specific repair and replacement are listed at the beginning of each procedure.

7.2.1.1 STANDARD HANDTOOLS

The following standard handtools, or equivalents, are required for the repair and replacement procedures presented in this section:

- No. 1 Phillips screwdriver
- No. 2 Phillips screwdriver
- Small size flat-blade screwdriver
- Medium size flat-blade screwdriver
- X-acto® knife, with round No. 10 and pointed No. 11 blades
- Wire cutter
- Wire stripper
- Electrician's knife
- Set of Allen wrenches
- Nutdriver set
- Long needle-nose pliers
- 1/4 inch right angle socket wrench
- External retaining ring pliers

- Grease extension
- Digital multimeter (DMM), Fluke model 77
- PlumSet® List No. 6426
- Large bore needle (18 gauge)
- 20 cc syringe
- Digital pressure meter (DPM), 0 to 50 psig, Bio-Tek DPM II
- Three-way stopcock, List 3233

7.2.1.2
MATERIALS

The materials required for repair and replacement procedures include the following:

- Grease, Braycote® 804, P/N 743-38212-001
- Lint-free cloth or cotton swabs
- Red GLPT insulating varnish
- Electro-Wash® 2000 or isopropyl alcohol
- Small six-inch brush

7.2.1.3
ACCESSORIES

The accessories required for repair of optional features on 1.6 series infusion systems are listed in *Table 7-1, Accessories for 1.6 Series Infusion Systems*. Refer to *Figure 7-12, DataPort Accessory Cable Schematics*, for cable schematics.

Table 7-1. Accessories for 1.6 Series Infusion Systems

Part Description	List/Part Number
DataPort cable assembly, infusion system to PC. 8-foot, male DB-15 to female DB-9 connector	11431-01
DataPort cable assembly, infusion system to PC. 8-foot, male DB-15 to female DB-25 connector	11431-02
DataPort cable assembly, junction box to PC. 8-foot, 6-pin modular connector to female DB-9 connector	11431-03
DataPort cable assembly, junction box to PC. 8-foot, 6-pin modular connector to female DB-25 connector	11431-04
DataPort cable assembly, junction box to junction box. 2-foot, 6-pin modular connector to 6-pin modular connector	11431-06
DataPort cable assembly, junction box to junction box. 4-foot, 6-pin modular connector to 6-pin modular connector	11431-07

Table 7-1. Accessories for 1.6 Series Infusion Systems	
Part Description	**List/Part Number**
DataPort cable assembly, junction box to junction box. 8-foot, 6-pin modular connector to 6-pin modular connector	11431-08
Flow detector	1907-25
Junction Box assembly	11429
LifeCare 5000 Concurrent Flow Infusion System With DataPort Programmer's Guide	430-03681-001

7.2.2 BATTERY PACK REPLACEMENT

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

Note: Before replacing the battery pack, check the fuse and battery charger circuits for proper operation.

To replace the battery pack, refer to *Figure 7-1, Battery Pack Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Place the infusion system on its side on a soft surface.
3. Using a No. 2 Phillips screwdriver, remove the three screws and washers securing the battery pack cover to the bottom of the infusion system.
4. Slide the battery pack cover towards the rear of the infusion system to disengage the cover tabs. Remove the battery pack cover.
5. Remove the battery pack.
6. Disconnect the female connector from the male connector. Connect the female connector of the replacement battery pack to the male connector.

   Note: The connectors are keyed to eliminate misconnections.

7. Insert the replacement battery pack into its compartment and position until seated properly.

   Note: Verify the battery pack top is positioned toward the infusion system center and the battery pack cable end is positioned toward the infusion system outside (base), as shown in *Figure 7-1, Battery Pack Replacement*.

8. Place the cable and connector into the battery compartment on top of the battery pack, taking care not to kink the cable.
9. Using a No. 2 Phillips screwdriver, replace the three screws and washers securing the battery pack cover to the infusion system.
10. Insert a cassette in the infusion system.

11. Close the cassette door. Verify that the red battery symbol illuminates and the infusion system self test successfully completes.
12. To assure that the battery pack is charged, connect the infusion system to AC (mains) power for 24 hours.

    Note: The battery pack recharges to 80 percent of the prior charge in 16 hours, while the infusion system is operating at a delivery rate of 125 ml/hr or lower.

To verify successful replacement of the battery pack, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*. Then perform the battery charger current test as detailed in *Section 5.5.1 (1.5 series)* or *Section 5.5.2 (1.6 series)*.

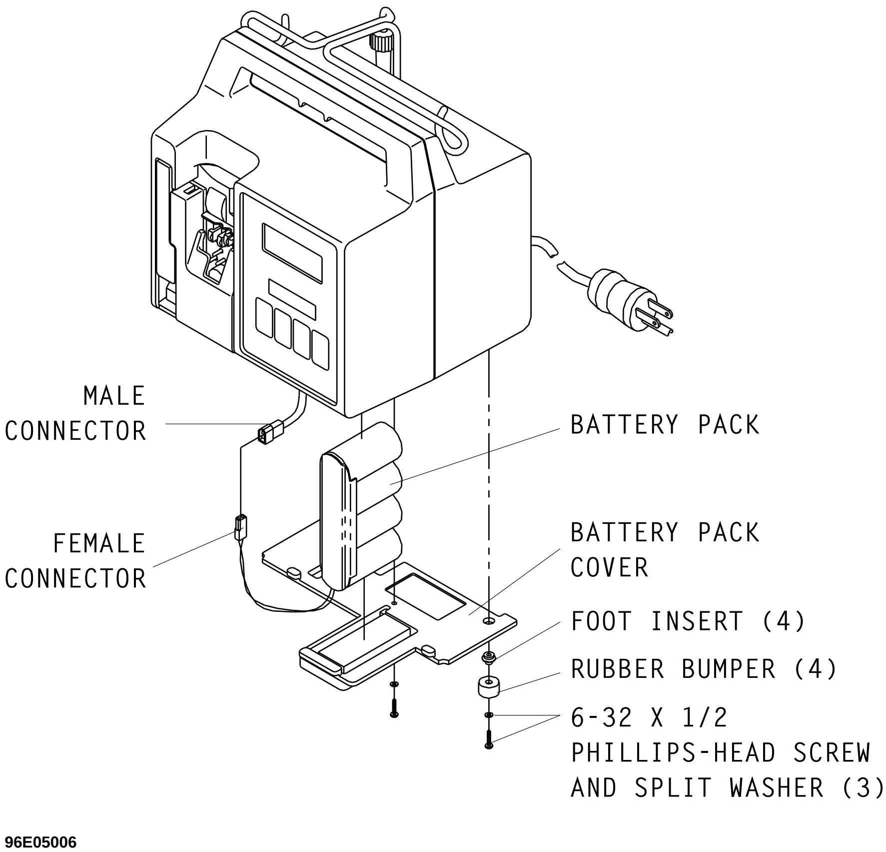


Figure 7-1. Battery Pack Replacement

7.2.3 AC (MAINS) POWER CORD (UL QUALIFIED) REPLACEMENT

This procedure requires a No. 2 Phillips screwdriver.

Note: Replacement of the AC (mains) power cord involves removal of the retaining plate on the rear of the infusion system. If the retaining plate is damaged, replace it.

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

1. Disconnect the infusion system from AC (mains) power.

2. Using a No. 2 Phillips screwdriver, remove the four screws and washers securing the AC (mains) power cord retaining plate to the rear housing. Remove the retaining plate.
3. Grasp the cord plug and remove it from the infusion system AC (mains) power receptacle.

   Note: Do not disconnect power cord by pulling on power cable.
4. Connect the replacement AC (mains) power cord to the infusion system AC (mains) power receptacle.

   Note: The plug is keyed to eliminate misconnections.

5. Using a No. 2 Phillips screwdriver, replace the four screws and washers securing the retaining plate to the rear housing.

To verify successful replacement of the AC (mains) power cord, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*. Then perform the battery charger current test as detailed in *Section 5.5.1 (1.5 series)* or *Section 5.5.2 (1.6 series)*.

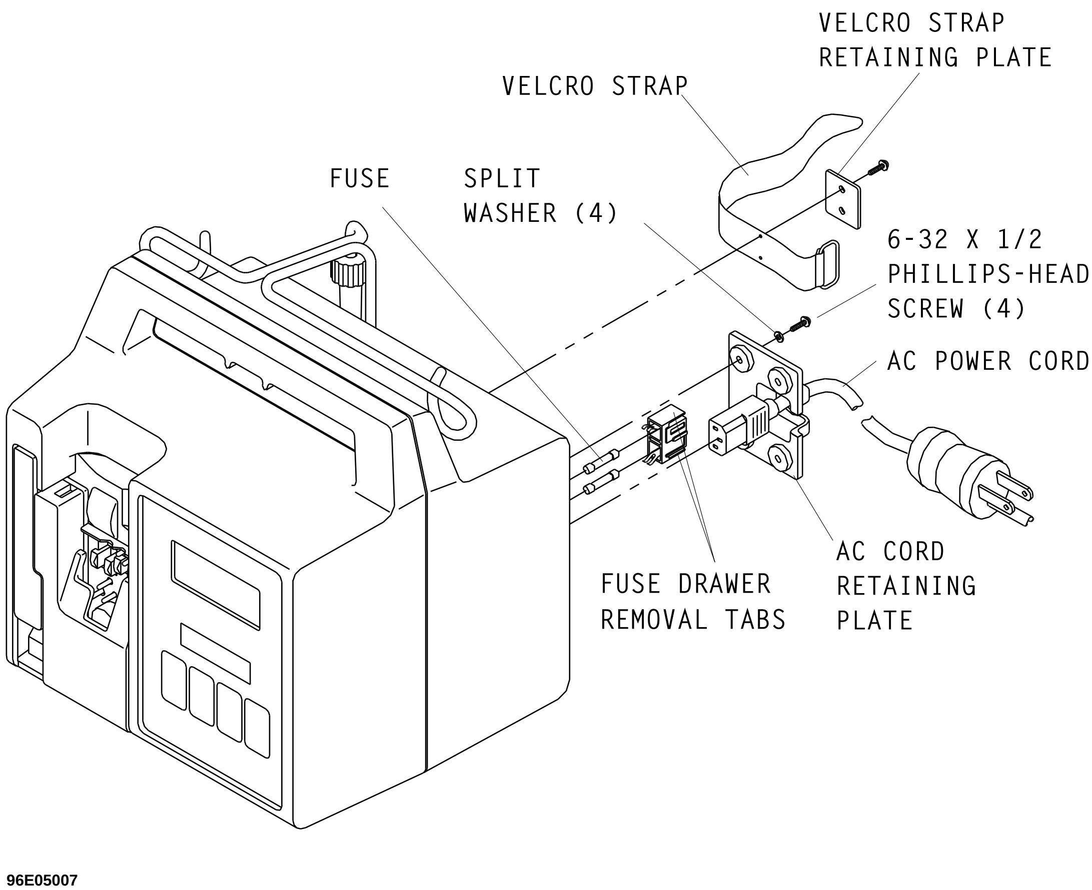


Figure 7-2. Fuses, AC (Mains) Power Cord, Velcro Strap, and Retaining Plate Replacement

7.2.3.1 AC (MAINS) POWER CORD (IEC QUALIFIED) REPLACEMENT

No tools are recommended for this procedure.

To replace the AC (mains) power cord, disconnect the power cord from the rear of the infusion system and connect the new power cord.

Replacement of the IEC qualified AC (mains) power cord is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.4 AC (MAINS) POWER CORD PLUG REPLACEMENT

The recommended tools for this procedure are as follows: wire stripper, wire cutter, medium flat-blade screwdriver, and electrician's knife.

Note: The following procedure is only a general guide, not a specific method for AC (mains) power cord plug replacement. The AC (mains) power cord plug can be replaced by a hospital-grade replacement plug. The exact procedure depends upon the replacement AC (mains) power cord plug.

To replace the AC (mains) power cord plug, proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Using a wire cutter, remove the plug from the AC (mains) power cord.
3. Using a medium flat-blade screwdriver, disassemble the replacement plug to access the plug terminals and to estimate the amount of insulation needed to be removed from the AC (mains) power cord.
4. Using an electrician's knife, remove sufficient outer insulation from the power cord end to expose three individual wires.
5. Using a wire stripper, remove approximately 1/4 inch (0.63 cm) of insulation from the three wires to permit connection of bare conductors to the replacement plug.
6. Connect each wire to the replacement plug. Connect the ground (earth) wire to the plug ground lug.
7. Re-assemble the replacement plug.

To verify successful replacement of the AC (mains) power cord plug, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.5
FUSE AND FUSE DRAWER REPLACEMENT

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

To replace the fuses or fuse drawer, refer to *Figure 7-2, Fuses, AC (Mains) Power Cord, Velcro Strap, and Retaining Plate Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Using a No. 2 Phillips screwdriver, remove the AC (mains) power cord retaining plate to access the fuse drawer.
3. Using a small flat-blade screwdriver, wedge the screwdriver tip between each removal tab and the side of the fuse drawer compartment to loosen the fuse drawer.
4. Compress the removal tabs until the fuse drawer unlatches. Slide the fuse drawer from the compartment.
5. Remove the fuses from the fuse drawer. Replace the fuse drawer if defective. Replace the fuses.
6. Insert the fuse drawer into the compartment. Push the fuse drawer until it clicks securely in place.
7. Replace the AC (mains) power cord and retaining plate.
8. Connect the infusion system to a hospital grade AC (mains) outlet and verify that the AC (mains) symbol illuminates.

To verify successful replacement of the fuses or fuse drawer, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.6
VELCRO STRAP AND RETAINING PLATE REPLACEMENT

The recommended tools for this procedure are as follows: No. 2 Phillips screwdriver and X-acto knife with pointed No. 11 blade.

To replace the Velcro strap and the retaining plate, refer to *Figure 7-2, Fuses, AC (Mains) Power Cord, Velcro Strap, and Retaining Plate Replacement*, then proceed as follows:

1. Remove the two screws that attach the Velcro strap and retaining plate to the rear of the infusion system. Remove the retaining plate and strap. Do not discard the strap.

   Note: The replacement Velcro strap does not have holes for mounting screws. The holes must be punched at the time of installation.

2. Set the replacement Velcro strap on the work surface with the fuzzy side down. Place the retaining plate on the strap in the exact location as on the old strap, using the old strap as a template. Mark hole locations on the replacement strap.
3. Using an X-acto knife, punch holes in the replacement strap at the marked locations.
4. Replace the retaining plate if damaged.

5. Install the replacement strap and retaining plate using the two screws removed in Step 1.

Replacement of the Velcro strap is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.7 POLE CLAMP COMPONENT REPLACEMENT

The recommended tools for this procedure are as follows: 5/64 inch and 7/64 inch Allen wrenches, No. 1 Phillips screwdriver, external retaining ring pliers, and grease.

To replace the pole clamp knob, pole clamp shaft and screw, and pole clamp friction plate, proceed as follows:

7.2.7.1 POLE CLAMP KNOB REPLACEMENT

To replace the pole clamp knob, refer to *Figure 7-3, Pole Clamp and Minipole Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Using a 5/64 inch Allen wrench, loosen the setscrew from the pole clamp knob. Separate the pole clamp knob from the pole clamp screw by pulling on the pole clamp knob.
3. Replace the knob. Secure and tighten the setscrew.

Replacement of pole clamp components is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

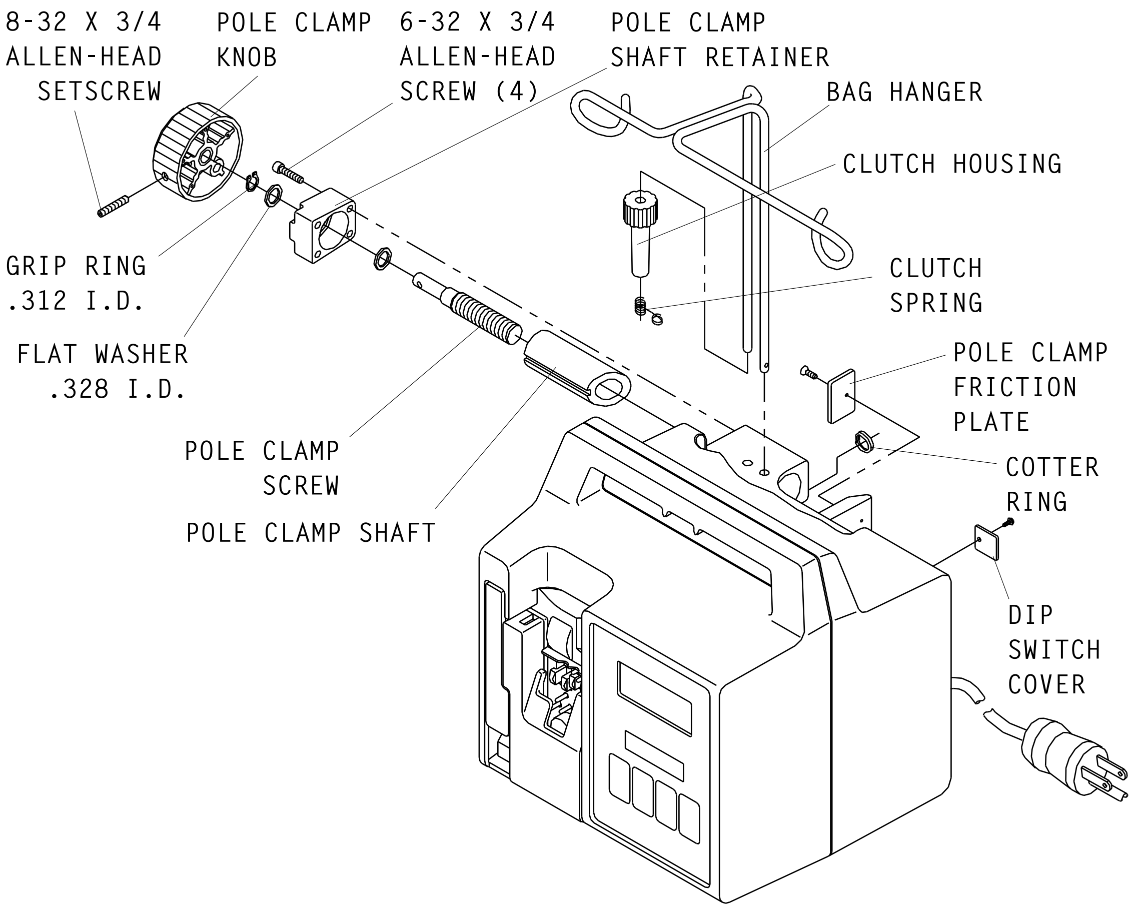


Figure 7-3. Pole Clamp and Minipole Assembly Replacement

7.2.7.2
POLE CLAMP SHAFT AND POLE CLAMP SCREW REPLACEMENT

To replace the pole clamp shaft and pole clamp screw, refer to *Figure 7-3, Pole Clamp and Minipole Assembly Replacement*, then proceed as follows:

1. Remove the pole clamp knob as described in *Section 7.2.7.1, Pole Clamp Knob Replacement*.
2. Using the external retaining ring pliers, remove the grip ring and flat washer.
3. Using a 7/64 inch Allen wrench, remove the four screws securing the pole clamp shaft retainer to the rear case. Set the pole clamp shaft retainer aside for re-assembly.
4. Remove the pole clamp shaft. Rotate the shaft counterclockwise to separate it from the pole clamp screw.
5. Replace the pole clamp screw in the shaft; lubricate with grease if necessary.
6. Reinsert the pole clamp shaft and screw in the rear case. Verify the shaft bevel is positioned toward the inside of the casing.
7. Using a 7/64 inch Allen wrench, replace the four screws securing the pole clamp shaft retainer to the rear case. Re-assemble the grip ring and washer; replace if necessary.

8. Clamp the infusion system to an IV pole. Verify the infusion system does not slide on the pole.

Replacement of pole clamp components is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.7.3
POLE CLAMP FRICTION PLATE REPLACEMENT

To replace the pole clamp friction plate, refer to *Figure 7-3, Pole Clamp and Minipole Assembly Replacement*, then proceed as follows:

1. Remove the pole clamp knob as described in *Section 7.2.7.1, Pole Clamp Knob Replacement*, and the shaft and screw as described in *Section 7.2.7.2, Pole Clamp Shaft and Pole Clamp Screw Replacement*.
2. Using a No. 2 Phillips screwdriver, remove the screw securing the friction plate to the rear case. Set the screw aside for re-assembly.
3. Replace the friction plate. Using a No. 2 Phillips screwdriver, replace the screw securing the friction plate to the rear case.
4. Re-assemble the pole clamp components in exact reverse order of disassembly.
5. Clamp the infusion system to an IV pole. Verify the infusion system does not slide on the pole.

Replacement of pole clamp components is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.8
DIP SWITCH COVER REPLACEMENT

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

Note: The DIP switch cover is located in the recessed I/O port panel on the left rear of the infusion system. In 1.6 series infusion systems with DataPort accessory cables, the DIP switch cover is located below the DataPort accessory cable connector; in other models, the DIP switch cover is located at the top of the I/O port panel.

To replace the DIP switch cover, refer to *Figure 7-3, Pole Clamp and Minipole Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Using a small flat-blade screwdriver, remove the screw securing the DIP switch cover to the recessed I/O port panel.
3. Remove and replace the DIP switch cover. Using a small flat-blade screwdriver, replace the screw securing the DIP switch cover to the recessed I/O port panel.

Replacement of the DIP switch cover is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.9 RUBBER FOOT PAD AND FOOT INSERT REPLACEMENT

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

To replace rubber foot pads and foot pad inserts refer to *Figure 7-1, Battery Pack Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Place the infusion system on its side with the bottom of the infusion system facing the technician.
3. Using a No. 2 Phillips screwdriver, remove the screw securing the rubber foot pad and foot insert on each corner of the infusion system.
4. Position the new rubber foot pad and foot insert.
5. Using a No. 2 Phillips screwdriver, replace the screw securing the rubber foot pad and foot insert.

Replacement of the rubber foot pad and foot insert is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.10 FLOW DETECTOR REPLACEMENT (1.6 SERIES)

No tools are recommended for this procedure.

Note: The flow detector connects to the ACC jack that is located in the recessed I/O port panel on the left rear of the infusion system.

To replace the flow detector, disconnect the detector from the ACC jack and connect the replacement flow detector.

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

7.2.11 NURSE-CALL CABLE REPLACEMENT

No tools are recommended for this procedure.

Note: The nurse-call cable connects to the NURSE CALL jack in the recessed I/O port panel on the left rear of the infusion system.

To replace the nurse-call cable, proceed as follows:

1. Disconnect the old nurse-call cable from the NURSE CALL connector and connect the new nurse-call cable.
2. Verify that the new cable is operational by performing the nurse-call test in *Section 5.2.5 (1.5 series)* or *Section 5.3.5 (1.6 series)*.

Replacement of the nurse-call cable is a routine maintenance procedure and no additional verification procedure is normally required. However, if the infusion system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.12
MINIPOLE ASSEMBLY REPLACEMENT

No tools are recommended for this procedure.

Note: The minipole assembly attaches to the infusion system 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.

7.2.12.1
COTTER RING REPLACEMENT

To replace the cotter ring, refer to *Figure 7-3, Poleclamp and Minipole Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Place the infusion system face down on a soft surface.
3. Grasp the cotter ring with thumb and finger. Twist, rotate, and remove the cotter ring from 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 system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.12.2
BAG HANGER REPLACEMENT

To replace the bag hanger, refer to *Figure 7-3, Poleclamp and Minipole Assembly Replacement*, 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 routine maintenance procedure and no verification procedure is normally required. However, if the infusion system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.12.3 CLUTCH HOUSING REPLACEMENT

To replace the clutch housing, refer to *Figure 7-3, Poleclamp and Minipole Assembly Replacement*, then proceed as follows:

1. Remove the bag hanger from the infusion system 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 system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.12.4 CLUTCH SPRING REPLACEMENT

To replace the clutch spring, refer to *Figure 7-3, Poleclamp and Minipole Assembly Replacement*, 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 system may have been damaged during this procedure, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.13
SEPARATING THE FRONT AND REAR COVERS

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

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

To separate the front and rear covers, refer to *Figure 7-4, Front and Rear Cover Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Remove the battery pack as described in *Section 7.2.2, Battery Pack Replacement*.
3. If attached, remove minipole assembly as described in *Section 7.2.12, Minipole Assembly Replacement*.
4. Using a No. 2 Phillips screwdriver, remove the two screws and washers from the infusion system handle. Remove the two screws from the lower rear of the infusion system cover. Remove the rear cover.
5. Place infusion system face down on a soft surface.
6. Remove the rubber foot pads and foot inserts as described in *Section 7.2.9, Rubber Foot Pad and Foot Insert Replacement*.
7. Using a flat-blade screwdriver, wedge the front cover so that it clears the hex-head screws on the bottom of the infusion system. Remove the front cover.
8. Re-assemble the front and rear covers in the exact reverse order of separation.

To verify successful replacement of the front and rear covers, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

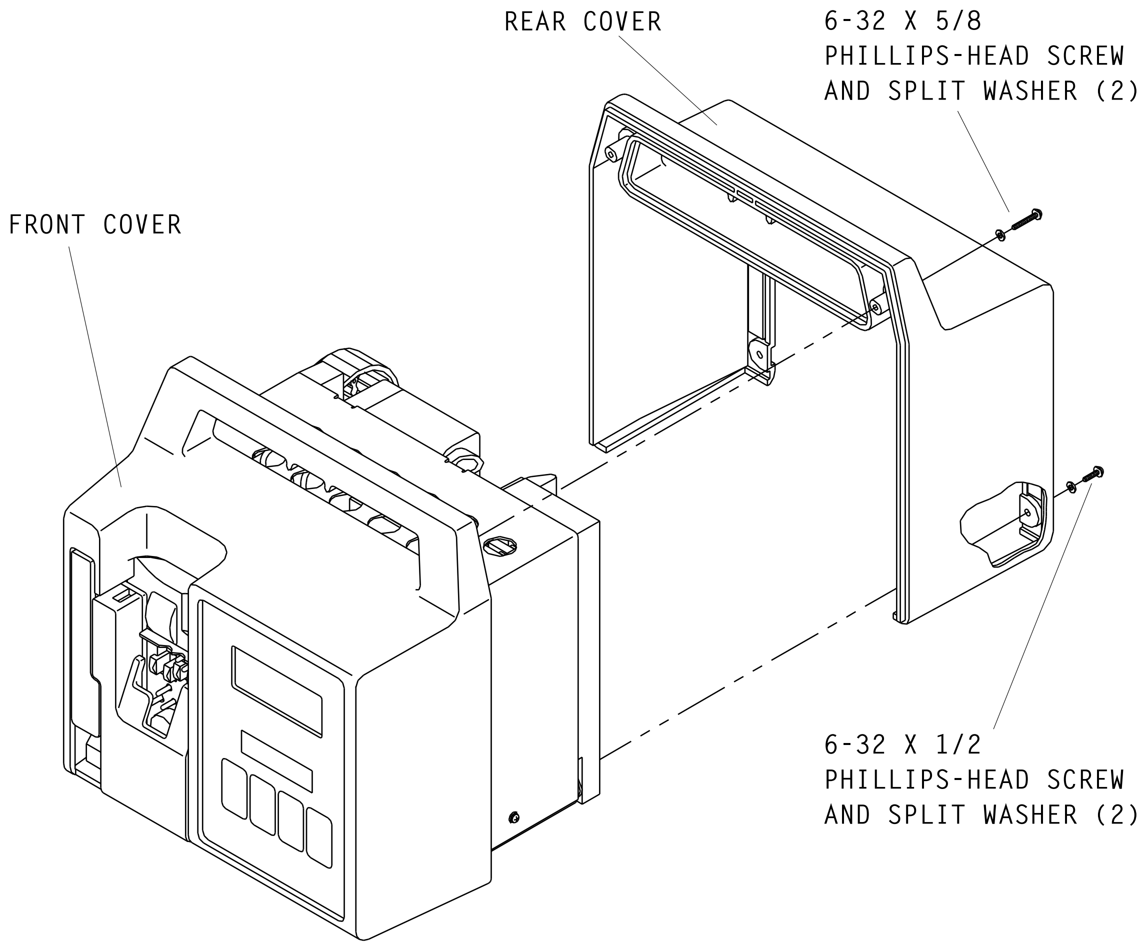


Figure 7-4. Front and Rear Cover Replacement

7.2.14 EMI SHIELD REPLACEMENT

The recommended tools for this procedure are as follows: medium flat-blade screwdriver, No. 2 Phillips screwdriver, and 1/4 inch nutdriver.

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

Note: The EMI shield must be removed in order to access the PWAs, the piezoelectric alarm, or the AC (mains) receptacle assembly for replacement as described in *Section 7.2.16* through *Section 7.2.19* and *Section 7.2.24* through *Section 7.2.26*.

To replace the EMI shield, refer to *Figure 7-5, EMI Shield Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*.

3. Position the infusion system on its base, with the rear of the infusion system facing the technician.
4. Using a No. 2 Phillips screwdriver, remove the two screws on the left side of the infusion system. Set the two screws and washers aside for re-assembly.
5. Using a 1/4 inch nutdriver, loosen the two screws at the top rear of the infusion system and one screw at the top right of the infusion system. Set the three screws aside for re-assembly.
6. Lift the EMI shield; tilt it up at left to avoid damaging PWAs. Remove the EMI shield.
7. Install the replacement EMI shield.
   Note: The two tabs on front of shield fit into slots at the top of the front panel.
8. Re-assemble the infusion system in the exact reverse order of disassembly.

To verify successful replacement of the EMI shield, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

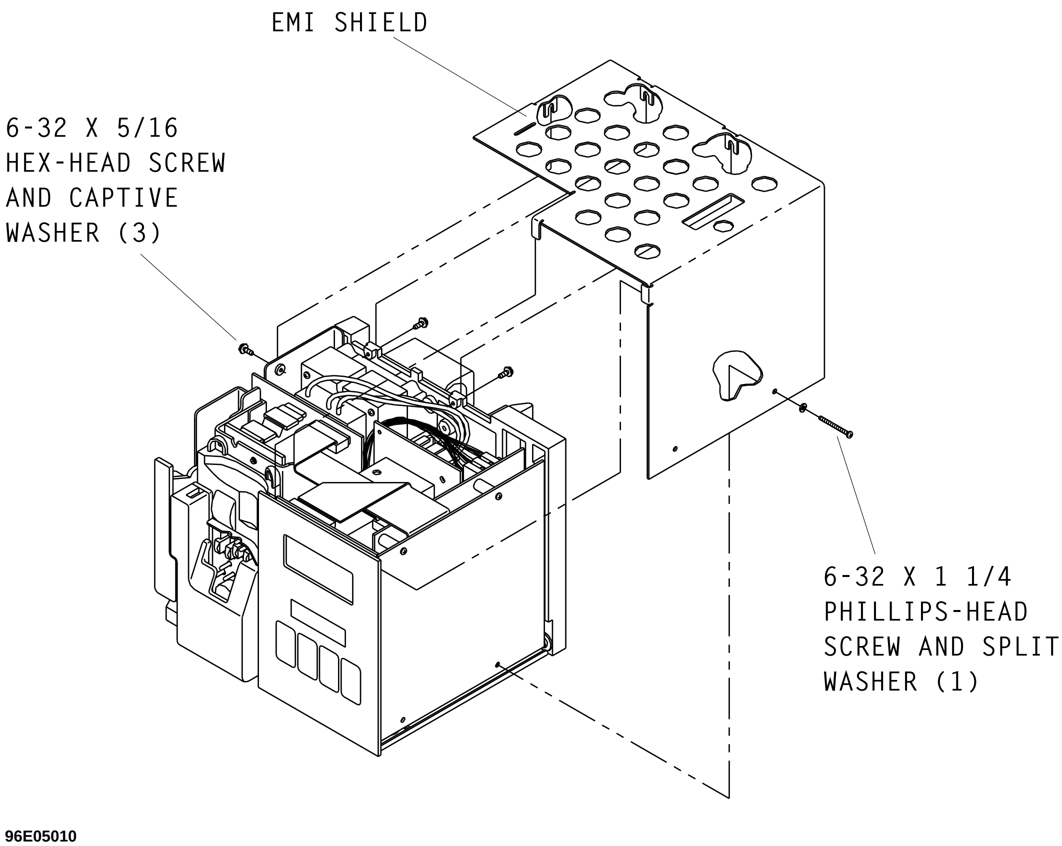


Figure 7-5. EMI Shield Replacement

7.2.15
LCD SCREEN CONTRAST ADJUSTMENT

The recommended tools for this procedure are as follows: small and medium flat-blade screwdrivers, No. 2 Phillips screwdriver, and 1/4 inch nutdriver.

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

To adjust the LCD screen contrast, refer to *Figure 7-6, LCD Screen Contrast Adjustment*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. Remove the EMI shield as described in *Section 7.2.14, EMI Shield Replacement*.
4. Position the infusion system on its base with the front of the infusion system facing the technician.
5. Locate the main PWA and potentiometer R1.
6. Using a small flat-blade screwdriver, turn the LCD adjustment screw to achieve optimum contrast of the LCD screen.
7. Re-assemble the infusion system in the exact reverse order of separation.

To verify correct LCD screen contrast adjustment, inspect the contrast and perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

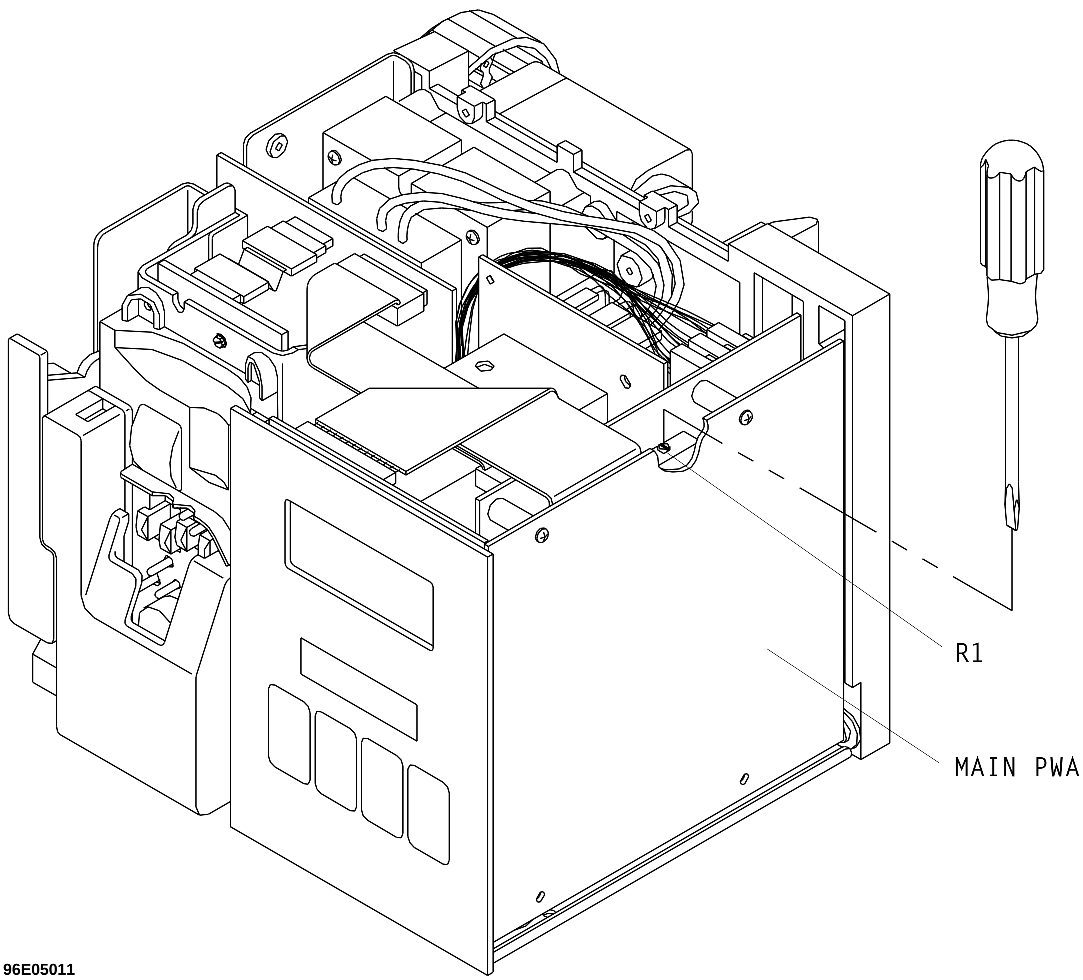


Figure 7-6. LCD Screen Contrast Adjustment

7.2.16
FRONT PANEL ASSEMBLY REPLACEMENT

The recommended tools for this procedure are as follows: No. 2 Phillips screwdriver, medium flat-blade screwdriver, 1/4 inch and 5/32 inch nutdrivers, X-acto knife, and long needle-nose pliers. A mild solvent is required if the front panel is to be removed and replaced.

The front panel assembly consists of the following components: display PWA, LCD assembly, and front panel. Procedures for replacing the front panel assembly components follow.

Note: The front panel assembly must be removed in order to replace any front panel assembly component. In addition, the front panel assembly must be removed in order to access the main PWA or the I/O PWA.

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

To replace the front panel assembly, refer to *Figure 7-7, Front Panel Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. Remove the EMI shield as described in *Section 7.2.14, EMI Shield Replacement*.
4. Using the long needle-nose pliers to support the ribbon cable, disconnect the ribbon cable ends that connect the main PWA to the LCD assembly. Gently pull the ribbon cable connector pins back and free from the main PWA.

   Note: Use caution when handling the ribbon cable and connector pins. A protective covering may be attached to the ribbon cable and to the solder side of the main PWA.

5. Disconnect the two-row connector (located at the bottom right of the display PWA) that connects to the main PWA by grasping the front panel assembly and pulling the left side clear of the mechanism assembly. Gently rock the front panel assembly until the display PWA is free from the connector.

   Note: Support the main PWA while disconnecting the display PWA.

6. Disconnect the front panel assembly from the infusion system.
7. At the I/O PWA, disconnect the ribbon cable connector joining the front panel to the I/O PWA.
8. Replace the front panel assembly in exact reverse order of removal. Prior to re-assembling the front and rear covers, connect the infusion system to AC (mains) power and verify successful completion of the self test.
9. Disconnect the AC (mains) power, then re-assemble the front and rear covers in the exact reverse order of separation.

To verify successful replacement of the front panel assembly, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

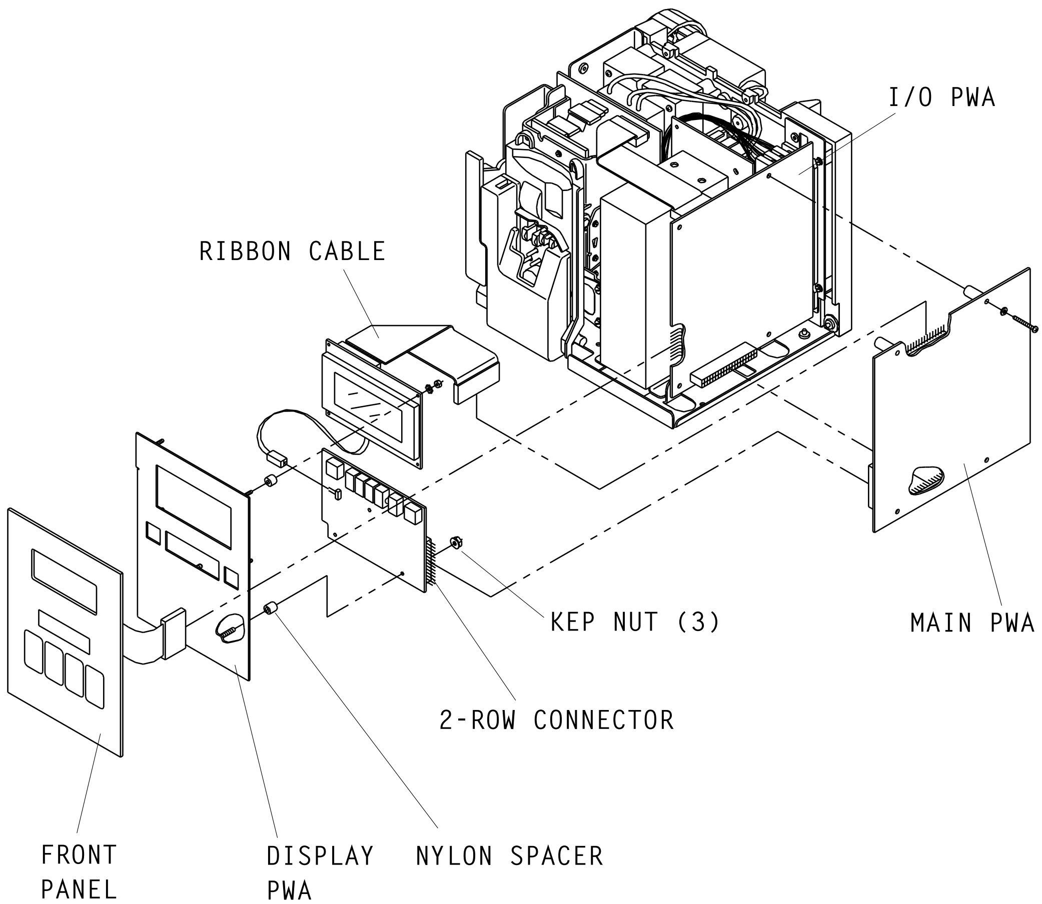


Figure 7-7. Front Panel Assembly Replacement

7.2.16.1
DISPLAY PWA REPLACEMENT

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

To replace the display PWA, refer to *Figure 7-7, Front Panel Assembly Replacement*, then proceed as follows:

1. Remove the front panel assembly as described in *Section 7.2.16, Front Panel Assembly Replacement*.
2. Using a 1/4 inch nutdriver, remove the three kep nuts from the display PWA. Set the kep nuts aside for re-assembly. Remove the clear acetate insulator and set aside for re-assembly.
3. Lift the display PWA from the studs and disconnect the two-pin connector that connects the display PWA to the LCD assembly. Set the nylon spacers, located under the display PWA, aside for re-assembly.
4. Replace the display PWA. Reconnect all cables and wire harnesses to the replacement display PWA. Connect the infusion system to AC (mains) power to verify the self test successfully completes.

5. Disconnect AC (mains) power. Install the display PWA on studs and spacers in the exact reverse order of removal. Verify the two-pin connector wires are retained in the insulator loop retainer.
6. Replace the front panel assembly in the exact reverse order of disassembly.
7. Re-assemble the infusion system in the exact reverse order of disassembly.

To verify successful replacement of the display PWA, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.16.2
LCD ASSEMBLY REPLACEMENT

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

To replace the LCD assembly, refer to *Figure 7-7, Front Panel Assembly Replacement*, then proceed as follows:

1. Remove the front panel assembly as described in *Section 7.2.16, Front Panel Assembly Replacement*.
2. Using a 1/4 inch nutdriver, remove the three kep nuts from the display PWA. Set the kep nuts aside for re-assembly. Remove the clear acetate insulator and set aside for re-assembly.
3. Lift the display PWA from the studs and disconnect the two-pin connector that connects the display PWA to the LCD assembly. Set the nylon spacers, located under the display PWA, aside for re-assembly. Verify the two-pin connector is removed from the display PWA.
4. Using a 5/32 inch nutdriver, remove the four hex nuts and lockwashers securing the LCD assembly to the display PWA. Set the hex nuts and lockwashers aside for re-assembly.
5. Lifting the LCD assembly from the studs, set the spacers aside for re-assembly, then remove and replace the LCD assembly.
6. Reconnect all headers, cables, and wire harnesses. Connect the infusion system to AC (mains) power and verify successful completion of the self test.
7. Disconnect AC (mains) power. Replace the LCD assembly on studs and spacers.
8. Using a 5/32 inch nutdriver, replace the four hex nuts and lockwashers securing the LCD assembly to the display PWA. Verify that the two-pin connector is reconnected to the display PWA and that the display PWA is secured.
9. Re-assemble the infusion system in the exact reverse order of disassembly.

To verify successful replacement of the LCD assembly PWA, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.16.3
FRONT PANEL REPLACEMENT

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

To replace the front panel, refer to *Figure 7-7, Front Panel Assembly Replacement*, then proceed as follows:

1. Remove the front panel assembly as described in *Section 7.2.16, Front Panel Assembly Replacement*.
2. Using an X-acto knife with a round blade, pry the front panel loose from the sub panel.
3. Using a mild solvent, remove adhesive residue from the sub panel, then dry it thoroughly.
4. Replace the front panel; remove the protective paper backing, then carefully center the front panel on the sub panel surface and press it into place.
5. Connect the infusion system to AC (mains) power and verify successful completion of the self test. Disconnect AC (mains) power.
6. Replace the front panel assembly in the exact reverse order of disassembly.

To verify successful replacement of the front panel, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.17 MAIN PWA AND I/O PWA REPLACEMENT

The recommended tools for this procedure are as follows: medium flat-blade screwdriver, No. 2 Phillips screwdriver, 1/4 inch nutdriver, and long needle-nose pliers.

To replace the main PWA or the I/O PWA, proceed as follows:

7.2.17.1 MAIN PWA REPLACEMENT

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

To replace the main PWA, refer to *Figure 7-8, Main PWA and I/O PWA Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*. Remove the EMI shield, as described in *Section 7.2.14, EMI Shield Replacement*, and the front panel assembly, as described in *Section 7.2.16, Front Panel Assembly Replacement*.
3. Using a No. 2 Phillips screwdriver, remove the screws and lockwashers securing the I/O PWA to the main PWA. Set the screws and lockwashers aside for re-assembly.
4. Using a slight rocking motion, gently pull the main PWA from the infusion system side to disconnect the main PWA from the I/O PWA 40-pin connector (located at I/O PWA bottom) and the display PWA two-row connector.
5. Remove and replace the main PWA. Reconnect all cables, headers, and wire harnesses in exact reverse order of removal.

6. Locate the main PWA and potentiometer R1 *(See Figure 7-6, LCD Screen Contrast Adjustment)*.
7. Using a small flat-blade screwdriver, turn the LCD adjustment screw to achieve optimum contrast of the LCD screen.
8. Connect the infusion system to AC (mains) power and verify successful completion of the self test. Disconnect AC (mains) power.
9. Replace the front panel assembly and EMI shield in exact reverse order of removal.
10. Re-assemble the infusion system in the exact reverse order of disassembly.

To verify successful replacement of the main PWA, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

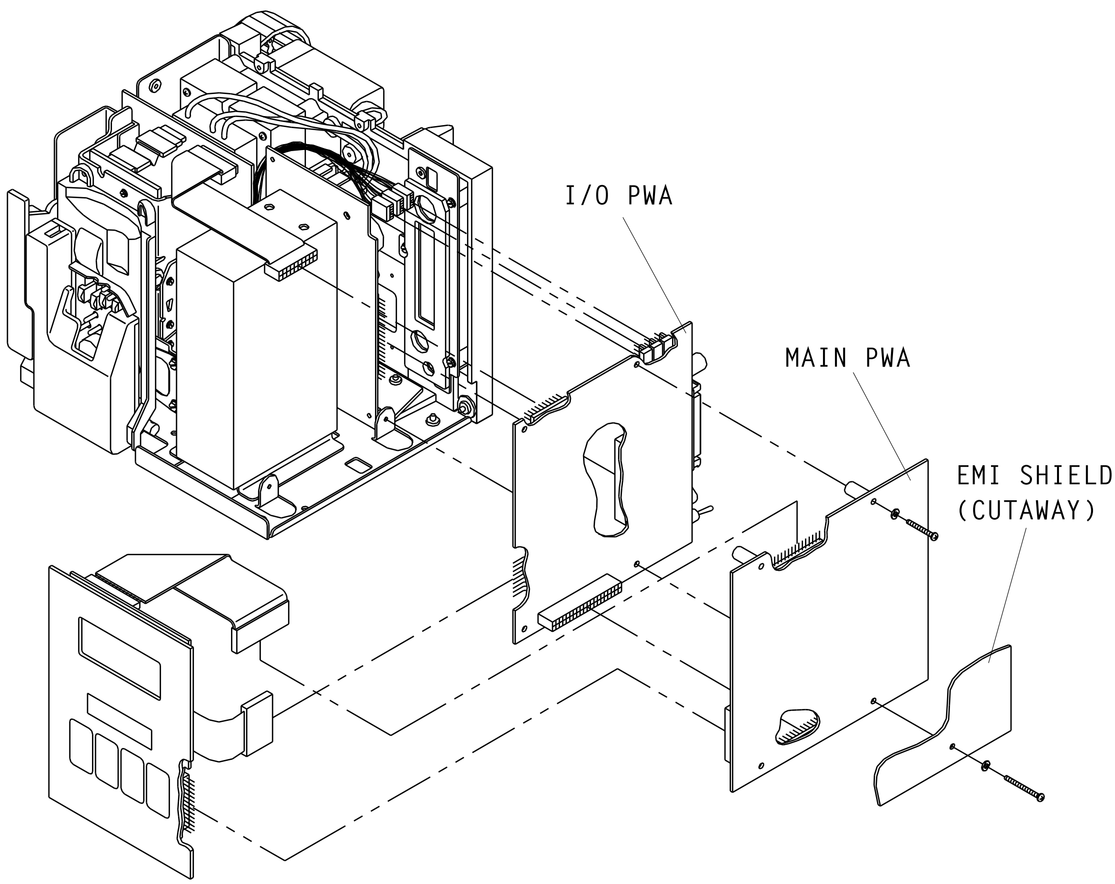


Figure 7-8. Main PWA and I/O PWA Replacement

7.2.17.2 I/O PWA REPLACEMENT

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

Note: The nurse-call jack, DIP switches and cover, audible alarm level switch, and flow detector jack are integral components of the I/O PWA. In 1.6 series infusion systems with DataPort accessory cables, a DB-15 interface connector is also included on the I/O PWA.

The location of the DIP switch cover on the recessed I/O port panel varies according to the presence or absence of the Dataport connector.

To replace the I/O PWA, refer to *Figure 7-8, Main PWA and I/O PWA Replacement*, then proceed as follows:

1. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*. Remove the EMI shield, as described in *Section 7.2.14, EMI Shield Replacement*, and the front panel assembly, as described in *Section 7.2.16, Front Panel Assembly Replacement*.
2. Using a No. 2 Phillips screwdriver, remove the screws and lockwashers securing the I/O PWA to the main PWA. Set the screws and lockwashers aside for re-assembly. Separate the main PWA from the I/O PWA.
3. Using a slight rocking motion, gently pull out the 40-pin, 2-row, right-angle connector connecting the I/O PWA to the power supply PWA. At the top of the I/O PWA, disconnect the ribbon cable connecting the I/O PWA to the sensor PWA. Pull the I/O PWA from the infusion system, removing the I/O panel connectors from panel cutouts.

   Note: Mark mating reference designations to facilitate reconnection.

4. At the top of the I/O PWA, disconnect the motor cable plugs P7 through P9. Remove the I/O PWA and record the DIP switch settings. Insert the replacement I/O PWA. Reconnect all cables, headers, and wire harnesses in the exact reverse order of removal. Re-install the main PWA in the exact reverse order of removal.
5. Connect the infusion system to AC (mains) power. Load a primed cassette into the cassette door and close the cassette door. Verify the successful completion of the self test. Open the cassette door. Disconnect the infusion system from AC (mains) power.
6. Replace the front panel assembly and EMI shield in the exact reverse order of removal. Re-assemble the infusion system in the exact reverse order of disassembly.
7. Using a No. 2 Phillips screwdriver, remove the screw from the DIP switch cover. Remove the cover to expose the DIP switches. Set the DIP switches to the macro (single channel) configuration *(refer to Figure 1-1, DIP Switch Settings for Each Delivery Mode)*.
8. With the cassette loaded, close the cassette door. Verify the delivery mode displayed on the LCD screen corresponds to the DIP switch setting LCD display listed in *Figure 1-1*. Open the cassette door.
9. Set the DIP switches to the next delivery mode configuration listed in *Figure 1-1*. Repeat Step 10 until all delivery modes are tested.
10. Set the DIP switches to the delivery mode configuration recorded in Step 6.

To verify successful replacement of the I/O PWA, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.18
POWER SUPPLY PWA AND MECHANISM ASSEMBLY REPLACEMENT (1.5 SERIES)

The recommended tools for this procedure are as follows: medium flat-blade screwdriver, No. 2 Phillips screwdriver, 1/4 inch nutdriver, 3/16 inch nutdriver, 5/32 inch nutdriver, X-acto knife, and needle-nose pliers.

The procedures in this section apply only to infusion systems with 1.5 series software. For 1.6 series infusion systems, refer to *Section 7.2.19, Power Supply PWA, Mechanism Assembly, and Battery Charger PWA Replacement (1.6 Series)*.

7.2.18.1
POWER SUPPLY PWA REPLACEMENT (1.5 SERIES)

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

To replace the power supply PWA, refer to *Figure 7-9, Mechanism Assembly, Power Supply PWA, and Battery Charger PWA Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*. Remove the EMI shield, as described in *Section 7.2.14, EMI Shield Replacement*. Remove the front panel assembly, as described in *Section 7.2.16, Front Panel Assembly Replacement*. Remove the main PWA and I/O PWA as described in *Section 7.2.17.2, I/O PWA Replacement*.
3. Place the infusion system face down on a soft surface with base facing technician.
4. Using a 3/16 inch nutdriver, remove the five closely grouped hex-head screws securing the power supply PWA to the chassis bottom. Set the screws aside for re-assembly.
5. Place infusion system upright on its base.
6. Disconnect the connectors from J16, J17, and J18. Disconnect connectors P1 and P2 to the battery boost PWA, if installed.

   Note: Confirm that all cables and wires are moved away from the power supply PWA.

7. Viewing the infusion system from the main PWA side, grasp the top of the power supply PWA and lift it slightly, tilting the top toward the power transformer. Slide the power supply PWA out toward the main PWA.
8. Remove and replace the power supply PWA. Reconnect all cables, headers, and wire harnesses in exact reverse order of removal.
9. Re-install the I/O PWA and main PWA in the exact reverse order of removal.
10. Connect the infusion system to AC (mains) power and verify successful completion of the self test.
11. Disconnect AC (mains) power. Replace the front panel assembly and EMI shield in exact reverse order of removal. Join the front and rear covers in exact reverse order of separation.

12. Re-assemble the infusion system in the exact reverse order of disassembly.

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

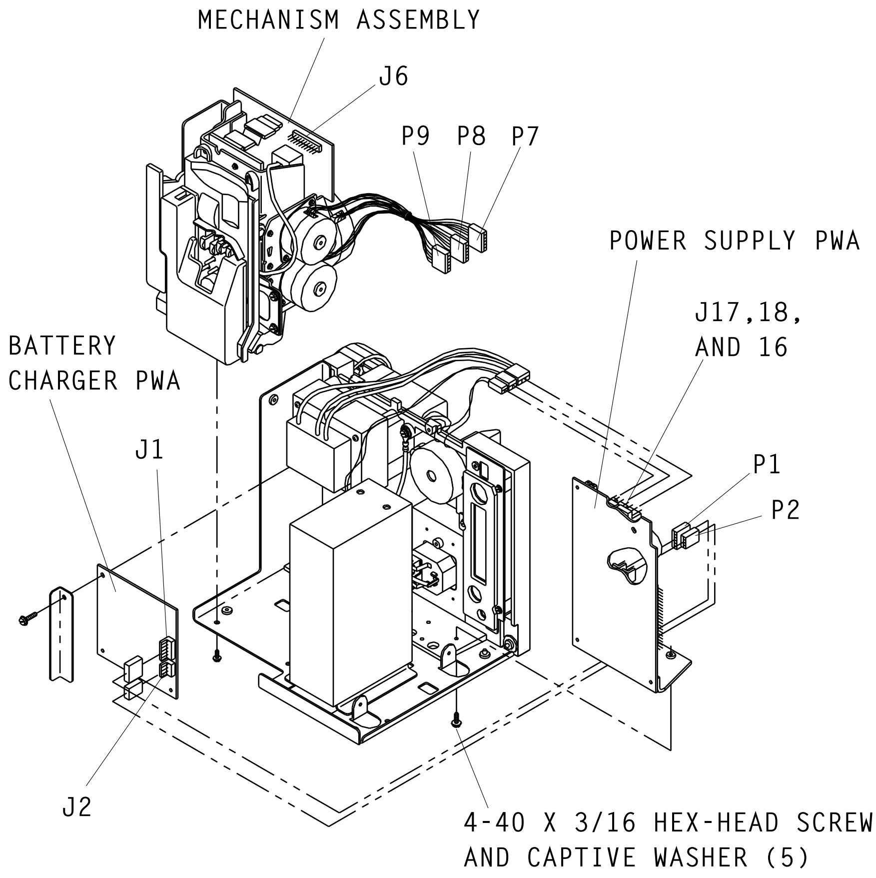


Figure 7-9. Mechanism Assembly, Power Supply PWA, and Battery Charger PWA Replacement

7.2.18.2 MECHANISM ASSEMBLY REPLACEMENT (1.5 SERIES)

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

Note: The mechanism assembly includes the bubble sensor PWA, the sensor PWA, and the pumping mechanism. This entire assembly is field-replaceable only as a single unit.

To replace the mechanism assembly, refer to *Figure 7-9, Mechanism Assembly, Power Supply PWA, and Battery Charger PWA Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*. Remove the EMI shield, as described in *Section 7.2.14, EMI Shield Replacement*, and the front panel assembly, as described in *Section 7.2.16, Front Panel Assembly Replacement*.

3. Using a 1/4 inch nutdriver, remove the three closely grouped hex-head screws securing the mechanism assembly to the chassis bottom. Support the mechanism assembly until all three screws are removed. Set the screws aside for re-assembly.

   Note: Two screws are located just under the cassette door; the third is toward the infusion system rear.
4. Disconnect plugs 7, 8, and 9 from the I/O PWA.
5. Remove and replace the mechanism assembly.
6. Using a 1/4 inch nutdriver, replace the three hex-head screws securing the mechanism assembly to the chassis bottom. Support the mechanism assembly until all three screws are replaced. Reconnect plugs 7, 8, and 9 to the I/O PWA.
7. Connect the infusion system to AC (mains) power and verify successful completion of the self test.
8. Disconnect AC (mains) power, then re-assemble the infusion system in the exact reverse order of disassembly.

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

7.2.19
POWER SUPPLY PWA, MECHANISM ASSEMBLY, AND BATTERY CHARGER PWA REPLACEMENT (1.6 SERIES)

The recommended tools for this procedure are as follows: medium flat-blade screwdriver, No. 2 Phillips screwdriver, 1/4 inch nutdriver, 3/16 inch nutdriver, 5/32 inch nutdriver, X-acto knife, and needle-nose pliers.

The procedures in this section apply to infusion systems with 1.6 series software only. For infusion systems with 1.5 series software, refer to *Section 7.2.18, Power Supply PWA and Mechanism Assembly Replacement (1.5 Series)*.

Note: If a defective battery charger PWA is to be replaced, the mechanism assembly must first be removed.

7.2.19.1
POWER SUPPLY PWA REPLACEMENT (1.6 SERIES)

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

To replace the power supply PWA, refer to *Figure 7-9, Mechanism Assembly, Power Supply PWA, and Battery Charger PWA Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*. Remove the EMI shield, as described in *Section 7.2.14, EMI Shield Replacement*. Remove the front panel assembly, as described in *Section 7.2.16, Front Panel Assembly Replacement*. Remove the main PWA and I/O PWA, as described in *Section 7.2.17.2, I/O PWA Replacement*.

3. Place the infusion system face down on soft surface with base facing technician.
4. Using a 3/16 inch nutdriver, remove the five closely grouped hex-head screws securing the power supply PWA to the chassis bottom. Set screws aside for re-assembly.
5. Place infusion system upright on its base.
6. Disconnect the connectors from J16, J17, and J18. Disconnect connectors P1 and P2 to the battery boost PWA.

   Note: Confirm that all cables and wires are moved away from power supply PWA.

7. Using the needle-nose pliers, disconnect the power supply PWA harness connectors from J1 and J2 on the battery charger PWA.
8. Viewing the infusion system from the main PWA side, grasp the top of the power supply PWA and lift it, tilting the top toward the power transformer. Slide power supply PWA out toward the main PWA.
9. Remove and replace the power supply PWA. Reconnect all cables, headers, and wire harnesses in exact reverse order of removal.
10. Connect the infusion system to AC (mains) power and verify successful completion of the self test.
11. Disconnect the infusion system from AC (mains) power. Replace the front panel assembly and EMI shield in exact reverse order of removal.
12. Re-assemble the infusion system in the exact reverse order of disassembly.

To verify successful replacement of the power supply PWA, perform the PVT as described in *Section 5.3*.

7.2.19.2
MECHANISM ASSEMBLY REPLACEMENT (1.6 SERIES)

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

Note: The mechanism assembly includes the bubble sensor PWA, the sensor PWA, and the pumping mechanism. This entire assembly is field-replaceable only as a single unit.

To replace the mechanism assembly, refer to *Figure 7-9, Mechanism Assembly, Power Supply PWA, and Battery Charger PWA Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*. Remove the EMI shield, as described in *Section 7.2.14, EMI Shield Replacement* and the front panel assembly, as described in *Section 7.2.16, Front Panel Assembly Replacement*.
3. Using a 1/4 inch nutdriver, remove the three closely grouped hex-head screws securing the mechanism assembly to the chassis bottom. Support the mechanism assembly until all three screws are removed. Set the screws aside for re-assembly.

   Note: Two screws are located just under the cassette door; the third is toward the infusion system rear.

4. Disconnect plugs 7, 8, and 9 from the I/O PWA.

5. Remove and replace the mechanism assembly.
6. Using a 1/4 inch nutdriver, replace the three hex-head screws securing the mechanism assembly to the chassis bottom. Support the mechanism assembly until all three screws are replaced. Reconnect plugs 7, 8, and 9 to the I/O PWA.
7. Connect the infusion system to AC (mains) power and verify successful completion of the self test.
8. Disconnect AC (mains) power, then re-assemble the infusion system in the exact reverse order of disassembly.

To verify successful replacement of the mechanism assembly, perform the PVT as described in *Section 5.3*.

7.2.19.3
BATTERY CHARGER PWA REPLACEMENT (1.6 SERIES)

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

To replace the battery charger PWA, refer to *Figure 7-9, Mechanism Assembly, Power Supply PWA, and Battery Charger PWA Replacement*, then proceed as follows:

1. Disconnect AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*. Remove the EMI shield, as described in *Section 7.2.14, EMI Shield Replacement*. Remove the front panel assembly, as described in *Section 7.2.16, Front Panel Assembly Replacement*. Remove the mechanism assembly as described in *Section 7.2.19.2, Mechanism Assembly Replacement (1.6 Series)*.
3. Using a 3/16 inch nutdriver, remove the hex-head screw securing the hold-down bracket to the infusion system chassis and heatsink. Set the screw and bracket aside for re-assembly.
4. Remove and replace the battery charger PWA.
5. Using a 3/16 inch nutdriver, replace the hex-head screw securing the hold-down bracket to the infusion system chassis and heatsink.
6. Connect the infusion system to AC (mains) power and verify successful completion of the self test.
7. Disconnect AC (mains) power. Replace the front panel assembly and EMI shield in exact reverse order of removal.
8. Disconnect AC (mains) power, then re-assemble the infusion system in the exact reverse order of disassembly.

To verify successful replacement of the battery charger PWA, perform the PVT as described in *Section 5.3*. Then perform the battery charger current test as described in *Section 5.5.2, Battery Charger Current Test (1.6 Series)*.

7.2.20
DOOR HANDLE REPLACEMENT

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

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

To replace the door handle, refer to *Figure 7-10, Door Assembly and Door Handle Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. With the cassette door closed, use a No. 2 Phillips screwdriver to remove the two Phillips-head screws securing the door handle to the door mechanism.
4. Open the cassette door and remove a third Phillips-head screw. Remove the door handle.
5. Replace the door handle in exact reverse order of removal.
6. Open and close the door handle several times to confirm that it is operational.
7. Re-assemble infusion system covers, battery pack connectors, and cover in the exact reverse order of removal.

To verify successful replacement of the door handle, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

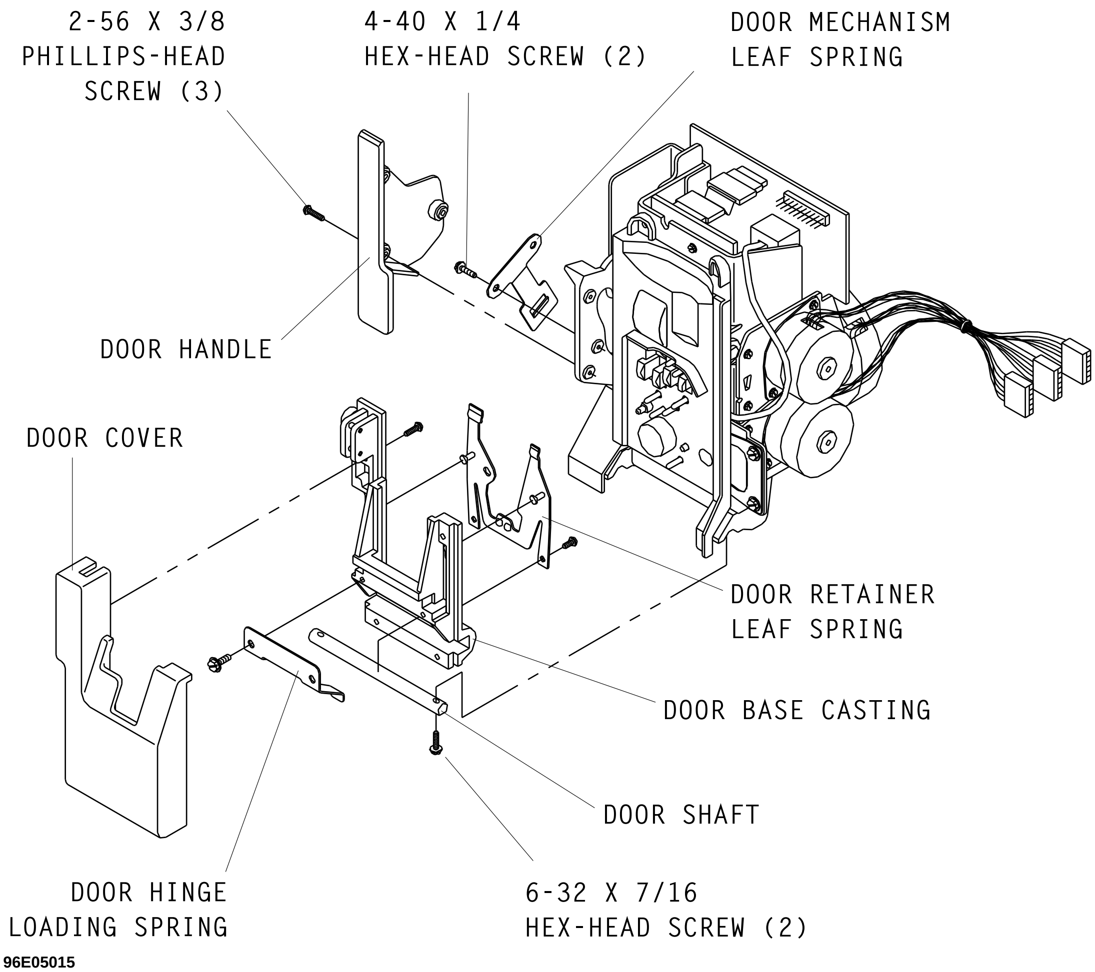


Figure 7-10. Door Assembly and Door Handle Assembly Replacement

7.2.21
DOOR MECHANISM LEAF SPRING REPLACEMENT

The recommended tools for this procedure are as follows: 3/16 inch nutdriver or medium flat-blade screwdriver, and No. 1 Phillips screwdriver.

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

To replace the door mechanism leaf spring, refer to *Figure 7-10, Door Assembly and Door Handle Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers, as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. With the cassette door closed, use a No. 2 Phillips screwdriver to remove the two Phillips-head screws securing the door handle to the door mechanism.
4. Open the cassette door and remove a third Phillips-head screw. Remove the door handle.

5. Using a 3/16 inch nutdriver or medium flat-blade screwdriver, remove the two hex-head screws securing the door mechanism leaf spring to the door mechanism. Set the screws aside for re-assembly. Remove the door mechanism leaf spring.
6. Replace the door mechanism leaf spring and door handle in the exact reverse order of removal.
7. Open and close the door handle several times to confirm that it is operational.
8. Re-assemble infusion system covers, battery pack connectors, and cover in the exact reverse order of removal.

To verify successful replacement of the door mechanism leaf spring, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.22 DOOR RETAINER LEAF SPRING REPLACEMENT

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

To replace the door retainer leaf spring, refer to *Figure 7-10, Door Assembly and Door Handle Assembly Replacement*, then proceed as follows.

1. Disconnect the infusion system from AC (mains) power.
2. Lift the door handle. Compress the door mechanism leaf spring and pull down cassette door assembly.
3. Using a small flat-blade screwdriver, remove the two screws securing the door retainer leaf spring to the door assembly. Remove the door retainer leaf spring.
4. Replace the door retainer leaf spring by guiding the two locator pins on the bottom of the door retainer leaf spring into the slotted holes on the cassette door assembly. Position the leaf spring to align the screw holes.
5. Using a small flat-blade screwdriver, replace the two screws securing the leaf spring to the door assembly.
6. Compress the door mechanism leaf spring and lift the cassette door assembly into the locked position. Close the door handle to secure the door.

To verify successful replacement of the door retainer leaf spring, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.23 DOOR ASSEMBLY REPLACEMENT

The recommended tools for this procedure are as follows: No. 1 Phillips screwdriver, No. 2 Phillips screwdriver, small flat-blade screwdriver, medium flat-blade screwdriver, 1/4 inch nutdriver, and grease.

This procedure details replacing the door assembly. Replacement of the door assembly components follows.

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

Note: Replace the door assembly only if the entire assembly is defective.

To replace the door assembly, refer to *Figure 7-10, Door Assembly and Door Handle Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers, as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. Using a 1/4 inch nutdriver, remove the two hex-head screws located on the cassette door shaft.
4. Place the infusion system on its back. Grasping the cassette door, pull up on the door handle and remove the door assembly.
5. Verify that the flat side of the cassette door shaft is facing the technician and the shaft is centered with the shaft hole. Position the cassette door shaft in the infusion system frame shaft cradle. Verify the door base casting ball bearing snaps into position behind door mechanism leaf spring.
6. Align the cassette door shaft screw holes with the cradle screw holes.
7. Using a 1/4 inch nutdriver, replace the two hex-head screws located on the cassette door shaft.
8. Re-assemble the front and rear covers in the exact reverse order of disassembly.

To verify successful replacement of the door assembly, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.23.1
DOOR COVER REPLACEMENT

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

To replace the door cover, refer to *Figure 7-10, Door Assembly and Door Handle Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate front and rear covers, as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. Using a 1/4 inch nutdriver, remove the two hex-head screws located on the cassette door shaft.
4. Place the infusion system on its back. Grasping the cassette door, pull up on the door handle and remove the door assembly.
5. Using a No. 1 Phillips screwdriver, remove the four Phillips screws from the door base casting. Separate the door cover from the door base casting.
6. Replace the door cover by guiding the door base casting into the door cover cavity.
7. Using a No. 1 Phillips screwdriver, replace the four Phillips screws in the door base casting.

   CAUTION: Do not overtighten the screws. Overtightening may strip screw threads.

8. Install the door assembly. Confirm the flat side of the cassette door shaft is facing the technician and the shaft is centered within the shaft hole. Place the cassette

door shaft into the infusion system frame shaft cradle. Confirm the door base casting ball bearing snaps into position behind the door mechanism leaf spring.

9. Re-assemble the door assembly in the exact reverse order of disassembly.
10. Re-assemble the front and rear covers in the exact reverse order of disassembly.

To verify successful replacement of the door cover, perform the PVT as described in *Section 5.2, (1.5 series)* or *Section 5.2, (1.6 series)*.

7.2.23.2
DOOR HINGE LOADING SPRING REPLACEMENT

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

To replace the door hinge loading spring, refer to *Figure 7-10, Door Assembly and Door Handle Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate front and rear covers, as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. Using a 1/4 inch nutdriver, remove the two hex-head screws located on the cassette door shaft.
4. Place the infusion system on its back. Grasping the cassette door, pull up on the door handle and remove the door assembly.
5. Using a No. 1 Phillips screwdriver, remove the four Phillips screws from the door base casting. Separate the door cover from the door base casting.
6. Using a medium flat-blade screwdriver, remove the two hex-head screws securing the door hinge loading spring to the cassette door shaft. Lift the door hinge loading spring free from the door base casting.
7. Apply a small amount of grease to the door hinge loading spring at areas of contact with the cassette door shaft. Replace the door hinge loading spring.
8. Align the door hinge loading spring screw holes with the screw holes in the door base casting. Using a medium flat-blade screwdriver, replace the two hex-head screws securing the door hinge loading spring to the door base casting. Replace the cover by guiding the door base casting into the door cover cavity.
9. Re-assemble the door cover and door base casting in the exact reverse order of disassembly.

   CAUTION: Do not overtighten the screws. Overtightening may strip threads.

10. Re-assemble the door assembly in the exact reverse order of disassembly.
11. Re-assemble the front and rear covers in the exact reverse order of disassembly.

To verify successful replacement of the door hinge loading spring, perform the PVT as described in *Section 5.2, (1.5 series)* or *Section 5.3, (1.6 series)*.

7.2.23.3
CASSETTE DOOR SHAFT REPLACEMENT

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

To replace the cassette door shaft, refer to *Figure 7-10, Door Assembly and Door Handle Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate front and rear covers, as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. Using a 1/4 inch nutdriver, remove the two hex-head screws located on the cassette door shaft.
4. Place the infusion system on its back. Grasping the cassette door, pull up on the door handle and remove the door assembly.
5. Using a No. 1 Phillips screwdriver, remove the four Phillips screws from the door base casting. Separate the door cover from the door base casting.
6. Using a medium flat-blade screwdriver, remove the two hex-head screws securing the door hinge loading spring to the cassette door shaft. Lift the door hinge loading spring free from the door base casting.
7. Using a dry, lint-free cloth, clean the grease from the door hinge loading spring. Set the door hinge loading spring aside for re-assembly.
8. Remove the cassette door shaft by lifting it free of door base casting.
9. Using a dry, lint-free cloth, clean the grease from the cassette door shaft cradle. Apply a small amount of grease 5/8 inch inward from each end of the cassette door shaft cradle.
10. Insert the cassette door shaft and center it in the cradle.
11. Apply a small amount of grease to the door hinge loading spring at areas of contact with the cassette door shaft.
12. Replace the door hinge loading spring in the exact reverse order of disassembly.
13. Replace the door cover to the door base casting in the exact reverse order of disassembly.

    CAUTION: Do not overtighten the screws; overtightening may strip the screw threads.

14. Install the door assembly in the exact reverse order of disassembly.
15. Re-assemble the front and rear covers in the exact reverse order of disassembly.

To verify successful replacement of the cassette door shaft, perform the PVT as described in *Section 5.2, (1.5 series)* or *Section 5.3, (1.6 series)*.

7.2.23.4
DOOR BASE CASTING REPLACEMENT

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

To replace the door base casting, refer to *Figure 7-10, Door Assembly and Door Handle Assembly Replacement*, then proceed as follows:

Note: The door base casting has two roll pins, ball bearing, and a setscrew that are factory installed.

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers, as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. Using a 1/4 inch nutdriver, remove the two hex-head screws located on the cassette door shaft.
4. Place the infusion system on its back. Pull up on the cassette door handle and remove the door assembly from the infusion system.
5. Using a No. 1 Phillips screwdriver, remove the four Phillips screws from the door base casting. Separate the door cover from the door base casting.
6. Using a medium flat-blade screwdriver, remove the two hex-head screws securing the door hinge loading spring to the cassette door shaft. Life the door hinge loading spring free from the door base casting. Using a dry, lint-free cloth, clean the grease from the door hinge loading spring and set it aside for re-assembly.
7. Remove the cassette door shaft by lifting it free of the door base casting. Clean the existing grease from the cassette door shaft and the door base casting. Set the cassette door shaft aside for re-assembly.
8. Using a small flat-blade screwdriver, remove the two screws securing the door retainer leaf spring to the door base casting. Slide the door retainer leaf spring from the door base casting.
9. Replace the door retainer leaf spring on the new door base casting. Guide the two locator pins in the slotted on the door assembly. Slide the leaf spring back until the screw holes are aligned.
10. Using a small flat-blade screwdriver, replace the two screws securing the door retainer leaf spring to the door base casting.
11. Apply a small amount of grease 5/8 inch inward from each end of the cassette door shaft cradle.
12. Insert the cassette door shaft and center it in the cradle.
13. Apply a small amount of grease to the door hinge loading spring at areas of contact with the cassette door shaft. Replace the door hinge loading spring.
14. Align the door hinge loading spring screw holes with the screw holes in the door base casting. Using a medium flat-blade screwdriver, replace the two hex-head screws securing the door hinge loading spring to the cassette door shaft.
15. Replace the door cover by guiding the door base casting into the door cover cavity.
16. Using a No. 1 Phillips screwdriver, replace the four Phillips screws in the door base casting.

    CAUTION: Do not overtighten the screws. Overtightening may strip screw threads.

17. Place the infusion system upside down with the infusion system front facing the technician and the door handle in the open position.
18. Install the door assembly with the door assembly cover facing the technician. Confirm the flat side of the cassette door shaft is facing up and the shaft is centered

within the shaft hole. Place the cassette door shaft into the infusion system frame shaft cradle. Verify the door base casting ball bearing snaps into position behind the door retainer leaf spring.

19. Adjust the cassette door shaft so the screw holes are aligned with the screw holes in the cradle. Insert the two hex-head screws removed in Step 3. Close the door handle. Using a 1/4 inch nutdriver, secure the two hex-head screws.
20. Re-assemble the front and rear covers in the exact reverse order of disassembly.

To verify successful replacement of the door base casting, perform the PVT as described in *Section 5.2, (1.5 series)* or *Section 5.3, (1.6 series)*.

7.2.24
I/O PORT PLATE REPLACEMENT

The recommended tools for this procedure are as follows: medium flat-blade screwdriver, No. 2 Phillips screwdriver, 1/4 inch nutdriver, 5/32 inch nutdriver, X-acto knife, and needle-nose pliers.

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

Note: Although the I/O port plate does not wear, the foam gasket attached to the plate may need to be replaced. If the gasket is defective, the I/O port plate must also be replaced.

To replace the I/O port plate, refer to *Figure 7-11, I/O Port Plate, Piezoelectric Alarm, and AC Receptacle Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. Remove the EMI shield, as described in *Section 7.2.14, EMI Shield Replacement*,
4. Remove the front panel assembly, as described in *Section 7.2.16, Front Panel Assembly Replacement*,
5. Remove the main PWA and I/O PWA as described in *Section 7.2.17, Main PWA and I/O PWA Replacement*,
6. Remove the power supply PWA as described in *Sections 7.2.18, Power Supply PWA and Mechanism Assembly Replacement (1.5 series)*, or *Section 7.2.19, Power Supply PWA, Mechanism Assembly, and Battery Charger PWA Replacement (1.6 series)*.
7. Place infusion system on its base. Using a 1/4 inch nutdriver, remove the three hex-head screws attaching the I/O port plate to the rear casting. Set the screws aside for re-assembly.
8. Remove and replace I/O port plate.
9. Replace the power supply PWA, and the Main and I/O PWAs in exact reverse order of removal.
10. Reconnect all cables, headers, and wire harnesses in the exact reverse order of removal.
11. Connect the infusion system to AC (mains) power and verify successful completion of the self test.

12. Disconnect AC (mains) power. Replace the front panel assembly and EMI shield in exact reverse order of removal.
13. Re-assemble the front and rear covers in the exact reverse order of disassembly.

To verify successful replacement of the I/O port plate, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

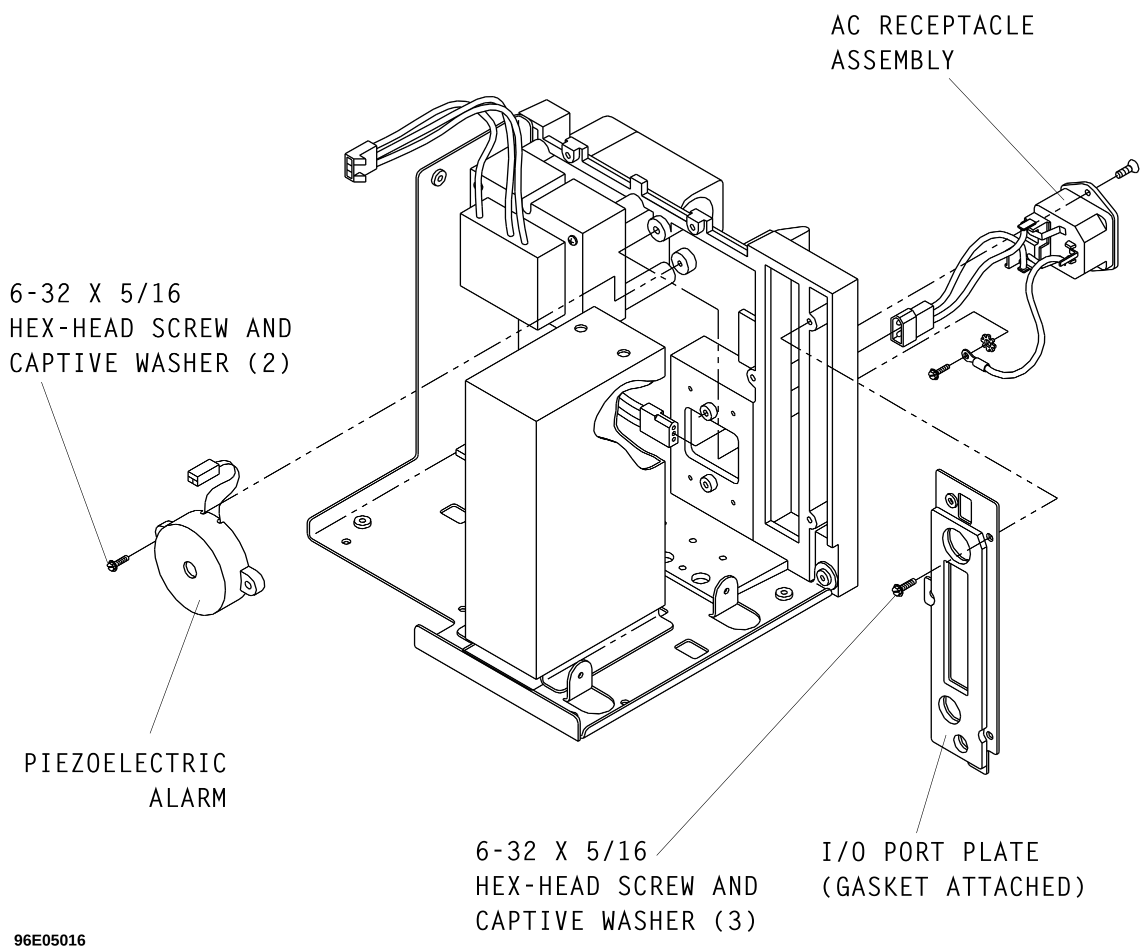


Figure 7-11. I/O Port Plate, Piezoelectric Alarm, and AC Receptacle Assembly Replacement

7.2.25 PIEZOELECTRIC ALARM ASSEMBLY REPLACEMENT

The recommended tools for this procedure are as follows: medium flat-blade screwdriver, No. 2 Phillips screwdriver, 1/4 inch nutdriver, 5/32 inch nutdriver, X-acto knife, needle-nose pliers, and 1/4 inch right-angle socket wrench.

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

To replace the piezoelectric alarm assembly, refer to *Figure 7-11, I/O Port Plate, Piezoelectric Alarm, and AC Receptacle Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.

2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. Remove the EMI shield, as described in *Section 7.2.14, EMI Shield Replacement*.
4. Remove the front panel assembly, as described in *Section 7.2.16, Front Panel Assembly Replacement*.
5. Remove the main PWA and I/O PWA as described in *Section 7.2.17, Main PWA and I/O PWA Replacement*.
6. Remove the power supply PWA as described in *Sections 7.2.18 Power Supply PWA and Mechanism Assembly Replacement (1.5 series)*, or *Section 7.2.19, Power Supply PWA, Mechanism Assembly, and Battery Charger PWA Replacement (1.6 series)*.
7. Place infusion system upright. Using a 1/4 inch right-angle socket wrench, remove the two hex-head screws securing the piezoelectric alarm assembly to the rear casting. Set the two screws aside for re-assembly.
8. Remove and replace the piezoelectric alarm assembly.
9. Replace the power supply PWA, and the Main and I/O PWAs in the exact reverse order of removal.
10. Reconnect all cables, headers, and wire harnesses in the exact reverse order of removal.
11. Connect the infusion system to AC (mains) power and verify successful completion of the self test.
12. Disconnect AC (mains) power. Replace the front panel assembly and EMI shield in the exact reverse order of removal. Re-assemble the front and rear covers in the exact reverse order of disassembly.

To verify successful replacement of the piezoelectric alarm assembly, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.26 AC RECEPTACLE ASSEMBLY REPLACEMENT

The recommended tools for this procedure are as follows: medium flat-blade screwdriver, No. 2 Phillips screwdriver, 1/4 inch nutdriver, 5/32 inch nutdriver, X-acto knife, needle-nose pliers, and 1/4 inch right-angle socket wrench.

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

To remove the AC (mains) receptacle assembly, refer to *Figure 7-11, I/O Port Plate, Piezoelectric Alarm, and AC Receptacle Assembly Replacement*, then proceed as follows:

1. Disconnect the infusion system from AC (mains) power.
2. Separate the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*.
3. Remove the EMI shield, as described in *Section 7.2.14, EMI Shield Replacement*.
4. Remove the front panel assembly, as described in *Section 7.2.16, Front Panel Assembly Replacement*.
5. Remove the main PWA and I/O PWA as described in *Section 7.2.17, Main PWA and I/O PWA Replacement*.

6. Remove the power supply PWA as described in *Sections 7.2.18 Power Supply PWA and Mechanism Assembly Replacement (1.5 series)*, or *Section 7.2.19, Power Supply PWA, Mechanism Assembly, and Battery Charger PWA Replacement (1.6 series)*.
7. Using a 1/4 inch right-angle socket wrench, remove the hex-head screw and lockwasher securing the ground (earth) wire to the rear casting. Set the screw and lockwasher aside for re-assembly.
8. Using a No. 2 Phillips screwdriver, remove the two screws securing the AC (mains) receptacle assembly and wire harness to the rear casting. Pull the receptacle assembly and wire harness through the rear casting opening until the T1 power transformer connector is visible.
9. Disconnect the power transformer connector from the power transformer leads.
10. Remove and replace AC (mains) receptacle assembly.
11. Install the power transformer connector through the receptacle opening.

    Note: If the power transformer connector has moved inside the rear casting opening, retrieve it with needle-nose pliers.

12. Connect the plug end of the AC (mains) receptacle assembly to the power transformer connector. Push the AC (mains) receptacle assembly and wire harness through the rear casting opening.
13. Using a 1/4 inch right-angle socket wrench, replace the hex-head screw and lockwasher securing the ground (earth) wire to the rear casting.

    Note: For proper grounding, the star lockwasher must be positioned between the ground lug and the rear casting housing.

14. Replace the power supply PWA, and the Main and I/O PWAs in the exact reverse order of removal.
15. Reconnect all cables, headers, and wire harnesses in the exact reverse order of removal.
16. Connect the infusion system to AC (mains) power and verify successful completion of the self test.
17. Disconnect AC (mains) power. Replace the front panel assembly and EMI shield in the exact reverse order of removal.
18. Re-assemble the front and rear covers in the exact reverse order of disassembly.

To verify successful replacement of the AC (mains) receptacle assembly, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.27 JUNCTION BOX REPLACEMENT (1.6 SERIES WITH DATAPORT)

No tools are recommended for this procedure.

To replace the junction box, proceed as follows:

1. Place the infusion system with the rear facing the technician.
2. Loosen the jackscrews securing the junction box to the infusion system connector. Remove and replace the junction box.

3. Tighten the jackscrews securing the junction box to the infusion system connector.

Replacement of the junction box is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion system may have been damaged during this procedure, perform the PVT as described in *Section 5.3*.

7.2.28 DATAPORT ACCESSORY CABLE REPLACEMENT (1.6 SERIES WITH DATAPORT)

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

Table 7-1, Accessories for 1.6 Series Infusion Systems, lists DataPort accessory cable part descriptions and associated list numbers. Refer to *Figure 7-12, DataPort Accessory Cable Schematics*, for connector information.

To replace a DataPort accessory cable that contains a six-pin modular connector at the junction box, compress the tab on the connector and disconnect the cable. To replace a DataPort accessory cable that contains a connector type other than six-pin modular at the junction box, use a small flat-blade screwdriver or compress the tabs as appropriate.

Replacement of the DataPort accessory cable is a routine maintenance procedure and no verification procedure is normally required. However, if the infusion system may have been damaged during this procedure, perform the PVT as described in *Section 5.3*.

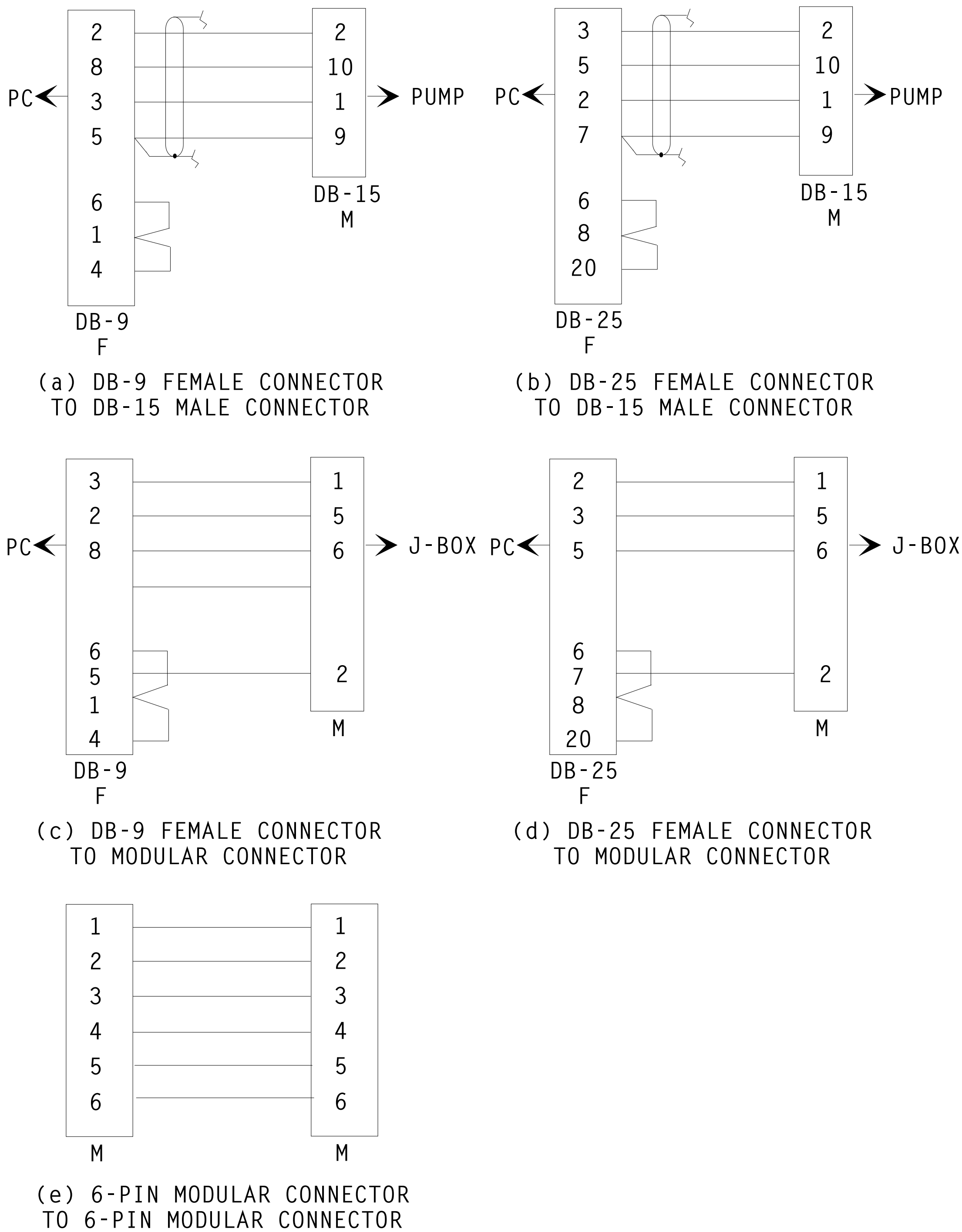


Figure 7-12. DataPort Accessory Cable Schematics

7.2.29 MECHANISM ASSEMBLY CLEANING AND LUBRICATION

The recommended tools for this procedure are as follows: small size flat-blade screwdriver, medium size flat-blade screwdriver, 1/4-inch nutdriver, small six-inch brush, PlumSet, Electro-Wash 2000 or isopropyl alcohol, cotton swabs, and Braycote 804 grease.

Note: Electro-Wash 2000 can be obtained locally. Isopropyl alcohol may be substituted for Electro-Wash 2000; however, if using isopropyl alcohol, assure that all residual lubricant is removed. Braycote 804 grease can be obtained from Abbott Laboratories, or may be obtained locally.

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

To clean and lubricate the mechanism assembly, refer to *Figure 7-13, Plunger Shaft Threads and Plunger Nut Lubrication*, and *Figure 7-14, Mechanism Assembly Lubrication Points*, then proceed as follows:

1. Remove the mechanism assembly as described in *Section 7.2.18.1, Mechanism Assembly Replacement (1.5 series)*, or *Section 7.2.19.2, Mechanism Assembly Replacement (1.6 series)*.

   Note: Do not remove the power supply PWA.

2. Load a cassette into the cassette door. Close the cassette door.
3. Remove the remaining three infusion system cables connecting the sensor PWA to the I/O PWA, bubble sensor PWA, and pressure sensor.
4. Using a 1/4-inch nutdriver, remove the two hex-head screws securing the sensor PWA to the mechanism assembly. Unclip the connectors on the component side of the sensor PWA. Remove the sensor PWA.
5. Using a 1/4-inch nutdriver, remove the two hex-head screws securing the plunger motor to the mechanism assembly.
6. Grasp the plunger motor and rotate the plunger motor coupling counterclockwise until the plunger motor and plunger motor coupling disengage from the plunger shaft.

   CAUTION: Do not remove the plunger motor coupling from the plunger motor. Do not remove the brass nut.

7. Inspect the door shield for foreign matter. If necessary, remove the door shield from the mechanism assembly as described in *Section 7.2.31, Door Shield Replacement*.
8. Using Electro-Wash 2000 or isopropyl alcohol, clean the mechanism assembly as follows:
   - Clean the plunger shaft. Use a small six-inch brush to remove the existing grease.
   - Clean the inside of the plunger nut. Use a cotton swab to remove the existing grease.
   - Clean any foreign matter from the component side of the bubble sensor PWA, the component side of the sensor PWA, each mechanism assembly lubrication

point *(refer to Figure 7-13, Plunger Shaft Threads and Plunger Nut Lubrication)*, and behind the door shield (if removed).

Note: If isopropyl alcohol is used, verify the alcohol evaporates prior to application of Braycote 804 grease.

9. Apply grease to the first 1/2 inch of the plunger shaft threads, using enough grease to fill the threads, as well as the threads inside the plunger nut *(refer to Figure 7-14, Mechanism Assembly Lubrication Points)*.
10. Apply an adequate amount of grease (approximately 0.1 cc) to each of the mechanism assembly lubrication points.
11. If the door shield was removed, replace it in the exact reverse order of removal.
12. Grasp the plunger motor, motor wires up, and insert the plunger motor coupling on the plunger shaft. Rotate the plunger motor coupling clockwise until the plunger motor is flush against the mechanism assembly.
13. Using a 1/4-inch nutdriver, replace the two hex-head screws securing the plunger motor to the mechanism assembly.

    Note: Confirm that the hex-head screws securing the plunger motor to the mechanism assembly are fully tightened.
14. Using a small size flat-blade screwdriver, rotate the I/O flags to the full up position.
15. Open the cassette door and remove the cassette. Close the cassette door.
16. Install the sensor PWA; do not force it into position. Use a small size flat-blade screwdriver to compress the microswitch lever located on the sensor PWA.

    Note: Pressing the primary valve pin while seating the sensor PWA will reposition the I/O flags and allow the sensor PWA to be seated more easily.
17. Verify that the sensor PWA is fully seated in the motor base notches. Using a 1/4-inch nutdriver, replace the two hex-head screws securing the sensor PWA to the mechanism assembly.
18. Inspect the four optical interrupters. Verify that the four optical interrupter motor flags rotate freely and have adequate sensor clearance.
19. Replace the three infusion system cables connecting the sensor PWA to the I/O PWA, bubble sensor PWA, and pressure sensor.
20. Replace the mechanism assembly in exact reverse order of removal.

To verify successful cleaning and lubrication of the mechanism assembly, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

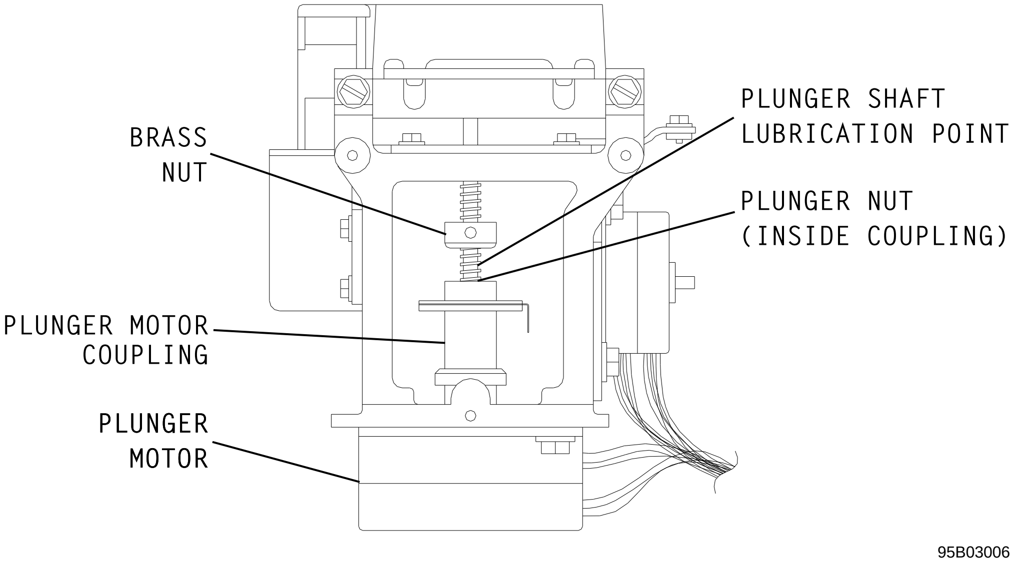


Figure 7-13. Plunger Shaft Threads and Plunger Nut Lubrication

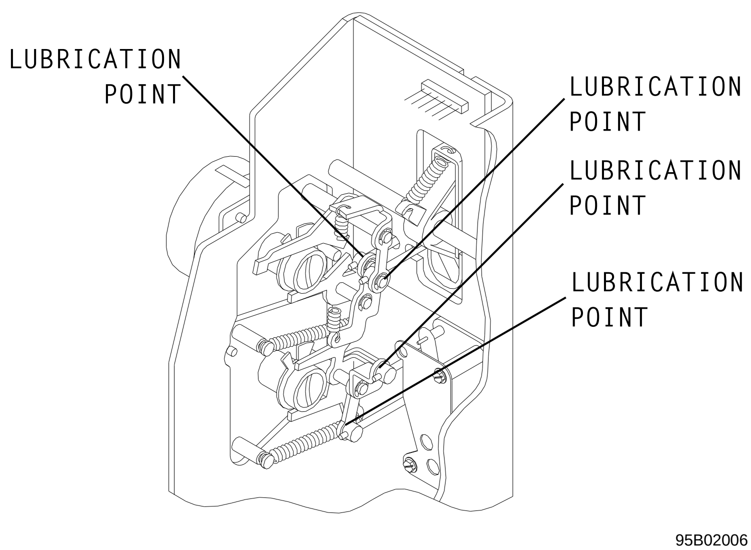


Figure 7-14. Mechanism Assembly Lubrication Points

7.2.30 DISTAL PRESSURE SENSOR ELECTRICAL ADJUSTMENT

Recommended tools for this procedure are as follows: small flat-blade screwdriver; DMM; red GLPT insulating varnish; PlumSet, List No. 6426, or equivalent; large bore needle (18-gauge); 20 cc syringe with the volume limited at 20 cc; DPM; and a three-way stopcock.

Note: For all testing, the vertical height distance from the top of the fluid in the flexible container to midline of the cassette must be 18 ± 6 inches (46 ± 15 cm).

Note: Cassettes used in this procedure should be replaced daily.

To perform the distal pressure sensor electrical adjustment, proceed as follows:

1. Remove the front and rear covers as described in *Section 7.2.13, Separating the Front and Rear Covers*. Remove the EMI shield as described in *Section 7.2.14, EMI Shield Replacement*.
2. Insert a primed cassette and close the door. Attach the negative lead of the DMM to TP0 and the positive lead to TP1 on the sensor PWA.
3. Connect the distal tubing to the three-way stopcock and attach to the DPM.
4. Attach the 18-gauge needle or blunt cannula into the lower Y site of the distal tubing.
5. Open the stopcock to air.
6. Verify that the DPM reads 0 psi. Adjust R15 to obtain 1.37 ± 0.015 V on the DMM.
7. Move the stopcock to read the pressure. Using the 20 cc syringe, create a back pressure of 8 psi.
8. While holding 8 psi of pressure, adjust R14 to obtain 2.97 ± 0.015 V.
9. Repeat Steps 5 through 7 until the specified voltages are within limits.

   Note: If the voltage cannot be adjusted within specifications, the infusion system must be returned for mechanical adjustment of the sensors. See *Section 6.1, Technical Assistance*.

10. Add one drop of red GLPT insulating varnish to R14 and R15.
11. Re-assemble the infusion system in the exact reverse order of disassembly.

To verify successful digital pressure sensor electrical adjustment, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

7.2.31 DOOR SHIELD REPLACEMENT

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

To replace the door shield, refer to *Figure 7-15, Door Shield Replacement*, then proceed as follows:

1. Remove the door assembly as described in *Section 7.2.23, Door Assembly Replacement*.
2. Using a medium size flat-blade screwdriver, remove the four screws securing the door shield to the mechanism assembly.
3. Remove the door shield by pulling it straight out.
4. Replace the door shield in the exact reverse order of removal.
5. Replace the door assembly in the exact reverse order of removal.

To verify successful door shield replacement, perform the PVT as described in *Section 5.2 (1.5 series)* or *Section 5.3 (1.6 series)*.

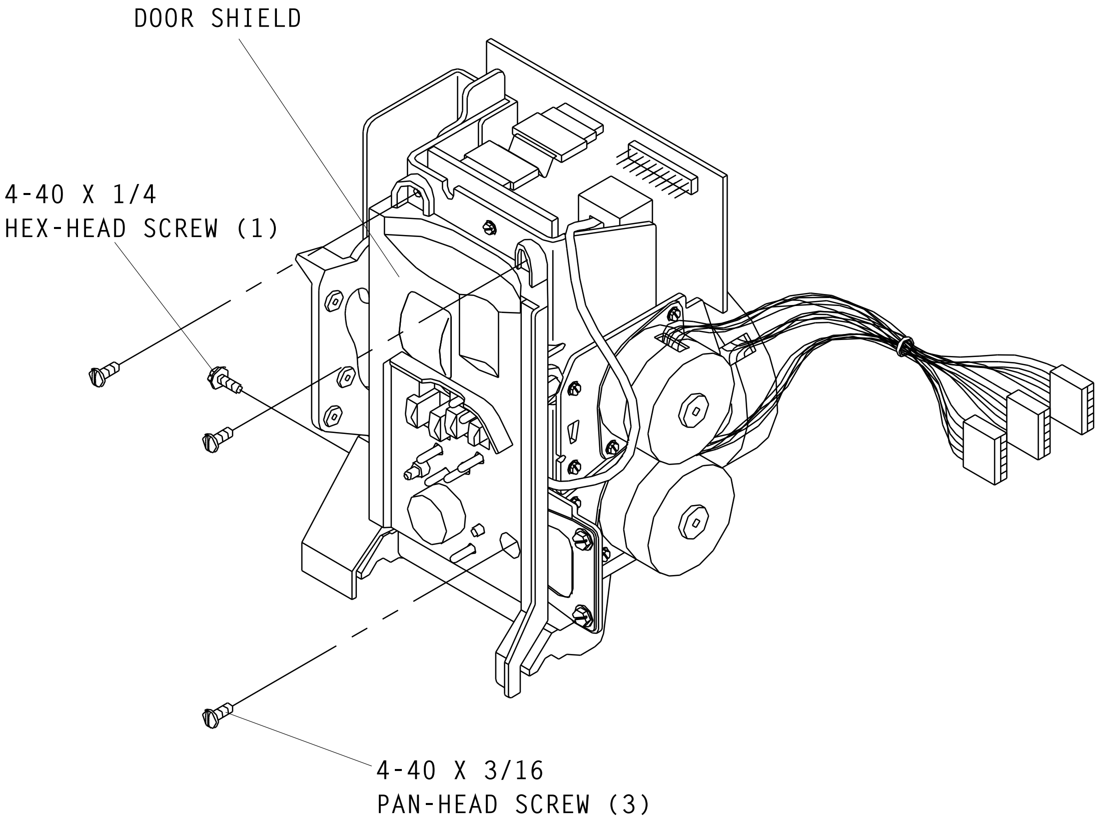


Figure 7-15. Door Shield Replacement

Section 8

SPECIFICATIONS

This section contains specifications for the 1.5 series and 1.6 series domestic and international infusion systems.

8.1

DOMESTIC INFUSION SYSTEM (1.5 SERIES)

The following specifications apply to the domestic infusion system (1.5 series) only.

PHYSICAL

Dimensions:	Approximately 18 x 23 x 23 cm (7 x 9 x 9 inches), excluding pole clamp protrusion and power cord storage
Weight:	Approximately 6.0 kg (13 lbs), with battery
Casing:	High-impact plastic

ELECTRICAL

Power Requirements:	110 to 120 AC, 50/60 Hz, 30 W
Power Cord:	Hospital-grade AC (mains) power cord. 8 feet long, with transparent plug and retainer plate (on infusion system)
Fuses:	0.4 A or 0.5 A (depending on label), 250 V, slo-blo
Battery:	One sealed, rechargeable 8 volt battery, internal to system. Accessible for ease of field replacement, with color-coded leads and polarized connector Battery life (new batteries, full charge at 20° C): Approximately 500 ml total volume delivered, or six hours of operation, whichever occurs first
Battery Recharge:	Battery is on recharge any time infusion system is connected to AC (mains) power. Recharge rate: to 80% of prior charge in 16 hours while operating at a delivery rate of 125 ml/hr or less *(see Section 4.3, Battery Overview)*
Battery Self-Discharge:	50% of charge retained for at least one month when infusion system is neither connected to AC (mains) power nor operating
Electrical Leakage:	Risk current limits meet ANSI/AAMI ES1-1985 (ungrounded) standard

ENVIRONMENT

Temperature:	10° to 40° C (50° to 104° F)

Relative Humidity: 10% to 90%, noncondensing

Pressure: Equivalent altitudes from 0 to 10,000 feet

SHIPPING AND STORAGE

Temperature (infusion system only): -34° to 60° C (-29.2° to 140° F)

Temperature (set only): -34° to 55° C (-29.2° to 131° F)

Relative Humidity: 10% to 90% noncondensing at temperatures up to 40° C (104° F). A maximum of 15% noncondensing at temperatures from 41° to 60° C (105.8° to 140° F)

DELIVERY RATE RANGE

Micro Mode: 0.1 to 99.9 ml/hr (in 0.1 ml increments; total primary rate plus secondary rate cannot exceed 99.9 ml/hr). In the concurrent mode, the rates for either primary or secondary cannot be less than 0.5 ml/hr

Macro Mode: 1 to 999 ml/hr (in 1 ml increments). In the concurrent mode, total primary rate plus secondary rate cannot exceed 800 ml/hr

DOSE LIMIT RANGE

Micro Mode: 0.1 to 999 ml (in 0.1 ml increments)

Macro Mode: 1 to 9999 ml (in 1 ml increments)

SECONDARY DOSES:

Dual Channel Delivery: A single dose of a secondary fluid may be administered

Multidose Delivery: 1 to 24 doses of a secondary fluid may be administered at intervals from 15 minutes to 24 hours

OPERATING BACKPRESSURE: -2 to 8 psig (-14 to 55 kPa)

OCCLUSION ALARM: Maximum pressure is user selectable from 1 to 8 psig (7 to 55 kPa), through the front panel touchswitches

Distal: DISTAL OCCLUSION alarm sounds within two pumping cycles after the distal set tubing or set outlet fitting becomes occluded

Proximal: PROXIMAL OCCLUSION alarm sounds if the tubing proximal to the cassette becomes occluded

AIR-IN-LINE ALARM:

Distal: STOPPED AIR IN DISTAL LINE alarm sounds if a bubble 100 microliters or larger passes the distal air-in-line sensors. (Alarm may sound at detection of a bubble as small as 50 microliters)

Proximal: STOPPED AIR IN PROXIMAL LINE alarm sounds if a bubble approximately 1200 microliters or larger passes through the proximal air-in-line sensors

NURSE-CALL SYSTEM: NURSE-CALL alarm is factory set for normally open (NO)

Note: Contact Abbott Laboratories to make an internal adjustment to change the infusion system from a normally open (NO) to normally closed (NC) system

8.2 DOMESTIC INFUSION SYSTEM (1.6 SERIES)

The following specifications apply to the domestic infusion system (1.6 series) only.

PHYSICAL

Dimensions: Approximately 18 x 23 x 23 cm (7 x 9 x 9 inches), excluding pole clamp protrusion and power cord storage

Weight: Approximately 6.0 kg (13 lbs), with battery

Casing: High-impact plastic

ELECTRICAL

Power Requirements: 110 to 120 AC, 50/60 Hz, 30 W

Power Cord: Hospital-grade AC (mains) power cord. 8 feet long, with transparent plug and retainer plate (on infusion system)

Fuses: 0.5 A, 250 V, slo-blo

Battery: One sealed, rechargeable 8 volt battery, internal to system. Accessible for ease of field replacement, with color-coded leads and polarized connector

Battery life (new batteries, full charge at 20° C): Approximately 500 ml total volume delivered, or six hours of operation, whichever occurs first

Battery Recharge: Battery is on recharge any time infusion system is connected to AC (mains) power. Recharge rate: to 80% of prior charge in 16 hours while operating at a delivery rate of 125 ml/hr or less

Battery Self-Discharge: 50% of charge retained for at least one month when infusion system is neither connected to AC (mains) power nor operating

Electrical Leakage: Risk current limits meet ANSI/AAMI ES1-1985 (ungrounded) standard

ENVIRONMENT	
Temperature:	10° to 40° C (50° to 104° F)
Relative Humidity:	10% to 90%, noncondensing
Pressure:	Equivalent altitudes from 0 to 10,000 feet
SHIPPING AND STORAGE:	
Temperature (infusion system only):	-34° to 60° C (-29.2° to 140° F)
Temperature (set only):	-34° to 55° C (-29.2° to 131° F)
Relative Humidity:	10% to 90% noncondensing at temperatures up to 40° C (104° F). A maximum of 15% noncondensing at temperatures from 41° to 60° C (105.8° to 140° F)
DELIVERY RATE RANGE	
Micro Mode:	0.1 to 99.9 ml/hr (in 0.1 ml increments; total primary rate plus secondary rate cannot exceed 99.9 ml/hr). In the concurrent mode, the rates for either primary or secondary cannot be less than 0.5 ml/hr
Macro Mode:	1 to 999 ml/hr (in 1 ml increments). In the concurrent mode, total primary rate plus secondary rate cannot exceed 700 ml/hr
DOSE LIMIT RANGE	
Micro Mode:	0.1 to 999 ml (in 0.1 ml increments)
Macro Mode:	1 to 9999 ml (in 1 ml increments)
SECONDARY DOSES	
Dual Channel Delivery:	A single dose of a secondary fluid may be administered
Multidose Delivery:	1 to 24 doses of a secondary fluid may be administered at intervals from 15 minutes to 24 hours
OPERATING BACKPRESSURE	-2 to 10 psig (-14 to 69 kPa)
OCCLUSION ALARM:	Maximum pressure is user selectable from 0.1 to 10 psig (0.7 to 69 kPa), through the front panel touchswitches
Distal:	DISTAL OCCLUSION alarm sounds within two pumping cycles after the distal set tubing or set outlet fitting becomes occluded

Proximal: PROXIMAL OCCLUSION alarm sounds if the tubing proximal to the cassette becomes occluded

AIR-IN-LINE ALARM

Distal: STOPPED AIR IN DISTAL LINE alarm sounds if a bubble 100 microliters or larger passes the distal air-in-line sensors. (Alarm may sound at detection of a bubble as small as 50 microliters)

Proximal: STOPPED AIR IN PROXIMAL LINE alarm sounds if a bubble approximately 1200 microliters or larger passes through the proximal air-in-line sensors

NURSE-CALL SYSTEM NURSE-CALL alarm is factory set for normally open (NO)

Note: Contact Abbott Laboratories to make an internal adjustment to change the infusion system from a normally open (NO) to normally closed (NC) system

FLOW DETECTOR: Optional. Detects drops when attached to the primary site. Used to identify empty container conditions

DataPort: Optional. The DataPort communication system provides monitoring of up to 15 infusion systems connected to the same communication signal lines. The hardware configuration is a modified version of the EIA-232-D configuration

8.3 INTERNATIONAL INFUSION SYSTEM (1.5 SERIES)

The following specifications apply to the international infusion system (1.5 series) only.

PHYSICAL

Size: 18 x 23 x 23 cm (7 x 9 x 9 inches) excluding pole clamp

Weight: Approximately 6.0 kg (13 lbs), with battery

Mains Voltage: 110 to 120 V~, 50/60 Hz, 30 VA
220 to 240 V, 50/60 Hz, 35 VA
100 V, 50/60 Hz, 35 VA

Mains Fusing: (110 to 120 V~) Two each: (depending on label code), 250 V, 5 x 20 mm, T400 mA or T500 mA
(100 V~) Two each: T500 mA, 250 V, 5 x 20 mm
(220 to 240 V~) Two each: T160 mA, 250 V, 5 x 20 mm

Mains Cord (110 to 120 V~) UL hospital-grade AC (mains) power cord, 2.5 ± 0.5 m (8 feet) in length

(220 to 240 V~) IEC 601-1 approved detachable cord, 2.5 ± 0.5 m (8 feet) in length

Battery One sealed, rechargeable 8 volt battery, internal to infusion system. Accessible for ease of field replacement, with color-coded leads and polarized connector

Battery Operating Time: Battery life (new batteries, full charge at 20° C): Approximately 500 ml total volume delivered, or six hours of operation, whichever occurs first

With a new, fully charged battery, at a delivery rate of 125 ml/hr, the infusion system displays a LOW BATTERY alarm at least 15 minutes prior to shutdown

Note: If a LOW BATTERY alarm occurs, immediately connect the infusion system to mains power

Note: Gradual degradation over extended periods of use decreases the operational capacity of the battery. Typical battery life is three years. A yearly check is recommended to verify performance. When capacity drops to an unacceptable level, replace the battery. Battery replacement must be performed by qualified technical personal.

Battery Recharge: Battery recharges when infusion system is connected to mains power. Battery recharges to 80% of prior charge in 24 hours

Battery Charge Retention: A fully charged battery will retain at least 50% of its capacity after one month when infusion system is neither connected to mains power nor operating

Nurse-Call System: NURSE-CALL alarm is factory set for normally open (NO) systems. An internal adjustment may be made by qualified technical personnel

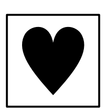
Electronic Memory: Settings are retained for four hours after power is turned off

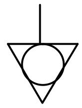
Electrical Safety: (110 to 120 V) meets UL 544 standards
(100 and 220 to 240 V) meets IEC 601-1 standards

Class 1: Mains supply equipment using protective earth

Type B:  Equipment providing adequate degree of protection against electrical shock (see pump labeling to determine class of protection)

Type BF:  Equipment providing adequate degree of protection against electrical shock (see pump labeling to determine class of protection)

Type CF:  Equipment providing adequate degree of protection against electrical shock (see pump labeling to determine class of protection)



Terminal for connection of an equipotential conductor

Drip Proof IPX1: Equipment protected against dripping water

Attention! Consult accompanying documents

Fluids and Cleaning: Infusion system is not affected by fluid spills or common cleaning solutions

Operating Environment: 10° to 40° C (50° to 104° F), 10% to 90% relative humidity

Shipping/Storage Environment: -20° to 60° C (-4° to 140° F), 10% to 90% relative humidity

Occlusion Alarm Pressure Limit: Selectable from 7 to 55 kPa (1 to 8 psig)

Maximum Occlusion Pressure 128 kPa (18 psig, approximate)

Delivery Rate Accuracy: ± 5% in typical clinical use

DELIVERY RATE RANGE

Micro Mode: 0.1 to 99.9 ml/hr (in 0.1 ml increments; total primary rate plus secondary rate cannot exceed 99.9 ml/hr). In the concurrent mode, the rates for either primary or secondary cannot be less than 0.5 ml/hr

Macro Mode: 1 to 999 ml/hr (in 1 ml increments). In the concurrent mode, total primary rate plus secondary rate cannot exceed 800 ml/hr

DOSE LIMIT RANGE

Micro Mode: 0.1 to 999 ml (in 0.1 ml increments)

Macro Mode: 1 to 9999 ml (in 1 ml increments)

AIR-IN-LINE ALARM

Distal: STOPPED AIR IN DISTAL LINE alarm sounds if a bubble 100 microliters or larger passes the distal air-in-line sensors. (Alarm may sound at detection of a bubble as small as 50 microliters)

Proximal: STOPPED AIR IN PROXIMAL LINE alarm sounds if a bubble approximately 1200 microliters or larger passes through the proximal air-in-line sensors

8.4 INTERNATIONAL INFUSION SYSTEM (1.6 SERIES)

The following specifications apply to the international infusion system (1.6 series) only.

PHYSICAL

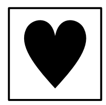
Size:	18 x 23 x 23 cm (7 x 9 x 9 inches) excluding pole clamp
Weight:	Approximately 6.0 kg (13 lbs), with battery
Mains Voltage:	110 to 120 V~, 50/60 Hz, 30 VA 220 to 240 V, 50/60 Hz, 35 VA 100 V, 50/60 Hz, 35 VA
Mains Fusing:	(110 to 120 V~) Two each: T500 mA, 250 V, 5 x 20 mm (100 V~) Two each: T630 mA, 250 V, 5 x 20 mm (220 to 240 V~) Two each: T200 mA, 250 V, 5 x 20 mm
Mains Cord	(110 to 120 V~) UL hospital-grade AC (mains) power cord, 2.5 ± 0.5 m (8 feet) in length (220 to 240 V~) IEC 601-1 approved detachable cord, 2.5 ± 0.5 m (8 feet) in length
Battery	One sealed, rechargeable 8 volt battery, internal to infusion system. Accessible for ease of field replacement, with color-coded leads and polarized connector
Battery Operating Time:	Battery life (new batteries, full charge at 20° C): Approximately 500 ml total volume delivered, or six hours of operation, whichever occurs first With a new, fully charged battery, at a delivery rate of 125 ml/hr, the infusion system displays a LOW BATTERY alarm at least 15 minutes prior to shutdown **Note:** If a LOW BATTERY alarm occurs, immediately connect the infusion system to mains power **Note:** Gradual degradation over extended periods of use decreases the operational capacity of the battery. Typical battery life is three years. A yearly check is recommended to verify performance. When capacity drops to an unacceptable level, replace the battery. Battery replacement must be performed by qualified technical personal.
Battery Recharge:	Battery recharges when infusion system is connected to mains power. Battery recharges to 80% of prior charge in 24 hours
Battery Charge Retention:	A fully charged battery will retain at least 50% of its capacity after one month when infusion system is neither connected to mains power nor operating

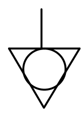
Nurse-Call System: NURSE-CALL alarm is factory set for normally open (NO) systems. An internal adjustment may be made by qualified technical personnel

Electronic Memory: Settings are retained for four hours after power is turned off

Electrical Safety: (110 to 120 V) meets UL 544 standards
(100 and 220 to 240 V) meets IEC 601-1 standards

Class 1: Mains supply equipment using protective earth

Type CF:  Equipment providing adequate degree of protection against electrical shock (see pump labeling to determine class of protection)

 Terminal for connection of an equipotential conductor

Drip Proof IPX1 Equipment protected against dripping water

 Attention! Consult accompanying documents

Fluids and Cleaning: Infusion system is not affected by fluid spills or common cleaning solutions

Operating Environment: 10° to 40° C (50° to 104° F), 10% to 90% relative humidity

Shipping/Storage Environment: -20° to 60° C (-4° to 140° F), 10% to 90% relative humidity

Occlusion Alarm Pressure Limit: Selectable from 7 to 55 kPa (1 to 8 psig)

Maximum Occlusion Pressure 128 kPa (18 psig, approximate)

Delivery Rate Accuracy: ± 5% in typical clinical use

DELIVERY RATE RANGE

Micro Mode: 0.1 to 99.9 ml/hr (in 0.1 ml increments; total primary rate plus secondary rate cannot exceed 99.9 ml/hr). In the concurrent mode, the rates for either primary or secondary cannot be less than 0.5 ml/hr

Macro Mode: 1 to 999 ml/hr (in 1 ml increments). In the concurrent mode, total primary rate plus secondary rate cannot exceed 700 ml/hr

DOSE LIMIT RANGE

Micro Mode: 0.1 to 999 ml (in 0.1 ml increments)

Macro Mode: 1 to 9999 ml (in 1 ml increments)

AIR-IN-LINE ALARM

Distal: STOPPED AIR IN DISTAL LINE alarm sounds if a bubble 100 microliters or larger passes the distal air-in-line sensors. (Alarm may sound at detection of a bubble as small as 50 microliters)

Proximal: STOPPED AIR IN PROXIMAL LINE alarm sounds if a bubble approximately 1200 microliters or larger passes through the proximal air-in-line sensors

Section 9

DRAWINGS

Figure 9-1 through *Figure 9-28* detail the infusion system through illustrated parts breakdown (IPB), interconnect, and schematic diagrams. *Table 9-1, Drawings*, lists drawings by figure number, title, and part number. *Table 9-2, IPB for the Infusion System*, identifies infusion system parts by index numbers that correlate to *Figure 9-1, IPB for the Infusion System*.

Note: Figures listed in *Table 9-1* are rendered as graphic representations to approximate actual product; therefore, figures may not exactly reflect the product. 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 Number	Title	Drawing Number
Figure 9-1	IPB for the Infusion System (3 Sheets)	N/A
Figure 9-2	Main Board Assembly	N/A
Figure 9-3	Partial Mechanism Assembly	N/A
Figure 9-4	Heatsink Assembly (International)	N/A
Figure 9-5	Main Chassis, Mechanism, Boards Assembly	N/A
Figure 9-6	Exterior Assembly	N/A
Figure 9-7	1.5 Series Interconnect Schematic	249-03100-001
Figure 9-8	1.6 Series Interconnect Schematic	249-03100-002
Figure 9-9	1.6 Series Battery Charger PWA Schematic	249-03644-002
Figure 9-10	LED Display PWA Schematic	249-03313-002
Figure 9-11	1.5 Series I/O PWA Schematic	249-03305-012
Figure 9-12	1.6 Series I/O PWA Schematic	249-03305-015
Figure 9-13	1.6 Series with DataPort I/O PWA Schematic	249-03305-016
Figure 9-14	1.5 Series Main PWA Schematic	249-03304-046
Figure 9-15	1.6 Series Main PWA Schematic	249-03304-034
Figure 9-16	1.5 Series Power Supply PWA Schematic (2 Sheets)	249-03308-005

Table 9-1. Drawings		
Figure Number	**Title**	**Drawing Number**
Figure 9-17	1.6 Series Power Supply PWA Schematic (2 Sheets)	249-03308-009
Figure 9-18	Bubble Sensor PWA Schematic	249-03322-009
Figure 9-19	1.5 Series Sensor PWA Schematic	249-03110-009
Figure 9-20	1.6 Series Sensor PWA Schematic (2 Sheets)	249-03110-011
Figure 9-21	1.6 Series Junction Box PWA Schematic	249-03658-003
Figure 9-22	1.5 Series Main PWA (International) Schematic	249-03304-057
Figure 9-23	1.6 Series Main PWA (International) Schematic	249-03304-052
Figure 9-24	1.5 Series I/O PWA (International) Schematic	249-03305-021
Figure 9-25	1.6 Series I/O PWA (International) Schematic	249-03305-022
Figure 9-26	Power Supply (International) Schematic (2 Sheets)	249-03308-010
Figure 9-27	Bubble Sensor (International) Schematic	249-03322-010
Figure 9-28	Current Boost Charger Schematic	249-03644-003

Table 9-2. IPB for the Infusion System		
Index No.	**Nomenclature**	**Replacement Procedure**
1	Cover, Front	*Section 7.2.13*
2	Cover, Rear	*Section 7.2.13*
3	Battery Pack Cover, Floor, Enclosure	*Section 7.2.2*
4	Shield, EMI	*Section 7.2.14*
5	PWA, Power Supply	*Section 7.2.18.1* or *Section 7.2.19.1*
6	Panel Assembly, Front, 1.6	*Section 7.2.16*
6A	Assembly, LCD, 1.6	*Section 7.2.16.2*
6B	PWA, Display, LC5000(CC)	*Section 7.2.16.1*
6C	Sub-Panel	N/A
6D	Panel, Front	*Section 7.2.16*

Table 9-2. IPB for the Infusion System		
Index No.	**Nomenclature**	**Replacement Procedure**
6E	Spacer, Round, .187 O.D. x .091 I.D. x .20 LG	N/A
6F	Spacer, Round, .250 O.D. x .140 I.D. x .25 LG	N/A
7	PWA, I/O LC5000, w/DataPort	*Section 7.2.17.2*
8	PWA, Main, Rev. 1.6 Generic	*Section 7.2.17.1*
9	PWA, Battery, Charger	*Section 7.2.19.3*
10	Assembly, Mechanism, 1.6	*Section 7.2.18.2* or *Section 7.2.19.2*
10A	Handle, Door	*Section 7.2.20*
10B	Leaf Spring, Door Mechanism	*Section 7.2.21*
10C	Shield, Door	*Section 7.2.31*
10D	Assembly, Leaf Spring/Retainer, Door	*Section 7.2.21*
10E	Base, Casting, Door	*Section 7.2.23.4*
10F	Shaft, Cassette, Door	*Section 7.2.23.3*
10G	Spring, Loading, Door Hinge	*Section 7.2.23.2*
10H	Cover, Door	*Section 7.2.23.1*
11	Assembly, Battery w/Wire, Harness	*Section 7.2.2*
12	Assembly, Chassis, Main	N/A
13	Enclosure, Heatsink	N/A
14	Assembly, Minipole (Sheets 1 and 5)	*Section 7.2.12*
14A	Bag Hanger	*Section 7.2.12.2*
14B	Clutch Housing	*Section 7.2.12.3*
14C	Clutch Spring	*Section 7.2.12.4*
15	Gasket, Cover, Front	N/A
16	Gasket, Front Panel	N/A
17	Gasket, Heatsink, Rear Cover	N/A
18	Pad, Battery	N/A

Table 9-2. IPB for the Infusion System		
Index No.	**Nomenclature**	**Replacement Procedure**
19	Gasket, I/O Port	N/A
20	Panel, I/O, Port	*Section 7.2.8*
21	Bracket, Holddown	*Section 7.2.19.3*
22	Assembly, Piezoelectric Alarm	*Section 7.2.25*
23	Cover, Line Plug (International)	*Section 7.2.3*
24	Cover, Line Plug	*Section 7.2.3*
25	Assembly, Cable, Ribbon Sensor-To-I/O	*Section 7.2.24*
26	Cordset, AC, Hospital Grade, Detachable	*Section 7.2.3*
27	Cordset, AC, Hospital Grade, Detachable (International)	*Section 7.2.3.1*
28	Strap, Velcro Hook and Loop, Light Gray	Section 7.2.6
29	Plate, Backing, Retainer, Cord	*Section 7.2.3* and *Section 7.2.6*
30	Cover, DIP, Switch	*Section 7.2.8*
31	Assembly, Plate, Friction, Pole Clamp	*Section 7.2.7.3*
32	Assembly, AC Receptacle	*Section 7.2.26*
33	Knob, Pole Clamp	*Section 7.2.7.1*
34	Retainer, Shaft, Pole Clamp	*Section 7.2.7.2*
35	Screw, Pole Clamp	*Section 7.2.7.2*
36	Clamp, Shaft, Pole	*Section 7.2.7.2*
37	Equipotential, Terminal (International)	N/A
38	Ring, Cotter	*Section 7.2.12.1*
39	Insert, Foot	*Section 7.2.9*
40	Bumper, Rubber, 0.563 Diameter x 0.383 High	N/A
41	Drawer, Fuse, 2-Pole	*Section 7.2.5*
42	Fuse, .5A, 250V, Metric, Time Lag	*Section 7.2.5*
43	Screw, 6-32 x .50, PNHD, PH, SS	N/A

Table 9-2. IPB for the Infusion System		
Index No.	**Nomenclature**	**Replacement Procedure**
44	Screw, 6-32 x .25, PNHD, PHHD, SS	N/A
45	Screw, 6-32 x .75, SKT HD, CAP, SS	N/A
46	Screw, 4-40 x .375, FLH, PHHD	N/A
47	Screw, 4-40 x 5/16 HH, SLTD, w/Washer	N/A
48	Screw, 6-32 x .875, PNHD, PH, SS	N/A
49	Screw, 6-32 x 5/16 HH, SLTD, w/Washer	N/A
50	Screw, 6-32 x 1.25, PNH, PHH	N/A
51	Screw, 6-32 x .375, FLH, PHH	N/A
52	Screw, 4-40 x 3/8, PNH, PHH	N/A
53	Screw, 4-40 x 1/4, HH, SLTD, w/Washer	N/A
54	Screw, 4-24 x .312, Dual, PNH, PHH, SST	N/A
55	Screw, 4-40 x 3/16, MAC, PNH, SLTD, SS	N/A
56	Screw, 6-32 x 7/16, HH, HEX, w/Washer	N/A
57	Screw, 6-32 x 3/8, FLH, PHHD	N/A
58	Screw, Set, 8-32NC x .75, ALHD, HAFDG	N/A
59	Grip-Ring, 0.312, SFT, SS	N/A
60	Washer, Flat, 0.328 I.D. x 0.567 O.D. x 0.06 Thick	N/A
61	Washer, Lock, Split, Helical Spr	N/A
62	Washer, Lock #2, .020 THK SPL, C, STL	N/A
63	Washer, Lock, #6 EXT TTH	N/A
64	Washer, Lock, 1/4, .025 THK, INT TTH	N/A
65	Nut, M6-1, Hex, STL	N/A
66	Nut, 2-56, Hex, CD PL, SML SER	N/A
67	Nut, 4-40, KEP w/CNCL Washer, Small	N/A

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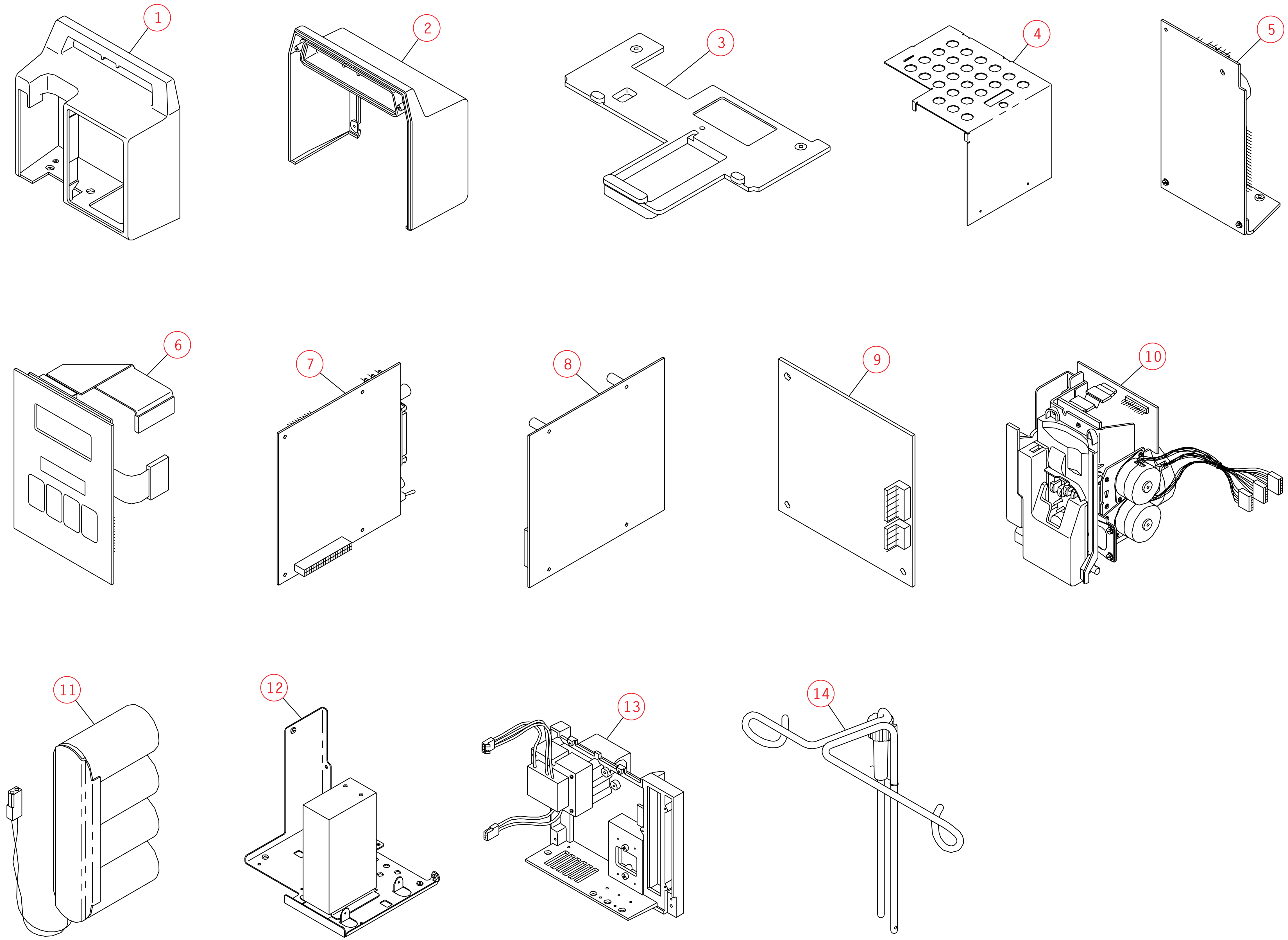

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ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-1. IPB for the Infusion System	
DRAWING NO.	REV. N/A
N/A	SHEET 1 OF 3

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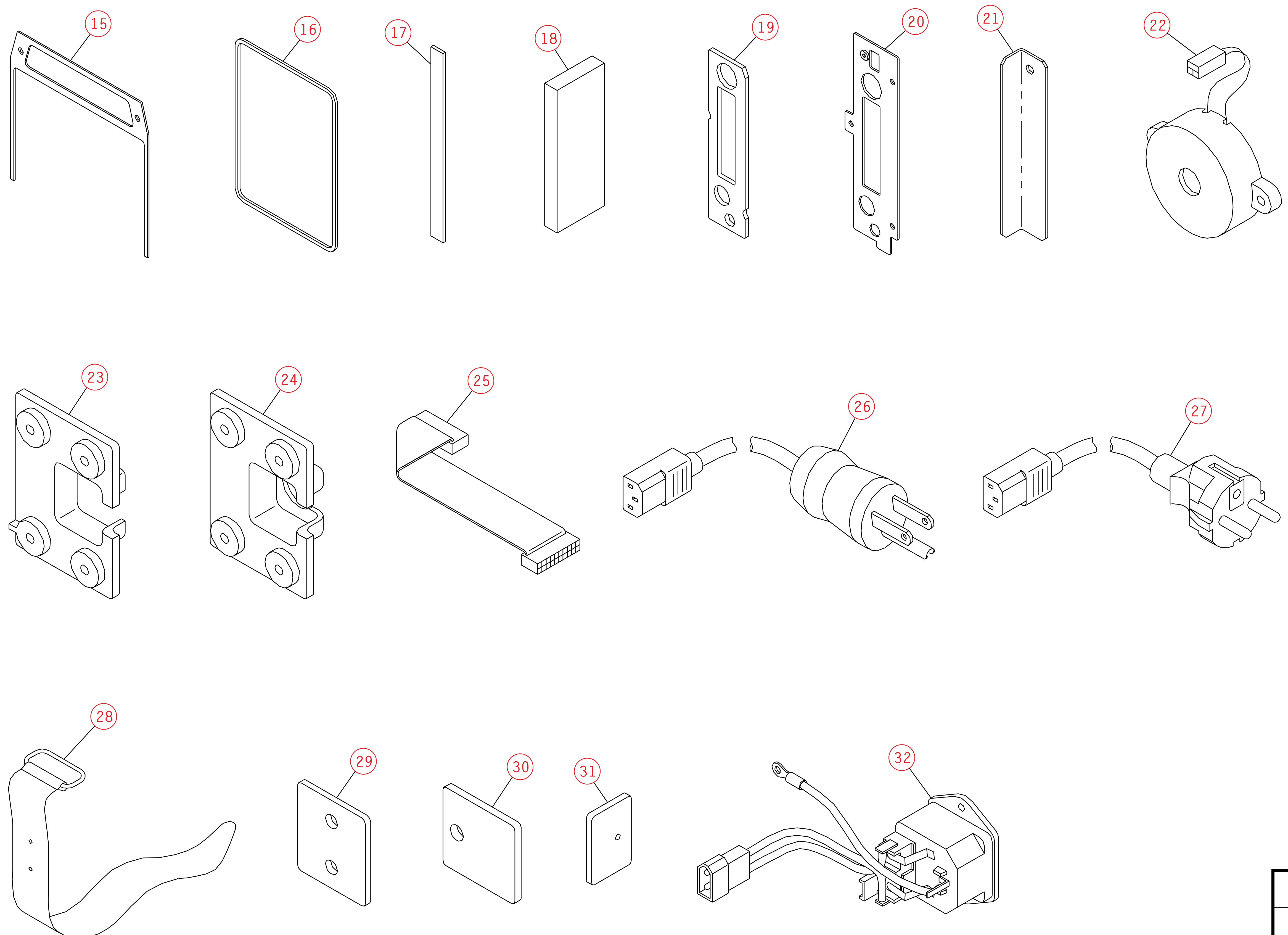

96E05019

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-1. IPB for the Infusion System	
DRAWING NO. N/A	REV. N/A SHEET 2 OF 3

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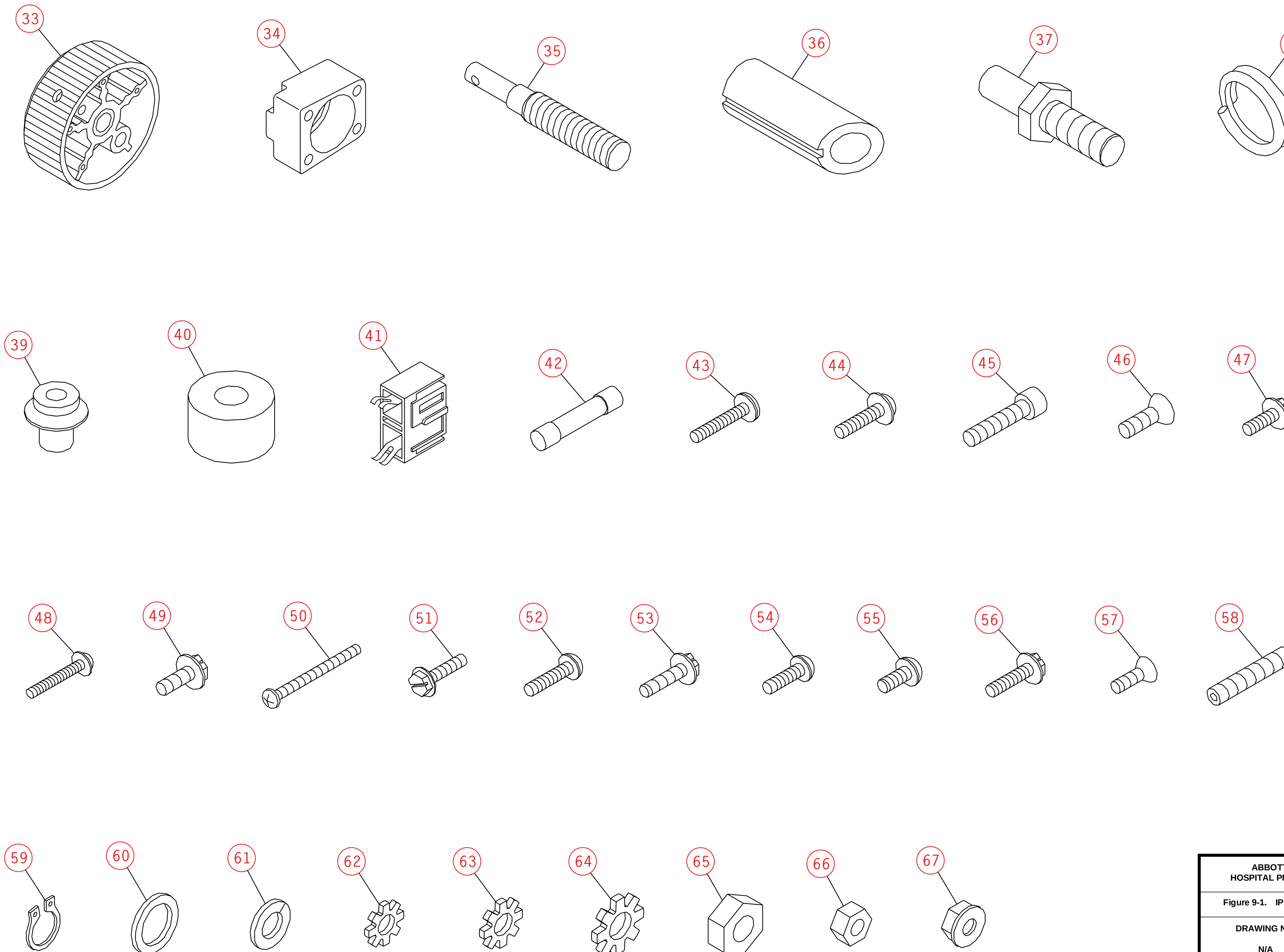

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-1. IPB for the Infusion System	
DRAWING NO.	REV. N/A
N/A	SHEET 3 OF 3

96E05020

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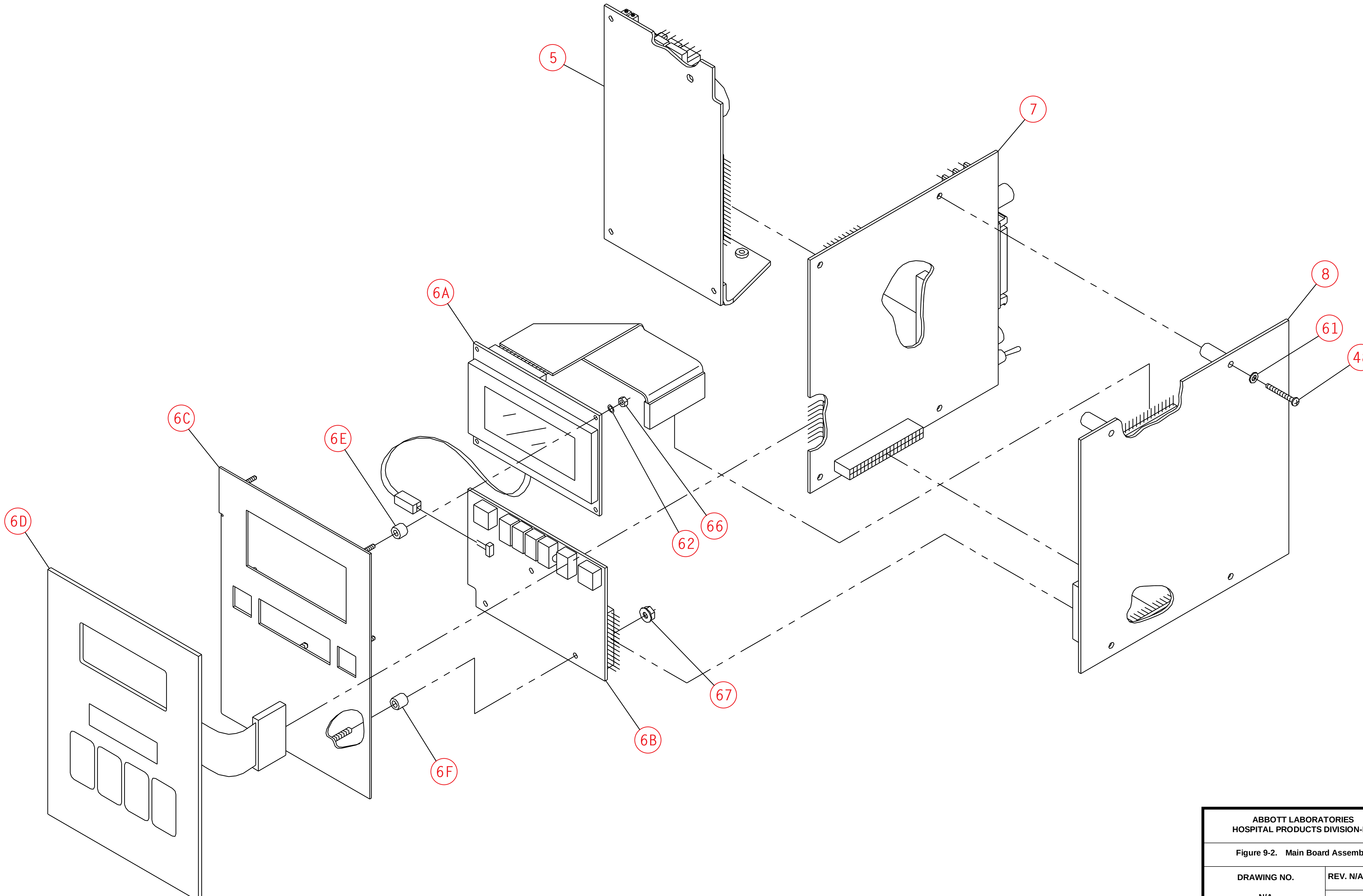

ABBOTT LABORATORIES
HOSPITAL PRODUCTS DIVISION-MV

Figure 9-2. Main Board Assembly

DRAWING NO. N/A	REV. N/A
	SHEET 1 OF 1

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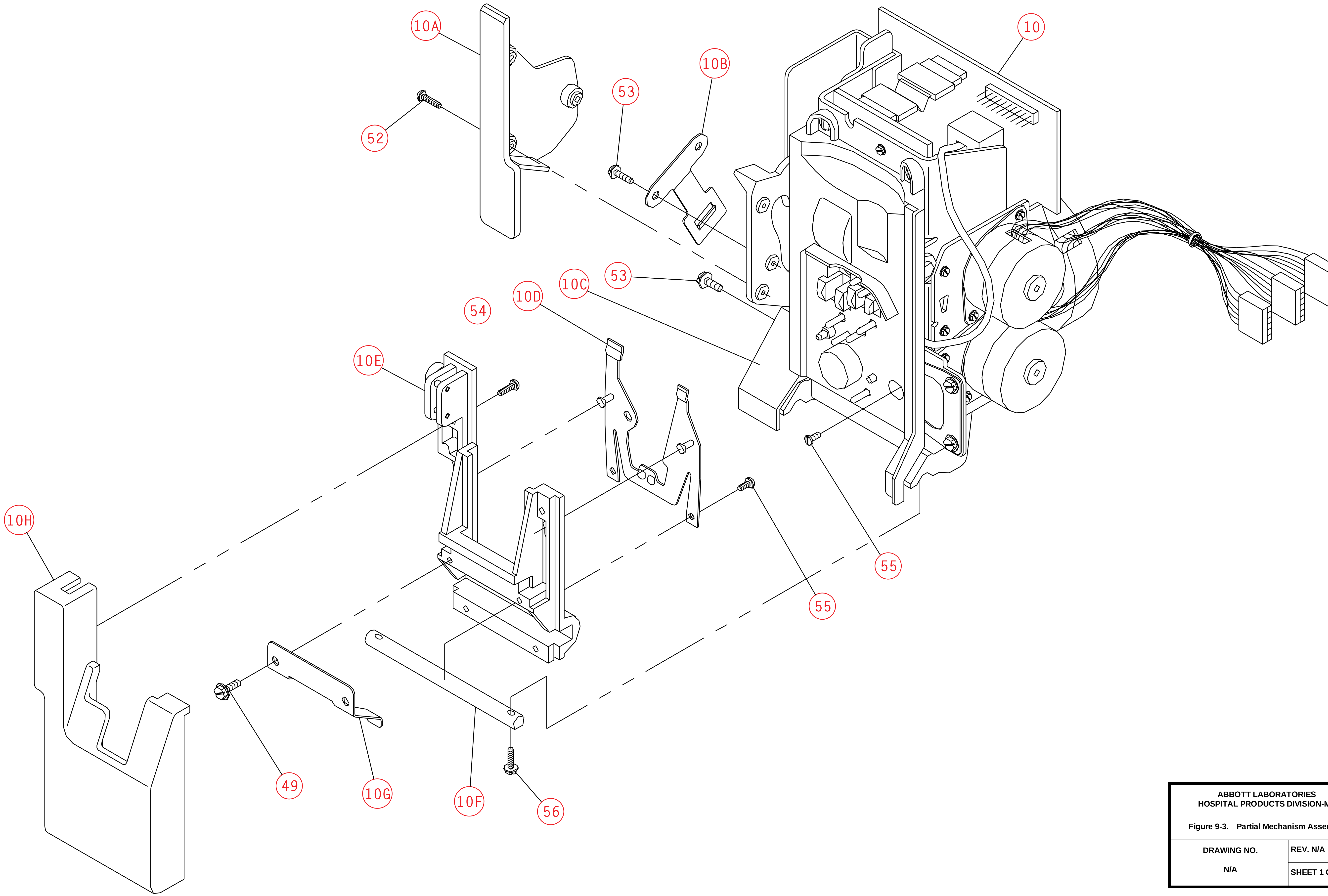

96E05002

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-3. Partial Mechanism Assembly	
DRAWING NO.	REV. N/A
N/A	SHEET 1 OF 1

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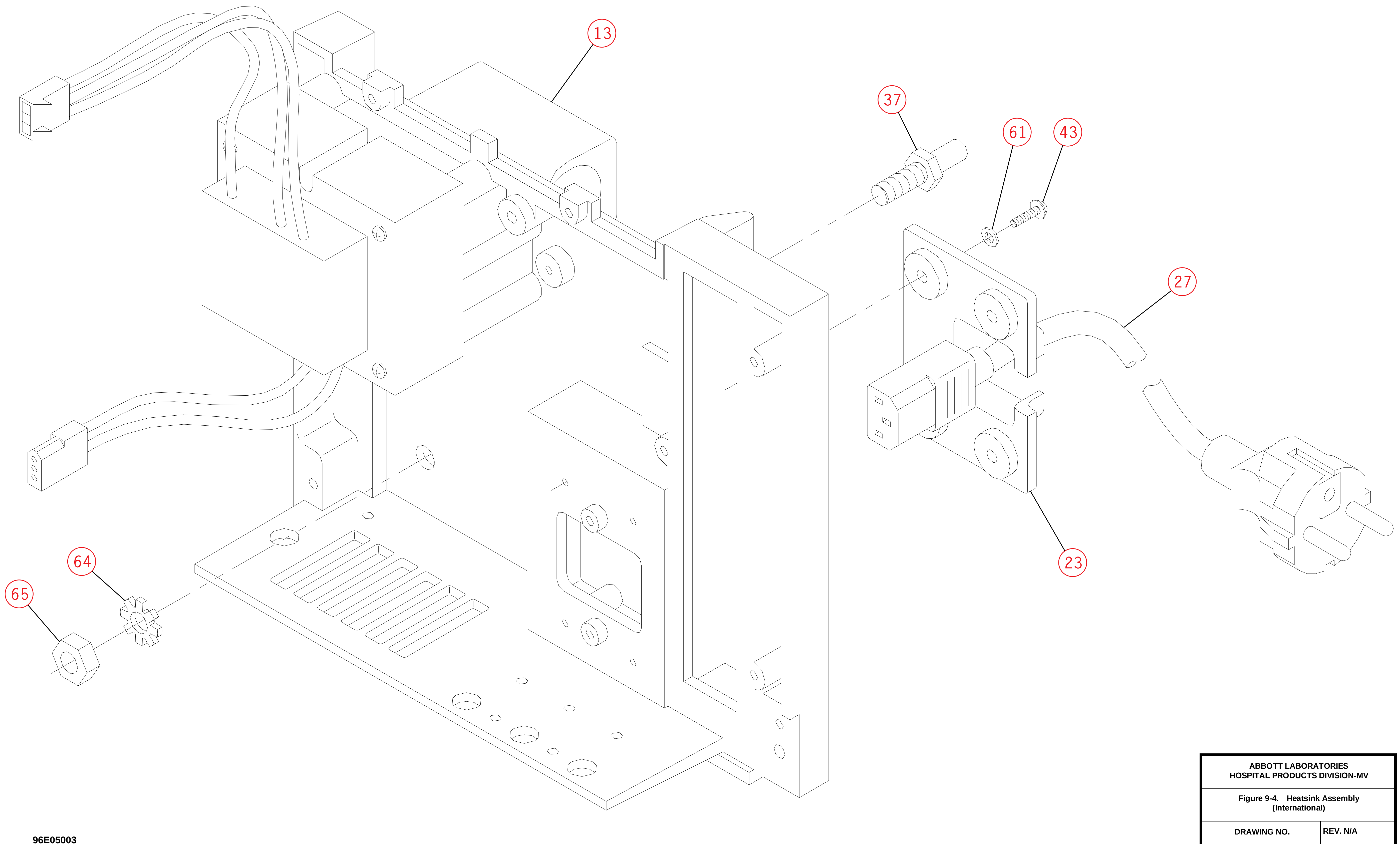

ABBOTT LABORATORIES
HOSPITAL PRODUCTS DIVISION-MV

Figure 9-4. Heatsink Assembly (International)

DRAWING NO.	REV. N/A
N/A	SHEET 1 OF 1

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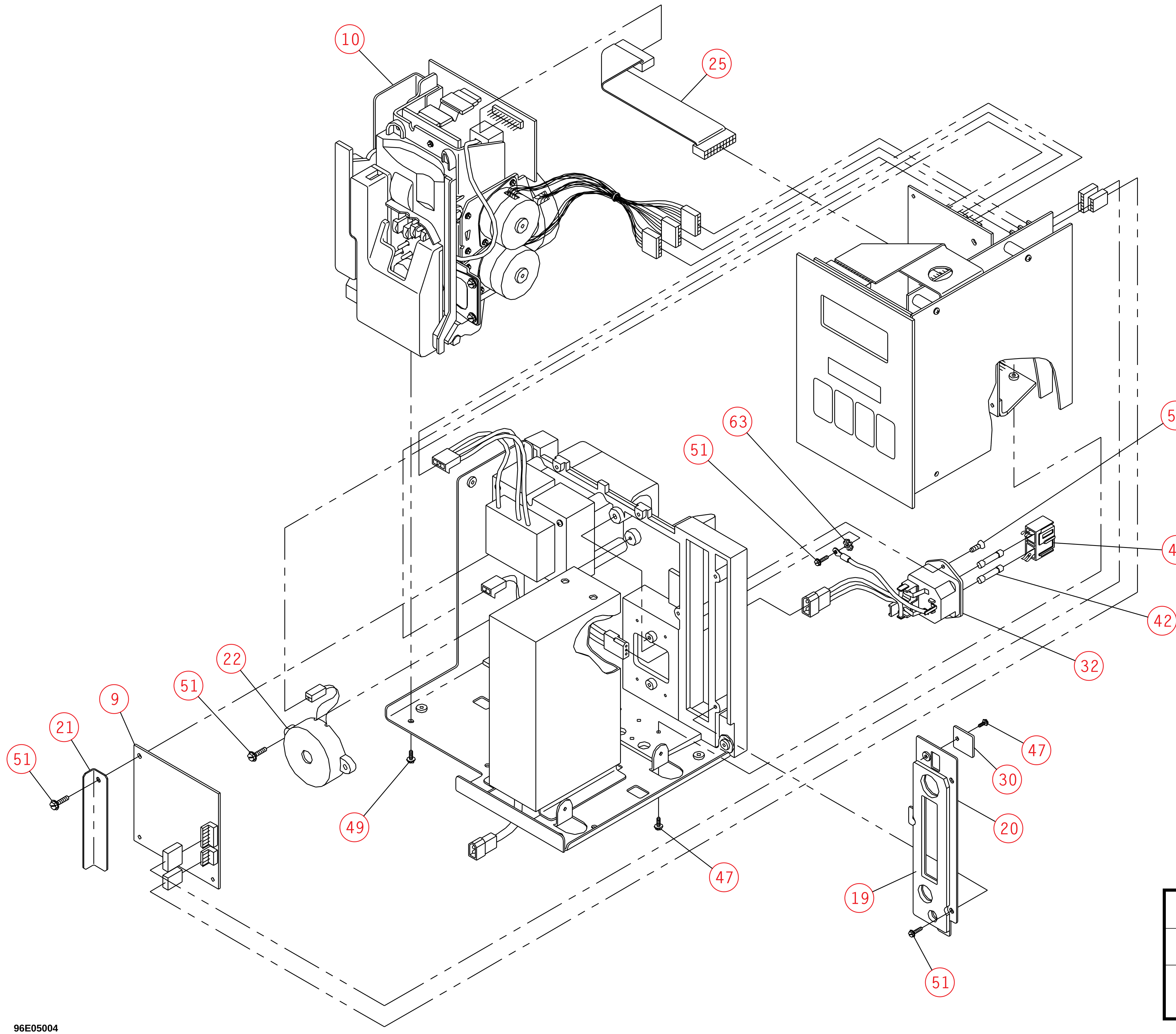

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-5. Main Chassis, Mechanism, Boards Assembly	
DRAWING NO.	REV. N/A
N/A	SHEET 1 OF 1

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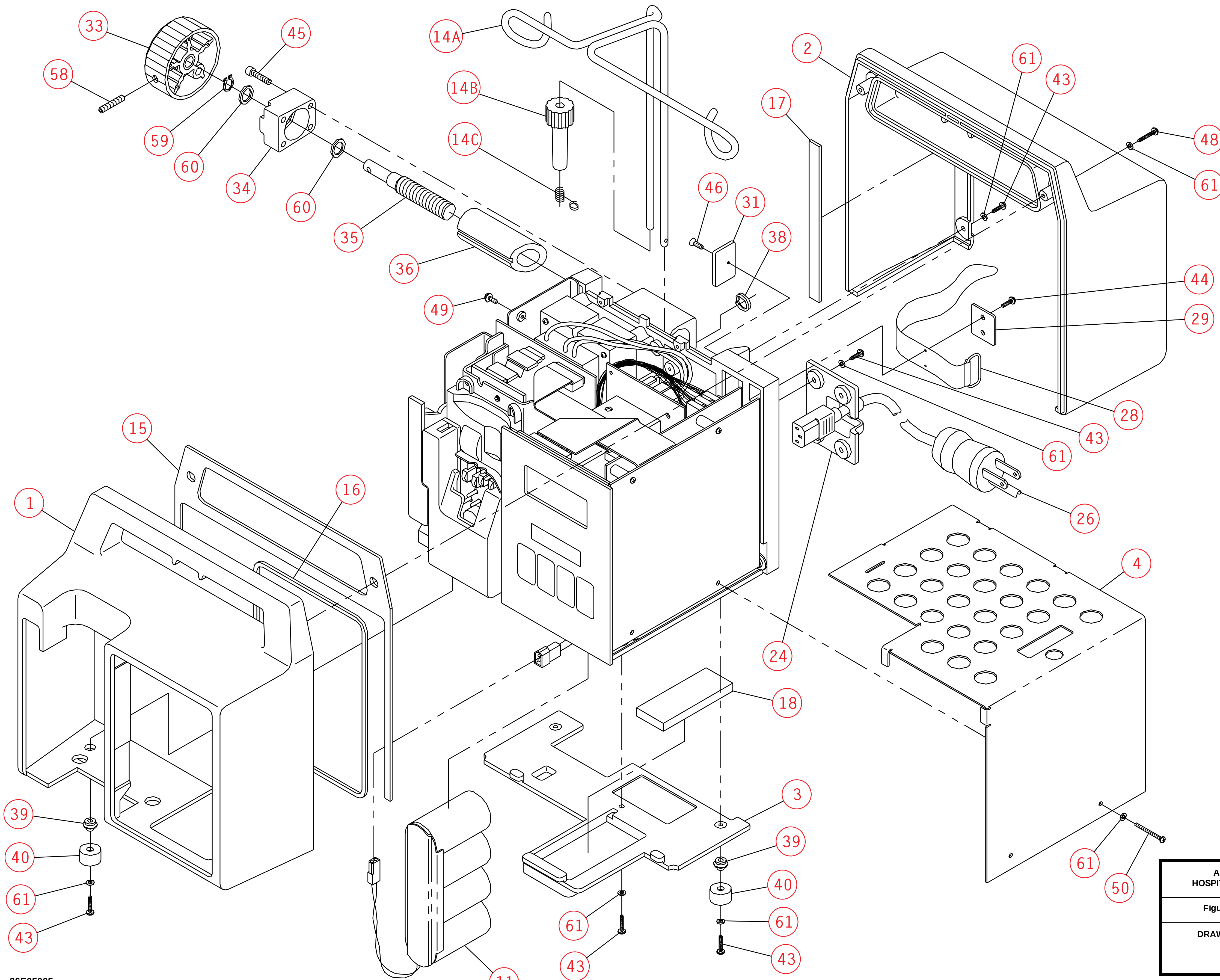

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-6. Exterior Assembly	
DRAWING NO. N/A	REV. N/A SHEET 1 OF 1

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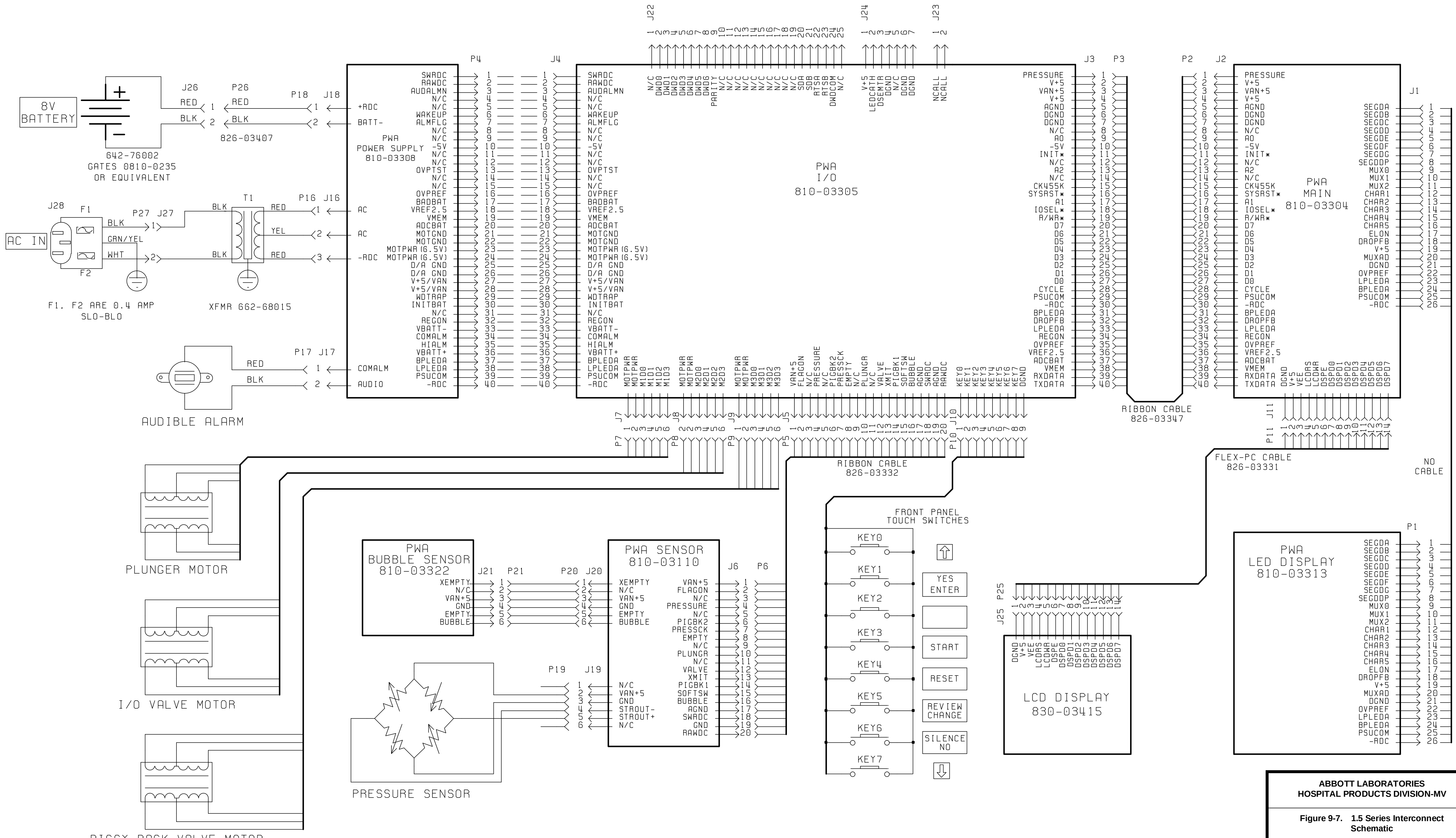

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-7. 1.5 Series Interconnect Schematic	
DRAWING NO. 249-03100-001	REV. B SHEET 1 OF 1

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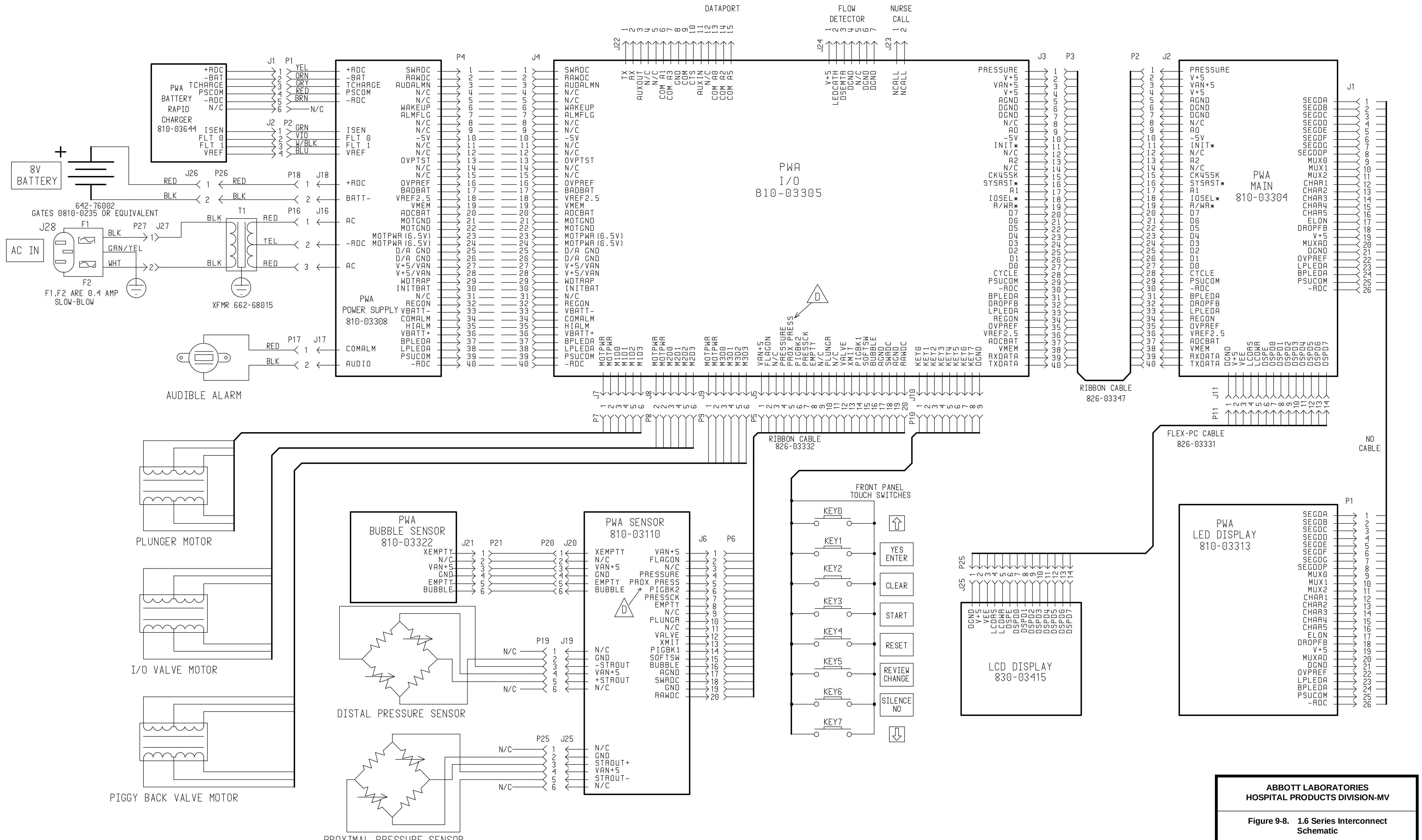

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-8. 1.6 Series Interconnect Schematic	
DRAWING NO. 249-03100-002	REV. D
	SHEET 1 OF 1

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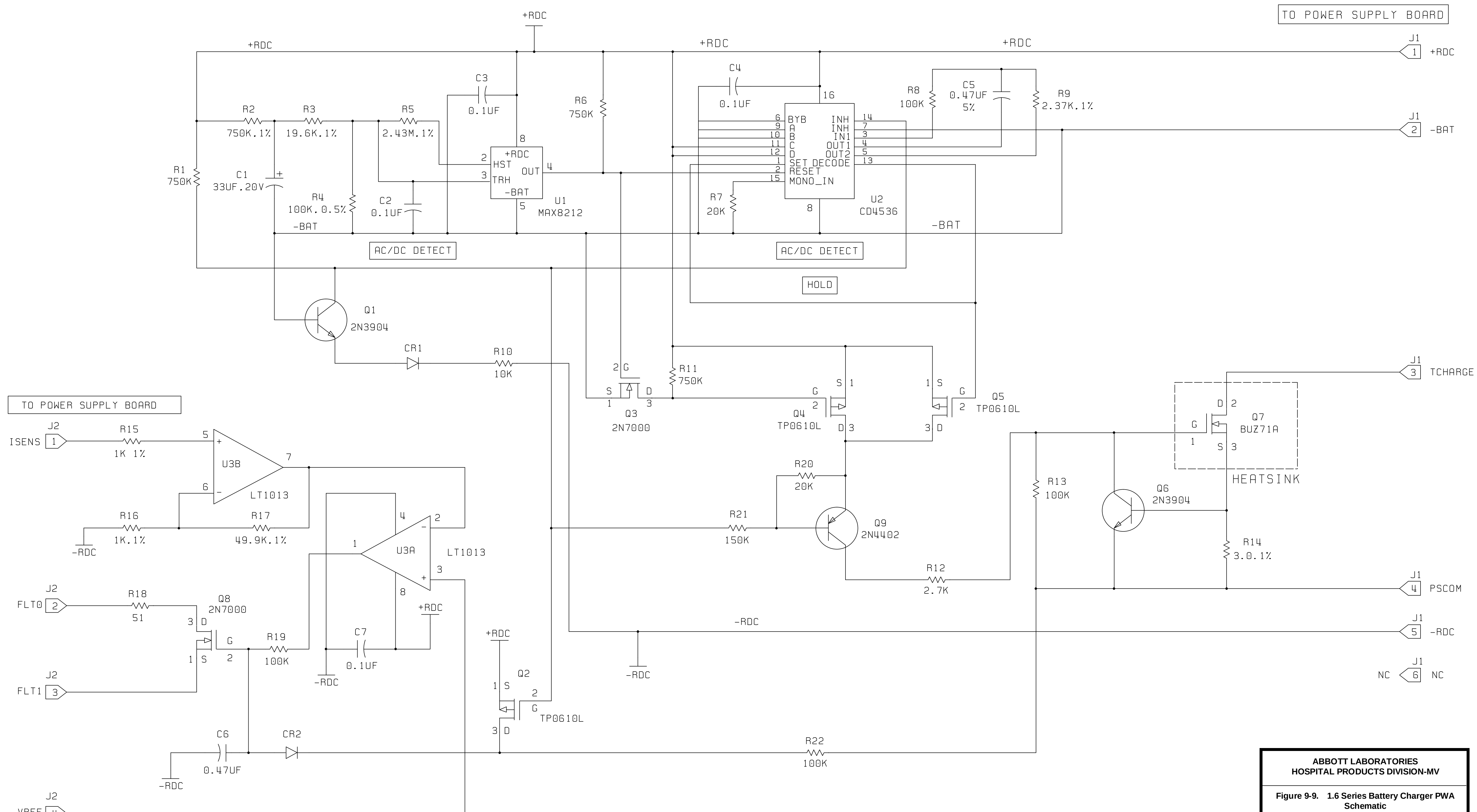

ABBOTT LABORATORIES
HOSPITAL PRODUCTS DIVISION-MV

Figure 9-9. 1.6 Series Battery Charger PWA Schematic

DRAWING NO.	REV. D
249-03644-002	SHEET 1 OF 1

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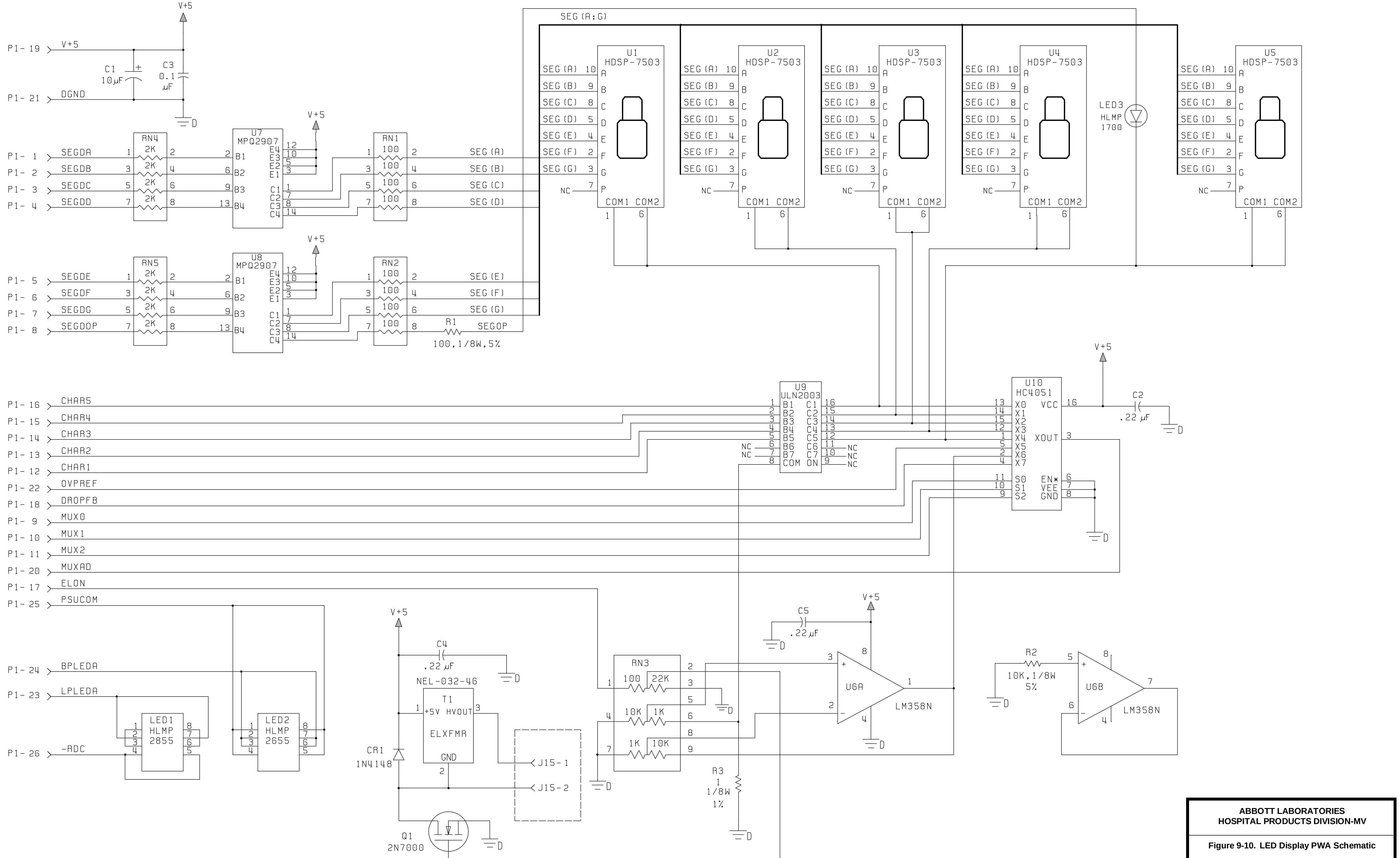

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-10. LED Display PWA Schematic	
DRAWING NO. 249-03313-002	REV. B SHEET 1 OF 1

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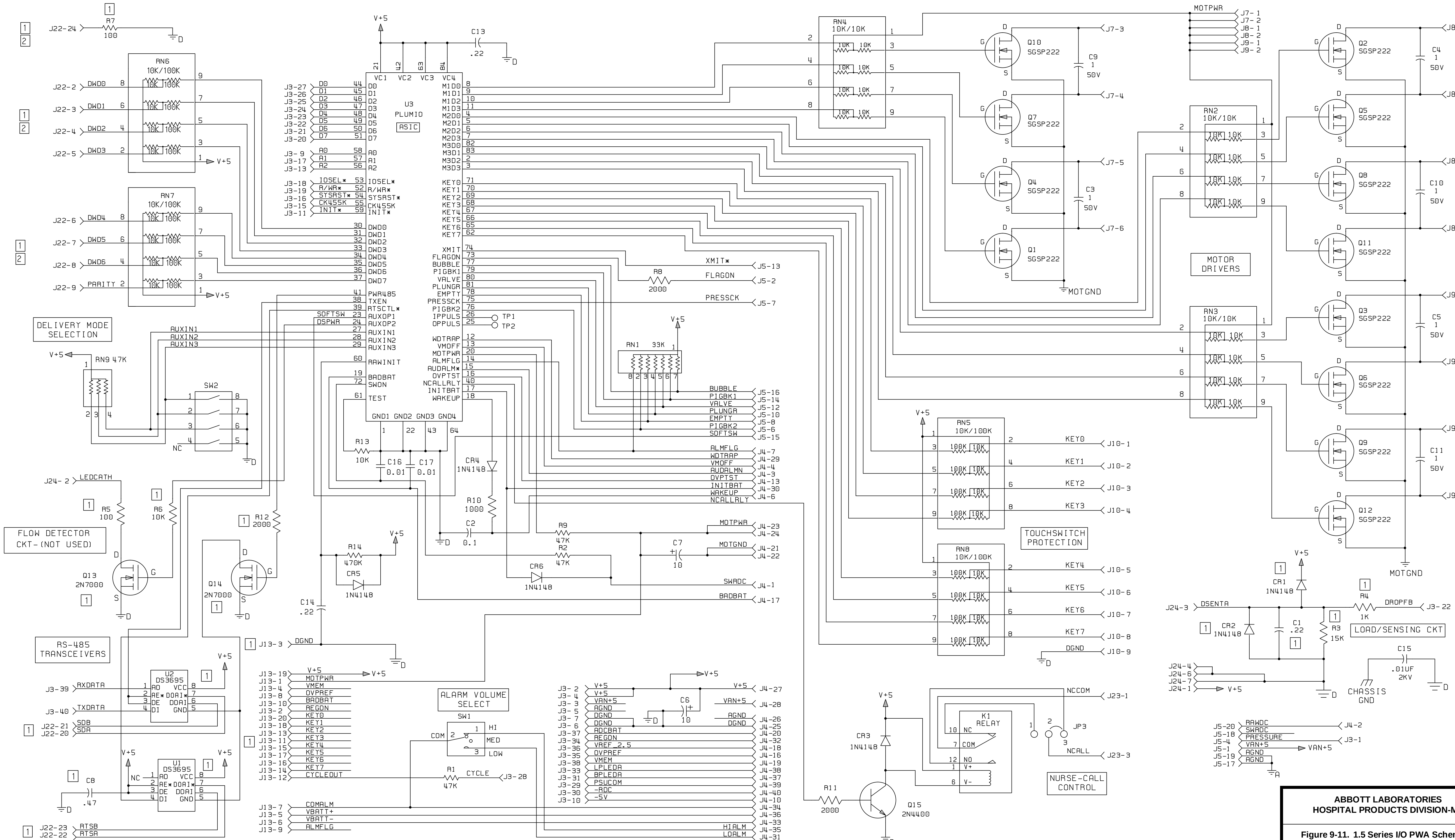

NOTES: 1 C1,C8,C12,CR1,CR2,J13,J22,Q13,Q14,R3,R4,R5,R6,R7,R12,U1, AND U2 NOT USED.

2 J22 NOT USED ON -009 PWA, BUT USED ON -010 PWA.

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-11. 1.5 Series I/O PWA Schematic	
DRAWING NO. 249-03305-012	REV. R SHEET 1 OF 1

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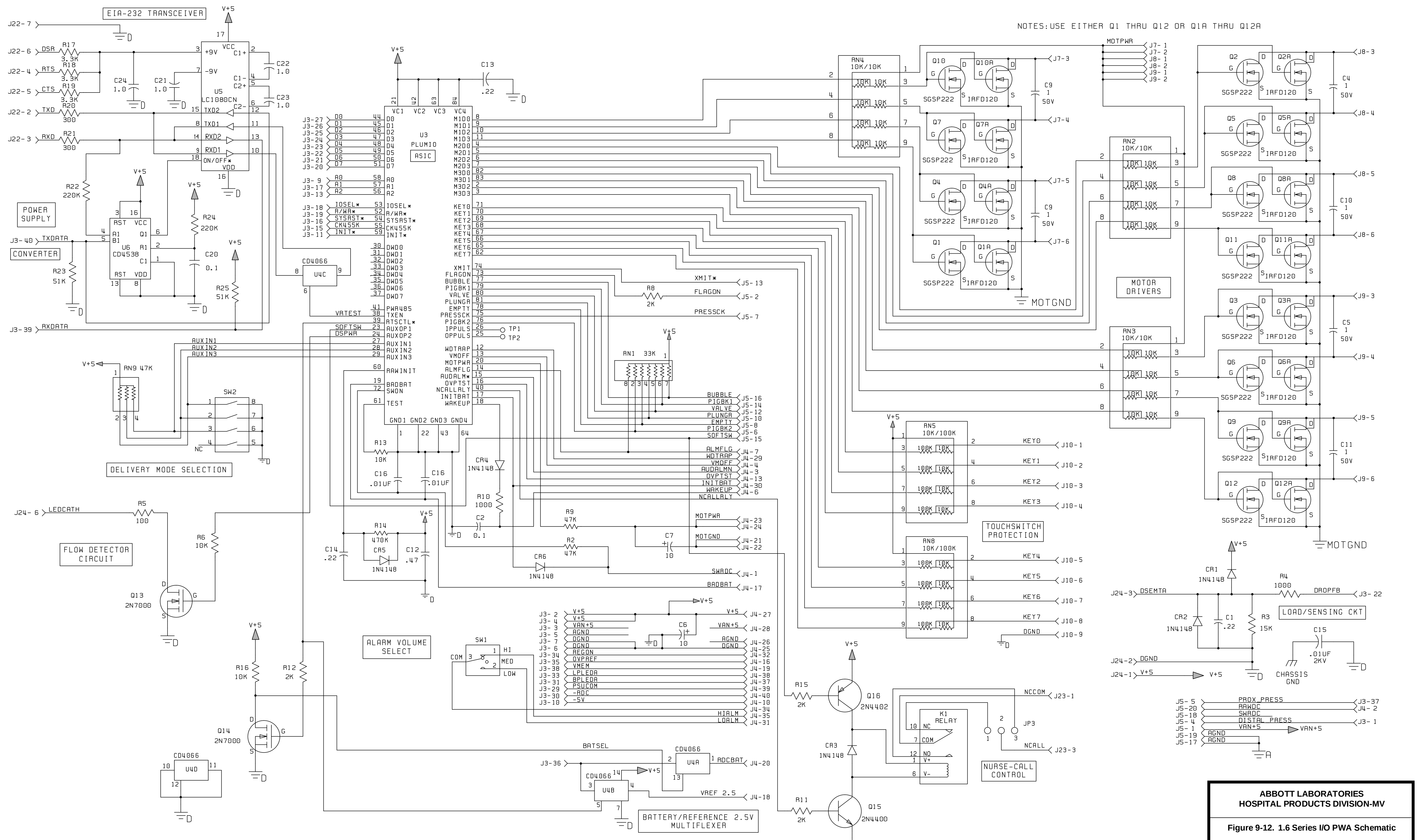

ABBOTT LABORATORIES
HOSPITAL PRODUCTS DIVISION-MV

Figure 9-12. 1.6 Series I/O PWA Schematic

DRAWING NO.	REV. R
249-03305-015	SHEET 1 OF 1

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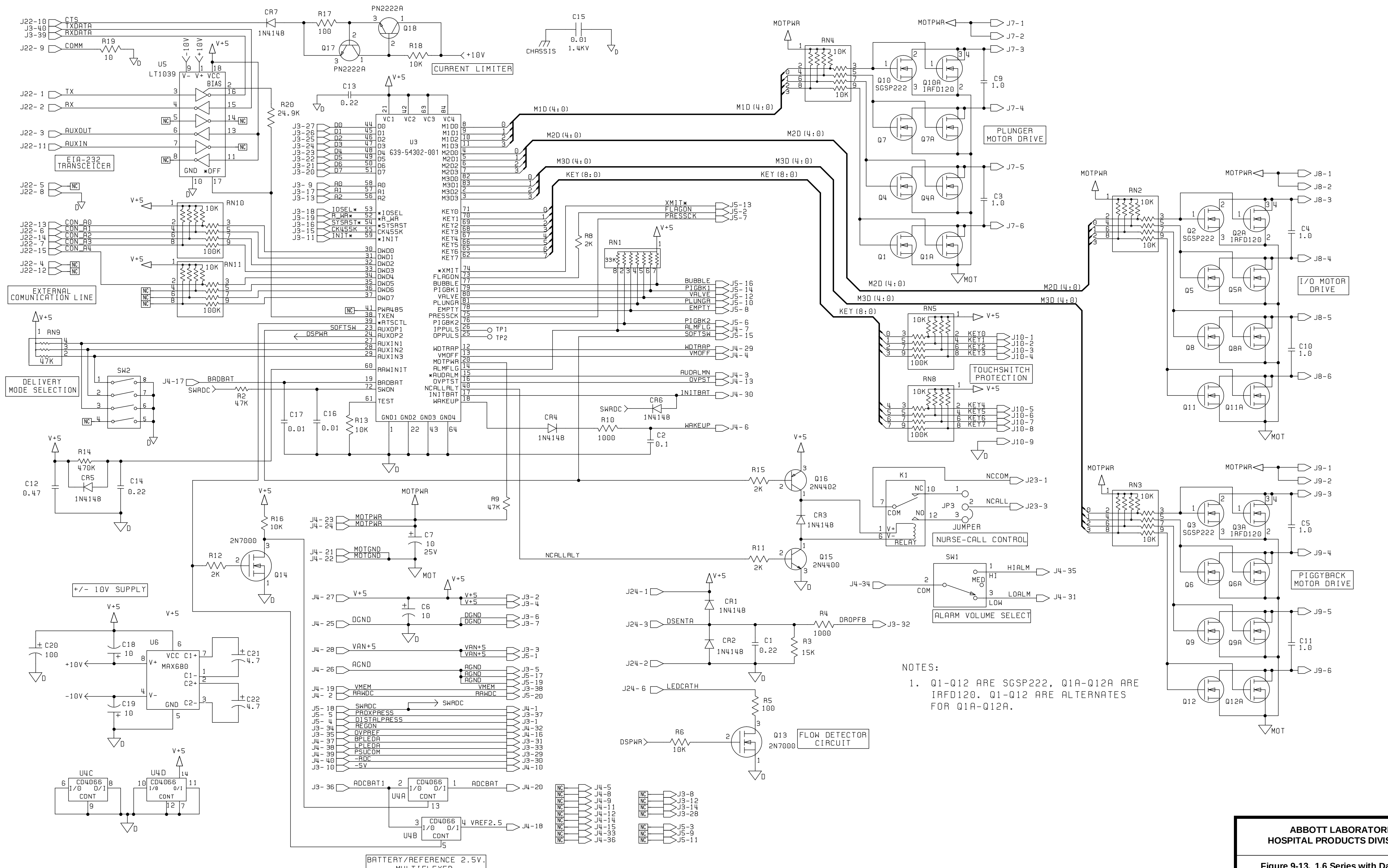

ABBOTT LABORATORIES
HOSPITAL PRODUCTS DIVISION-MV

Figure 9-13. 1.6 Series with DataPort I/O PWA Schematic

DRAWING NO.	REV. T
249-03305-016	SHEET 1 OF 1

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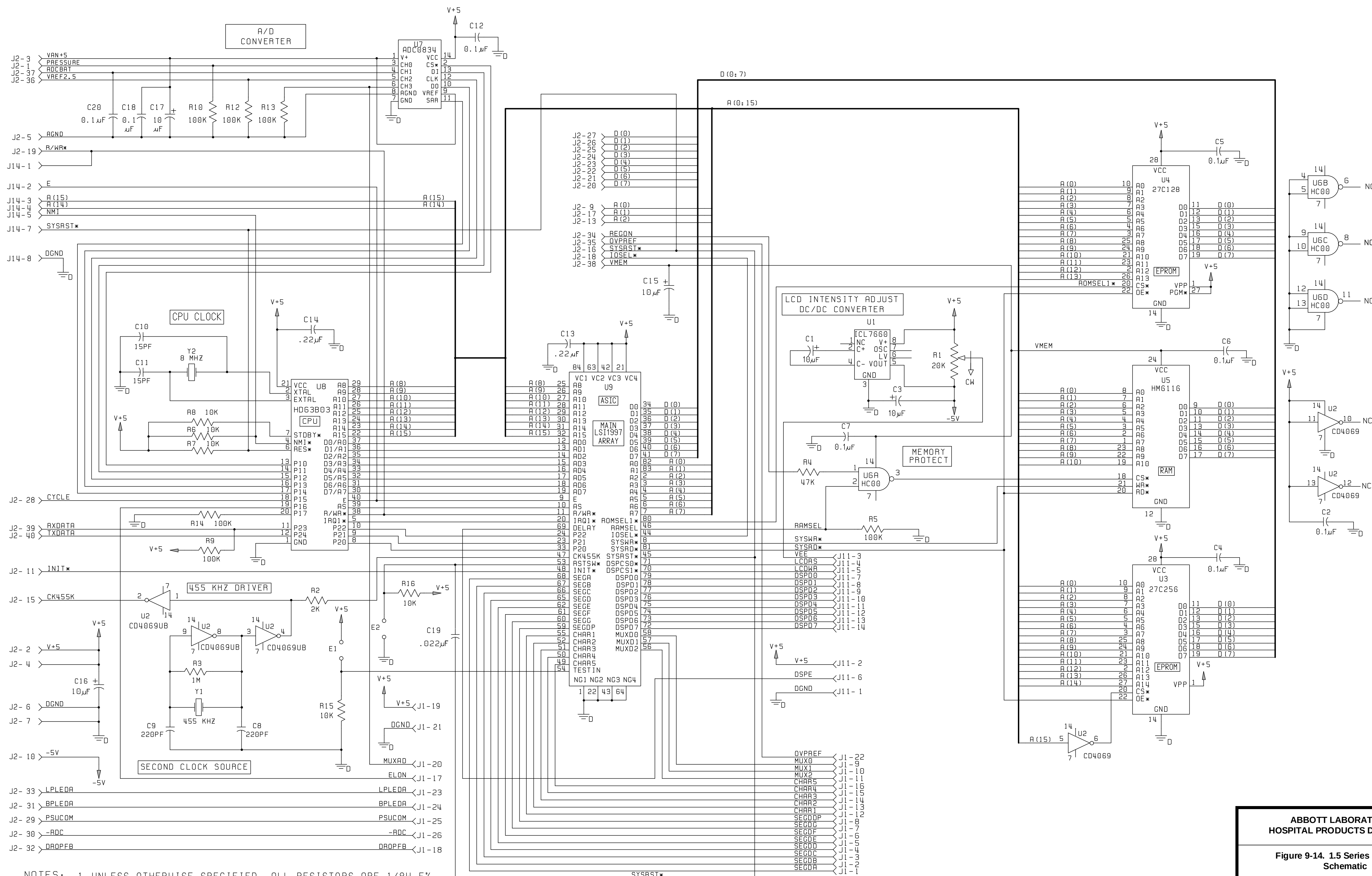

ABBOTT LABORATORIES
HOSPITAL PRODUCTS DIVISION-MV

Figure 9-14. 1.5 Series Main PWA Schematic

DRAWING NO.	REV. N
249-03304-046	SHEET 1 OF 1

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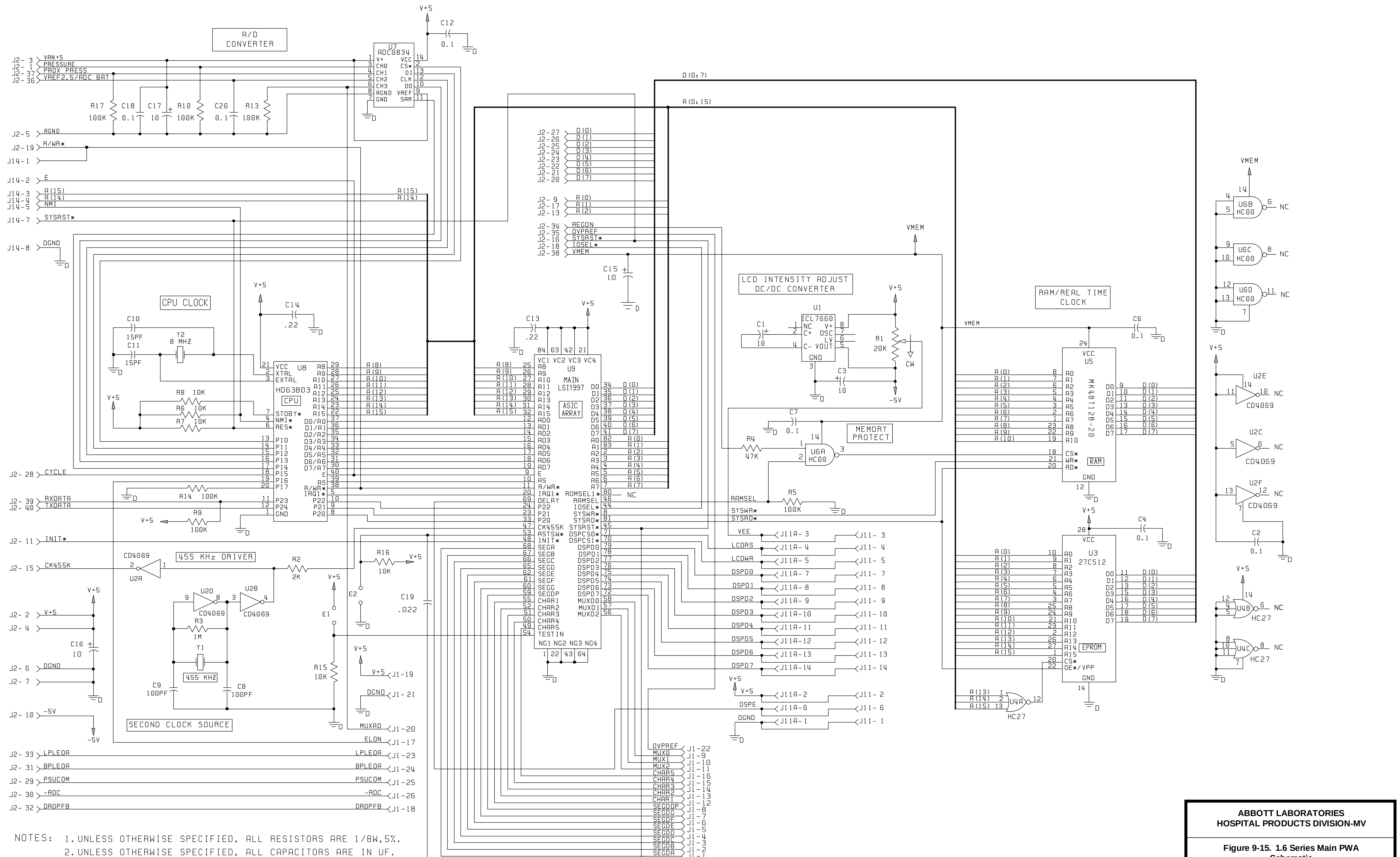

NOTES: 1. UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE 1/8W,5%.
2. UNLESS OTHERWISE SPECIFIED, ALL CAPACITORS ARE IN UF.

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-15. 1.6 Series Main PWA Schematic	
DRAWING NO.	REV. H
249-03304-034	SHEET 1 OF 1

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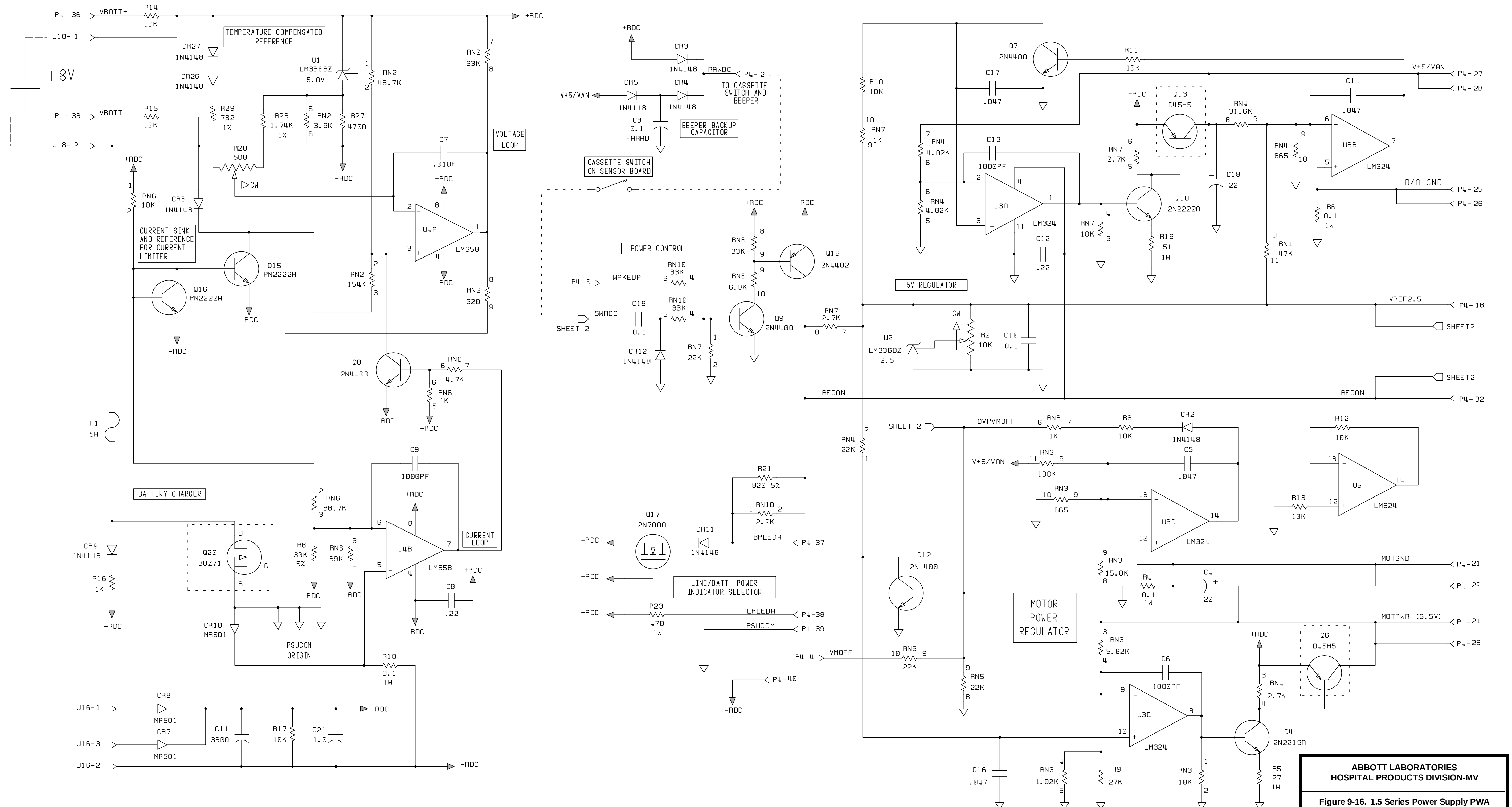

ABBOTT LABORATORIES
HOSPITAL PRODUCTS DIVISION-MV

Figure 9-16. 1.5 Series Power Supply PWA Schematic

DRAWING NO.	REV. R
249-03308-005	SHEET 1 OF 2

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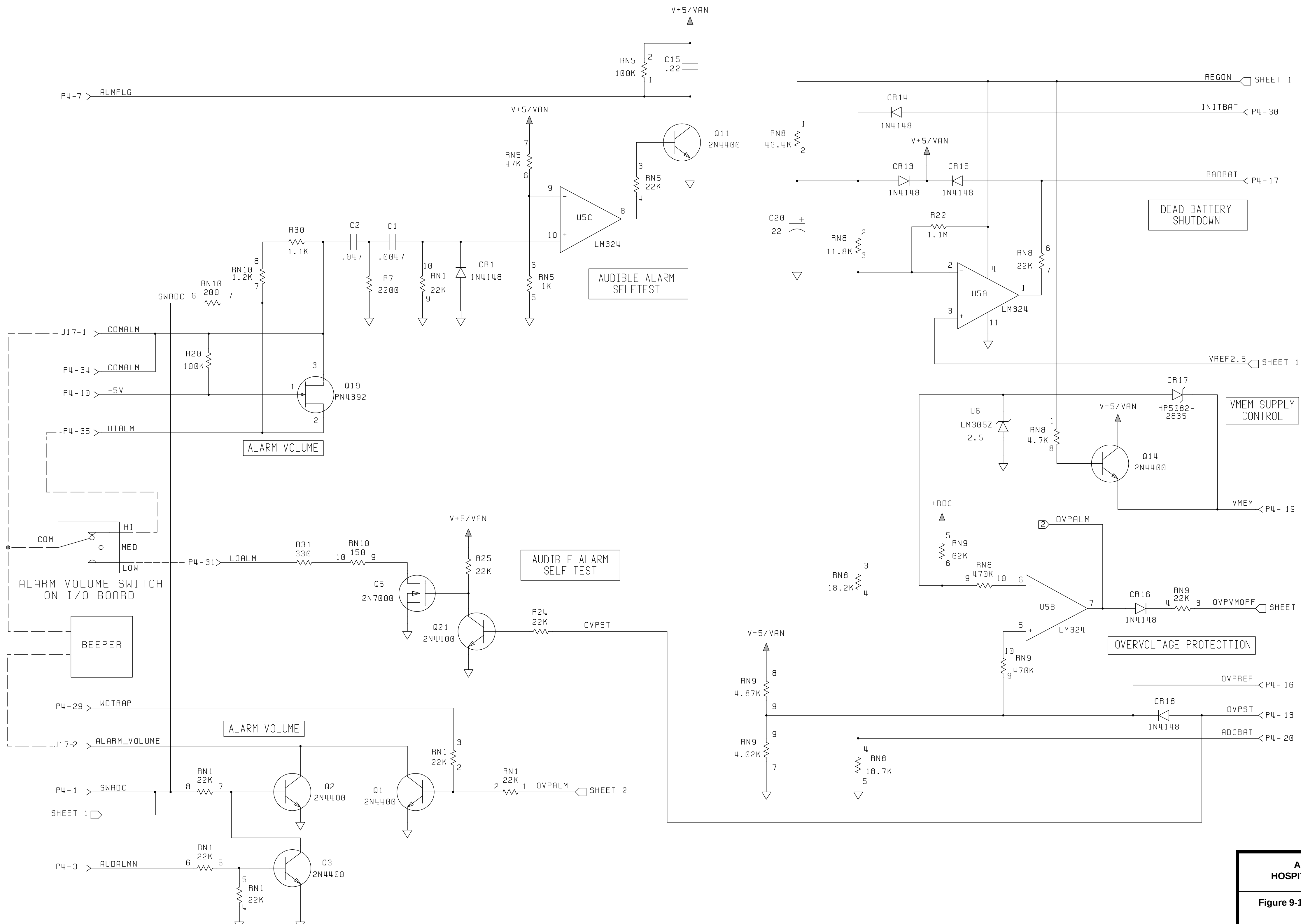

ABBOTT LABORATORIES **HOSPITAL PRODUCTS DIVISION-MV**
Figure 9-16. 1.5 Series Power Supply PWA Schematic
DRAWING NO. 249-03308-005 — **REV. R** — **SHEET 2 OF 2**

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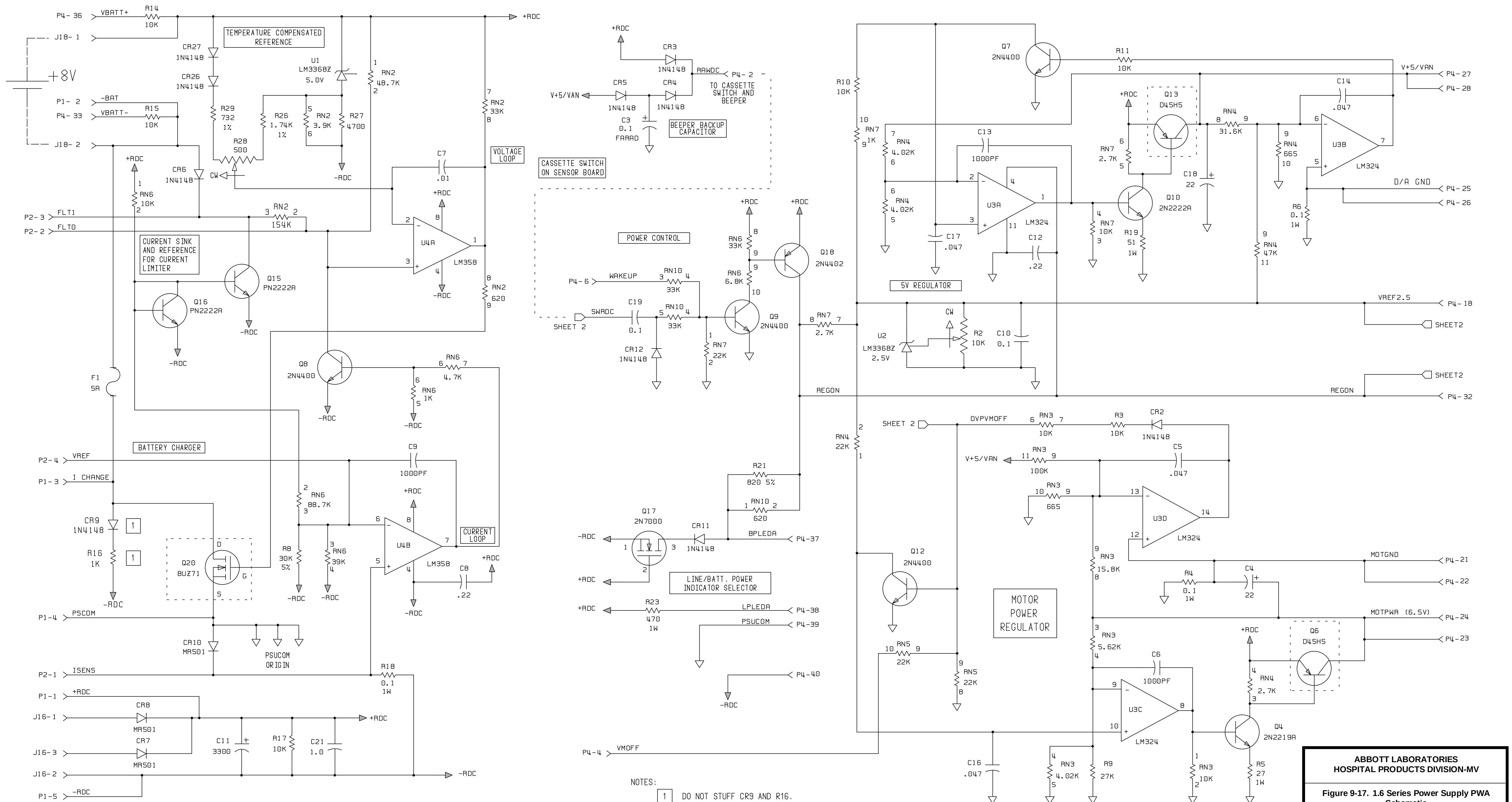

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-17. 1.6 Series Power Supply PWA Schematic	
DRAWING NO.	REV. S
249-03308-009	SHEET 1 OF 2

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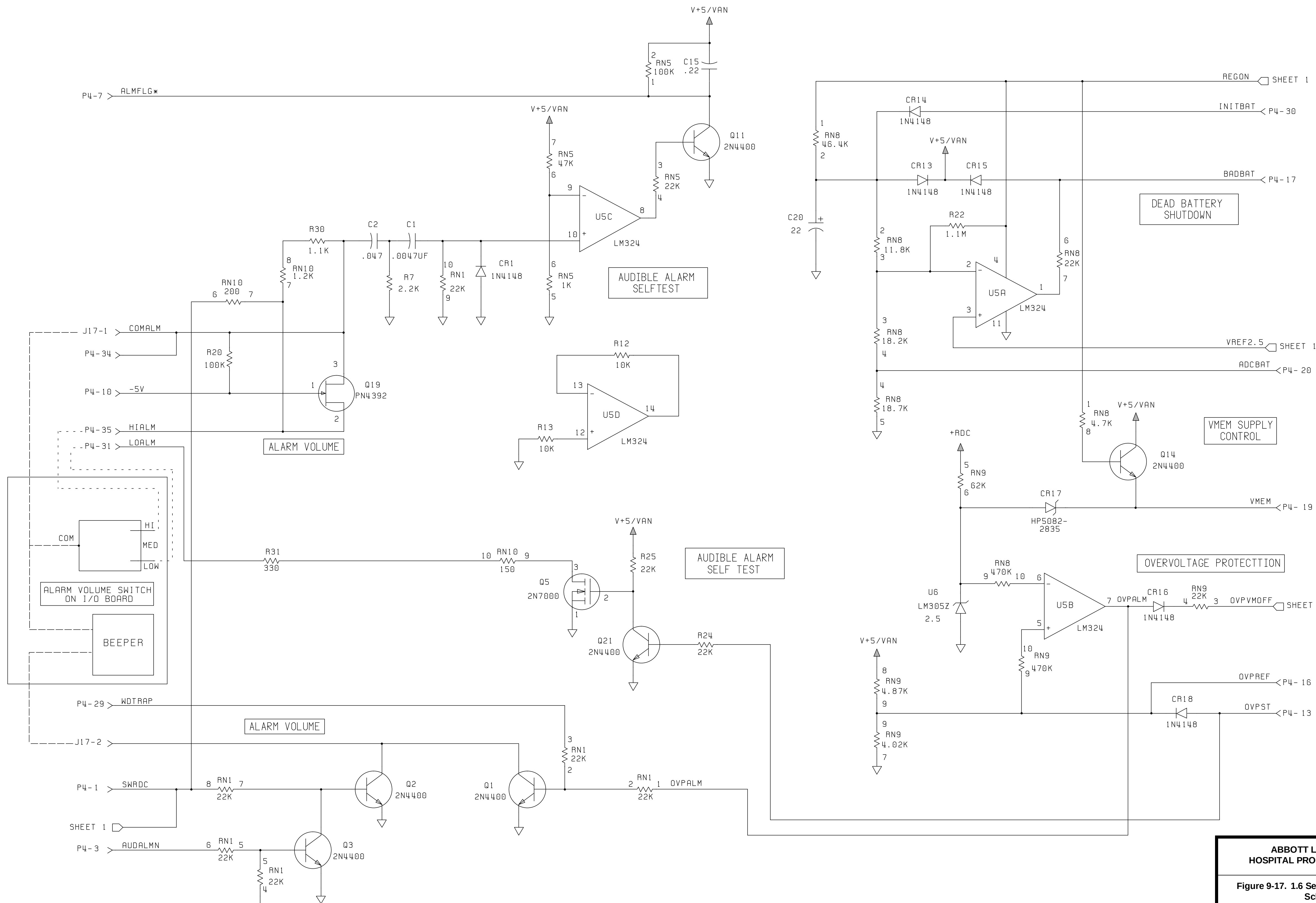

ABBOTT LABORATORIES **HOSPITAL PRODUCTS DIVISION-MV**	
Figure 9-17. 1.6 Series Power Supply PWA Schematic	
DRAWING NO. **249-03308-009**	**REV. S** **SHEET 2 OF 2**

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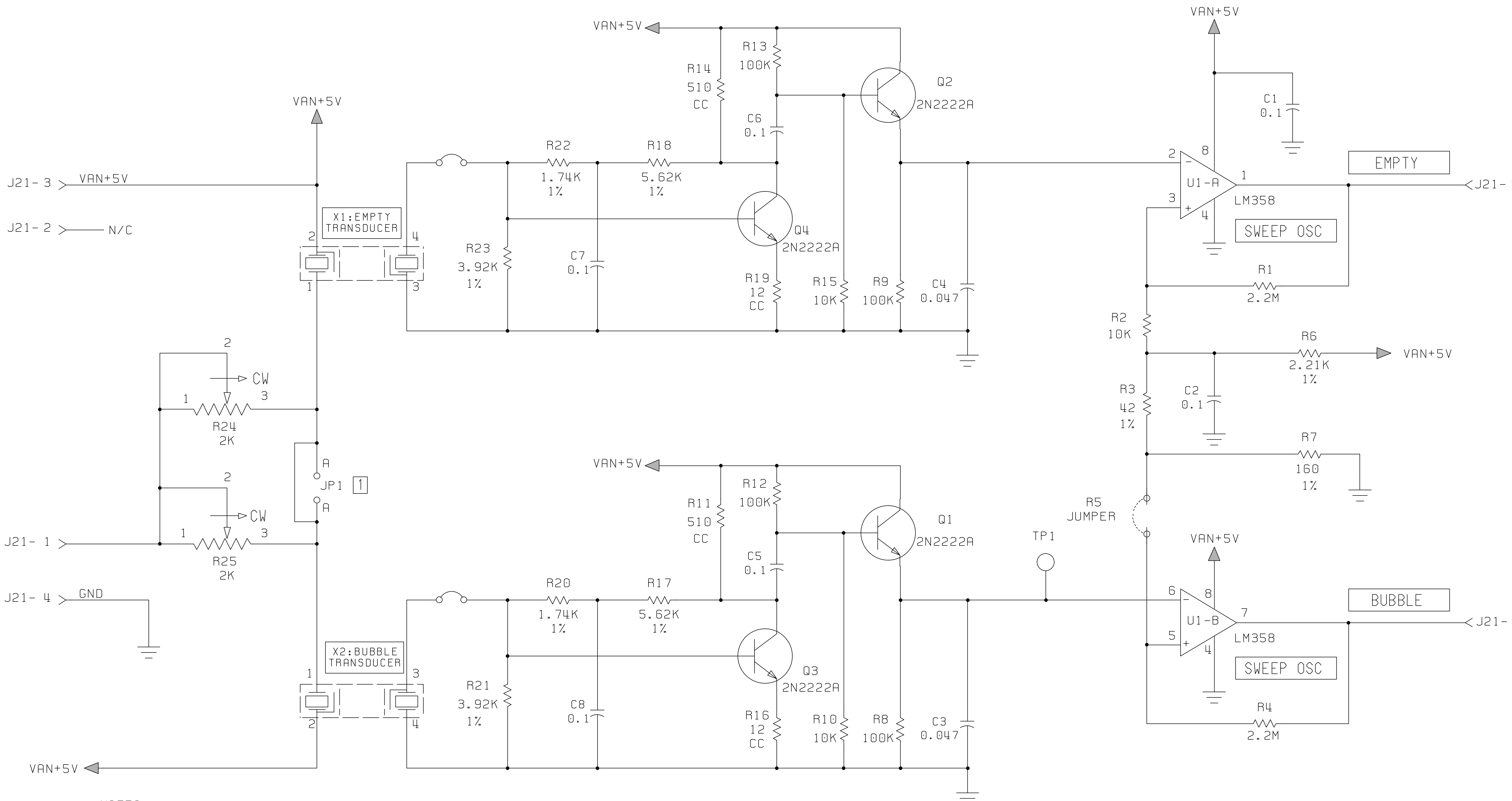

NOTES:

1. CUT TRACE BETWEEN JP1-A AND JP1-B IF R25 IS USED.
2. RESISTORS IN OHMS 5%, 1/4W UNLESS NOTED.
3. CAPACITORS IN MICROFARADS 20% UNLESS NOTED.

ABBOTT LABORATORIES
HOSPITAL PRODUCTS DIVISION-MV

Figure 9-18. Bubble Sensor PWA Schematic

DRAWING NO.	REV. K
249-03322-009	SHEET 1 OF 1

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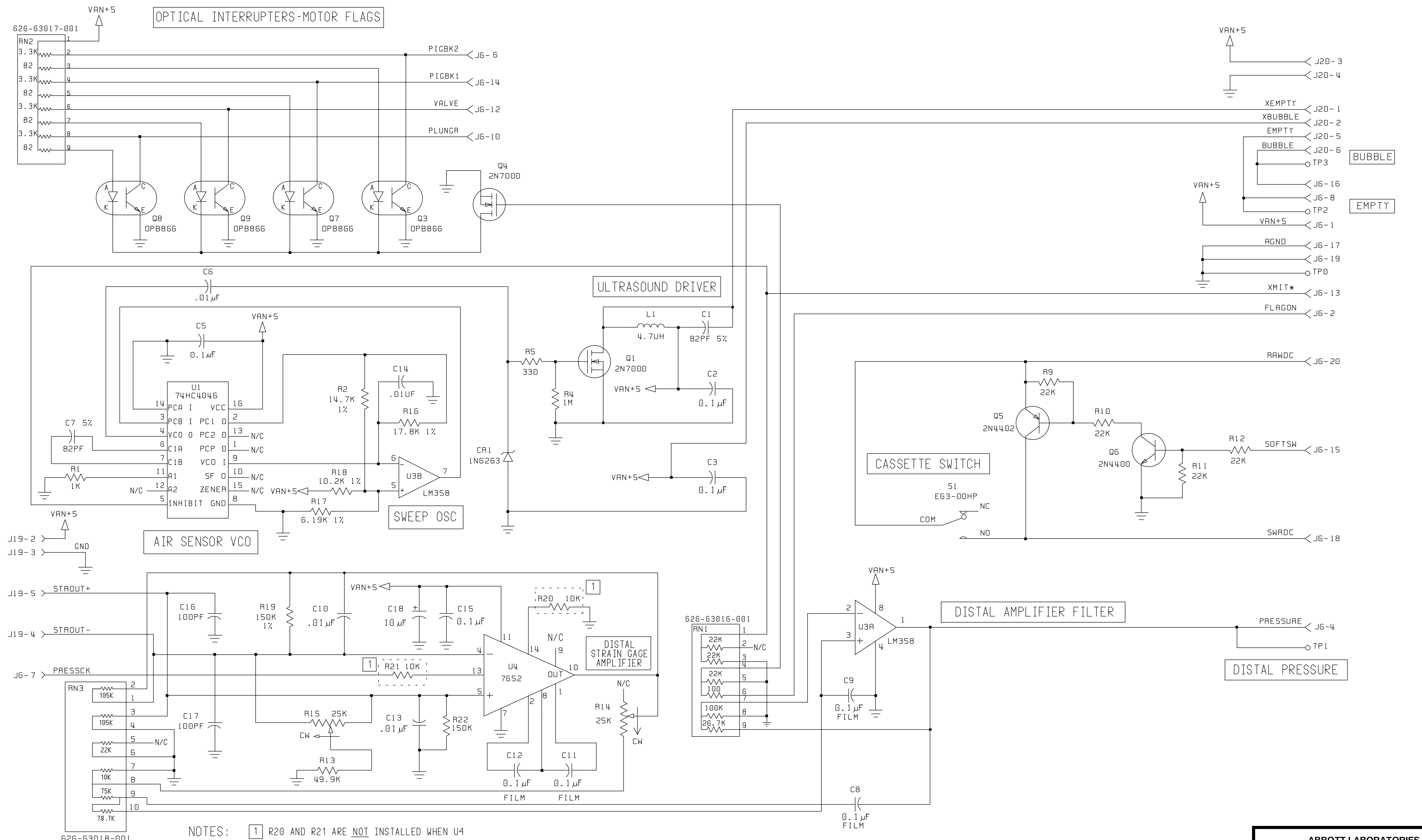

NOTES: 1 R20 AND R21 ARE NOT INSTALLED WHEN U4 IS USED WITH ITS INTERNAL CLOCK. R20 AND R21 ARE INSTALLED WHEN U4 OPERATES OFF AN EXTERNAL CLOCK FROM THE IO PWA.
2. Q2, L2, C4, R8 NOT USED.

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-19. 1.5 Series Sensor PWA Schematic	
DRAWING NO. 249-03110-009	REV. L SHEET 1 OF 1

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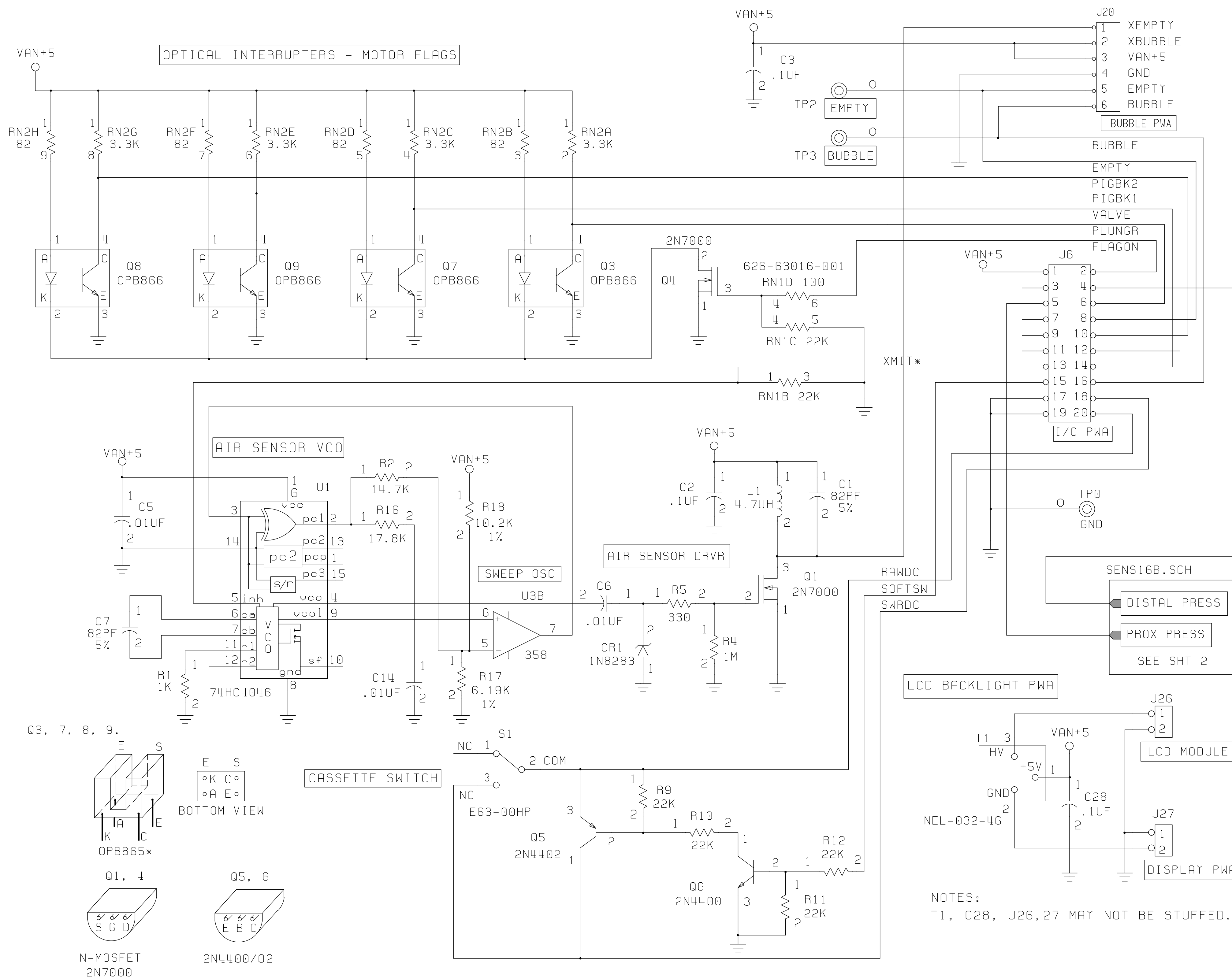

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-20. 1.6 Series Sensor PWA Schematic	
DRAWING NO. 249-03110-011	REV. L SHEET 1 OF 2

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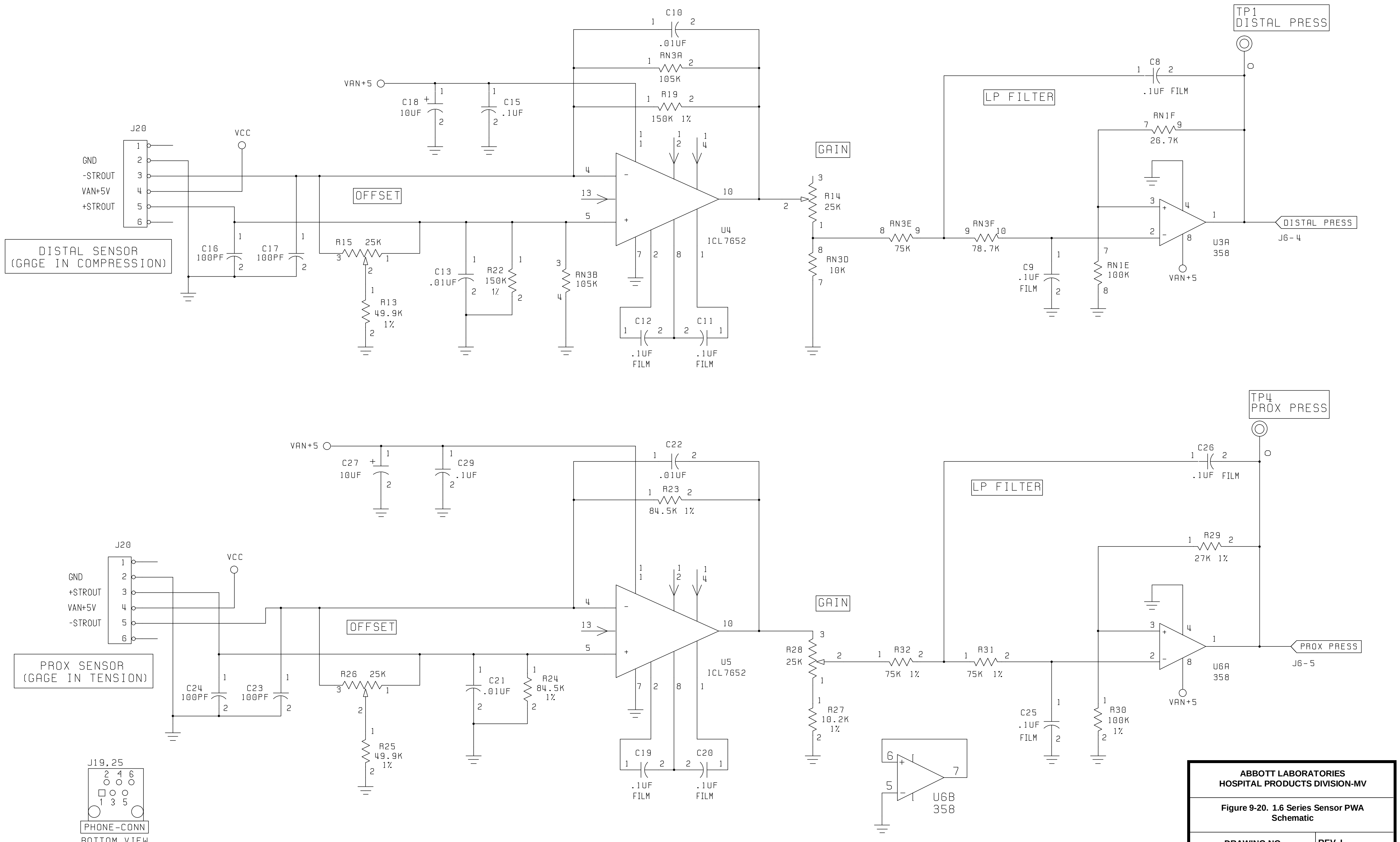

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Figure 9-20. 1.6 Series Sensor PWA Schematic	
DRAWING NO.	REV. L
249-03110-011	SHEET 2 OF 2

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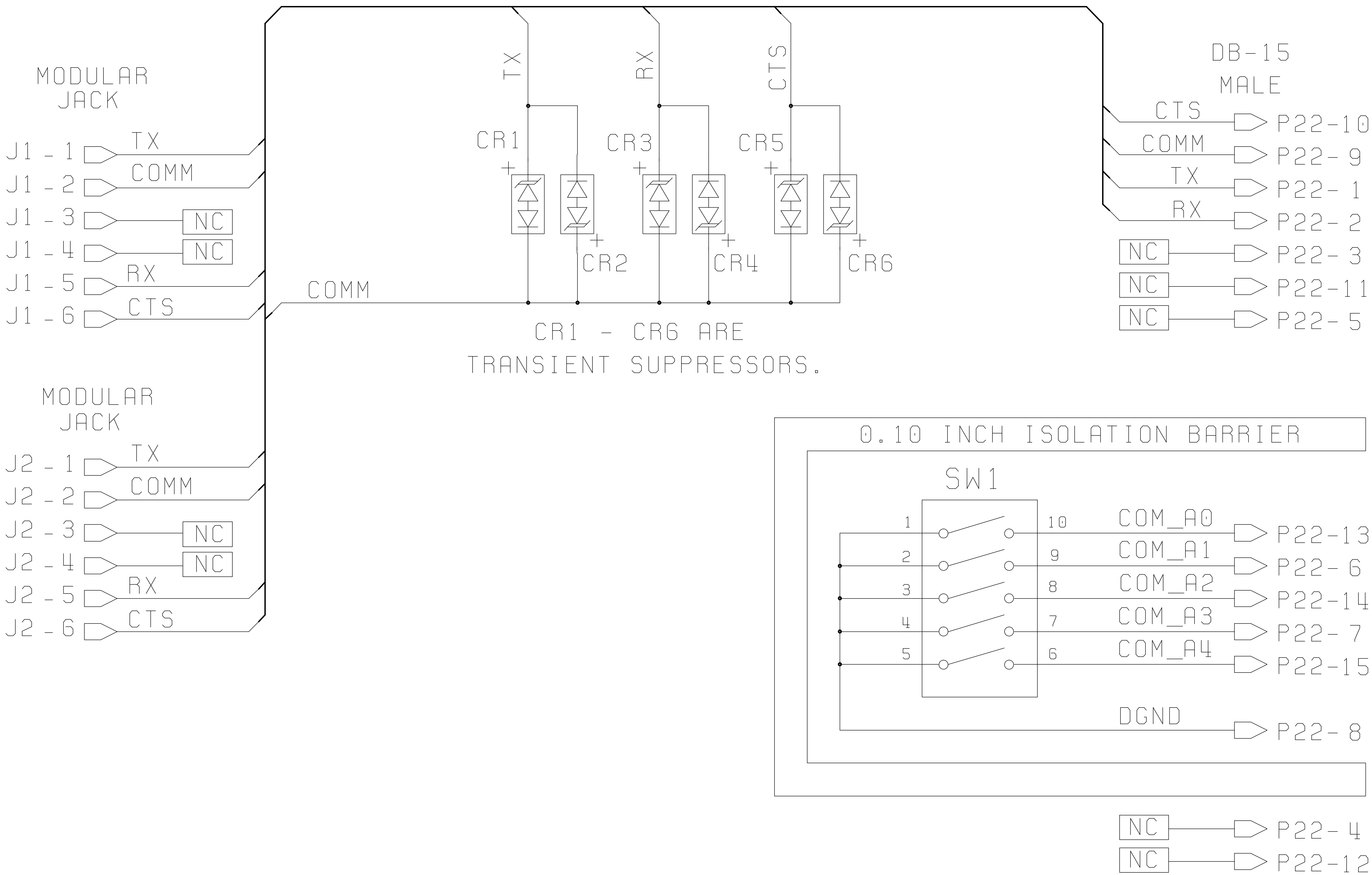

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-21. 1.6 Series Junction Box PWA Schematic	
DRAWING NO. 249-03658-003	REV. B SHEET 1 OF 1

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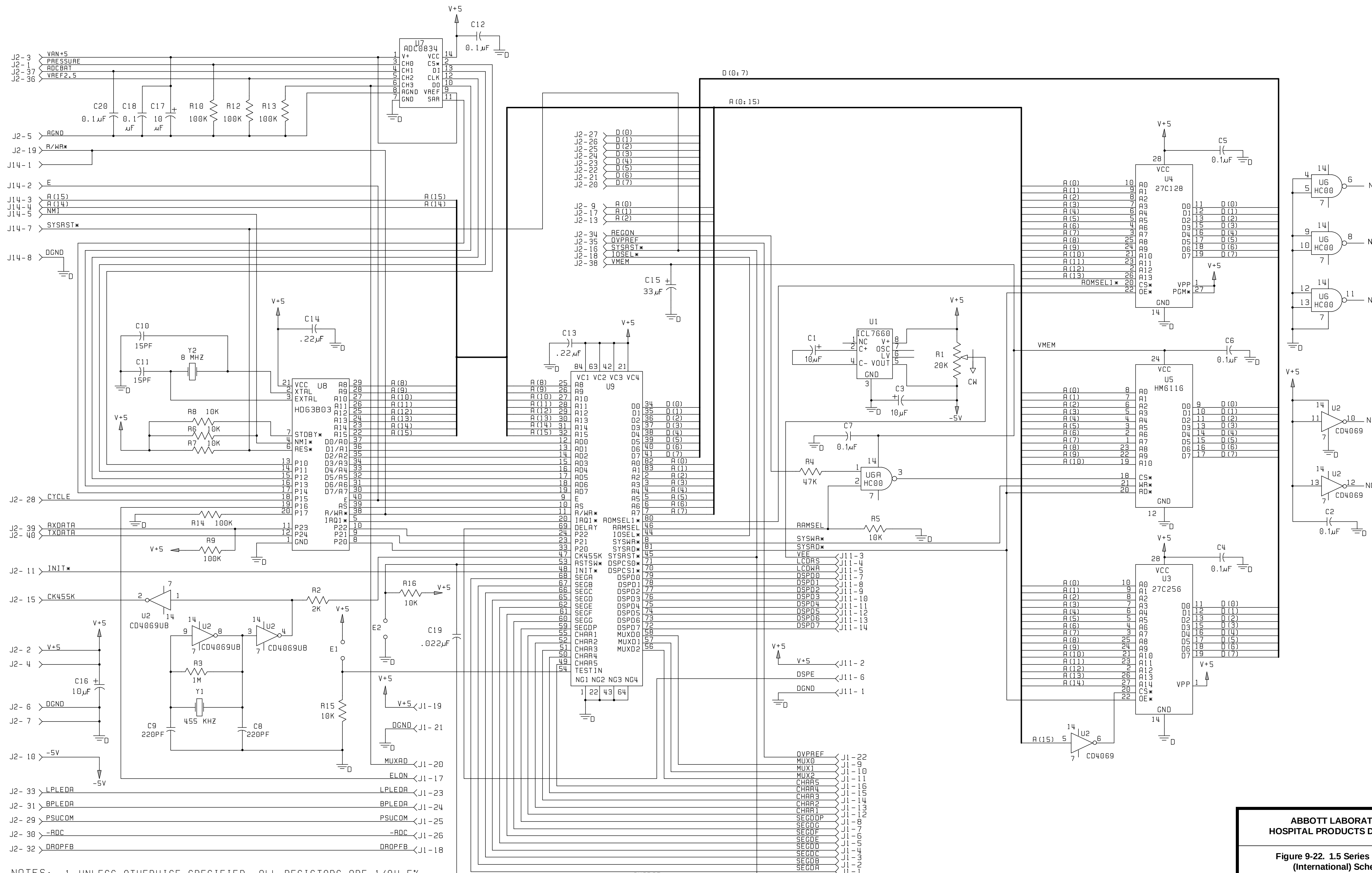

NOTES: 1. UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE 1/8W,5%.

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Figure 9-22. 1.5 Series Main PWA (International) Schematic	
DRAWING NO.	REV. M
249-03304-057	SHEET 1 OF 1

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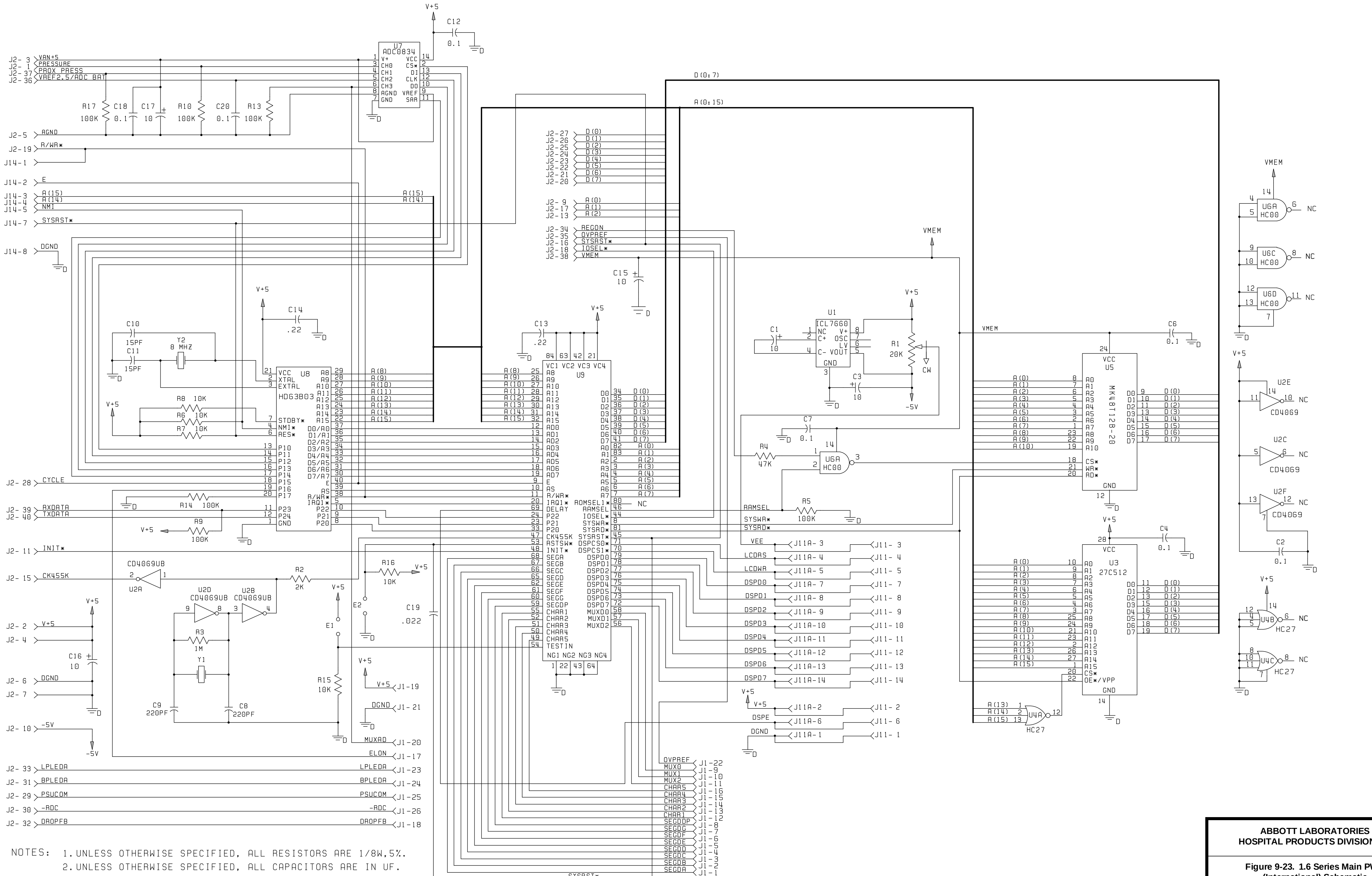

NOTES: 1. UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE 1/8W,5%.
2. UNLESS OTHERWISE SPECIFIED, ALL CAPACITORS ARE IN UF.
3. J11A NOT USED.

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-23. 1.6 Series Main PWA (International) Schematic	
DRAWING NO. 249-03304-052	REV. M SHEET 1 OF 1

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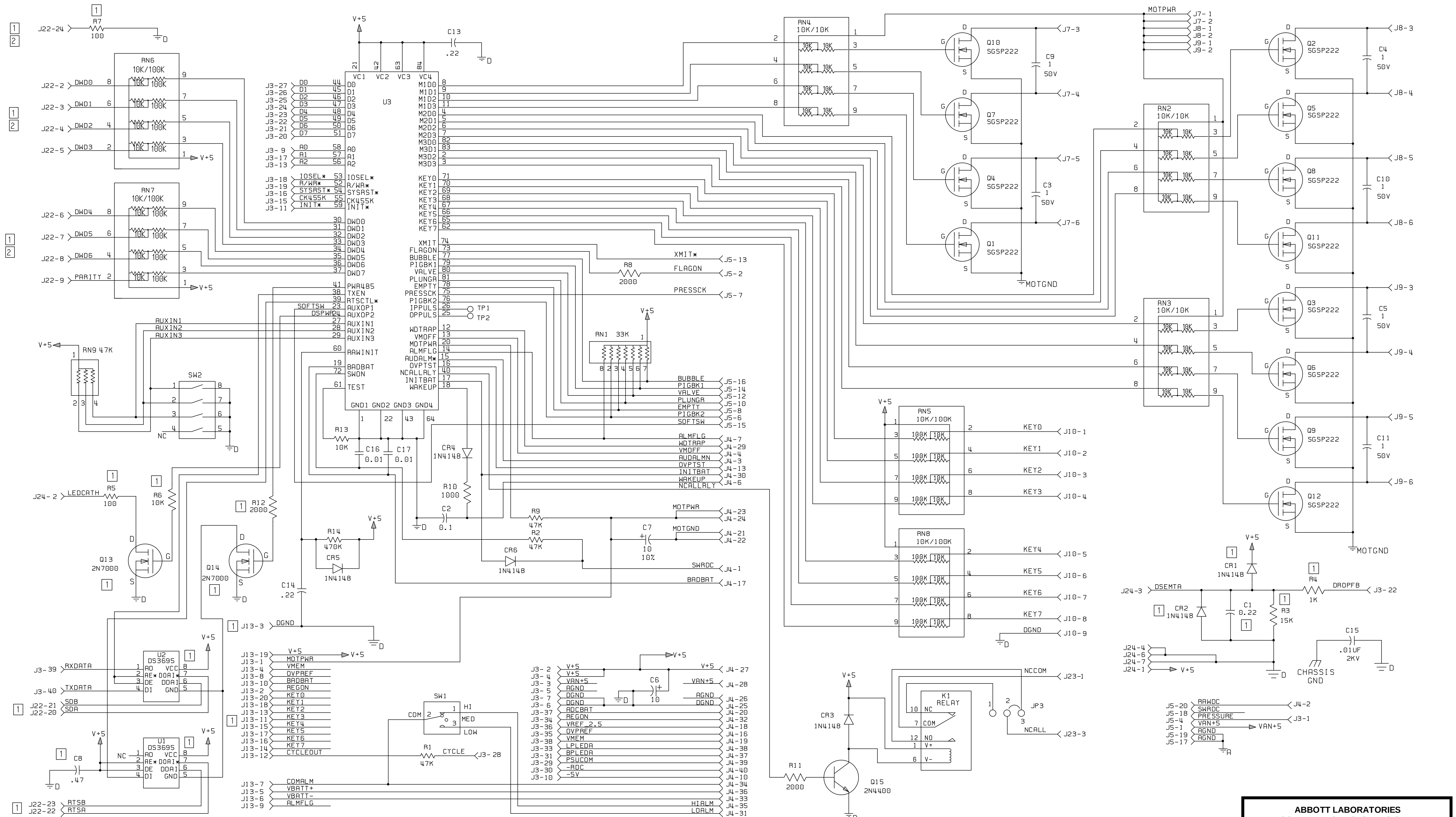

NOTES: 1 C1, C8, C12, CR1, CR2, J13.   Q13, Q14, R3, R4, R5, R6, R7, R12, U1, AND U2 NOT USED.

2 UNLESS OTHERWISE SPECIFIED: ALL R'S IN OHMS, 2%.

ALL C'S IN μF, 20%.

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-24. 1.5 Series I/O PWA (International) Schematic	
DRAWING NO.	REV. U
249-03305-021	SHEET 1 OF 1

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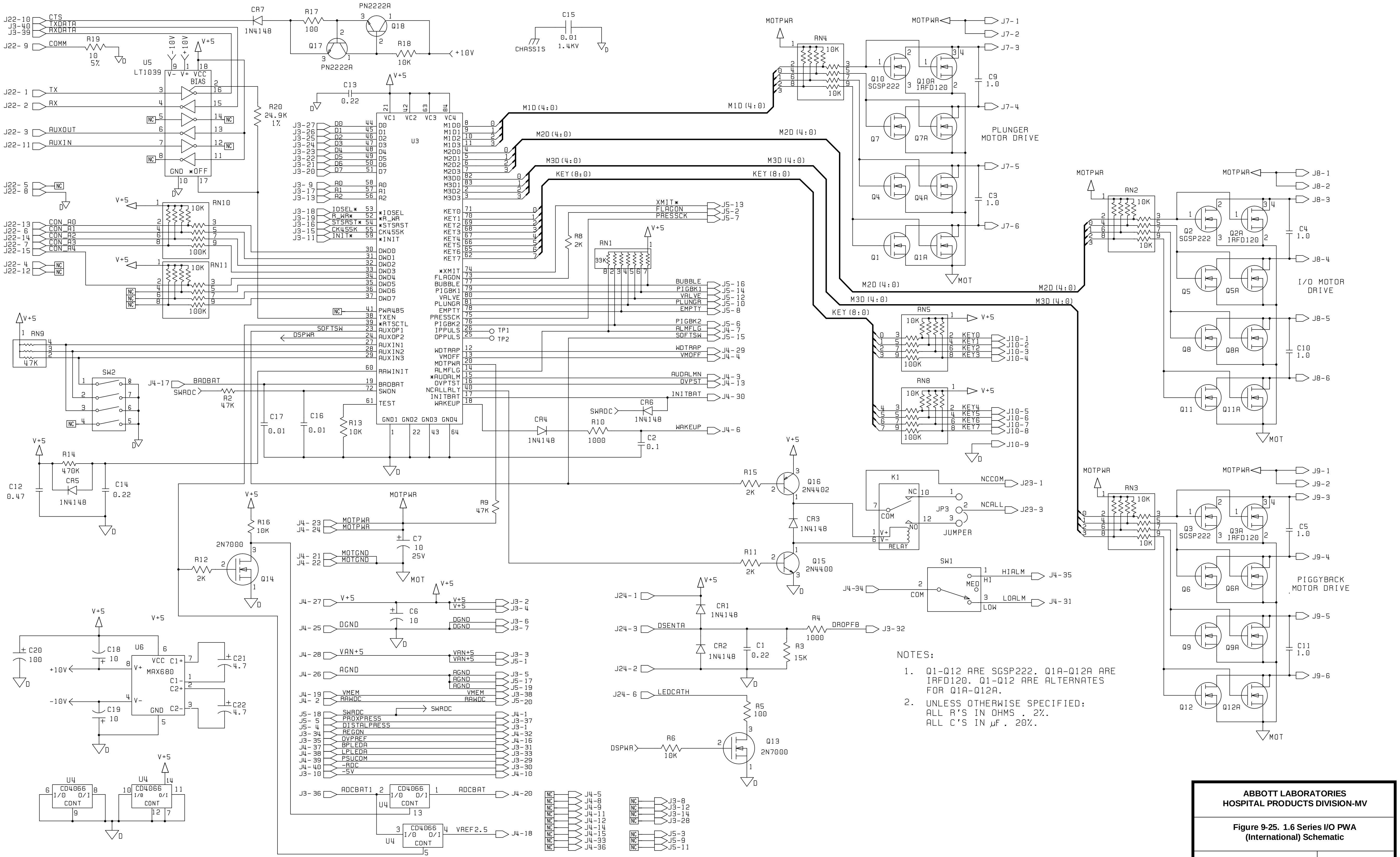

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-25. 1.6 Series I/O PWA (International) Schematic	
DRAWING NO.	REV. U
249-03305-022	SHEET 1 OF 1

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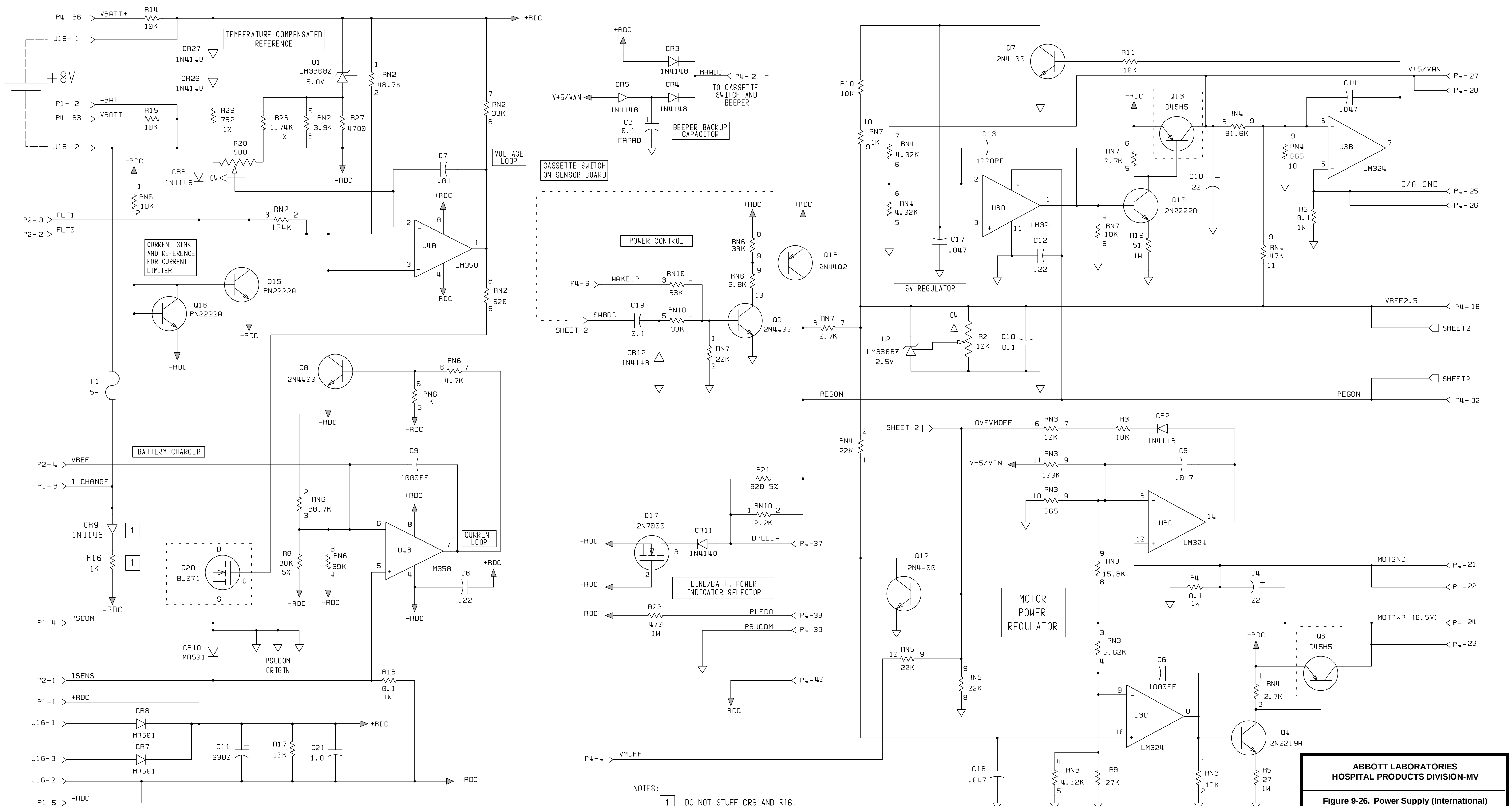

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Figure 9-26. Power Supply (International) Schematic

DRAWING NO.	REV. T
249-03308-010	SHEET 1 OF 2

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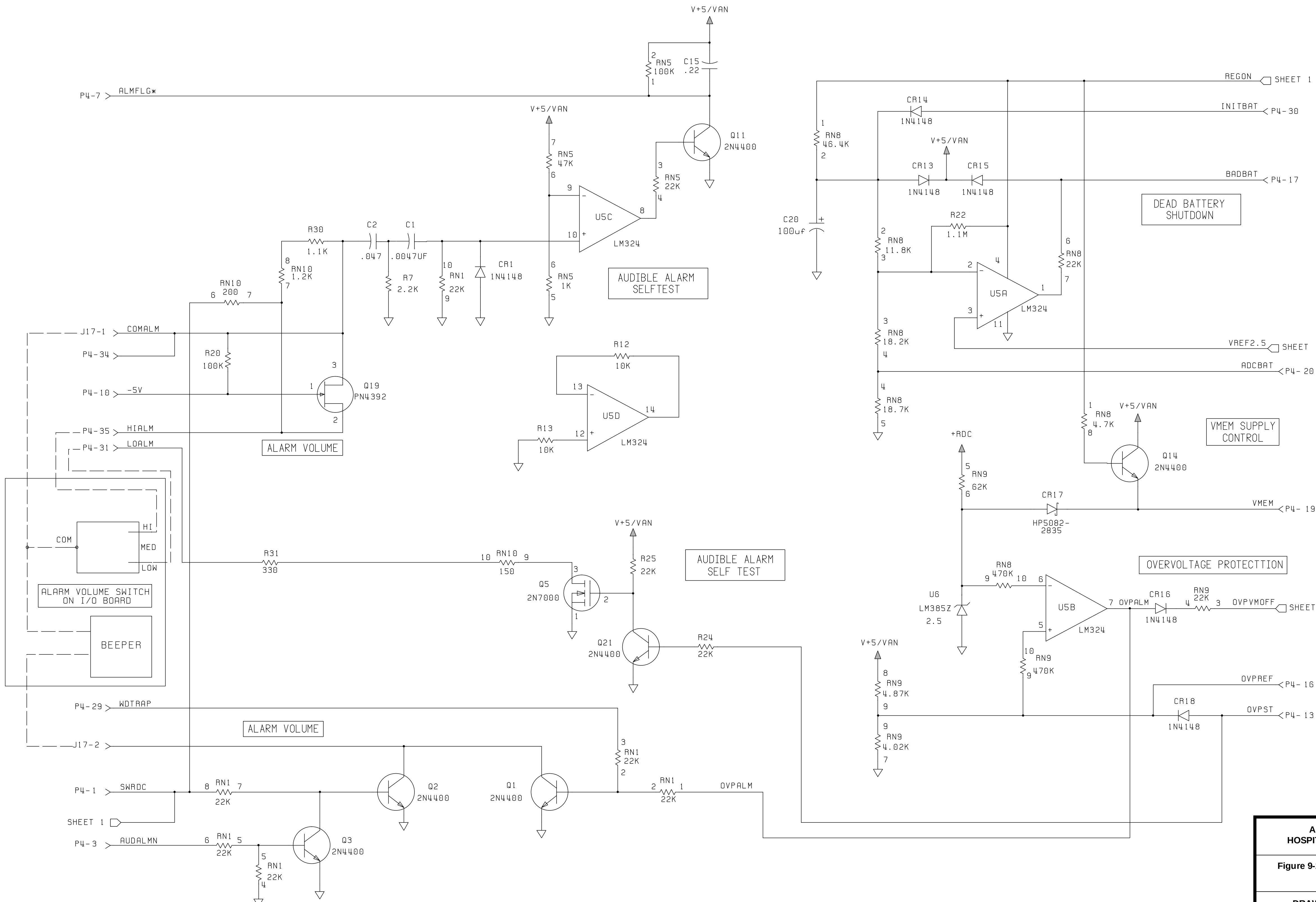

ABBOTT LABORATORIES
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Figure 9-26. Power Supply (International) Schematic

DRAWING NO.	REV. T
249-03308-010	SHEET 2 OF 2

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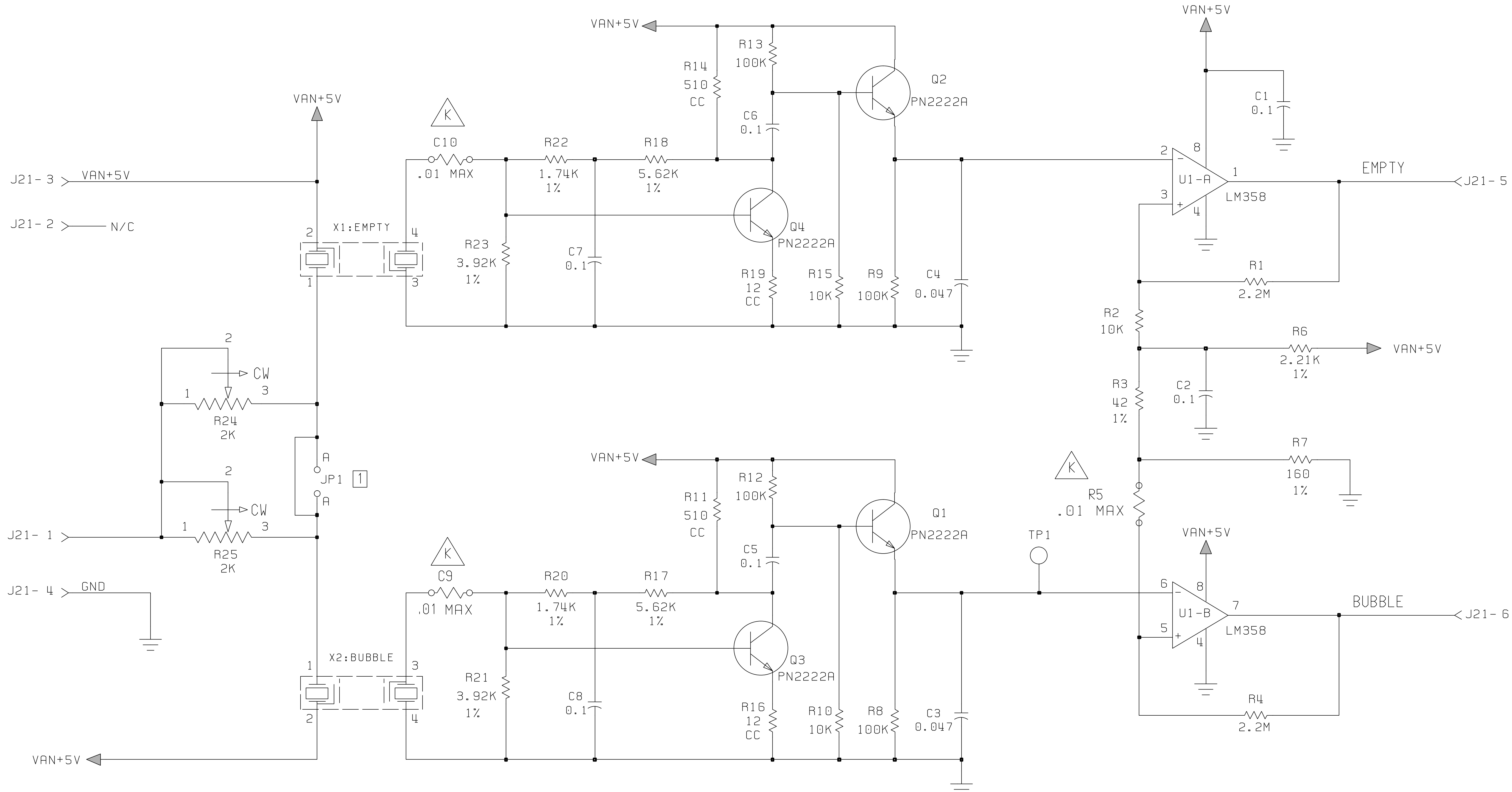

NOTES:

1. CUT TRACE BETWEEN JP1-A AND JP1-B IF R25 IS USED.
2. RESISTORS IN OHMS 5%, 1/4W UNLESS NOTED.
3. CAPACITORS IN MICROFARADS 20% UNLESS NOTED.

ABBOTT LABORATORIES HOSPITAL PRODUCTS DIVISION-MV	
Figure 9-27. Bubble Sensor (International) Schematic	
DRAWING NO. 249-03322-010	REV. K SHEET 1 OF 1

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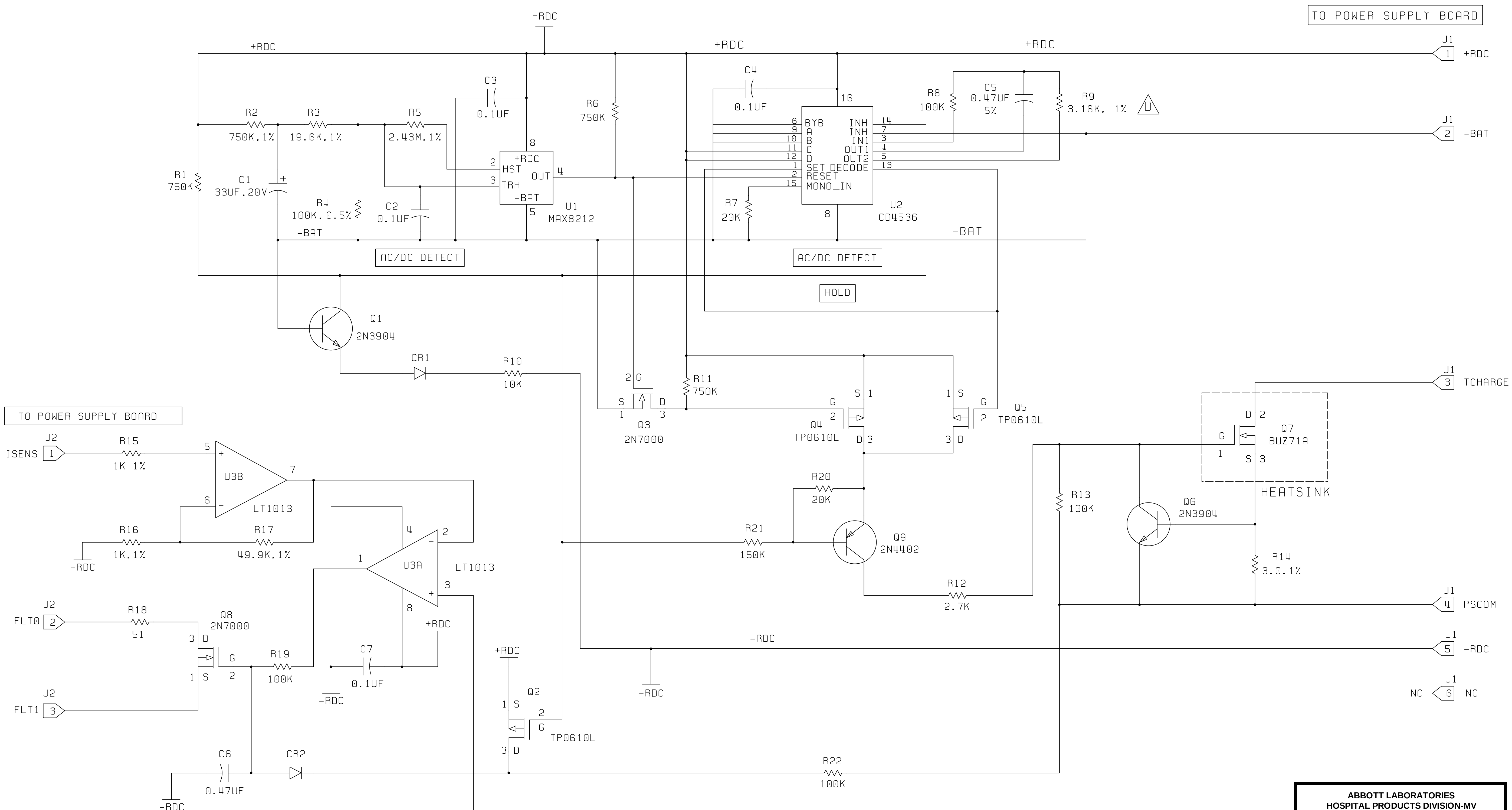

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HOSPITAL PRODUCTS DIVISION-MV

Figure 9-28. Current Boost Charger Schematic

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249-03644-003	SHEET 1 OF 1

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For technical assistance within the United States, contact:

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WARNING

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

Covered by one or more of the following U.S. patents: 4,336,800; 4,453,932; 4,552,336

IEC 601-1 Classification: Class 1, Type CF, Drip-proof Medical Equipment

IPX1

Attention, consult accompanying documents.

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LR 36894
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UL544

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