

LifeCare® and HomeCare® **MODEL 4 SERIES INFUSION PUMPS**

For use with:

LifeCare Model 4	List 1814, 1914, 1915
LifeCare Model 4P	List 2505, 2506
LifeCare Micro	List 1815, 1916, 1917
HomeCare Model 4H	List 22100, 24000

For country codes:

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

Technical Service Manual



Abbott Laboratories
North Chicago, IL, 60064
USA

430-01858-003 (Rev. 5/95)

Abbott Laboratories

Product
Information
Card
P. 8

Use

TO
be used in
the
laboratory

Instructions

21

Abbott
Labs
Abbott
Labs

Abbott Laboratories
Abbott Laboratories
Abbott Laboratories

Abbott
Labs
Abbott
Labs

Abbott
Labs
Abbott
Labs

Abbott
Labs
Abbott
Labs

Abbott
Labs
Abbott
Labs

Abbott
Labs
Abbott
Labs

© Copyright 1995

Abbott Laboratories

All Rights Reserved

This document and the subject matter disclosed herein are proprietary information. Abbott Laboratories retains all the exclusive rights of dissemination, reproduction, manufacture and sale. Any party using this document accepts it in confidence, and agrees not to duplicate it in whole or in part nor disclose it to others without the written consent of Abbott Laboratories.

Abbott
Labs
Abbott
Labs

Change History

Part Number	Description of Change	Remove and Destroy Pages	Insert Change Pages
430-01858-001 (Rev. 5/91)	Original issue		
430-01858-002 (Rev. 2/93)	Second issue		
430-01858-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
	Section 1 Added Section 1.2, Conventions Deleted Section 1.6 and renumbered subsequent subsections	1-1 to 1-10	1-1 to 1-10

Note: Change page manuals assembled by Abbott Laboratories include a change page identifier in the part number on the cover page. This change page manual is identified on the cover page as 430-01858-A02.

430-01858-B02 (Rev. 6/93)	Updated cover page and copyright page on reverse side	Cover	Cover
	Updated Change History	i, ii	i, ii
	Section 7.2.4.3: Revised voltage and pressure readings in calibration test	7-7 to 7-10	7-7 to 7-10

Note: Change page manuals assembled by Abbott Laboratories include a change page identifier in the part number on the cover page. This change page manual is identified on the cover page as 430-01858-B02.

430-01858-C02 (Rev. 11/93)	Updated cover page and reverse side page	Cover	Cover
	Updated Change History	i, ii	i, ii
	Update Contents	iii, iv	iii, iv
	Table 1-2: Updated table	1-7 to 1-10	1-7 to 1-8

Part Number

Description of Change

Remove and Destroy Pages

Insert Change Pages

Section 4.4.3.4: Updated hardware watchdog information;
Section 4.4.3.5: Updated hardware watchdog test

4-21, 4-22

4-21, 4-22

Section 4.5.4.1: Updated numeric and bar display digit drivers circuitry;
Section 4.5.4.2: Updated display enable stretcher and display protector circuitry;
Section 4.5.4.3: Updated numeric and bar display segment drivers information;
Section 4.5.4.4: Updated display test

4-31, 4-32

4-31, 4-32

Section 5.2: Updated PVT requirements

5-3, 5-4

5-3, 5-4

Section 5.2.5: Updated Step 5

5-5, 5-6

5-5, 5-6

Section 5.2.6: Added note;
Section 5.2.9: Update voltage reading Step 3

5-7, 5-8

5-7, 5-8

Section 5.4.3: Added Step 3;
Section 5.4.4: Updated Step 3

5-11, 5-12

5-11, 5-12

Figure 7-3: Clarified vertical distance between level of water in container and midline of set

7-7, 7-8

7-7, 7-8

Section 7.2.4.4: Clarified vertical distance between level of water in container and midline of set

7-9, 7-10

7-9, 7-10

Section 7.3.1.3: Updated materials

7-11, 7-12

7-11, 7-12

Section 7.3.1.3: Updated shroud assembly plunger guide replacement procedure

7-23, 7-24

7-23 to 7-26

Section 8: Updated specifications

8-1, 8-2

8-1, 8-2

Updated back page part number

back page

back page

Note: Change page manuals assembled by Abbott Laboratories include a change page identifier in the part number on the cover page. This change page manual is identified on the cover page as 430-01858-C02.

This page intentionally left blank.

Contents

Section 1

INTRODUCTION	1-1
1.1 SCOPE	1-1
1.2 CONVENTIONS	1-2
1.3 ACRONYMS AND ABBREVIATIONS	1-3
1.4 USER QUALIFICATIONS	1-5
1.5 ARTIFACTS	1-5
1.6 SERIES SPECIFIC FEATURES	1-6
1.7 INSTRUMENT INSTALLATION PROCEDURE	1-8
1.7.1 UNPACKING	1-9
1.7.2 INSPECTION	1-9
1.7.3 SELF TEST	1-9

Section 2

WARRANTY	2-1
--------------------	-----

Section 3

SYSTEM OPERATING MANUAL	3-1
-----------------------------------	-----

Section 4

THEORY OF OPERATION	4-1
4.1 GENERAL FUNCTIONS	4-1
4.1.1 CASSETTE	4-1
4.1.2 FLOW DETECTOR	4-2
4.1.3 ALARMS	4-2
4.1.3.1 AUDIBLE ALARM	4-2
4.1.3.2 NURSE-CALL ALARM	4-2
4.1.4 NUMERIC AND BAR DISPLAYS	4-2
4.2 EXTERNAL INTERFACE PORTS	4-3
4.2.1 ACC. CONNECTOR J23	4-3
4.2.2 NURSE-CALL JACK J21	4-4
4.2.3 FLOW DETECTOR CONNECTOR J22	4-4
4.2.4 RS-485 DATAWAY I/O CONNECTOR J101	4-5
4.2.5 RS-232 I/O PORT	4-5
4.2.6 20-MA I/O PORT	4-5
4.3 OPERATIONAL DESCRIPTION	4-6
4.3.1 MODES OF OPERATION	4-6
4.3.1.1 LOAD/OFF RECHARGE MODE	4-7
4.3.1.2 SELF TEST MODE	4-8
4.3.1.3 LOCAL CONTROL MODE	4-8
4.3.1.4 REMOTE CONTROL MODE	4-9
4.3.1.5 BATTERY DISCHARGED MODE	4-9
4.3.1.6 SYSTEM FAILURE MODE	4-10
4.3.2 SILENCE/ASK FUNCTION	4-11
4.3.3 DATA RETENTION FUNCTION	4-12
4.4 MONITORS AND DETECTORS	4-12
4.4.1 FLOW MONITORING SYSTEM	4-12
4.4.1.1 FLOW DETECTOR	4-13
4.4.1.2 DROP SIGNAL PROCESSOR	4-14
4.4.1.3 CURRENT AMPLITUDE MODULATOR	4-14
4.4.1.4 SYNCHRONOUS DEMODULATOR	4-15

4.4.1.5	DROP AMPLITUDE THRESHOLD DETECTOR	4 - 15
4.4.1.6	FLOW DETECTOR PRESENCE DETECTION	4 - 15
4.4.1.7	FLOW ALGORITHM	4 - 16
4.4.2	PRESSURE MEASURING SYSTEM	4 - 16
4.4.2.1	PRESSURE SENSOR PWA (-004 AND HIGHER)	4 - 17
4.4.2.2	PRESSURE SENSOR PWA (-003 AND LOWER)	4 - 17
4.4.2.3	OCCLUSION ALARM ALGORITHM	4 - 17
4.4.3	MALFUNCTION DETECTION CIRCUITRY	4 - 18
4.4.3.1	INTERNAL RAM TEST	4 - 18
4.4.3.2	ROM TEST	4 - 19
4.4.3.3	POWER-UP TEST	4 - 19
4.4.3.4	HARDWARE WATCHDOG	4 - 19
4.4.3.5	HARDWARE WATCHDOG TEST	4 - 20
4.4.3.6	SOFTWARE WATCHDOG	4 - 20
4.4.3.7	MICROPROCESSOR SANITY CHECK	4 - 20
4.5	ELECTRONICS SUBSYSTEM PRINCIPLES OF OPERATION	4 - 20
4.5.1	MPU PWA	4 - 21
4.5.1.1	MICROPROCESSOR CIRCUITRY	4 - 21
4.5.1.2	MEMORY CIRCUITRY	4 - 22
4.5.1.3	MEMORY LATCH CIRCUITRY	4 - 22
4.5.1.4	MEMORY PROTECTOR CIRCUITRY	4 - 22
4.5.1.5	I/O PORTS	4 - 22
4.5.2	MOTOR DRIVER PWA	4 - 23
4.5.2.1	I/O ADDRESS DECODER	4 - 26
4.5.2.2	INPUT DATA BUFFERS	4 - 27
4.5.2.3	A/D CONVERTER	4 - 27
4.5.2.4	RS-485 DATAWAY PORT	4 - 27
4.5.3	DISPLAY PWA	4 - 28
4.5.4	DISPLAY DRIVER PWA	4 - 29
4.5.4.1	HARDWARE WATCHDOG CIRCUITRY	4 - 29
4.5.4.2	NUMERIC AND BAR DISPLAY DIGIT DRIVERS CIRCUITRY	4 - 29
4.5.4.3	DISPLAY ENABLE STRETCHER AND DISPLAY PROTECTOR CIRCUITRY	4 - 30
4.5.4.4	NUMERIC AND BAR DISPLAY SEGMENT DRIVERS	4 - 30
4.5.4.5	DISPLAY TEST	4 - 30
4.5.5	POWER SUPPLY PWA	4 - 31
4.5.5.1	UNREGULATED DC POWER SUPPLY CIRCUITRY	4 - 31
4.5.5.2	BATTERY PACK	4 - 31
4.5.5.3	BATTERY CHARGER CIRCUITRY	4 - 32
4.5.5.4	DIODE POWER SWITCH CIRCUITRY	4 - 32
4.5.5.5	POWER CONTROL CIRCUITRY	4 - 32
4.5.5.6	5 VDC REGULATOR CIRCUITRY	4 - 33
4.5.5.7	5 VDC FAILURE DETECTOR CIRCUITRY	4 - 34
4.5.5.8	MOTOR VOLTAGE REGULATOR	4 - 34
4.5.5.9	BATTERY MONITOR CIRCUITRY	4 - 34
4.5.5.10	MEMORY SUPPLY CIRCUITRY	4 - 35
4.5.6	CURRENT BOOST CHARGER PWA	4 - 35
4.5.6.1	AC (MAINS) OPERATION	4 - 35
4.5.6.2	DC OPERATION	4 - 36
4.5.7	CONTROL SWITCHES	4 - 36
4.5.7.1	FRONT PANEL SWITCHES	4 - 36
4.5.7.2	REAR PANEL SWITCHES	4 - 37
4.6	MECHANICAL SUBSYSTEM PRINCIPLES OF OPERATION	4 - 38
4.6.1	CASSETTE	4 - 38
4.6.2	PUMP MECHANISM	4 - 39
4.6.3	MOTOR AND MOTOR DRIVERS	4 - 40
4.7	BATTERY OPERATION OVERVIEW	4 - 40

Section 5

MAINTENANCE AND SERVICE TESTS	5-1
5.1 PREVENTIVE MAINTENANCE	5-1
5.1.1 INSPECTING THE PUMP	5-1
5.1.2 CLEANING THE PUMP	5-2
5.1.3 SANITIZING THE PUMP	5-3
5.2 PERFORMANCE VERIFICATION TEST	5-3
5.2.1 EQUIPMENT AND MATERIALS REQUIRED	5-3
5.2.2 PUMP INSPECTION	5-4
5.2.3 DRY CASSETTE TEST	5-4
5.2.4 TEST SETUP	5-4
5.2.5 START UP TEST	5-5
5.2.6 PRESSURE TEST AND SILENCE SWITCH TEST	5-6
5.2.7 HIGH FLOW ALARM AND LOW FLOW ALARM (SIMULATED) AND AUDIBLE ALARM TESTS	5-7
5.2.8 DELIVERY ACCURACY TEST	5-7
5.2.9 PIGGYBACK TEST (MODEL 4P ONLY)	5-8
5.2.10 BATTERY CHARGING TEST	5-9
5.2.11 MALFUNCTION SIMULATION TEST	5-9
5.2.12 ELECTRICAL SAFETY TEST	5-9
5.2.13 END OF PERFORMANCE VERIFICATION TEST	5-9
5.3 BATTERY MAINTENANCE	5-10
5.3.1 DEPTH OF DISCHARGE	5-10
5.3.2 RECHARGING	5-10
5.4 BATTERY CIRCUIT ALARM AND CHARGER TESTS	5-11
5.4.1 TEST EQUIPMENT REQUIRED	5-11
5.4.2 LOW BATTERY ALARM TEST	5-11
5.4.3 BATTERY SHUTDOWN TEST	5-11
5.4.4 BATTERY CHARGING CIRCUIT TEST	5-12
5.5 PVT DATA FORM	5-13

Section 6

TROUBLESHOOTING	6-1
6.1 TECHNICAL ASSISTANCE	6-1
6.2 AUDIBLE ALARMS	6-1
6.3 ALARM CONDITIONS	6-2
6.4 ALARM CODES	6-2
6.5 OBTAINING AN ALARM HISTORY	6-2
6.6 PUMP TROUBLESHOOTING	6-4
6.7 PVT TROUBLESHOOTING	6-17
6.8 TEST CONNECTOR	6-19

Section 7

REPLACEABLE PARTS AND REPAIRS	7-1
7.1 REPLACEABLE PARTS LIST	7-1
7.2 ADJUSTMENT PROCEDURES	7-3
7.2.1 TOOLS AND MATERIALS REQUIRED	7-3
7.2.2 SHROUD TAB CHECK	7-3
7.2.3 SHROUD REAR TAB ADJUSTMENT	7-4
7.2.4 PRESSURE SENSOR CALIBRATION AND TEST	7-5
7.2.4.1 PRESSURE SENSOR CALIBRATION SETUP	7-5
7.2.4.2 CALIBRATION (PRESSURE SENSOR PWA -003 AND LOWER)	7-6
7.2.4.3 CALIBRATION (PRESSURE SENSOR PWA -004 AND HIGHER)	7-8

7.2.4.4	PRESSURE SENSOR TEST	7 - 10
7.3	REPLACEMENT PROCEDURES	7 - 11
7.3.1	SAFETY AND EQUIPMENT PRECAUTIONS	7 - 11
7.3.2	REQUIRED TOOLS AND MATERIALS	7 - 11
7.3.2.1	STANDARD HANDTOOLS	7 - 12
7.3.2.2	SPECIAL TOOLS	7 - 12
7.3.2.3	MATERIALS	7 - 12
7.3.3	BATTERY PACK REPLACEMENT	7 - 13
7.3.4	FUSE REPLACEMENT	7 - 14
7.3.4.1	FUSE REPLACEMENT (115 V~)	7 - 14
7.3.4.2	FUSE AND FUSE DRAWER REPLACEMENT (100 V~, 220 V~)	7 - 15
7.3.5	VELCRO ANCHOR PAD REPLACEMENT	7 - 15
7.3.6	AC POWER CORD STRAIN RELIEF BUSHING REPLACEMENT (115 V~)	7 - 16
7.3.7	AC POWER CORD PLUG REPLACEMENT	7 - 16
7.3.8	NURSE-CALL CABLE ASSEMBLY REPLACEMENT	7 - 17
7.3.9	FLOW DETECTOR ASSEMBLY REPLACEMENT	7 - 17
7.3.10	FLOW DETECTOR ASSEMBLY PLUG AND CLOSED ENTRY FEMALE TERMINAL REPLACEMENT	7 - 18
7.3.11	FLOW DETECTOR CONNECTOR HOUSING AND MALE PIN CONNECTOR(S) REPLACEMENT	7 - 19
7.3.12	MAIN CONTROL KNOB REPLACEMENT	7 - 20
7.3.13	POLE CLAMP KNOB REPLACEMENT	7 - 20
7.3.14	POLE CLAMP SHAFT REPLACEMENT	7 - 21
7.3.15	AUDIBLE ALARM LEVEL SWITCH REPLACEMENT	7 - 22
7.3.16	SHROUD ASSEMBLY PLUNGER GUIDE REPLACEMENT	7 - 23
7.3.17	ACCESSORY (ACC.) CONNECTOR (OR PINS) REPLACEMENT	7 - 24
7.3.18	CASE REPLACEMENT	7 - 26
7.3.18.1	ONE-PIECE CASE REPLACEMENT	7 - 26
7.3.18.2	CLAMSHELL CASE REPLACEMENT	7 - 28
7.3.19	PWA REPLACEMENT	7 - 30
7.3.19.1	POWER SUPPLY PWA REPLACEMENT	7 - 30
7.3.19.2	DISPLAY PWA, DISPLAY DRIVER PWA, MPU PWA, AND MOTOR DRIVER PWA REPLACEMENT	7 - 31
7.3.19.3	MOTHERBOARD PWA REPLACEMENT	7 - 33
7.3.20	AC POWER CORD REPLACEMENT (115 V~)	7 - 34
7.3.21	AC (MAINS) POWER CORD REPLACEMENT (100V~, 220 V~)	7 - 35
7.3.22	AC POWER CORD RETAINER CLIP REPLACEMENT (115 V~)	7 - 36
7.3.23	TOUCHSWITCH PANEL REPLACEMENT	7 - 36
7.3.24	PIEZOELECTRIC ALARM REPLACEMENT	7 - 38
7.3.25	TRANSFORMER CONNECTOR P10 AND CLOSED ENTRY FEMALE TERMINAL REPLACEMENT	7 - 39
7.3.26	MAIN CONTROL SWITCH SHAFT ASSEMBLY REPLACEMENT	7 - 40
7.3.27	MAIN CONTROL SWITCH SHAFT ASSEMBLY LUBRICATION	7 - 43
7.3.28	MAIN CONTROL SWITCH WAFER REPLACEMENT	7 - 44
7.3.29	FUSEHOLDER REPLACEMENT (115 V~)	7 - 45
7.3.30	NURSE-CALL JACK REPLACEMENT	7 - 46
7.3.31	PRESSURE LEVEL SELECT SWITCH REPLACEMENT	7 - 46
7.3.32	SET TYPE SWITCH REPLACEMENT (MICRO ONLY)	7 - 47
7.3.33	RUBBER FOOT PAD REPLACEMENT	7 - 48
7.3.34	MAINS RECEPTACLE ASSEMBLY REPLACEMENT (100 V~, 220 V~)	7 - 49

Section 8
SPECIFICATIONS 8 - 1

Section 9
DRAWINGS 9 - 1

Section 10
INDEX 10 - 1

Figures

Figure 4-1. Flow Detector Schematic Diagram 4 - 14
Figure 4-2. Power Control Circuitry 4 - 33
Figure 4-3. Pump Cassette 4 - 39
Figure 5-1. Delivery Accuracy Test Setup 5 - 5
Figure 7-1. Shroud Tab Check 7 - 4
Figure 7-2. Pressure Sensor Adjustment Resistors 7 - 6
Figure 7-3. Calibration Test Setup 7 - 8
Figure 7-4. Battery Pack Replacement 7 - 14
Figure 7-5. Main Control Knob Removal 7 - 20
Figure 7-6. Pole Clamp Knob Removal 7 - 21
Figure 7-7. Shroud Assembly Plunger Guide Replacement 7 - 24
Figure 7-8. ACC. Connector Pin Arrangement 7 - 26
Figure 7-9. Rear Panel Screw Removal (One-Piece Case) 7 - 27
Figure 7-10. Removing Chassis From Cover 7 - 28
Figure 7-11. Case Screw Removal (Clamshell Case) 7 - 29
Figure 7-12. Opening the Clamshell Case 7 - 29
Figure 7-13. Shield Removal 7 - 30
Figure 7-14. Heat Sink Screw Removal 7 - 31
Figure 7-15. PWA Removal 7 - 32
Figure 7-16. Motherboard PWA Removal 7 - 33
Figure 7-17. AC Power Cord Replacement (115 Volt) 7 - 35
Figure 7-18. Touchswitch Panel Replacement 7 - 37
Figure 7-19. Piezoelectric Alarm Replacement 7 - 39
Figure 7-20. Main Control Switch Shaft Assembly 7 - 42
Figure 7-21. Main Control Switch Shaft Assembly with Switch Housing Removed 7 - 42
Figure 7-22. Main Control Switch Shaft Assembly E-Ring Removal 7 - 43
Figure 9-1. Block Diagram, Series 4 9 - 3
Figure 9-2. Schematic, System Interconnect, Model 4P 9 - 5
Figure 9-3. Schematic, System Interconnect, Micro 4/MDL 4 9 - 9
Figure 9-4. Schematic, Interconnect, International, Micro 4/MDL 4 9 - 13
Figure 9-5. Schematic, Pressure Sensor PWA, Micro 4/Model 4 9 - 17
Figure 9-6. Schematic, Motherboard PWA, Series 4 9 - 21
Figure 9-7. Schematic, MPU PWA, Series 4 9 - 25
Figure 9-8. Schematic, MPU PWA, Micro 4/Model 4 9 - 29
Figure 9-9. Schematic, Motor Driver PWA, Micro 4/Model 4 9 - 31
Figure 9-10. Schematic, Motor Driver PWA, Series 4 9 - 33
Figure 9-11. Schematic, Display PWA, MDL 4 9 - 35
Figure 9-12. Schematic, Display PWA, Micro 4 9 - 39
Figure 9-13. Schematic, Display Driver PWA, Series 4 9 - 43
Figure 9-14. Schematic, Power Supply PWA, Micro 4/Model 4 9 - 45
Figure 9-15. Schematic, Current Boost Charger, MDL 4/PCA 9 - 65
Figure 9-16. IPB for the Pump 9 - 69

Tables

Table 1-1. Conventions	1 - 2
Table 1-2. Model 4 Series Case Types and I/O Capabilities	1 - 6
Table 1-3. Series Specific Features - Model 4 Series	1 - 7
Table 4-1. ACC. Connector J23 Pin Arrangement	4 - 4
Table 4-2. User Controls and Operating Modes	4 - 6
Table 4-3. ASK Function Messages	4 - 11
Table 4-4. I/O Address Table	4 - 24
Table 4-5. Numeric and Bar Displays	4 - 29
Table 5-1. Cleaning Solutions	5 - 2
Table 6-1. Alarm Codes	6 - 3
Table 6-2. Troubleshooting Audible Alarms	6 - 4
Table 6-3. Troubleshooting Fluid Flow	6 - 5
Table 6-4. Troubleshooting Battery Operations	6 - 9
Table 6-5. Troubleshooting Core Failures	6 - 11
Table 6-6. Troubleshooting the Pump Displays	6 - 12
Table 6-7. Troubleshooting External Controls	6 - 13
Table 6-8. Troubleshooting the Pump Touchswitches	6 - 13
Table 6-9. Troubleshooting the Pump Mechanism	6 - 13
Table 6-10. Troubleshooting the Dataway Function (RS-485 Only)	6 - 15
Table 6-11. Troubleshooting the Nurse-Call Alarm	6 - 16
Table 6-12. Troubleshooting Miscellaneous Conditions	6 - 16
Table 6-13. Troubleshooting with the PVT	6 - 18
Table 6-14. Test Connector (J23) Pin Assignments	6 - 19
Table 9-1. Drawings	9 - 1
Table 9-2. IPB for the Pump	9 - 89

Section 1

INTRODUCTION

LifeCare® and HomeCare® Model 4 Series Infusion Pumps, herein referred to as the pump, are identified by the following model designations:

- LifeCare Model 4
- LifeCare Model 4P
- LifeCare Micro
- HomeCare Model 4H

The LifeCare Model 4 is a baseline infusion pump. The LifeCare Model 4P is similar to the Model 4 except that Dual Rate™ automatic piggybacking is available on Model 4P. The LifeCare Micro features delivery rates from 0.1 to 99.9 milliliters per hour (ml/hr). The Model 4H version of the Model 4 has a limited delivery rate range for home care applications.

For details about the various pump configurations, refer to *Section 1.6, Series Specific Features*.

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

The material in this manual is limited to technical information necessary for battery testing, various service tests, interpreting system alarm and status messages, field adjustment procedures, troubleshooting, and authorized repairs on the pump.





Specific instructions for pump operation are provided in the LifeCare and HomeCare system operating manuals.

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

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, depending on the configuration of the pump system in use.

1.2 CONVENTIONS

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

Table 1-1. Conventions		
CONVENTION	APPLICATION	EXAMPLE
<i>Italic</i>	Reference to a section, figure, table, or publication	<i>(see Figure 5.1, Delivery Accuracy Test Setup)</i>
[ALL CAPS]	In-text references to keys are described in all caps and enclosed in brackets	[SILENCE]
ALL CAPS	Screen displays	CHK DOSE
Bold	Emphasis	CAUTION: Use proper ESD grounding techniques when handling components.
  	When a description or procedure is specific to a pump with a particular voltage rating, this is designated by an icon at the beginning of the section.	 To replace the fuse in a 115 volt pump, proceed as follows:

When a description or a procedure is specific to a particular series or version of the pump, the software version or final assembly dash number is shown in parentheses following the section heading.

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. It contains information that could prevent irreversible equipment damage or failure.

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

1.3

ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations used in this manual are as follows:

A	Ampere
ABS PRES	Absolute pressure
AC	Alternating current
ACC	Accessory
A/D	Analog-to-digital
ADC	Analog-to-digital converter
Ah	Ampere-hour
AS	Address strobe
CMOS	Complementary metal oxide semiconductor
dB	Decibel
DIF PRES	Differential pressure
DMM	Digital multimeter
DPM	Digital pressure meter
DS	Data strobe
DSPLN	Display enable
ECG	Electrocardiogram
EEG	Electroencephalogram
EMG	Electromyogram
EMI	Electromagnetic interference
ESD	Electrostatic discharge
ETO	Ethylene oxide
Hz	Hertz
IC	Integrated circuit

INIT	Initiate
I/O	Input/output
IOA	Input/output address
IOD	Input/output data
IPB	Illustrated parts breakdown
IRQ	Interrupt request
IV	Intravenous
kHz	Kilohertz
kPa	Kilopascal
KVO	Keep vein open
LED	Light emitting diode
LED CATH	LED cathode
LSB	Least significant bit
mA	Milliampere
MAL ALM CODE	Malfunction alarm code
MFULL	Message full
MHz	Megahertz
ml	Milliliter
ml/hr	Milliliter per hour
MPU	Microprocessor unit
ms	Millisecond
MSB	Most significant bit
mV	Millivolt
N/A	Not applicable
NC	Normally closed
NCALL	Nurse call
NO	Normally open
No.	Number
OKBATT	OK battery
P/N	Part number
psi	Pounds per square inch
psig	Pounds per square inch gauge
PVC	Polyvinyl chloride
PVT	Performance verification test
PWA	Printed wiring assembly
PWB	Printed wiring board
PWRCTL	Power control
PWR UP	Power up

RAM	Random access memory
ROM	Read only memory
RST	Reset
RTS	Request to send
SD	Serial Data
SFTWR REV	Software revision
SW	Switch
TRE	Transmit enable
UART	Universal asynchronous receiver/transmitter
V	Volt
VDC	Volt direct current
VMEM	Voltage memory
VMOT	Motor voltage requester
WDSTB	Watchdog strobe
μA	Microampere
μF	Microfarad
μs	Microsecond

1.4

USER QUALIFICATIONS

The Model 4 Series infusion pumps are for use at the direction or under the supervision of licensed physicians, and by licensed or certified healthcare professionals who are trained in the use of the pump and in the administration of intravenous (IV) fluids.

1.5

ARTIFACTS

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

1.6

SERIES SPECIFIC FEATURES

Features specific to the Model 4 Series infusion pumps are summarized in *Table 1-2, Model 4 Series Case Types and I/O Capabilities*, and *Table 1-3, Series Specific Features - Model 4 Series*.

Note: Case type A: One-piece case
Case type B: Clamshell case

When pumps with Type A cases are factory refurbished, they are refurbished with a Type B case.

Table 1-2. Model 4 Series Case Types and I/O Capabilities				
Model	List Numbers*	Final Assembly Number*	Case Type	I/O
Model 4	1814	850-01401-001	Type A	RS-232
	1914	850-01401-003 850-01614-001, -002, -003, -007, -009, -011	Type A	None
	1915	850-01401-004	Type A	RS-485
		850-01401-013, -015, -016, -018, -020, -022	Type B	RS-485
		850-01614-005, -006, -008, -010	Type A	RS-485
		850-01614-014 and above	Type B	RS-485
Model 4P	2505	850-01401-005, -007, -009	Type A	None
	2506	850-01401-006, -008, -010, -011	Type A	RS-485
		850-01401-014, -017, -021	Type B	RS-485
Micro	1815	850-01400-001	Type A	RS-232
	1916	850-01400-003 850-01627-001, -002, -009	Type A	None
	1917	850-01400-004	Type A	RS-485
		850-01400-006, -007, -008	Type B	RS-485
		850-01627-005, -006, 010	Type A	RS-485
		850-01627-015 and above	Type B	RS-485

Model	List Numbers*	Final Assembly Number*	Case Type	I/O
Model 4H	22100	850-01557-001	Type A	20 mA
	24000	850-01557-004	Type A	RS-485
		850-01557-006, -007, -008	Type B	RS-485

* List number and final assembly number are located on the rear of the pump.

Characteristic	Model 4 Series Infusion Pump			
	Model 4	Model 4P	Model 4 Micro	Model 4H
List numbers (see Table 1-2)	1814 1914 1915	2505 2506	1815 1916 1917	22100 24000
Piggyback pump set?	No	Yes	No	No
Set type switch?	No	No	Yes: Type A for 1/60 ml drops Type B for 1/15 ml drops	No
Flow alarms	Software version, below 232: FLOW KVO Software version 232 and above: HI FLOW LOW FLOW KVO	Software version 232 and above: HI FLOW LOW FLOW KVO	Software version, below 232: FLOW KVO Software version 232 and above: HI FLOW LOW FLOW KVO	Software version, below 232: FLOW KVO Software version 232 and above: HI FLOW LOW FLOW KVO
Flow detector required?	Optional	Optional	Yes	Optional
Pump cycle delivery characteristics:				
Number of drops falling in IV set drip chamber during filling stage	Approximately one 1/15 ml drop	Approximately one 1/15 ml drop	Approximately four 1/60 ml drops	Approximately one 1/15 ml drop
Average delivery increment during pumping stage	Not to exceed 5.6 µL	Not to exceed 5.6 µL	Not to exceed 2.8 µL	Not to exceed 5.6 µL

Table 1-3. Series Specific Features - Model 4 Series				
Characteristic	Model 4 Series Infusion Pump			
	Model 4	Model 4P	Model 4 Micro	Model 4H
KVO rate Note: Rate may be less if set delivery rate is lower	4 ml/hr	4 ml/hr	1 ml/hr	4 ml/hr
Flow monitoring: Operating angle from vertical Flow alarm monitoring	0° - 25° Number of drops minus number of pumping cycles is ≥ 5 with number of drops and number of cycles both set to zero whenever either reaches 12	0° - 25° Number of drops minus number of pumping cycles is ≥ 5 with number of drops and number of cycles both set to zero whenever either reaches 12	0° - 15° Type A: Number of drops divided by 4 minus number of pumping cycles is ≥ 5 with number of drops and number of cycles both set to zero whenever either reaches 12 Type B: Same as Model 4	0° - 25° Number of drops minus number of pumping cycles is ≥ 5 with number of drops and number of cycles both set to zero whenever either reaches 12

1.7

INSTRUMENT INSTALLATION PROCEDURE

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

CAUTION: Use of radio frequency emitting devices such as cellular telephones and two-way radios in close proximity of this device may affect its operation.

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

Note: Do not place the pump in service if the battery is not fully charged. To make certain the battery is fully charged, connect the pump to alternating current (AC) (mains) power for 24 hours.

1.7.1**UNPACKING**

Use care when unpacking the pump. Retain the packing slip and save all packing material for returning the pump to the factory in case it is damaged or fails the self test. The shipping container also contains a copy of the system operating manual.

1.7.2**INSPECTION**

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

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

1.7.3**SELF TEST**

Note: Do not place the pump in service until the self test has been conducted. To conduct the self test, proceed as follows:

1. Connect the power cord to a properly grounded AC (mains) outlet.
2. Connect the flow detector to the FLOW DET. receptacle on the back of the pump.
3. Set the AUD. ALM. switch on the back of the pump to the desired volume level: low, medium, or high.
4. Turn the main control switch to LOCK/ON.
5. The pump automatically enters the self-test mode and performs the following operations:
 - Initializes all data except history if the four-hour data retention interval has been reached
 - Tests random access memory (RAM) and read only memory (ROM)
 - Checks failure monitor test status
 - Illuminates all numeric elements, message display elements, and front panel legends
 - Activates audible alarm
 - Checks critical data integrity

If the pump fails the self test, do not place it in service; contact Abbott Laboratories (*see Section 6.1, Technical Assistance*).

This page intentionally left blank.

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.

This page intentionally left blank.

Section 3

SYSTEM OPERATING MANUAL

A copy of the *LifeCare and HomeCare Model 4 Series Infusion Pumps System Operating Manual* is included with every pump. For convenient reference, insert a copy of the appropriate system operating manual here.

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

This page intentionally left blank.

Section 4

THEORY OF OPERATION

This section describes the theory of operation for the Model 4 Series infusion pump. Related drawings are provided in *Section 9, Drawings*. The theory of operation describes general functions of the pump and provides a brief overview of external interface ports, operation, monitors and detectors, electronics subsystem principles of operation, and mechanical subsystem principles of operation.

Note: When a signal name is followed by an asterisk, such as INIT*, the asterisk indicates an active low signal.

4.1

GENERAL FUNCTIONS

The Model 4 Series infusion pump contains electromechanical drivers with a cassette housed positive displacement pump. The motor driver is housed with all the electrical and mechanical subassemblies used for operation and control of the pump. The subassemblies include printed wiring assemblies (PWA), the battery pack, the display panel, and the pump driver mechanism.

The pumping mechanism is stepper-motor driven to enable a simple control logic. The pumping volume is calculated as a function of the number of steps of the stepper motor (one motor revolution equals one pump stroke which equals displacement of 1/15 milliliter (ml) of fluid in a primed pump chamber).

The flow detector monitors fluid drops. The control logic compares the number of drops to the number of motor revolutions. When the number of drops exceeds the number of motor revolutions by more than four, or the number of motor revolutions exceeds the number of drops by more than four, a flow alarm is generated and the VOLUME DELIVERED light emitting diode (LED) display indicates the nature of the flow problem.

4.1.1

CASSETTE

The cassette is designed with an outlet valve that requires hydraulic pressure to operate. An air-trap chamber holds air bubbles or outgassing from solution. If too much air is trapped in the chamber, an air bubble may be carried through the cassette to the pumping chamber. The compressibility of the air bubble prevents the outlet valve from being forced open, resulting in no delivery of solution. This outlet valve feature prevents air from being pumped to the patient.

The cassette must be correctly primed. Incorrect cassette priming leaves air in the compression chamber or fails to clear sufficient air from the air trap, permitting the air to be carried into the compression chamber. In either case, if the flow detector is attached, pump operation stops and a flow/KVO alarm or low flow/KVO alarm sounds, depending on the model and version of the pump.

4.1.2

FLOW DETECTOR

The flow detector performs dual functions: it indicates there is fluid flow in the line, and provides a comparative value to the control logic so the pump can determine if the flow rate is correct. The flow detector is photoelectric. It is essential that the flow detector be clean, dry, and correctly mounted on the IV set drip chamber assembly. Flow alarms are often traced to dirty or improperly placed flow detectors.

Use of the flow detector is mandatory in some applications and optional in others (see *Table 1-3, Series Specific Features - Model 4 Series*).

4.1.3

ALARMS

The operational failures described throughout *Section 4* cause an alarm to sound. Alarm messages are displayed on the VOLUME DELIVERED display on the front panel of the pump.

4.1.3.1

AUDIBLE ALARM

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4*. The audible alarm is generated by the piezoelectric alarm transducer, located on the side of the clamp casting. The piezoelectric alarm transducer produces a 2.7 kilohertz (kHz) frequency after transistor Q6 is activated. Q6 is turned on by the signals TONE or reset (RST) to produce the piezoelectric alarm transducer signals AUDIO, AUDIO 2, and AUDIO 1. Q6 is turned off by interrupt request (IRQ) whenever the main control switch is in the LOAD/OFF RECHARGE position. The piezoelectric alarm transducer volume is controlled by the AUD. ALM. alarm level switch on the back of the pump.

4.1.3.2

NURSE-CALL ALARM

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4*. The nurse-call alarm is activated whenever the K1 nurse-call relay is de-energized while the master control switch is in the LOCK/ON position. K1 is controlled by signals nurse call (NCALL), RST, and initiate (INIT*). The purpose of INIT* is to drive K1 when the power is turned on. An actively high RST at pin 5 of U7B or an actively high NCALL at pin 6 of U7B while INIT* is low de-energizes the K1 nurse-call relay, causing an alarm.

4.1.4

NUMERIC AND BAR DISPLAYS

Refer to *Figure 9-11, Display PWA Schematic, MDL 4*, or *Figure 9-12, Display PWA Schematic, Micro 4*. There are four numeric displays used in the pump: DOSE LIMIT, DOSE DELIVERED, VOLUME DELIVERED, and DELIVERY RATE. Each display is a seven-segment, plus decimal, LED display. The LifeCare Micro LED display contains an

extra digit for displaying decimal points. Each LED display shares a common data bus to receive input/output data 0 (IOD0) through IOD7.

The bar display provides colored backlighting. The legends BATT (DS4) and LOW (DS5) are backlit by two LED bars, yellow and red, respectively, and contain two LEDs each. The legends REMOTE, OPERATING (Model 4 and 4H only), and PIGGYBACK (Model 4P only) are each backlit by a yellow bar containing four LEDs. The legend NO FLOW DET. contains four LEDs and is backlit by a red bar.

4.2

EXTERNAL INTERFACE PORTS

External interface ports on the Model 4 Series infusion pump are located on the back of the pump and are shown in *Figure 9-2, System Interconnect Schematic, Model 4P*; *Figure 9-3, System Interconnect Schematic, Micro 4/MDL 4*; and *Figure 9-4, Interconnect Schematic, Micro 4/MDL 4 (International)*. External interface ports include the following: accessory (ACC.) connector J23, nurse-call connector J21, and flow detector connector J22. Additionally, certain pump versions are equipped with an RS-485 Dataway input/output (I/O) connector J101, an RS-232 I/O port, or a 20-mA I/O port (*refer to Table 1-2, Model 4 Series Case Types and I/O Capabilities*). A description of Model 4 infusion pump external interface ports follows.

4.2.1

ACC. CONNECTOR J23

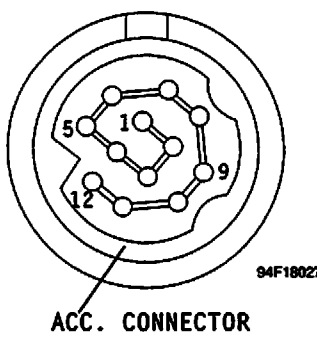
ACC. connector J23 is a 12-pin, male connector that provides access to 7 pins on the power supply PWA connector J16. The ACC. connector allows external monitoring and control of the pump. *Table 4-1, ACC. Connector J23 Pin Arrangement*, provides pin numbers, signal names, and descriptions.

The RATE 1* and RATE 2* signals are bidirectional and provide an external means for stopping and starting the pump. As outputs, RATE 1* and RATE 2* are low-going pulses that correspond with each incremental delivery step (32 per cycle) during the pumping stage. As inputs, when RATE 1* and RATE 2* are held below 0.5 volt direct current (VDC) pumping is inhibited. When only one of these rate signals is held below 0.5 VDC, the pump enters the failure mode.

The CYCLE* signal is transmitted at the completion of each pumping cycle.

The ALARM* signal goes low when the pump enters the alarm state or the failure mode.

Table 4-1. ACC. Connector J23 Pin Arrangement

Diagram	Pin	Signal Name	Description
	1	+5V	Digital +5 VDC supply
	2	AUDIO 2	Audible alarm signal
	5	GND	Digital ground
	6	BATTERY MONITOR	Battery monitor
	8	CYCLE*	Pulse transmitted at the completion of each pumping cycle
	9	RATE 1*	External bidirectional pump start and stop control
	10	RATE 2*	External bidirectional pump start and stop control
	11	DOSE COMPLETE*	Dose complete alarm signal
	12	ALARM*	Alarm signal

4.2.2

NURSE-CALL JACK J21

The nurse-call jack J21 is a standard, two-contact phone jack. A right angle phone plug is used to clear the drip shield on the pump. A switch closure activates the hospital nurse-call system when the pump is in an alarm state.

An alarm signal is sent from the pump when the nurse-call relay K1 on the power supply PWA is energized. Depending on the hospital nurse-call system software, a normally open (NO) or a normally closed (NC) switch configuration is required. The factory setting is NO. For NC operation, the power supply PWA must be returned to the factory for jumper reconnection. See *Section 4.1.3.2, Nurse-Call Alarm*, for more information.

4.2.3

FLOW DETECTOR CONNECTOR J22

The flow detector connector J22 is a 7-pin male connector that provides access to 4 pins on the power supply PWA connector J16. See *Section 4.4.1, Flow Monitoring System*, for more information.

4.2.4

RS-485 DATAWAY I/O CONNECTOR J101

Certain versions of the Model 4 Series infusion pump are equipped with an RS-485 Dataway I/O connector J101. See *Table 1-2, Model 4 Series Case Types and I/O Capabilities*, for a list of the Model 4 Series infusion pumps with RS-485 Dataway capability.

The RS 485 Dataway I/O connector is a bidirectional, serial data interface used to transmit and receive information between a maximum of 31 electrically connected pumps and an external host device such as a hospital patient data management system or a computerized nurse station console. Information such as status, alarm history, or malfunction codes can be obtained from the pump through the I/O port. Information such as rates or dose limits can be transmitted to the pump from the host device.

A universal asynchronous transmit/receive (UART) device, U1, is mounted on the motor driver PWA. For a detailed description of the operation of the Dataway UART, see *Section 4.5.2, Motor Driver PWA*, and *Section 4.5.2.4, RS-485 Dataway Port*.

To use the Dataway interface, the pump must be operating in the remote mode. The remote mode is accessed from the external device through the I/O interface. When in remote mode, a Dataway timer in the pump produces a Dataway alarm if one minute passes without a command to the pump. Each time the pump receives a reset Dataway timer command, or any other command from a remote device, the timer is reset. This function makes certain that continued interactive communications with the external device cannot be disabled. See *Section 4.3.1, Modes of Operation*, for additional information on local and remote operations.

Note: For detailed Dataway technical information, see the *Technical Specification Guide and Interface Manual, LifeCare Model 4 Series Infusion Pumps RS-485 Dataway, Manual number 430-01761-XXX*. This manual should be read before connecting the Dataway port to any external device.

4.2.5

RS-232 I/O PORT

This technical service manual does not support the RS-232 I/O port.

4.2.6

20-MA I/O PORT

This technical service manual does not support the 20-mA I/O port.

4.3

OPERATIONAL DESCRIPTION

This section describes the six modes of pump operation, the silence/ASK function, and the data retention function.

4.3.1

MODES OF OPERATION

The Model 4 Series infusion pump has six modes of operation as follows:

1. Load/Off recharge
2. Self test
3. Local control
4. Remote control
5. Battery discharged
6. System failure

Certain modes of operation are user controlled. Other modes of operation are controlled by the pump. See *Table 4-2, User Controls and Operating Modes*, for additional information.

Table 4-2. User Controls and Operating Modes								
User Control	Mode of Operation							
	Load/Off	Self Test	Local Control			Remote Control	Battery Discharged	System Failure
			Reset	Operate	Alarm			
LOAD/LOCK control	X	X	X	X	X	X	X	X
DELIVERY RATE set switch			X					
volume delivered CLEAR switch			X					
DOSE LIMIT set switch			D					
Dose LIMIT ON/OFF CLEAR switch			X					
START switch			X		R	X		
RESET switch				X	X	X		

Table 4-2. User Controls and Operating Modes								
User Control	Mode of Operation							
	Load/Off	Self Test	Local Control			Remote Control	Battery Discharged	System Failure
			Reset	Operate	Alarm			
SILENCE switch			X	X	X	X		
Audible level switch	X	X	X	X	X	X	X	X
Occlusion pressure selector switch	X	X	X	X	X	X	X	X
Set type switch (Micro only)	X	X	X	X	X	X	X	X

Note: X = active state; D = active only when dose control function is ON; R = active only during reset time-out alarm.

4.3.1.1

LOAD/OFF RECHARGE MODE

To enter the pump load/off recharge mode, turn the main control switch to LOAD/OFF RECHARGE. The following conditions occur when the pump is in the load/off recharge mode:

- Pump ceases operation
- Displays and legends are not illuminated
- Cassette clamps and plunger shroud are unlocked for cassette insertion or removal
- Mechanism pivot arm is raised to its highest position for cassette insertion or removal
- Nurse-call alarm is disabled
- Data is retained as specified in *Section 4.3.3, Data Retention Function*.

The following events occur when the pump is in the load/off recharge mode:

- Failure monitor is tested
- Current alarms and failure messages are cleared
- Dose limit is enabled or disabled
- Audible alarm is enabled or disabled
- Audible alarm is silenced
- Pump retains operating and history data for four hours (see *Section 4.3.3* for additional information)

4.3.1.2

SELF TEST MODE

To enter the pump self test mode, turn the main control switch to LOCK/ON. The pump performs the following operations in self test mode:

- All data except history data is initialized if the four-hour data retention interval has been reached
- RAM and ROM are tested
- Failure monitor test status is checked
- All numeric elements, message display elements, and front panel legends are illuminated
- Audible alarm is activated
- Critical data integrity is checked

If any self test fails, the pump enters the system failure mode and an error code is displayed. See *Table 6-1, Alarm Codes*, for a list of error codes and descriptions. If all tests are successful, the pump automatically enters the local control mode.

4.3.1.3

LOCAL CONTROL MODE

The pump enters the local control mode following a successful self test. In local control mode, front and rear panel touchswitches control pump operations (*see Table 4-2, User Controls and Operating Modes*).

If the pump has an RS-485 Databay I/O port connected to a remote host terminal, it transmits status messages and permits interrogation from the remote terminal. The pump does not permit remote control unless the remote host terminal transmits instruction code. When the code is transmitted, the REMOTE legend is illuminated on the pump.

Exit the local control mode by turning the main control switch to LOAD/OFF RECHARGE, or by sending a command from the remote host terminal (*see Section 4.2.4, RS-485 Databay I/O Connector J101*). Exit from the local control mode occurs automatically at system failure, or when a discharged battery is detected.

The local control mode has three activity states: reset, operating, and alarm.

The reset state is always the first state entered in the local control mode following a successful self test. The user can also switch the pump to the reset state at any time by pressing the [RESET] touchswitch.

Note: If the pump must be stopped during operation for any reason (alarm, change of dose, etc.), the user should press the [RESET] touchswitch first. [RESET] will save operating parameters and critical data stored in RAM that would otherwise be lost.

The following conditions occur in the reset state:

- The pumping mechanism is stopped and the cassette plunger is retracted
- The message panel displays two alternating messages: RESET and a number representing the volume delivered in milliliters. Each message is displayed for approximately 1.3 seconds

- The alarm sounds a beep once a minute
- If the reset state exceeds five minutes, the pump automatically enters the alarm state, flashes RESET, and sounds the alarm
- All alarms are prevented except the reset timer, cassette, and system failure alarms

The operating state is the normal pumping state during which the pump operates according to parameters set by the user. The operating state can be entered only from the reset state. The following conditions occur in the operating state:

- The pump mechanism drives the cassette at the delivery rate set by the user
- The user-set delivery rate is continuously indicated on the delivery rate display
- All front panel controls are inhibited except the [RESET] and [SILENCE] touchswitches and the main control switch. The audible level switch, the occlusion pressure select switch, and the set type switch (Micro only) on the back panel are active
- All alarm circuits are active

The alarm state is entered when an alarm condition is detected by the pump. Exit from the alarm state is accomplished by pressing the [RESET] touchswitch or by turning the main control switch to LOAD/OFF RECHARGE. The following conditions occur in the alarm state:

- The pumping mechanism can either drive the cassette at the keep vein open (KVO) rate, or it can be stopped, depending on the alarm type
- The delivery rate display flashes either the number representing the KVO rate or all zeros, as required by the alarm type
- If other alarm conditions occur before the existing condition is reset, the message display shows all alarms in sequence
- The nurse-call system signals that an alarm condition exists
- The alarm sounds a pattern
- The [SILENCE] touchswitch is activated so that the alarm can be silenced
- The message display shows either the appropriate alarm indication, or, when the [SILENCE] touchswitch is pressed, the appropriate response.

4.3.1.4

REMOTE CONTROL MODE

The remote control mode can be entered only from the local control mode and only on pump models equipped with the RS-485 Dataway I/O port. When the pump is in remote control, the REMOTE legend on the front panel is illuminated and only four front panel controls can be used: the main control switch, and the [RESET], [SILENCE], and [START] touchswitches. The [DOSE LIMIT], [DELIVERY RATE], [LIMIT ON/OFF/CLEAR], and [PIGGYBACK] touchswitches (4P only) are inactive in the remote control mode.

4.3.1.5

BATTERY DISCHARGED MODE

The battery discharged mode is entered automatically when the pump is operating on battery power and the battery pack becomes discharged to the point where proper operating

power can no longer be supplied. Battery discharged voltage is between +6.85 VDC and +7.15 VDC. During this mode of operation, the following conditions occur:

- Main power supply is shut off
- History data memory power is lost
- Pump is inoperable and all communications and control functions are suspended
- Alarm sounds a continuous tone
- Critical data required for continuing pump operation is erased

Exit from the battery discharged mode is accomplished by performing the following:

- Connect the pump to AC (mains) power or replace the battery pack.
- Turn the main control switch to **LOAD/OFF RECHARGE** and then to **LOCK/ON**. The pump automatically completes a self test following an exit from the battery discharged mode.

4.3.1.6

SYSTEM FAILURE MODE

The system failure mode is entered whenever the pump detects a malfunction in any of its mechanical or electrical elements. There are two states defined for this condition: the core failure state and the peripheral failure state.

Core failure state is entered when the failure monitor detects a permanent or long-duration failure in the microprocessor or core circuitry. The following conditions occur in the core failure state:

- Pump sounds a continuous alarm tone
- Pump operation stops
- Nurse-call system alarm is activated
- ASK function is inhibited
- Core failure error code is displayed (unless prevented by the failure)

Peripheral failure state is entered when the microprocessor detects one of the following conditions:

- Malfunction in the failure monitor circuitry
- Mechanical failure
- Failure in noncritical electric circuitry
- Short-duration, nonpermanent failure in the microprocessor
- Any control override by the failure monitor

In the peripheral failure state, the following conditions occur:

- Pump operation stops
- VOLUME DELIVERED** display flashes **MALFUNCT**
- Alarm sounds

- ❑ One or more of the failure codes shown in *Table 6-1, Alarm Codes*, appear on the VOLUME DELIVERED display when two touchswitches, [SILENCE] and [RESET], are pressed simultaneously

Exit from the system failure mode is accomplished by either of the following:

- ❑ Turn the main control switch to LOAD/OFF RECHARGE
- ❑ Pump automatically enters the battery discharged mode

4.3.2

SILENCE/ASK FUNCTION

The [SILENCE] touchswitch on the pump front panel performs one of two functions, depending on the state of the pump.

When the pump is in an alarm state, pressing the [SILENCE] touchswitch silences all alarms for one minute, except low battery, which is silenced for five minutes.

When the pump is in the local or remote control modes, pressing the [SILENCE] touchswitch alone or simultaneously with another touchswitch for at least 1.25 seconds causes the VOLUME DELIVERED display to display the messages listed in *Table 4-3, ASK Function Messages*. During an occlusion alarm, the message pertaining to the alarm is displayed continuously while the touchswitch is pressed, and the remaining applicable messages are displayed in sequence when the touchswitch is released.

Touchswitches	Condition	Messages
[SILENCE]	Power on	OCCLUSION PRESSURE SWITCH POSITION MAX PRES MID PRES MIN PRES
[SILENCE]	Power on (Micro only)	SET TYPE SWITCH TYPE A TYPE B
[SILENCE]	Occlusion alarm Absolute pressure	ABS PRES
	Differential pressure	DIF PRES
	Amplifier saturation	ABS PRES
[SILENCE][CLEAR]	Power on	SFTWR REV
[SILENCE][RESET]	Malfunction	MAL ALM CODE

Table 4-3. ASK Function Messages		
Touchswitches	Condition	Messages
[SILENCE][START]	Pump operating	NUMBER OF BITS 3 BITS = 1 psi (6.9 kPa)

4.3.3

DATA RETENTION FUNCTION

Critical operating data is automatically stored in memory for four hours when the [RESET] touchswitch is pressed and the main control switch is turned to LOAD/OFF RECHARGE. Critical data includes all data required to define the mode of operation, activity state, state of dose function, volume delivered, delivery rate, dose limit, dose delivered, and the state of any other features critical to pump operation. The memory hold time is restored by returning the main control switch to LOCK/ON. Critical data is erased when the four-hour period is exceeded, or when the pump is in either the battery discharged mode or the failure mode.

History data is held in nonvolatile memory and is not lost unless AC (mains) and battery power are lost, or the pump enters a malfunction state.

Once critical data has been erased, the memory values revert to default values when the pump is powered on again.

4.4

MONITORS AND DETECTORS

Monitors and detectors in the Model 4 Series infusion pump consist of the flow monitoring system, the pressure measuring system, and the malfunction detection circuitry. These systems and circuitry are described in the following sections.

4.4.1

FLOW MONITORING SYSTEM

Refer to *Figure 9-2, System Interconnect Schematic, Model 4P*; *Figure 9-3, System Interconnect Schematic, Micro 4/MDL 4*; or *Figure 9-4, Interconnect Schematic, Micro 4/MDL 4, International*. The flow monitoring system consists of a flow detector (drop sensor), the drop signal processor on the power supply PWA, and associated circuitry on the motor driver PWA.

The flow detector clips onto the drip chamber of the administration set and provides a voltage pulse through the J22 flow detector connector to the drop detector circuitry on the power supply PWA. The output of the drop detector circuitry on the power supply PWA is used as an input to the motor driver PWA, where it is converted to data for the system I/O data bus and used as input to the microprocessor on the microprocessor unit (MPU) PWA.

The flow monitoring system checks for a correspondence between the number of drops falling in the drip chamber and the number of pump cycles to detect fluid supply depletion or other flow interruptions.

In the Micro pump, the flow detector also checks which set type switch selection has been made. This selection may be read on the VOLUME DELIVERED display by holding the [SILENCE] touchswitch for more than 1.25 seconds.

Note: The flow detector is required for some versions of the Model 4 Series infusion pumps and is an optional accessory for others (see Table 1-3, *Series Specific Features - Model 4 Series*).

4.4.1.1

FLOW DETECTOR

Refer to *Figure 4-1, Flow Detector Schematic Diagram*. The flow detector optically senses drops falling within the drip chamber. The flow detector consists of three phototransistors, Q1 through Q3; two diodes, DS1 and DS2; and infrared and limited acceptance angle filters (not illustrated). All components of the flow detector reside within a polycarbonate housing that clips to the drip chamber.

Diodes DS1 and DS2 emit narrow beams of infrared light toward phototransistors Q1 through Q3. The resulting currents are summed at the output of the photo sensor printed wiring board (PWB) and represent the total infrared energy emitted from the diodes to the phototransistors. When a drop falls through the infrared beam, the total amount of infrared energy is reduced, resulting in a corresponding current reduction in the output signal, SNSR OUT, which is transferred to the drop signal processor (*refer to Section 4.4.1.2, Drop Signal Processor*).

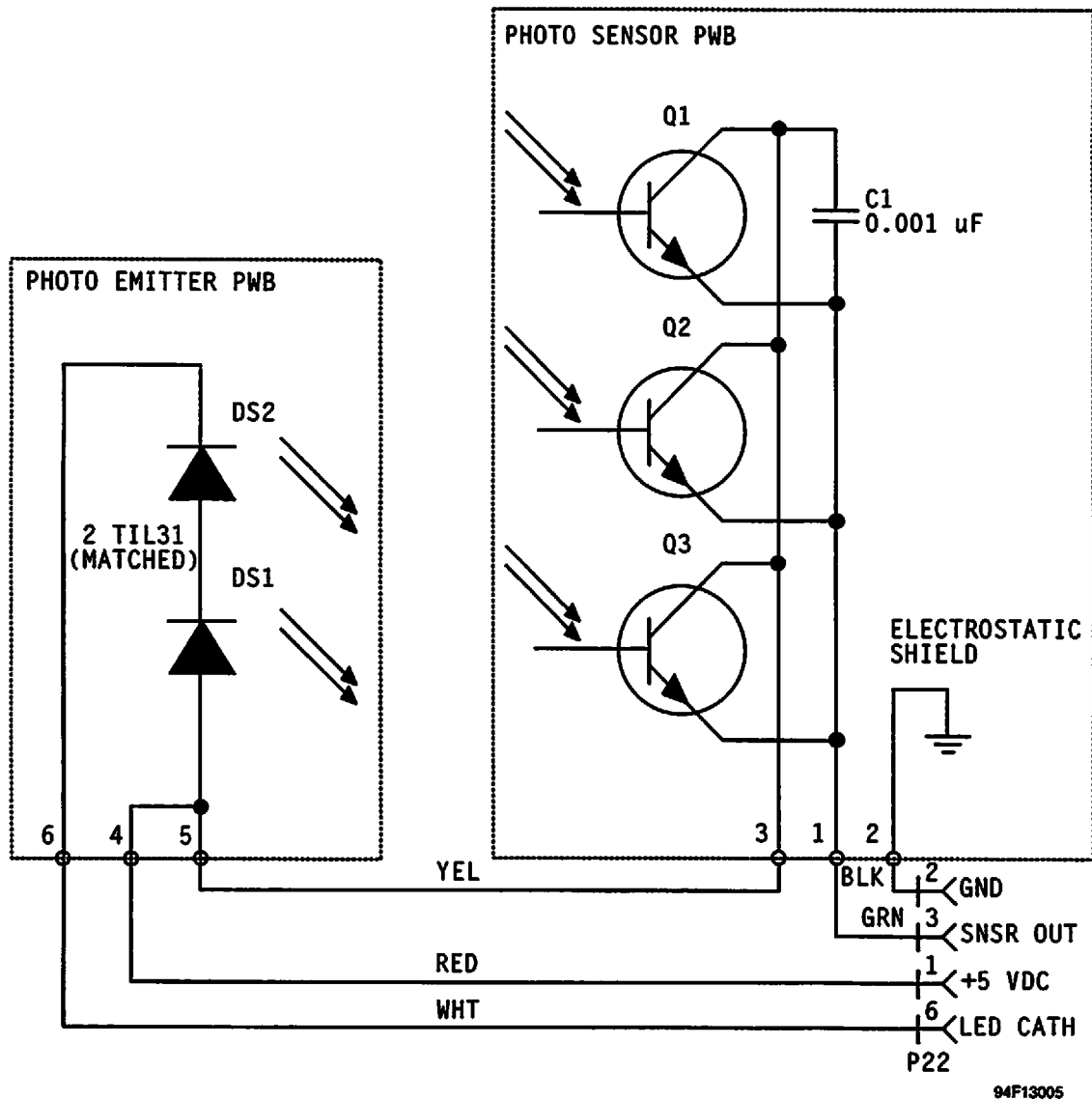


Figure 4-1. Flow Detector Schematic Diagram

4.4.1.2

DROP SIGNAL PROCESSOR

The drop signal processor accepts signals produced by drops falling in the drip chamber and rejects extraneous signals produced by external light sources, electromagnetic interference (EMI), splashes, and condensation on the walls of the drip chamber. The drop signal processor circuitry is resident on the power supply PWA and consists of the following components: current amplitude modulator, synchronous demodulator, and drop amplitude threshold detector.

4.4.1.3

CURRENT AMPLITUDE MODULATOR

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4*. The current amplitude modulator consists of U6D, and transistor Q3. The current amplitude modulator is driven by the 2.38 kHz clock signal, DSLDCK. DSLDCK is buffered by U6D prior to turning on

transistor Q3 without loading the clock line. The output of transistor Q3 is conditioned through resistor R12 prior to being transferred to the photo detector diodes DS1 and DS2 return line as the signal, LED CATH (refer to Figure 4-1, Flow Detector Schematic Diagram). LED CATH provides peak currents of approximately 100 milliamperes (mA) with a 25 percent duty cycle. When transistor Q3 is off, resistor R11 provides a low-level current for phototransistors Q1 through Q3 to reduce gain non linearity, which enhances the ability of the system to reject extraneous infrared light.

4.4.1.4

SYNCHRONOUS DEMODULATOR

Refer to Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4. The synchronous demodulator consists of a bandpass filter that includes capacitors C6 and C8, resistor R18, integrated circuit (IC) U3A, holding capacitor C3, and buffer amplifier U1A with its associated components. The synchronous demodulator is driven by the DSLDCK and DEMCLK clocks, which are both 2.38 kHz signals that differ in phase and duty cycle. DSLDCK has a 25 percent duty cycle while DEMCLK has a 12.5 percent duty cycle that is delayed by about 53 milliseconds (ms) with respect to DSLDCK. Whenever DSLDCK is active, flow detector diodes DS1 and DS2 are enabled and pin 4 of U3A is open (refer to Figure 4-1, Flow Detector Schematic Diagram). Whenever DEMCLK is active, pin 1 of U3A is closed. With this clock phasing, flow detector diodes DS1 and DS2 are turned on fully approximately 53 ms before the photo sensor PWA output at P22-3 (SNSR OUT) is sampled at pin 2 or pin 10 of U3A, allowing SNSR OUT to reach peak value before being stored in capacitor C3.

4.4.1.5

DROP AMPLITUDE THRESHOLD DETECTOR

Refer to Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4. The drop amplitude threshold detector provides pulse-width discrimination and consists of U1C, U1D, U6A, and associated components. The drop amplitude threshold detector rejects short-duration reflections and splashes and accepts signals with a duration above the threshold value of 80 millivolts (mV) that exceed 3 ms.

Resistors R1, R2, and R15 form a reference voltage divider for both the comparator U1C and the pulse-width discriminator U1D. Diode CR1, resistor R3, and capacitor C1 form an integrator whose output voltage must exceed 2.54 VDC (the reference voltage of U1D) for the signal to be accepted. Any signal that is less than or equal to the 2.54 VDC reference is rejected.

Upon acceptance of a signal, drop latch U6A outputs DROP to indicate to the microprocessor that a drop has been detected. The DROP line is sampled every 5 ms by the microprocessor. The microprocessor acknowledges DROP by issuing DRPAK* for approximately 128 ms. DRPAK* resets U6A. The 128 ms pulse width of DRPAK* prevents splashes from the main drop from setting U6A again and being counted as legitimate drops.

4.4.1.6

FLOW DETECTOR PRESENCE DETECTION

Refer to Figure 4-1, Flow Detector Schematic Diagram. The presence of the flow detector is detected by measuring the LED cathode (LED CATH) voltage level. If the flow detector is connected, then the voltage level of LED CATH equals +5 VDC minus the combined voltage

drop of DS1 and DS2. If the flow detector is not connected, then the voltage level of LED CATH is approximately 0 VDC.

The voltage level of LED CATH is measured by U3, the analog-to-digital (A/D) converter located on the motor driver PWA (refer to Figure 9-9, *Motor Driver PWA Schematic, Micro 4/Model 4* or Figure 9-10, *Motor Driver PWA Schematic, Series 4*). If the voltage level of LED CATH is greater than 1 VDC, then the flow detector is assumed to be present; if the voltage level of LED CATH is less than 1 VDC, then the flow detector is assumed to be absent.

4.4.1.7

FLOW ALGORITHM

The microprocessor U3 on the MPU PWA retains count of the number of pump cycles and the number of drops detected in the drip chamber. For Models 4, 4P, and 4H, the MPU expects one 1/15 ml drop per pump cycle. For the Micro, the number of drops expected depends upon the set type: set type A yields four drops per pump cycle (60 drops/ml); set type B yields one drop per pump cycle (15 drops/ml). If the set type switch is in the A position, the MPU divides the actual number of drops by four to ascertain an effective number of drops. For set type B, the effective number of drops equals the actual number of drops. The drop and cycle counters are reset to zero when either of the counters reaches a count of 12, or when the pump is stopped. If, during the count to 12, the number of drops exceeds the number of pump cycles by more than four, or if the number of pump cycles exceeds the number of drops by more than four, a flow alarm is generated. For high flow, the pump stops. For low flow, the pump cycles to the KVO preset minimum rate. For either flow condition, the alarm is sounded, and the message display indicates the nature of the flow alarm.

For the Micro, a flow alarm also occurs if the set type switch is in the A position and no drops are detected during any one pump cycle. In addition, the Micro microprocessor assures that the number of drops expected for the set type corresponds to the number of drops detected. The number of drops is counted during the first complete pump cycle after the [START] touchswitch has been pressed. For set type A, four drops are expected; a check cassette alarm is sounded if less than three drops are detected. For set type B, one drop is expected; an alarm is sounded if more than two drops are detected.

4.4.2

PRESSURE MEASURING SYSTEM

The pressure measuring system measures pressure within the cassette and distal tubing. The pressure measuring system consists of the pressure sensor PWA and the pressure sensor.

4.4.2.1

PRESSURE SENSOR PWA (-004 AND HIGHER)

The pressure sensor PWA measures the pressure within the cassette by sensing the strain in the cassette plunger arm. The strain is proportional to the force required to move the fluid through the cassette outlet valve, and therefore reflects the pressure in the distal tubing. Microprocessor U3 on the MPU PWA monitors both the absolute pressure and the differential pressure (difference between the pressure required to initiate delivery and pressures encountered during delivery). When the absolute differential pressure limit is exceeded, an occlusion alarm is generated and pump operation ceases.

Pressure sensing is accomplished with a full-bridge strain gauge mounted to a beam. The electrical resistance of the strain gauge is 350 ohms after activation by +5AN. The strain gauge connects to the pressure sensor PWA through a four-wire jacketed cable.

Refer to *Figure 9-5, Pressure Sensor PWA Schematic, Micro 4/Model 4 (Sheet 2)*. -STROUT and +STROUT, the full-bridge strain gauge outputs, are transferred to the pressure sensor PWA stable amplifier, U1. Capacitors C1 and C2 filter high frequency noise. Resistors R3 and R1 balance -STROUT and +STROUT prior to input at U1, pins 13 and 5, respectively. Resistor R2 sets the gain and, in combination with capacitor C8, rolls the bandwidth at 7 hertz (Hz) for noise suppression. Resistors R5 and R6 attenuate the PRESSURE_SIGNAL output to the desired level. The PRESSURE_SIGNAL output is directed to a two-pole pressure filter on the power supply PWA. Capacitors C4 and C5 are part of the sample and hold circuitry for stable amplifier, U1. Resistor R4 and capacitor C3 are part of the differential output.

4.4.2.2

PRESSURE SENSOR PWA (-003 AND LOWER)

The pressure measuring system uses a dual element, 90 degree, strain gauge rosette mounted on a beam attached to the end of the cassette plunger pivot arm and components of the pressure sensor PWA. The strain gauge rosette and components of the pressure sensor PWA form an active half of the bridge circuit. The strain gauge RM is aligned along the cassette pivot arm and senses the strain due to pivot arm flexure. Resistor R90 provides temperature compensation.

Refer to *Figure 9-5, Pressure Sensor PWA Schematic, Micro 4/Model 4 (Sheet 1)*. Amplifiers U1 and U2 and associated components residing on the pressure sensor PWA form a high gain, chopper-stabilized amplifier for the low-level signal generated by the strain gauge. Resistor R4 provides offset adjustment and resistor R5 controls sensitivity adjustment. The output of the pressure sensor PWA is transferred to U12B on the power supply PWA. U12B and associated components form a low-pass pressure filter that provides additional amplification for the pressure signal before it is applied to the motor driver PWA A/D converter. U1 on the pressure sensor PWA requires -5 VDC as well as +5 VDC. The -5 VDC is supplied to U1 by U4 on the power supply PWA.

4.4.2.3

OCCLUSION ALARM ALGORITHM

Pressure is measured by taking the difference between the strain at the bottom of the pump stroke and the strain at the top of the pump stroke (that is, at the beginning and at the end of the intake phase of the pump cycle). The difference is due to the passive stretch of the rubber diaphragm as the plunger moves up and down, and the force caused by

backpressure. The difference is displayed in bits (approximately three bits per pound per square inch gauge (psig)) in the VOLUME DELIVERED display if the [START] and [SILENCE] touchswitches are pressed simultaneously while the pump is operating. The nominal value for the difference is 62 bits at 0.0 psig (due only to the passive diaphragm stretch and cassette outlet valve opening pressure) and is subtracted from the amplifier output to give the absolute pressure reading. The reading has a great deal of variability due to cassette and mechanism differences, resulting in an overall tolerance of ± 5 psig (34.5 kilopascals (kPa)) for absolute pressure readings.

The pressure measured during the second intake phase after the [START] touchswitch has been pressed is stored as the reference pressure. This reference pressure is subtracted from the pressures measured during the third and subsequent pump cycles to give the differential pressure.

The differential pressure limit is selected by the occlusion pressure switch located on the back panel. The setting may be read from the VOLUME DELIVERED display by pressing the [SILENCE] touchswitch for longer than 1.25 seconds. MAX pressure sets the differential pressure limit to 12 ± 4 psig (82.8 ± 27.6 kPa), MID pressure sets it to 8 ± 3 psig (55.2 ± 20.7 kPa), and MIN pressure is 4 ± 2 psig (27.6 ± 13.8 kPa). If the differential pressure is greater than the limit set by the occlusion pressure switch, or if the measured pressure is greater than 15 ± 5 psig (103.5 ± 34.5 kPa), an OCCLUSION message will be displayed and an occlusion alarm will result. The type of occlusion alarm (absolute or differential pressure) can be called up to the message display by pressing the [SILENCE] touchswitch for more than 1.25 seconds.

An absolute occlusion alarm occurs if the pressure amplifier output remains less than 0.175 VDC or greater than 4.4 VDC either when the main control switch is turned to LOCK/ON, or during pumping.

4.4.3

MALFUNCTION DETECTION CIRCUITRY

The malfunction detection circuitry detects hardware malfunctions at any one of three stages of pump activity: during the self test when the main control switch is rotated to LOCK/ON or LOAD/OFF RECHARGE, and during normal operation.

Alarm and failure codes are listed in *Table 6-1, Alarm Codes*. These codes are called up by pressing the [SILENCE] and [RESET] touchswitches simultaneously while the malfunction alarm is sounding. Alarm and failure codes are also stored in the external RAM for use with the RS-485 Dataway I/O port.

4.4.3.1

INTERNAL RAM TEST

When the main control switch is turned to LOCK/ON, every byte in the microprocessor RAM is exercised by writing a checkerboard pattern to all bits, reading it back, then writing and reading the inverse of that pattern to verify that every bit is fully functional. If any bit is found to be defective, a malfunction alarm occurs.

 4.4.3.2

ROM TEST

After the RAM test, a complex mathematical checksum is generated using all ROM bytes, and compared against a checksum stored in ROM. If the calculated and stored checksums do not match, the ROM is defective, and a malfunction alarm occurs.

 4.4.3.3

POWER-UP TEST

Refer to *Figure 9-7, MPU PWA Schematic, Series 4* or *Figure 9-8, MPU PWA Schematic, Micro 4/Model 4*. Resistor R2 and capacitor C8 form the power-up (PWR UP) detector signal which is read at pin 4 of microprocessor buffer U8. The PWR UP line is tested immediately after pump initialization to distinguish between a cold powerup and a restart during the four-hour data retention period. If the PWR UP line is low, U8 initializes all critical data (e.g., sets the delivery rate, turns the dose limit off, etc.). If the PWR UP line is high, the critical data is left as is. Following the external RAM test, the PWR UP line is tested again; if it is still low, a malfunction alarm occurs.

 4.4.3.4

HARDWARE WATCHDOG

The hardware watchdog on the display driver PWA monitors the functionality of the microprocessor by comparing a 25-Hz signal generated by the main program with a 24.4 Hz fixed frequency signal derived from the reference oscillator Y1. If the two frequencies are significantly different, the hardware watchdog sounds a continuous tone, sets the nurse-call relay, and attempts to restart the microprocessor.

Refer to *Figure 9-13, Display Driver PWA Schematic, Series 4*. In performing the frequency comparison, the four-bit binary counter U16 receives the 24.4-Hz signal at pin 1 and the 25-Hz main program signal watchdog strobe (WDSTB) at pin 9. When either counter A (the 24.4-Hz signal) or counter B (WDSTB) reaches the count of 12, its respective output (counter A equals Q3A and Q4A; counter B equals Q3B and Q4B) is high; causing the output at U15 to go low, and allowing the output of U17D to go high and clock U18B. If one counter (either counter A or counter B) has reached at least the count of 8 by the time the other counter reaches the count of 12, its respective Q4 output will be high. Since both inputs of U17B are high, its output is low. Clocking the J-K flip-flop U18B while both the J and K inputs are low produces no change in the state, and the flip-flop remains reset. The output of U17D not only clocks the flip-flop, but also clears the U16 counter to restart the process.

If one counter (either counter A or counter B) has not reached at least the count of 8 by the time the other counter reaches the count of 12, its respective Q4 output will be low, resulting in the output of U17B being high and setting the J-K flip-flop U18B to cause the reset (RST) line to go high and the RST line to go low. This resets the microprocessor through capacitor C10, keeps the motor power supply disabled to prevent further pumping, sounds the alarm tone continuously, and activates the nurse-call alarm. The microprocessor monitors the RST line through the I/O input buffer U8 and flashes the MALFUNCTION message if the RST line is found to be high. The U18B flip-flop remains in the set state until it is reset by an INIT pulse generated by turning the main control switch from LOAD/OFF RECHARGE to LOCK/ON. This process assures that the reference oscillator is operating properly, the microprocessor is successfully passing the sanity check and is operating at the proper rate, and if either fails, the motor will be disabled.

4.4.3.5

HARDWARE WATCHDOG TEST

Refer to *Figure 9-13, Display Driver PWA Schematic, Series 4*. The hardware watchdog is tested each time the main control switch is turned to LOAD/OFF RECHARGE. Two tests are performed, one each time the pump is turned off. During the first test, WDSTB is toggled to cause a hardware watchdog malfunction, which results in the setting of U18B on the display driver PWA and subsequent resetting of the microprocessor. After 2.5 seconds, the microprocessor checks to see that the RST line has been set high; if not, the malfunction is stored and displayed the next time the pump is activated, as long as the data retention period (four hours) has not elapsed. If the high frequency test is passed, the next time the pump is turned off, WDSTB is held low long enough to cause a hardware watchdog malfunction. Again, the microprocessor monitors the RST line and stores a malfunction if the line is low. The third time the pump is turned off, the microprocessor performs no test, but prepares to repeat the cycle the next time it is turned off.

4.4.3.6

SOFTWARE WATCHDOG

If the microprocessor successfully passes the hardware watchdog test and strobesc the hardware watchdog at the proper rate, but a software malfunction causes the motor to pump at an incorrect rate, the software watchdog detects the condition. The software watchdog is an independent subroutine, and is not affected by the presence or absence of the motor flag. The software watchdog also performs calculations on the rate information from RAM and predicts the passage of the motor flag. If the predicted number of flag passages differs from the detected occurrences by more than 20 percent, a malfunction alarm sounds.

4.4.3.7

MICROPROCESSOR SANITY CHECK

The microprocessor sanity check consists of a set of instructions with known inputs and outputs that the microprocessor must perform without error every 25 ms. The microprocessor sanity check includes many of the commonly used instructions, the accumulator and index register, and RAM locations. If the sanity check is passed, there is reasonable certainty that the microprocessor is functional, and WDSTB is sent. If the test is not passed, WDSTB is not sent, causing a hardware watchdog malfunction. In this malfunction condition a continuous tone sounds, the motor power supply is shut down, and the nurse-call alarm sounds.

4.5

ELECTRONICS SUBSYSTEM PRINCIPLES OF OPERATION

The electronics subsystem of the Model 4 Series infusion pump performs the following major functions:

- Controls delivery rate as set by the front panel controls

- Provides dose limit capability
- Processes signals from the flow detector and the pressure sensor
- Displays rate, dose, volume, alarm, and status information
- Provides audible indication of any alarm or malfunction condition
- Allows capability to use the hospital nurse-call system as an alarm indicator
- Furnishes communications between pump and host computer or terminal for remote monitoring and/or control of pump operation if the pump is equipped with a Dataway I/O port
- Provides internal monitors and self-checking functions to monitor pump performance and safety

The electronics subsystem of the Model 4 Series infusion pump consists of the following PWAs and associated interconnect cabling:

- MPU PWA
- Motor driver PWA
- Display PWA
- Display driver PWA
- Power supply PWA
- Pressure sensor PWA
- Motherboard PWA
- Current boost charger PWA

The operation of the pressure sensor PWA is described in *Section 4.4.2.1, Pressure Sensor PWA (-004 and Higher)*, and *Section 4.4.2.2, Pressure Sensor PWA (-003 and Lower)*. Since the motherboard PWA has no active components, it is not covered in the principles of operation (see *Figure 9-6, Motherboard PWA Schematic, Series 4*). In addition, some functions of the power supply PWA are described in *Section 4.4, Monitors and Detectors*, since they are an integral part of the monitoring and detection functions of the pump. The principles of operation for the remainder of the PWAs, as well as the control switches and the alarm circuitry, follow.

4.5.1

MPU PWA

Refer to *Figure 9-7, MPU PWA Schematic, Series 4* or *Figure 9-8, MPU PWA Schematic, Micro 4/Model 4*. The MPU PWA provides microprocessor control for the pump. Through microprocessor circuitry control, the MPU PWA exchanges data, control, and status with pump components through connector P5. In addition to the microprocessor circuitry, the MPU PWA consists of memory circuitry, memory latch circuitry, memory protector circuitry, and I/O ports.

4.5.1.1

MICROPROCESSOR CIRCUITRY

Refer to *Figure 9-7, MPU PWA Schematic, Series 4* or *Figure 9-8, MPU PWA Schematic, Micro 4/Model 4*. The microprocessor circuitry consists of microprocessor U3 and oscillator Y1. Microprocessor U3 is a complementary metal oxide semiconductor (CMOS)

IC that provides central processing for the pump. U3 contains 112 bytes of RAM, two 8-bit bidirectional ports (PA0 through PA07 and PB0 through PB07), a multiplexed address data bus (B0 through B7), an address bus (A8 through A12), a timer, and oscillator Y1.

Oscillator Y1 consists of the 5 megahertz (MHz) crystal Y2, resistor R1, and capacitors C3 and C4. Y1 is internally divided by five to provide a 1 MHz system frequency.

4.5.1.2

MEMORY CIRCUITRY

Refer to *Figure 9-7, MPU PWA Schematic, Series 4* or *Figure 9-8, MPU PWA Schematic, Micro 4/Model 4*. The memory circuitry consists of RAM U5 and ROM U9. RAM U5 is a 2K X 8 IC. U5 is mapped into memory addresses 0₍₁₆₎ to 3FF₍₁₆₎ by IC U11A. U5 is powered by the voltage memory (VMEM) signal. VMEM is a 5 VDC signal during normal pump operation. After the four hour memory retention period has passed and system power is disabled by the MCU PWA, VMEM remains active at approximately 2.3 VDC as long as the batteries remain charged or AC (mains) power is available. The uninterrupted activity of VMEM provides non-volatile retention of alarm and malfunction codes.

ROM U9 is an 8K x 8 IC. U9 is mapped into memory addresses from 400₍₁₆₎ to 1FFF₍₁₆₎ by U2A and U1A.

4.5.1.3

MEMORY LATCH CIRCUITRY

Memory latch is provided by IC U4. Microprocessor U3 has a multiplexed address-then-data bus configuration. During a microprocessor read or write cycle from RAM or ROM, the low order address byte appears on the microprocessor bus as B0 through B7, and the address strobe (AS) line (U3-6) goes low to latch the B0 through B7 address byte into memory latch U4. Since the high order address bits (A8 through A12) are not multiplexed, the complete memory address is available in parallel. The microprocessor bus is then prepared for the read or write operation. When the DS line goes high, the RAM or ROM is enabled, depending on the address decoding by ICs U2A, U1A, and U11A.

4.5.1.4

MEMORY PROTECTOR CIRCUITRY

Memory protector circuitry is provided by ICs U11B and U11C (also U2C and U2D for non-I/O pumps). U11B and U11C prevent the U5 RAM from accepting data during microprocessor powerup and powerdown. During powerup, PWR UP is low, forcing the RAM CS line (U5-18) high through ICs U11C and U11B, and preventing any data transfer to the RAM. At the initiation of powerdown, REGON goes low, holding CS high as the 5 VDC power decays and the microcomputer shuts down.

4.5.1.5

I/O PORTS

Communication between the MPU PWA and the pump is provided through two eight-bit I/O ports: the interrupt request (IRQ*) line, and the reset (RST) line. Since many of the system components with which the MPU PWA must communicate cannot do so at the

1 MHz microprocessor frequency, separate I/O busses for address and data are provided through the two eight-bit ports.

The port B lines are designated input/output data (IOD) 0 through IOD7. IOD0 through IOD7 are configured as an eight-bit, bidirectional I/O data bus.

The port A lines are designated input/output address (IOA) 0 through IOA5 and are configured for output only. IOA0 through IOA3 form the I/O address bus. IOA4 is unused and IOA5 enables the microprocessor address decoder. WDSTB is the microprocessor strobe to the hardware watchdog. The IRQ* line is used to sense the position of the main control switch and the RST line is used by the hardware watchdog to reset the microprocessor.

4.5.2

MOTOR DRIVER PWA

Refer to *Figure 9-9, Motor Driver PWA Schematic, Micro 4/Model 4* or *Figure 9-10, Motor Driver PWA Schematic, Series 4*. The motor driver PWA consists of the I/O address decoder, an A/D converter, and a UART which is only used if the pump is equipped with an RS-485 Dataway port. For I/O addresses, see *Table 4-4, I/O Address Table*.

Table 4-4. I/O Address Table		
Address	Device	
00	LED bars and numeric digital display drivers	
	SHIFT REGISTER LOCATIONS:	
	0-1 LED bars:	BIT LEGEND
		0-1 Flow detector inoperative
		2 Battery operation
		3 Low (battery)
		4-5 Piggyback (Model 4P)
		4-5 Operating (other models)
		6-7 Remote control
	For numeric displays below:	BIT SEGMENT
		0 a
		1 b
		2 c
		3 d
		4 e
	5 f	
	6 g	
	7 Decimal point	
	ADULT MICRO	
2 RATE, left most digit	100	10
3 next digit	10	1
4 next digit	1	0.1
5 DOSE, left most digit	1000	100
6 next digit	100	10
7 next digit	10	1
8 next digit	1	0.1
9 DOSE LIMIT, left most digit	1000	100
10 next digit	100	10
11 next digit	10	1
12 next digit	1	0.1
13 RATE	----	dP
14 DOSE	----	dP
15	----	dP
01	Messages/volume-delivered display and shift register clock	
	Bits 0-5	ASCII Code
	Bits 6-7	Unused
02	A/D converter multiplexer	
	Bits 0-4	unused
	5	A/D converter multiplexer least significant bit (LSB)
	6	A/D converter multiplexer
	7	A/D converter multiplexer most significant bit (MSB)
	Addr 0	(0000000) Pressure amplifier
	1	(0010000) Battery voltage / 2
	2	(0100000) Drop sensor LED anode
	3	(0110000) Pressure select
	4	(1000000) Segment check voltage
5	(1010000) Digit check voltage	
6	(1100000) +2.5 V reference	
7	(1110000) +5 V analog supply	

Table 4-4. I/O Address Table	
Address	Device
03	Motor winding energizer Bits 0-3 Phasing (1=winding energized)
04	Miscellaneous outputs (active high unless noted) Bits 0 Drop sensor LED control (0=on) 1 Nurse-call (1=on) 2 Message display clear (0=clear) 3 Power supply control (1=on) 4 Motor/cassette interrupter LED control (0=on) 5 RTS flag (SIO port) (Model 4P only) 5 Pressure sensor Pk det. reset (1=reset) 6 Audible tone control (1=on) 7 Accessory port rate bit 1
05	Miscellaneous outputs Bits 0 Accessory port stroke 1 Accessory port rate bit 2 2 Accessory port dose (0=limit reached) 3 Accessory port dose (0=limit reached) 4 I/O A1 signal 400 kHz enable (0=enabled) 5 Motor voltage off (0=limit reached) 6 Drop acknowledge bit (0=acknowledge) 7 (Reserved for shift register input)
06	Keyboard buffer number 1 (1=key pressed) Bits 0 Increase rate 1 Decrease rate 2 Clear volume 3 Silence 4 Reset 5 Dose limit on/off/clear 6 Increase dose limit 7 Decrease dose limit
07	Miscellaneous inputs, 1st buffer Bits 0 Start switch 1 Power up 2 Drop-sensed signal 3 Motor flag (interrupter) signal 4 Watchdog reset signal 5 Accessory port stop bit 1 6 Micro cassette interrupter signal 7 Message-display-full signal

Table 4-4. I/O Address Table	
Address	Device
08	Miscellaneous inputs, 2nd buffer Bits 0 Digit driver shift register output bit 1 Accessory port stop bit 2 2 UART transmit buffer empty 3 UART reset bit 4 Set type 0=Set type A (60 drops/ml) 1=Set type B (15 drops/ml) 5 Mode switch ([PIGGYBACK] touchswitch on front panel) (Model 4P only) 6-7 Unused (Model 4P only) 5-7 Unused (All other Models)
09	A/D converter output
10	UART status bits Bits 0 Date received (DR) 1 Parity error (PE) 2 Framing error (FE) 3 Overflow error (OE) 4 Transmitter ready (TRE) 5 Transmitter buffer ready (TBRE) 6-7 Unused
11-15	Unused (Model 4P only)
11	UART receive character
12	UART transmit character
13	Display checking multiplexer Bit 0-2 segment driver check Bit 3 unused Bit 4-7 digit driver check
14	Unused
15	Unused

4.5.2.1

I/O ADDRESS DECODER

Refer to *Figure 9-9, Motor Driver PWA Schematic, Micro 4/Model 4* or *Figure 9-10, Motor Driver PWA Schematic, Series 4*. The motor driver PWA contains the I/O address decoder, which consists of ICs U8, U9, and U10. These address decoders receive the five address lines IOA0, IOA1, IOA2, IOA3, and IOA5 from the microprocessor, U3, on the MPU PWA. The four I/O address lines IOA0 through IOA3 define one of 16 possible I/O devices. All addresses are disabled unless IOA5 is active (low). Each address decoded by U8, U9, and U10 corresponds to one external device with which the I/O data bus communicates. These devices, listed in *Table 4-4, I/O Address Table*, include the front panel displays and

keyboard, the A/D converter and multiplexer, UART status, three transmit and receive buffers, and miscellaneous input buffers and output latches.

4.5.2.2

INPUT DATA BUFFERS

Refer to *Figure 9-9, Motor Driver PWA Schematic, Micro 4/Model 4* or *Figure 9-10, Motor Driver PWA Schematic, Series 4*. Data buffer U7 is enabled when A8* is active low. Data buffer U8 is reset at powerup and is gated by A7*. U7 and U8 input data from the power supply PWA, the display driver PWA, the motor driver PWA, and the front panel. This data is placed on the eight-bit I/O data bus (IOD0-IOD7) and transmitted to the MPU PWA microprocessor, U3, and off-board to the motor driver PWA.

4.5.2.3

A/D CONVERTER

Refer to *Figure 9-9, Motor Driver PWA Schematic, Micro 4/Model 4* or *Figure 9-10, Motor Driver PWA Schematic, Series 4*. The A/D converter, U3 or U5 on the motor driver PWA, is an eight channel, multiplexed-input, eight-bit binary output converter. The A/D converter is clocked by a 400 kHz signal generated on the display driver PWA by U4 and associated circuitry. The eight-bit output is connected to the MPU PWA through the eight-bit bidirectional I/O data bus. Input channel selection is controlled by the address generated by the three most significant bits of the I/O address bus. Conversion timing is controlled by address A2, and output enable is controlled by address A9. The eight input channels follow:

1. Channel 0 measures pressure.
2. Channel 1 monitors the unregulated DC power supply voltage to determine if the pump is operating on battery pack and if the battery pack is low.
3. Channel 2 determines if a flow detector is connected.
4. Channel 3 monitors the setting of the occlusion pressure select switch.
5. Channel 4 measures the LED anode voltages of the numeric and bar displays.
6. Channel 5 measures the LED cathode voltages of the numeric and bar displays.
7. Channel 6 monitors the power supply reference voltage (2.5 VDC nominal).
8. Channel 7 monitors the +5 VDC reference supply.

The A/D converter uses the +5 REF line as the reference voltage from which all inputs are scaled. For example, using an input voltage of 2.5 VDC: $2.5 \text{ VDC} / 5 \times 256 = 128$. Thus, the converted output is expressed as 10000000(2).

4.5.2.4

RS-485 DATAWAY PORT

On versions of the Model 4 Series infusion pump that have an RS-485 Dataway port, the motor driver PWA has an interface with the RS-485 Dataway port through J101 (see *Table 1-3, Series Specific Features - Model 4 Series*). This I/O function utilizes the UART U2 for RS-485 receive/transmit functions during remote operation from a host computer. On versions of the Model 4 Series infusion pump that do not have an RS-485 Dataway port, the UART device on the motor driver PWA is designated U1 and is configured for serial

data receive/transmit functions through the power supply PWA. These functions are not supported by software.

The RS-485 station ID bits (address bits 0-5 and the device address parity bit) input to buffer U4. This buffer places data representing the address bits on the I/O data bus when address 15* (the output of U10, pin 9) is active low. These data outputs are then latched into U3 when address 14 (address 14* output of U10, pin 10, inverted by U15) is active high. When enabled, U3 provides a data output to U2 which is an eight-stage downconverter. This downconverter translates the status of the station ID bits to determine the baud rate input to the UART U1.

The RS-485 request to send (RTS) lines (RTSA and RTSB) are connected to U12, which is a high-speed differential tri-state bus/line transceiver. This device is controlled by the RTSCTL signal, which is applied to the DI input of U12 from output O5 (pin 15) of the output latch U6. The inputs to U6 are the I/O data bus bits 0-7 from the microprocessor on the MPU PWA, thus effecting microprocessor control of U12 by means of the RTSCTL signal. The operation of U12 is such that the RSTA and RSTB outputs of this device are only active when the pump is in a transmitting mode as instructed by the host computer. When RTSCTL is high, the RTSB line is active high; when RTSCTL is low, the RSTA line is active high.

The RS-485 serial data lines (SDA and SDB) are connected to U13, which is functionally identical to U12, but with a different external configuration. When commanded by software, the UART U1 transmits serial data to the RS-485 Dataway port via the TRO3 output (pin 25) of the UART, or receives serial data from the RS-485 Dataway port via the RRI input (pin 20) of the UART. The TRO signal is connected to the DI input to U13 and the RRI signal is connected to the RO output of U13.

The operation of U13 is controlled by the ECTRE signal from the transmit enable (TRE) output of U1 (pin 24) which is inverted by U15. ECTRE is also sent to the data buffer, U7, on the MPU PWA to serve as a data input to the microprocessor. The state of ECTRE determines whether U13 is functioning as a serial data transmitting/receiving device on the SDA line or on the SDB line.

4.5.3

DISPLAY PWA

Refer to *Figure 9-11, Display PWA Schematic, MDL 4* or *Figure 9-12, Display PWA Schematic, Micro 4*. The display PWA contains an eight-character alphanumeric display, three numeric displays, and LED bars. The alphanumeric display is for messages. The three numeric displays are for delivery rate, dose limit, and dose delivered. The LED bars, as shown in *Table 4-5, Numeric and Bar Displays*, are for backlighting the legends PIGGYBACK (Model 4P only), BATT, LOW, NO FLOW DET, and REMOTE (Dataway option only).

The alphanumeric message display (DS2) consists of 16-segment LED characters driven by the decoder/driver U1. The decoder/driver, used in the serial access mode, accepts the ASCII code for one of the eight characters from the I/O data bus each time the I/O address line A1 is toggled. The decoder/driver stores these characters in an internal RAM, decodes them, then drives the eight 16-segment displays at a 400 Hz rate. The MFULL line indicates that the eighth character has been written. If this line does not go high, the microprocessor sets a malfunction alarm to assure that all characters have been received. The MCLR line is toggled before the display is updated (every 40 ms) to clear the display and reset the character address to zero.

The numeric and bar displays are driven by segment drivers U2/U3/U4 on the display PWA and by digit drivers U7/U3 on the display driver PWA. All displays are refreshed by the microprocessor every 5 ms.

The segment drivers found on the display PWA consist of eight-bit latch U4, drive transistors U2/U3, and current-limiting resistors RN6/RN7. The drive for the bars and for the seven-segment displays is decoded by the microprocessor and is written to latch U4, which is clocked by the display enable line DSPLN* (see Table 4-1, ACC. Connector J23 Pin Arrangement). Peak current is limited to approximately 44 mA by resistors RN6/RN7. RN6 must have a lower value than RN7 to equalize the currents in the bar and numeric display LEDs, because the LEDs in the bars have higher forward voltages than the LEDs in the numeric displays. The bars remain illuminated for 1.3 ms every 5 ms, while the numeric displays remain illuminated for 72 microseconds (μ s) every 5 ms, because the bars are dimmer for equal currents.

Table 4-5. Numeric and Bar Displays			
Legend	Display		
	Micro	4, 4H	4P
PIGGYBACK	---	---	DS3
OPERATING	DS4	DS3	---
BATT	DS5	DS4	DS4
LOW	DS6	DS5	DS5
NO FLOW DET	DS7	DS6	DS6
REMOTE	DS8	DS7	DS7

4.5.4

DISPLAY DRIVER PWA

Refer to Figure 9-13, *Display Driver PWA Schematic, Series 4*. The display driver PWA consists of the following circuitry: hardware watchdog, numeric and bar display digit drivers, display enable stretcher and display protector, and numeric and bar display segment drivers. The following sections detail these circuitries.

4.5.4.1

HARDWARE WATCHDOG CIRCUITRY

Refer to Figure 9-13, *Display Driver PWA Schematic, Series 4*. For a functional description of the hardware watchdog circuitry, refer to Section 4.4.3.4, *Hardware Watchdog*.

4.5.4.2

NUMERIC AND BAR DISPLAY DIGIT DRIVERS CIRCUITRY

Refer to Figure 9-13, *Display Driver PWA Schematic, Series 4*. Numeric and bar displays are selected using digit drivers U7/U3 and shift registers U2 and U8, which are serially

cascaded. IOD7 provides the serial data input to U8, which in turn provides a serial data output to the input of U8. Each output of the digit drivers U7/U3, K0 to K15, consists of a Darlington transistor capable of sinking the current from eight LEDs, whether bar or numeric segments. The Darlington transistor is activated if the corresponding position in the shift register is a logic 1.

Before the bar or numeric displays are illuminated, the shift registers are cleared by clocking 16 times with a logical 0 at IOD7. Clocking is accomplished using the 400-kHz clock gated through U13A by the A1FST (A1 Fast) signal from the output buffers. To illuminate the bar displays, numeric ones (1) are clocked into the first two positions, pulling lines K0 and K1 low, by toggling A1 twice while IOD7 is held high. The bar displays are enabled until the display protector times out (1.3 ms). The numeric displays are illuminated serially by clearing the shift registers again, then clocking through a one (1). Each digit is illuminated for approximately 72 ms; the segment data is latched into the segment drivers during the brief off periods between digits.

4.5.4.3

DISPLAY ENABLE STRETCHER AND DISPLAY PROTECTOR CIRCUITRY

Refer to *Figure 9-13, Display Driver PWA Schematic, Series 4*. The numeric and bar display shift registers U8/U2 are enabled by the display enable (DSPLEN*) signal. The display enable stretcher sets a lower limit on the length of DSPLEN* using presettable down-counter U5 on the display driver PWA. The display enable stretcher allows time for the microcomputer to access the A/D converter during the display test (*refer to Section 4.5.4.5, Display Test*).

4.5.4.4

NUMERIC AND BAR DISPLAY SEGMENT DRIVERS

Refer to *Figure 9-13, Display Driver PWA Schematic, Series 4*. An active low signal on the DISPLAY ON* line, A0*, holds the output pin 14 of U5 high and jams the counter with data at pins 4 to 7 and 10 to 13. When DISPLAY ON* goes high, the counter U5 begins to count down from 27 at a 400-kHz rate. When the counter reaches zero, the output goes low, resulting in an output pulse lasting approximately 67.5 μ s longer than the DISPLAY ON* pulse.

The display protector disables DSPLEN* if DISPLAY ON* is active low longer than 1.3 ms. If the microcomputer should fail, a character that remains illuminated will be turned off to prevent LED destruction. The display protector consists of binary counter U19 on the display driver PWA. When the DISPLAY ON* signal goes low, the reset condition is removed from U19, allowing it to count at a 6.25 kHz rate. If the DISPLAY ON* signal remains low, the counter will reach a count of eight within 1.3 ms. The Q3A output then goes high, causing the DSPLEN* signal to go high, which disables the digit drivers. Q3A also disables U19 clocking so that it remains at a count of eight until reset by the DISPLAY ON* signal.

4.5.4.5

DISPLAY TEST

Refer to *Figure 9-13, Display Driver PWA Schematic, Series 4*. After the main control switch is turned to LOCK/ON, a hardware test is performed to verify proper functioning of all

displays. The operation of the message display driver is verified by checking that the message-full (MFULL) signal is received after sending eight characters.

The numeric and bar displays are tested by measuring the voltage across each LED. Eight-bit latch U9, clocked by A13, contains the addresses for the two analog multiplexers, U1 and U11, which route the LED cathode and anode voltages to the A/D converter. The voltage across one segment is measured while each segment of the digit is illuminated, one at a time. The test is repeated for each segment (except for the decimal point) in each digit. (For those digits reserved for decimal points in the Micro pump, only the decimal points are checked.) Then, two segments (the center horizontal segment and the decimal point) of each digit are illuminated while the digit drivers are individually checked. If any LED fails in the open or short circuit condition, the MPU will signal a malfunction.

After the hardware test, all segments of all displays are illuminated for 2.5 seconds as a visual test. Because no single character turns on all of the message display segments, the characters 0 and * are displayed alternately to illuminate all segments.

4.5.5

POWER SUPPLY PWA

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4.*

Power for the Model 4 Series infusion pumps is obtained from AC (mains) power or from an internal 8 VDC, 2.5 ampere-hour (Ah) (9000 coulombs) battery pack. This section describes the power circuitry used for these power supplies. Some of the circuitry on the power supply PWA is an integral part of other functions in the system and is described elsewhere in *Section 4.*

4.5.5.1

UNREGULATED DC POWER SUPPLY CIRCUITRY

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4.* The AC (mains) power voltage is applied to the primary of transformer T1 through the power cord and fuse(s). The secondary of T1 produces 14.2 VAC under no-load conditions, supplying this voltage through J10 to the AC (mains) inputs of the diode rectifier bridge CR14. The rectifier output is filtered by the 2200 microfarad (μ F) capacitor C31.

4.5.5.2

BATTERY PACK

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4.* An 8 VDC battery pack powers the pump and memory if AC (mains) power is not available when the main control switch is rotated to LOCK/ON. A fully-charged battery pack normally provides approximately four hours of operation at a delivery rate of 125 ml/hr.

CAUTION: The battery charger circuitry is designed to maintain the battery pack in a fully-charged condition. To prevent discharge and to maintain full operating capacity for emergency or portable operation, the pump should always be connected to AC (mains) power except during ambulatory use.

4.5.5.3**BATTERY CHARGER CIRCUITRY**

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4*. The battery charger circuitry is located on the power supply PWA and consists of a constant-voltage, current-limited source and a supplemental current source.

The constant voltage source consists of a difference amplifier, U11A, transistors Q19 and Q1, and associated components. Transistor Q21 is an adjustable voltage reference. The output of the battery charger is controlled by the amplified difference of the voltage at the junction of Q21, which is nominally 2.5 VDC. Resistor R79 is used to set the charger voltage to 9.8 VDC \pm 0.04 VDC into a 20 mA load.

Current limiting is performed by transistor Q20, which senses the ground return current flowing through resistor R62. If the current through R62 exceeds 0.9 A, Q20 turns on and limits the output current by reducing the battery charger output voltages. All the current from the unregulated DC supply passes through R62, so that the current limiting of the battery charger depends on the total system drain. As the current drawn by the 5 VDC supply and motor regulators increases, the voltage level across R62 decreases. In this way, the battery charger uses only excess current available from the unregulated DC supply, making the most efficient use of the unregulated DC supply capacity.

Diode CR8 isolates the battery charger from the battery pack when the pump is not connected to AC (mains) power. Fuse F1 prevents large overcharge currents if the charger fails. Fuse F2 prevents damage to cables and printed circuit wiring if a short occurs at the input of the regulators.

4.5.5.4**DIODE POWER SWITCH CIRCUITRY**

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4*. Diodes CR11 and CR12 form an automatic power switch that determines the source of power to the regulators. When the pump is not connected to AC (mains) power, the battery pack supplies power to the regulators through diode CR12. When the pump is connected to AC (mains) power, the unregulated DC supply voltage is greater than the battery voltage, so CR12 is reverse-biased and current flows from the unregulated DC supply to the regulators through diode CR11.

4.5.5.5**POWER CONTROL CIRCUITRY**

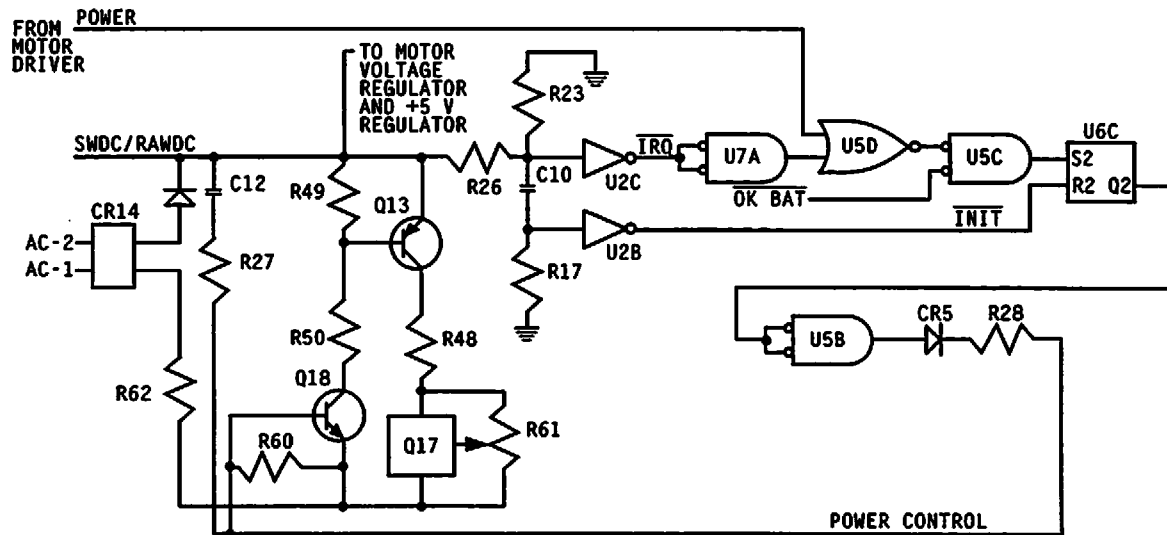
Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4*. The power control circuitry on the power supply PWA consists of transistors Q18 and Q13; Schmitt triggers U2B, U2C, and U2E; gates U7A, U5B, U5C and U5D; latches U6B and U6C; and associated components.

Refer to *Figure 4-2, Power Control Circuitry*. During normal operation, the POWER signal is high and OK battery (OKBATT*) is low. The power control latch U6C is reset, keeping transistors Q18 and Q13 saturated and power applied to the 5 VDC regulator amplifier U10. When the microcomputer shuts off power after the IRQ* pump has been turned off for four hours, POWER goes low. Since IRQ* is high, latch U6C is set, turning off power to transistor Q18. The same effect is obtained when the battery shutoff point is sensed

by the battery monitor and OKBATT* goes high, except in this case, action is independent of the state of IRQ*.

After pump power has been shut off, power on is controlled by the action of the main control switch. When the main control switch is turned to LOCK/ON, power is applied to the base of transistor Q18 through capacitor C12 and resistor R27 (power supply PWA) and to the Schmitt-trigger inverters U2B and U2C through resistor R26; this saturates Q18, turning on Q13 and applying power to the 5 VDC regulator amplifier U10 and reference Q17. At the same time, IRQ* goes low, generating an interrupt to the microcomputer. INIT* goes low for approximately 100 ms, keeping the power control latch U6C reset and charging capacitor C29 of the battery monitor through U2E, U6B, and CR3. INIT* assures that the OKBATT* signal is low and that the power control (PWRCTL) signal is high long enough to allow the microcomputer and the power supply to initialize.

INIT* also energizes the nurse-call relay to verify it is in the non alarm state by the time the main control switch activates the nurse-call system. IRQ* remains low for as long as the main control switch is turned to LOCK/ON. The IRQ* low state enables the audible alarm through gate U7D and assures that the power is not shut off by the microprocessor.



94F18025

Figure 4-2. Power Control Circuitry

4.5.5.6

5 VDC REGULATOR CIRCUITRY

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4*. The output voltage of the 5 VDC regulator is divided by resistors R58 and R59. The difference between this voltage and the reference voltage of 2.5 VDC is amplified by error amplifier U10A. The emitter voltage of transistor Q16 follows the output of U10A and, together with R56, determines the base current of the series pass transistor Q4. By feedback action, the error amplifier controls transistor Q4 to keep the error close to zero and the output voltage at 5 VDC. The series pass transistor is operated in a common-emitter mode, which allows the regulator to operate with a low input-output voltage differential.

The regulator output current is sensed by resistor R54. When the voltage drop across R54 exceeds approximately 0.6 VDC, transistor Q15 turns on, increasing the feedback voltage

from the R58-R59 divider to the error amplifier, thus reducing the base drive to the series pass transistor, and limiting the output current to approximately 1.1 A.

4.5.5.7

5 VDC FAILURE DETECTOR CIRCUITRY

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4*. Loss of the +5 VDC supply is detected by transistors Q22 and Q23, and resistors R82 through R84 on the power supply PWA. When the main control switch is turned to LOCK/ON, SWDC is applied to the base of transistor Q23 through resistor R82. In the absence of +5 VDC due to a supply failure, Q23 switches on and grounds the audio 1 line, causing the alarm to sound continuously. If +5 VDC is present, the INIT* line is high (+5 VDC) and is applied to the base of transistor Q22 through resistor R84; this switches Q22 on and shunts the base current away from Q23, thus, the audio 1 line is high and the audible alarm is silent. If the main control switch is turned to LOAD/OFF RECHARGE, no current is available to the base of Q23, and the audible alarm is silent.

4.5.5.8

MOTOR VOLTAGE REGULATOR

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4*. The motor voltage regulator is similar to the +5 VDC regulator, except that its output current is limited to approximately 1.4 A, and it incorporates a remote shutdown feature. Remote shutdown is performed by transistor Q8, which when turned on reduces the reference voltage to approximately zero.

4.5.5.9

BATTERY MONITOR CIRCUITRY

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4*. The battery monitor circuitry is located on the power supply PWA. One output, REGCK, is connected to the A/D converter. REGCK controls the BATT and LOW legends on the front panel and generates a low battery alarm when a low battery condition occurs.

The voltage at the input to the regulators, less the drop across transistor Q13, is scaled by resistors R45, R77, and R76 for the A/D converter and comparator U12A. IC U6B and diode CR3 assure that the filter capacitor C29 is charged after the pump is powered on.

With the pump connected to AC (mains) power, the Q13 collector voltage is larger than 8.2 VDC which is detected by the microprocessor (through the A/D converter), and turns the BATT and LOW legends off.

If AC (mains) power is disconnected, the regulator input voltage decreases to the battery voltage which is detected by the microprocessor (through the A/D converter), and illuminates the BATT legend.

As the battery pack is discharged and the battery voltage falls to between 7.35 VDC and 7.65 VDC, the BATT LOW legend flashes, the alarm sounds, and the nurse-call is activated.

If battery discharge continues so that the voltage at the comparator U12A falls below VREF (between 6.85 VDC and 7.15 VDC), the OKBATT* line goes high, turning off the regulator.

 4.5.5.10

MEMORY SUPPLY CIRCUITRY

Refer to *Figure 9-14, Power Supply PWA Schematic, Micro 4/Model 4*. Some versions of the power supply PWA contain provision for powering the RAMs so that volatile data stored in memory is not lost when the main control switch is turned to LOAD/OFF RECHARGE or when the pump is disconnected from AC (mains) power. Transistor Q10, voltage reference Q14, and Schottky diode CR9 on the power supply PWA compose a low-quiescent-current memory power supply that powers RAMs U5 and U6 and controls gate U11 on the MPU PWA.

Whenever the 5 VDC regulator is on, voltage memory (VMEM) is supplied through the saturated transistor Q10 from the 5 V supply. When the 5 V regulator is off, VMEM drops to approximately 2.3 V and is supplied from AC (mains) power or the batteries through the RAWDC line and resistor R51, with voltage reference transistor Q14 serving as the regulator for VMEM.

 4.5.6

CURRENT BOOST CHARGER PWA

Refer to *Figure 9-15, Current Boost Charger Schematic, MDL 4/PCA*. The current boost charger PWA is installed in certain Model 4 Series pumps. The current boost charger PWA contains the following circuitry:

- Differential amplifier (U3) and 20 mA shut-off circuitry (Q2)
- Window comparator with hysteresis (U1)
- 60 minute battery charger timer (U2)
- 200 mA constant current source (transistors Q7, Q8, Q9) and associated logic (transistors Q3, Q4, Q5, Q6)
- AC (mains) detector (transistor Q1)

The current boost charger PWA functions during pump AC (mains) power and battery power operation, as described in the following sections.

 4.5.6.1

AC (MAINS) OPERATION

Refer to *Figure 9-15, Current Boost Charger Schematic, MDL 4/PCA*. 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, the output of U1 goes low, disabling transistors Q3 and Q4, and triggering the timer, U2.

The clock frequency of timer U2 is determined by capacitor C5 and resistor 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 which disables Q5, since Q4 is already disabled, and removes the supply to transistor Q9, 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 (mains)/DC detector consists of transistor Q1 and associated resistors. When the pump operates on AC (mains) power, the collector of Q1 is at logic low, enabling the timer U2 and transistors Q6. During DC operation, the +VRDC signal is at ground level and keeps Q1 off.

Current is limited to 200 mA by the quotient of the voltage-base-emitter of transistor Q8 divided by the resistance value of resistor R17. Transistor Q7 acts as a power switch that is enabled and disabled by transistor Q9.

IC U3-B, acts as a differential amplifier with a gain of approximately 20 decibels (dB). Current is sensed across resistor R62 in the battery charging circuitry of the power supply PWA. When current drops below approximately 20 mA, the output of U3-B, pin 1 (which is also the input to comparator U3-A, pin 6), is at 100 mV or below. Pin 3 of U3-A is referenced at 500 mV from the battery charger circuitry on the power supply PWA. U3-A switches to a logic high and turns on transistor Q2, disabling the charging circuit (Q1 and Q19) on the power supply PWA. Resistor R26 and capacitor C8 act as a noise filter to Q8.

4.5.6.2

DC OPERATION

Refer to *Figure 9-15, Current Boost Charger Schematic, MDL 4/PCA*. When the pump operates on battery power and the battery pack drains to approximately 8 VDC, pin 4 of the voltage detector U1 switches to logic high which resets the timer U2, enabling transistors Q3, Q4, and Q5. Transistor Q6 remains disabled because Q1 is disabled.

4.5.7

CONTROL SWITCHES

Control switches are located on both the front and the back of the pump. These switches are described in the following sections.

4.5.7.1

FRONT PANEL SWITCHES

The front panel of the pump contains nine or ten (depending on the model) membrane-type touchswitches, as follows:

1. [START]
2. [RESET]
3. [SILENCE]
4. [CLEAR]
5. [LIMIT ON OFF CLEAR]
6. DELIVERY RATE [↑]
7. DELIVERY RATE [↓]
8. DOSE LIMIT/DOSE DELIVERED [↑]
9. DOSE LIMIT/DOSE DELIVERED [↓]
10. [PIGGYBACK] (4P only)

The front panel touchswitches are normally open with a common return connected to ground. Touchswitch closures are converted to logic levels by pull-up resistors in resistor network RN1 on the display driver PWA. The state of the front panel touchswitches is read by the microprocessor circuitry through tri-state buffers U3 and U10 on the motor driver PWA when enabled by A6* and A7*.

A short beep sounds whenever an active touchswitch is pressed. The [SILENCE] touchswitch always sounds a beep when it is pressed, whether it is active or not.

Note: When a front panel touchswitch is pressed continuously for approximately 2-1/2 minutes, or fails to open after being closed, an alarm sounds and a MALFUNCTION message is displayed.

The front panel also houses the main control switch, which is a rotating knob connected to a shaft. The shaft of the main control switch drives the cassette locking mechanism to permit cassette insertion, and operates the nurse-call enable wafer and the power control switch wafer. The nurse call enable switch prevents false nurse-call alarms that would result if the main control switch were turned to LOAD/OFF RECHARGE with the nurse-call connected. The power control switch wafer sends a power on command to the power control circuitry on the power supply PWA through the SWDC line when the main control switch is turned to LOCK/ON.

4.5.7.2

REAR PANEL SWITCHES

User-accessible switches on the back panel of the Model 4 Series infusion pump are as follows: occlusion pressure setting switch (SW2), audible alarm level switch (SW3), and on the Micro only, set type switch (SW4). A legend for these switches is on the label above the drip shield.

The occlusion pressure setting switch allows the user to select the increase in backpressure necessary to cause the pump to sound an occlusion alarm. The three settings (MIN, MID, MAX) correspond to differential alarm threshold pressures of 4 ± 2 psig (27.6 ± 13.8 kPa), 8 ± 3 psig (55.2 ± 20.7 kPa), and 12 ± 4 psig (82.8 ± 27.6 kPa), respectively. This switch can be either a vertically mounted toggle switch or a horizontally mounted slide switch, depending on pump configuration.

The occlusion pressure setting switch changes the level on the signal OCSEL, which is connected to input 3 on the A/D converter, and enables the microcomputer to read the switch position. OCSEL levels are 0 VDC, +2.5 VDC, and +5 VDC which correspond to settings MIN, MID, and MAX, respectively.

The audible alarm level switch (AUD. ALM.) sets the audible alarm sound intensity to one of three positions: HIGH, medium, or LOW.

In the HIGH position, the piezoelectric alarm is connected directly to the driver transistor Q6 on the power supply PWA, allowing maximum current flow (above 2.7 mA) when the audible alarm is activated. In the medium position, R25 is switched in series with the piezoelectric alarm, limiting the current to approximately 1.9 mA. In the LOW position, R25 remains in series with the piezoelectric alarm, and R19 is connected in parallel with the piezoelectric alarm, further reducing the current to about 0.3 mA.

The set type switch, on the Micro pump only, allows the user to select the flow monitor alarm criteria to suit the type of set being used: type A for a 60 drops/ml set, and type B for a 15 drops/ml set. The position of the switch is sensed by the MPU PWA through the

STYPE signal. The STYPE signal governs how many drops must be present to match the rate settings and controls the high and low flow alarm operation.

4.6

MECHANICAL SUBSYSTEM PRINCIPLES OF OPERATION

The principle mechanical elements of the LifeCare Model 4 Series infusion pump include the cassette, pump mechanism, and motor and motor drivers. These elements are described in the following sections.

Operationally, the mechanical elements function as follows: the cassette is locked into the cassette receptacle on the front of the pump when the main control switch is turned to LOCK/ON. This action also turns on the power to the pump motor drivers and places the pivot arm of the pump at the top of its stroke. When the [START] touchswitch is pressed, the motor drives the pivot arm up and down, and valving inside the cassette causes a one-way fluid flow through the fluid lines.

4.6.1

CASSETTE

The pump cassette operates on a fluid displacement principle to deliver fluid volumetrically. A spring-loaded outlet valve is biased to permit flow only when the internal pressure developed in the compression chamber exceeds the mechanical resistance of the valve (5 to 7 pounds per square inch (psi) (34.5 to 48.3 kPa)). The necessary pressure cannot be achieved when too much air is present in the compression chamber. It is therefore mechanically impossible for air to be pumped through the cassette into the distal line of the administration set.

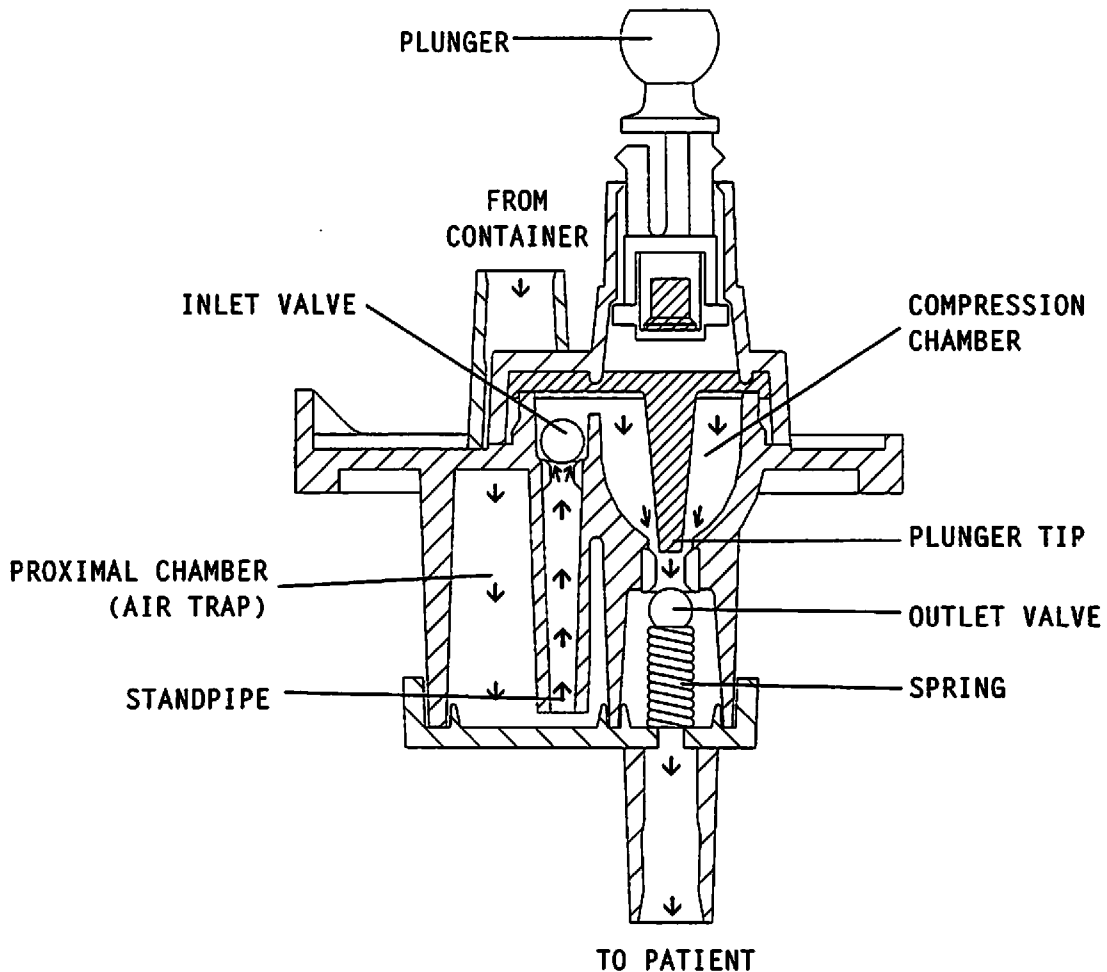
The cassette has two chambers separated by the inlet valve and siphon tube. A 2.5 ml air trap chamber collects any bubbles that may form in the part of the set above the cassette and prevents them from entering the compression chamber. The compression chamber lies between the inlet and outlet valves. The volume of the compression chamber changes when the diaphragm is compressed by the plunger (*see Figure 4-3, Pump Cassette*).

The two-stage pumping cycle begins with the diaphragm being moved about 1/16 inch into the compression chamber by the pump motor. The resulting increase in fluid pressure immediately closes the inlet valve, preventing backflow to the fluid container. As the pressure increases beyond that required to open the outlet valve, a precise volume of fluid is metered out of the compression chamber into the distal tubing to the patient.

In the second stage of the pump cycle, the diaphragm returns to its original position, causing a drop in pressure in the compression chamber, allowing the outlet valve to close, and opening the inlet valve. Fluid then refills the compression chamber and the system begins the next cycle.

To prime the pump cassette, an over-travel position of the plunger mechanically opens the outlet valve. A detent holds the plunger in this priming position, so that the user can adjust fluid flow with the manual flow control clamp and remove air bubbles from the compression chamber. After priming, the plunger is returned to its operating (undetented) position and the outlet valve closes to prevent fluid flow.

Note: The LifeCare microcassette cannot be inserted into the cassette port of the Model 4, 4P, or 4H pump without using force. If a non-microcassette is inserted into the Micro pump, an alarm sounds and the pump will not start. To reset the pump, the main control switch must be turned to LOAD/OFF RECHARGE. The CHECK CASSETTE message appears after the [START] touchswitch is pressed if the set type switch (Micro) is not set for the appropriate microcassette (type A or type B).



94F18030

Figure 4-3. Pump Cassette

4.6.2

PUMP MECHANISM

The pump mechanism performs the following major functions:

- Locks a pump set cassette into place
- Causes the cassette plunger to cycle once per pump motor revolution, with stroke length appropriate to deliver 1/15 ml of fluid
- Measures backpressure by measuring the force required to drive the cassette plunger

With the main control switch turned to LOAD/OFF RECHARGE, the cassette can be inserted or removed from the cassette receptacle. A detenting action allows the user to ascertain proper seating of the cassette.

Turning the main control switch from LOAD/OFF RECHARGE to LOCK/ON causes the mechanism to lock the cassette firmly in the receptacle and the pumping portion of the mechanism to firmly grasp the ball of the cassette plunger.

When the [START] touchswitch is pressed, the pumping portion of the mechanism executes one pump stroke per motor rotation. The motor rotation is translated into linear pumping motion through a cam arrangement.

4.6.3

MOTOR AND MOTOR DRIVERS

The pumping action of the mechanism is controlled by a four-phase stepping motor rotated by the sequential energizing of the four windings. The pump motor is controlled by the microprocessor through the I/O data bus. Winding energizing data is latched in U1 or U11, which controls the motor drive transistors Q1, Q2, Q3, and Q4 on the motor driver PWA. RV1 and RV2 are varistors used to limit the back EMF which is generated when a motor coil is turned off.

The motor is operated in one of two modes. In the stepping mode, full current is applied to the appropriate coils by turning on the +5 VDC motor supply for approximately 10 ms and turning on the proper drive transistors. In the holding mode, the motor current is reduced by turning off the motor supply, but leaving on the drive transistors. With the motor supply off, the holding current is supplied by the 5 VDC digital supply through R12 and CR1 on the motherboard PWA.

The motor voltage regulator (VMOT) is turned on and off by the microcomputer through the output latch U5 or U7 on the motor driver PWA, which controls the signal line VMOFF. VMOFF is one of the two signal lines connected to the base of Q8 on the power supply PWA. When VMOFF is high, it turns on Q8 which, in turn, shunts the +2.5 VDC reference to ground and shuts off the motor power supply.

4.7

BATTERY OPERATION OVERVIEW

The pump is intended to operate on battery power on an exception basis only, such as emergency backup or temporary portable operation. Examples of emergency backup include AC (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. A new, fully-charged battery pack provides approximately four hours of operation at a delivery rate of 125 ml/hr.

If the battery pack is not new or not fully charged, or if the delivery rate setting is higher than 125 ml/hr, battery power is exhausted at a faster rate. To assure continued operation of the pump and to avoid damage to the battery pack, the AC (mains) power cord should be immediately connected to AC (mains) power when the low battery alarm sounds.

The pump should be connected to AC (mains) power whenever possible to allow the battery to remain fully charged. The AC (mains) power symbol turns off and the battery power symbol illuminates when the pump 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 pump is operating, the alarm sounds and the BATT LOW message displays. Although it is not recommended to continue operating the pump on battery power at this point, the battery will continue providing power until discharged. At this point, the pump enters the battery discharged mode and operation ceases.

CAUTION: As soon as the low battery alarm occurs, connect the pump to AC (mains) power.

Recharging occurs any time the pump is connected to AC (mains) power. It is recommended that the pump be connected to AC (mains) power whenever practicable 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 pump is operating is rate dependent.

See *Section 5.3, Battery Maintenance*, for more information.

This page intentionally left blank.

Section 5

MAINTENANCE AND SERVICE TESTS

This section contains preventive maintenance information, a performance verification test (PVT), and battery maintenance information for the LifeCare and HomeCare Model 4 Series infusion pumps.

5.1

PREVENTIVE MAINTENANCE

A preventive maintenance program is important for longevity and trouble-free operation of the pump. Such a program includes periodic inspection, exterior cleaning and sanitizing, and checking for proper operation of the pump using the PVT in *Section 5.2, Performance Verification Test*.

As a minimum requirement, clean the pump after each use. Establish a regular cleaning schedule during use. In addition, clean the pump and run the PVT as part of any scheduled service or after any repair procedure.

5.1.1

INSPECTING THE PUMP

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

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

- Power and accessory cords
- Pump case
- Pole clamp and pads
- Main control switch
- Front and the rear panel switches
- Accessory connector (ACC.)
- Flow detector connector (FLOW DET.)
- Faceplate
- Pressure pads (feet)
- Screws
- Flow detector
- Accessories
- Plunger guide

5.1.2**CLEANING THE PUMP**

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

Follow hospital protocol for establishing the pump cleaning schedule.

WARNING

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

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

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

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

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

Table 5-1. Cleaning Solutions

Cleaning Solution	Manufacturer	Preparation
Vesphene® Ilse	Calgon Vestal Laboratories	Per manufacturer's recommendation
Manu-Klenz®	Calgon Vestal Laboratories	Per manufacturer's recommendation
Formula C™	Diversey Corporation	Per manufacturer's recommendation
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
LifeCare® Germicidal Towelette	Manufactured for Abbott Laboratories	Per manufacturer's recommendation; use undiluted

5.1.3

SANITIZING THE PUMP

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

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

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

5.2

PERFORMANCE VERIFICATION TEST

As a part of a preventive maintenance schedule, it is recommended that the PVT be conducted periodically per hospital procedures for compliance with accreditation requirements.

The PVT is used for overall verification of pump performance and as a diagnostic tool during pump troubleshooting. The PVT consists of the tests described in the following sections. The PVT can be used for diagnostic purposes during the troubleshooting of a malfunctioning pump, and for verification of the overall performance of a pump as part of a preventive maintenance schedule. In addition, the PVT should be used for performance verification before a pump is returned to service after repair. If any malfunction is detected as a result of the PVT, refer to *Table 6-13, Troubleshooting with the PVT*.

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

5.2.1

EQUIPMENT AND MATERIALS REQUIRED

The following equipment and materials, or equivalents, are required to perform the PVT for the Model 4 Series infusion pump:

- Digital pressure meter (DPM), Bio-Tek[®] DPM II
- Abbott LifeCare IV set, List No. 3704 (List No. 9243 for Micro)
- Dry cassette
- Waste water collection container
- 21-gauge Butterfly[®] needle, List No. 4492
- Glass or flexible IV container of sterile water (tap water may be used as an alternate)
- IV pole
- Safety analyzer, Dynatech Nevada[®] Model 231D
- Digital multimeter (DMM), Fluke[®] Model 77
- Three-way stopcock, List No. 3233
- Accessory connector cable, P/N 561-D1617
- Malfunction simulator plug, List No. 561-81620-001

- Graduate, 25 ml (0.2 graduations)
- Flow detector, List No. 1907-25

5.2.2

PUMP INSPECTION

Before starting the test procedures, perform a thorough inspection of the pump as described in *Section 5.1.1, Inspecting the Pump*.

5.2.3

DRY CASSETTE TEST

To perform the dry cassette test, proceed as follows:

Note: If the locking tabs do not seat properly, adjust them as described in *Section 7.2.3, Shroud Rear Tab Adjustment*.

1. Insert a dry cassette into the shroud. The cassette should slide in freely.
2. Turn the main control switch to LOCK/ON. The switch should move to the LOCK/ON position without binding or dragging.
3. Verify that the rear locking tabs are seated in the cassette hold down notches on both the left and right sides of the cassette.
4. Turn the main control switch to LOAD/OFF RECHARGE. Remove the cassette. The cassette should withdraw freely.

5.2.4

TEST SETUP

WARNING

DURING PUMP TESTING, DO NOT CONNECT THE PUMP TO A PATIENT.

Note: For all testing, the vertical distance from the cassette midline to the vent filter in the set (using a rigid container) or to the fluid level in the container (using a non-rigid container) must be 18 ± 6 inches (46 ± 15 centimeters (cm)) (see *Figure 5-1, Delivery Accuracy Test Setup*).

Before performing the PVT, set up the pump as follows:

1. Attach the appropriate LifeCare set to the IV container; hang the container from the IV pole and prime the set. (For the correct priming procedure, refer to the appropriate system operating manual).
2. Connect the flow detector to the pump, but do not attach it to the drip chamber of the IV container.
3. Turn the main control switch to the LOAD OFF RECHARGE position and insert the cassette into the pump receptacle.
4. Have a waste water receptacle at hand. The pump is now set up for testing.

5.2.5

START UP TEST

To perform the start up test, proceed as follows:

1. Set up the pump as described in *Section 5.2.4, Test Setup*.
2. Turn the main control switch to LOCK/ON and verify that all LED segments and the display legends illuminate, and a double confirmation beep sounds.
3. Gently wiggle the flow detector connector. The NO FLOW DET message should not illuminate on the front panel display legend.
4. Disconnect the pump from AC (mains) power and verify the battery message BATT illuminates. Connect the pump to AC (mains) power to complete the remainder of the tests.

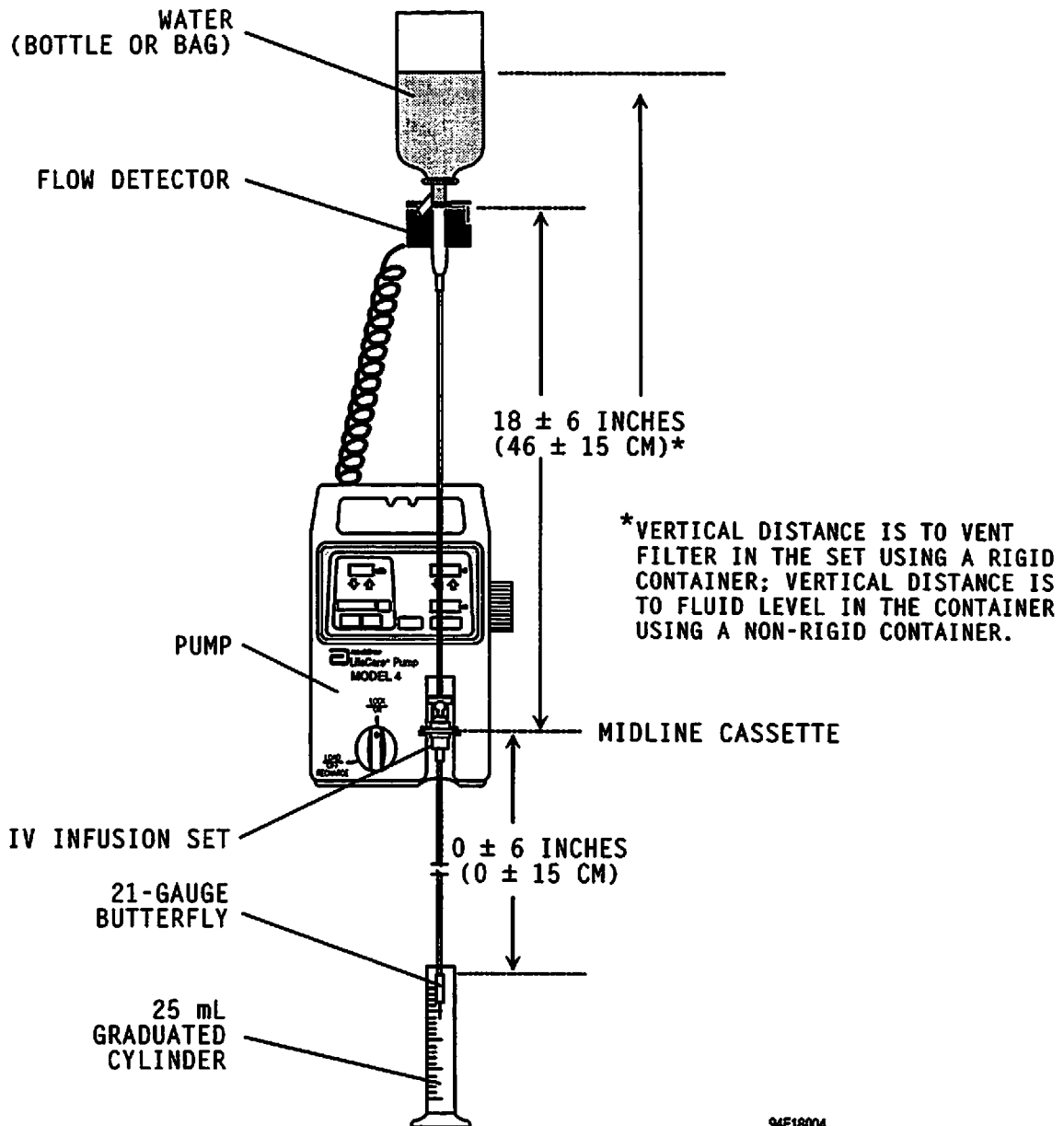


Figure 5-1. Delivery Accuracy Test Setup

5.2.6

PRESSURE TEST AND SILENCE SWITCH TEST

If the pump fails the pressure test, and the pressure sensor PWA is suspected of causing the test failure, refer to *Section 7.2.4, Pressure Sensor Calibration and Test*. To perform the pressure test and silence switch test, proceed as follows:

1. Set up the test equipment as shown in *Figure 5-1, Delivery Accuracy Test Setup*. Make certain the water in the container is at 18 ± 6 inches (46 ± 15 cm) above the midline of the cassette.
2. Connect the DPM to the end of the set with a three-way stopcock. Open the stopcock to air. Turn the main control switch to LOCK/ON.

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

3. Set the pressure switch on the back of the pump to the MIN position. Press and hold the [SILENCE] touchswitch and read the switch position on the VOLUME DELIVERED display. Change the switch setting to MAX, then MIN, and observe the corresponding change in the VOLUME DELIVERED display.
4. Set the delivery rate to 300 ml/hr (99.9 ml/hr for Micro).
5. With the pressure switch set to MIN, press the [START] touchswitch. After three pump strokes, verify the DPM reads 0, then close the three-way stopcock. At occlusion, the pressure should read 4.0 ± 1.5 psig (27.6 ± 10.3 kPa).
6. An alarm should sound and a flashing OCCLUDED message should appear in the VOLUME DELIVERED display. The DELIVERY RATE display should flash 000. Press and hold the [SILENCE] touchswitch; the VOLUME DELIVERED display should show DIF PRES. When the [SILENCE] touchswitch is released, the pressure switch setting is displayed for one flash (for the Micro, the set type A or B is displayed for one flash, followed by the pressure switch setting). Press [RESET] then release the three-way stopcock.

Repeat Steps 5 and 6 for MID and MAX pressures; at occlusion, pressure should read: 8.0 ± 2.5 psig (55.2 ± 17.3 kPa) and 12.0 ± 3.5 psig (82.8 ± 24.2 kPa), respectively.

Note: After the MAX pressure test, do not release the three-way stopcock.

Note: It is possible to get an absolute pressure reading at the MAX position because of the absolute pressure tolerance (15.0 ± 4.5 psig, 103.5 ± 31.1 kPa).

7. Start the pump. At occlusion (15 ± 4.5 psig (103.5 ± 31.1 kPa)) press and hold the [SILENCE] touchswitch; the VOLUME DELIVERED display should read ABS PRES. If the display reads DIF PRES, repeat the step.
8. Press [RESET] and disconnect the DPM.

Note: The occlusion pressure reading varies widely due to cassette and mechanism differences, resulting in the overall tolerance of ± 4.5 psig (31.1 kPa) for absolute pressure readings.

5.2.7**HIGH FLOW ALARM AND LOW FLOW ALARM
(SIMULATED) AND AUDIBLE ALARM TESTS**

The high flow alarm test and the low flow alarm test can be performed in one sequence. With the equipment set up as described in *Section 5.2.4, Test Setup*, proceed as follows:

1. Connect the flow detector to the rear of the pump, but do not attach it to the drip chamber.
2. Set the delivery rate to 1 ml/hr, and the dose limit to 50 ml (Micro: Set type switch to position A). Press the [START] touchswitch.
3. Using a pencil or similar object, interrupt the drop path within the flow detector about twice a second; note that the alarm sounds and the VOLUME DELIVERED display flashes HI FLOW after five strokes for the Model 4P and flashes FLOW for the other models. The pump operations cease.
4. Observe the DELIVERY RATE display flashes 000. Press the [RESET] touchswitch. Turn the main control switch to LOAD OFF RECHARGE.
5. Set the dose limit to 50 ml, and set the delivery rate as follows:
 - Model 4, 4H, 4P: 300 ml/hr
 - Micro: 99.9 ml/hr; set type switch to position A
6. Press the [START] touchswitch. After the pump completes approximately five strokes, observe the following:
 - Alarm tone
 - VOLUME DELIVERED display alternates between LOW FLOW and KVO for the Model 4P, and FLOW and KVO for the Models 4, 4H, and Micro
 - DELIVERY RATE display flashes KVO rate of 4 ml/hr (1.0 ml/hr for the Micro)
7. Switch the alarm volume levels through LOW, medium, and HIGH. Verify that the volume changes.
8. Press the [RESET] touchswitch. Confirm alarm and messages cease.

5.2.8**DELIVERY ACCURACY TEST**

Note: Accuracy testing is for informational purposes only, and is not to be used as a re-release test. If there is any concern as to the accuracy of the pump, return it to Abbott Laboratories (see *Section 6.1, Technical Assistance*).

To perform the delivery accuracy test, proceed as follows:

1. Set up the equipment as shown in *Figure 5-1, Delivery Accuracy Test Setup*, using a 25 ml graduated cylinder or burette.

Note: Use a cylinder or burette certified or calibrated to Class A tolerances (ASTM E694) or better (with 0.2 ml graduations).

2. Check the cassette and tubing for air and clear if necessary.
3. Attach a flow detector to the drip chamber. Attach a 21-gauge Butterfly needle to the IV set and prime. Turn the main control switch to LOCK/ON.

4. Tap the needle to eliminate any drop of water on its tip.
5. Insert the Butterfly needle into the 25 ml graduated cylinder (confirm the cylinder is dry). Press the [LIMIT ON/OFF CLEAR] touchswitch twice to reset DOSE DELIVERED. Press [CLEAR] to clear VOLUME DELIVERED.
6. Set the delivery rate and dose limits as follows:
 - Model 4, 4P: Delivery rate: 400 ml/h; Dose: 20 ml
 - Model 4H: Delivery rate: 350 ml/h; Dose: 20 ml
 - Micro: Delivery rate: 99.9 ml/h; Dose: 20 ml
7. Press the [START] touchswitch and allow the pump to operate until the dose end. Verify the volume in the graduate is between 19 and 21 ml.

Note: Prior to each delivery accuracy test, turn the main control switch to LOAD/OFF RECHARGE to place the piston in the START/HOME position.

8. Turn the main control switch to LOAD OFF RECHARGE.
9. If the test fails, retest with a new cassette. If the test fails again, contact Abbott Laboratories (see Section 6.1, Technical Assistance).

5.2.9

PIGGYBACK TEST (MODEL 4P ONLY)

The piggyback test is conducted on the Model 4P only. To perform the piggyback test, proceed as follows:

1. Set up the pump as described in Section 5.2.4, Test Setup.
2. With the dose limit off, remove the flow detector from the pump and observe that the DOSE LIMIT display and NO FLOW DET display legend illuminate.
3. Set the primary rate to 200 ml/hr, and the primary dose limit to 1 ml. Press the [PIGGYBACK] touchswitch and set the secondary rate to 300 ml/hr, and the secondary dose limit to 1 ml. Reconnect the flow detector and attach the flow detector to the drip chamber. Confirm the NO FLOW DET display legend extinguishes and the PIGGYBACK display legend illuminates.
4. Press the [START] touchswitch from piggyback mode.
5. Observe that pumping occurs, the VOLUME DELIVERED display shows SECNDRY and XXXX ML alternately, and the rotating bar is displayed.
6. After a minimum of 12 seconds, verify that the VOLUME DELIVERED display shows PRIMARY and XXXX ML alternately, and the rotating bar is displayed.

Note: The secondary rate must be equal to or greater than the primary rate; otherwise, a CHK RATE message flashes.

7. When KVO and DOSE END occur alternately on the VOLUME DELIVERED display, verify that the DOSE DELIVERED display shows 0001 ml, and pumping stops.
8. Press the [RESET] touchswitch.

5.2.10**BATTERY CHARGING TEST**

To perform the battery charging test, proceed as follows:

1. Disconnect the pump from AC (mains) power.
2. Set the DMM to measure VDC, then insert one end of the accessory connector cable into the ACC. connector and connect the other end to the DMM. Verify that the DMM reading is greater than or equal to +8.4 VDC.
3. Connect the pump to AC (mains) power; the DMM reading should be greater than the DC voltage reading, but not greater than +11.0 VDC.
4. Disconnect the accessory connector cable.

5.2.11**MALFUNCTION SIMULATION TEST**

To perform the malfunction simulation test, proceed as follows:

1. Insert the malfunction simulator plug into the ACC. connector on the back of the pump.
2. Press the [START] touchswitch. Observe MALFUNCT flashes on the VOLUME DELIVERED display, 000 flashes on the DELIVERY RATE display, and the alarm sounds.
3. Press the [RESET] touchswitch and confirm the alarm continues.
4. Press the [START] touchswitch and confirm pumping does not occur.
5. Disconnect the malfunction simulator plug, turn the main control switch to LOAD/OFF RECHARGE, then remove the cassette.

5.2.12**ELECTRICAL SAFETY TEST**

To perform the electrical safety test, connect the pump AC (mains) power cord to the safety analyzer, then proceed as follows:

1. Connect a case-to-ground lead from the safety analyzer socket to the audible alarm level switch. The leakage current should be at least 2 microamperes (μA) but less than 50 μA .
2. Using the safety analyzer, measure the resistance between the ground lug of the AC (mains) connector and the pole clamp shaft. Resistance should not exceed 0.1 ohm (100 milliohms).

5.2.13**END OF PERFORMANCE VERIFICATION TEST**

If all tests have been successful, return the pump to service. If any of the tests fail, refer to *Section 6, Troubleshooting*.

5.3

BATTERY MAINTENANCE

Proper battery use and maintenance are essential for optimum pump operation. Should the battery pack require replacement, refer to *Section 7.3.3, Battery Pack Replacement*.

When the pump is neither connected to AC (mains) power, nor operating, the battery pack retains 50 percent of a full charge for at least one month.

5.3.1

DEPTH OF DISCHARGE

When the battery pack is discharged below 7.4 VDC while the pump is operating, an alarm sounds and the BATT LOW message is illuminated on the front panel display legend.

CAUTION: When the low battery alarm sounds, connect the pump to AC (mains) power.

Although continuing to operate the pump is not recommended, the battery pack provides power until discharged to approximately 7.0 VDC. At 7.0 VDC, the dead battery alarm activates and pump operation ceases.

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.

5.3.2

RECHARGING

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

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

5.4

BATTERY CIRCUIT ALARM AND CHARGER TESTS

The battery circuit alarm and charger tests consist of three tests:

1. Low battery alarm test
2. Battery shutdown test
3. Battery charging circuit test

5.4.1

TEST EQUIPMENT REQUIRED

Equipment required for the battery circuit alarm and charger tests is as follows:

- DMM, Fluke Model 77, or equivalent
- Parallel network, P/N 561-88419-001
- Adjustable DC power supply (0-10 VDC)

5.4.2

LOW BATTERY ALARM TEST

To perform the low battery alarm test, proceed as follows:

1. Disconnect the pump from AC (mains) power.
2. Remove the battery pack cover on the bottom of the pump. See *Section 7.3.3, Battery Pack Replacement*, for instructions on battery pack removal.
3. Set the DMM to measure VDC, then disconnect the battery pack and connect the power supply leads to the adjustable DC power supply, adjusted to +8.5 VDC. Monitor the voltage with the DMM.
4. Turn the main control switch to LOCK/ON. Confirm the BATT message is illuminated on the front panel display legend at all times. Press the [START] touchswitch.
5. Slowly reduce the power supply test voltage while observing the front panel display legend. When the BATT LOW message starts flashing and the alarm sounds, the battery voltage on the DMM should read between +7.35 and +7.65 VDC.

5.4.3

BATTERY SHUTDOWN TEST

To perform the battery shutdown test, proceed as follows:

1. Continue to reduce the power supply voltage until the pump shuts down.
2. The voltage must read between +6.85 and +7.15 VDC immediately before the pump shuts down.

3. Turn the main control switch to LOAD/OFF RECHARGE.

Note: The voltage reading at this point must be at least 0.3 VDC less than the voltage reading taken in *Section 5.4.2, Low Battery Alarm Test, Step 5*.

5.4.4

BATTERY CHARGING CIRCUIT TEST

To check the battery charger circuitry, proceed as follows:

1. Disconnect the pump from AC (mains) power. Remove the battery pack cover as described in *Section 7.3.3, Battery Pack Replacement*. Disconnect the battery pack from the internal charging circuit (red and black leads).
2. Connect the parallel network to the charging circuit plug.
3. Connect the pump to AC (mains) power, turn the main control switch to LOCK/ON, and measure the voltage across the network. The DMM should indicate the following:
 - Pump models with boost charger PWA: 15.0 VDC \pm 2.5 VDC
 - Pump models without boost charger PWA: 9.40 VDC \pm 0.1 VDC
4. Turn the main control switch to LOAD/OFF RECHARGE.
5. Remove the parallel network. Reconnect and re-install the battery pack. Verify that the battery pack wires are not pinched. Replace the battery pack cover.

5.5 PVT DATA FORM

List Number: _____ Serial Number: _____

Inspection

- | | |
|--|---------------|
| 1. Inspect the electrical cord and nurse-call cable for damage or foreign material. | Pass__ Fail__ |
| 2. Inspect the case for cracks or stains. | Pass__ Fail__ |
| 3. Inspect the pole clamp and pads for damage. | Pass__ Fail__ |
| 4. Verify that the main control switch has no cracks or other damage. | Pass__ Fail__ |
| 5. Inspect the front and rear panel switches for damage or foreign material. | Pass__ Fail__ |
| 6. Inspect the ACC. and FLOW DET. connectors for cracked housing and broken or bent pins. | Pass__ Fail__ |
| 7. Inspect the faceplate for any damage. | Pass__ Fail__ |
| 8. Verify that the four bottom pressure pads (feet) are present and do not have excessive wear. | Pass__ Fail__ |
| 9. Verify that all screws are tight. | Pass__ Fail__ |
| 10. Inspect the flow detector for spills or damage and verify that the Velcro® strap is present. | Pass__ Fail__ |
| 11. Inspect any accessories for spills or damage. | Pass__ Fail__ |
| 12. Inspect the plunger guide for cracks or other damage. | Pass__ Fail__ |

Dry Cassette Test

- | | |
|--|---------------|
| 1. Verify that a dry cassette slides into the shroud easily. | Pass__ Fail__ |
| 2. Verify that the main control switch rotates properly without binding or dragging. | Pass__ Fail__ |
| 3. Verify that the rear locking tabs are seated on both the left and right sides of the cassette. | Pass__ Fail__ |
| 4. Turn the main control switch to LOAD/OFF RECHARGE and remove the cassette. Verify that the cassette withdraws freely. | Pass__ Fail__ |

Start-Up Test

Verify that the IV set is primed.

- | | |
|--|---------------|
| 1. Turn the main control switch to LOCK/ON and verify that all LED segments and display legends light momentarily. | Pass__ Fail__ |
| 2. Verify that wiggling the flow detector connection does not produce the NO FLOW DET message. | Pass__ Fail__ |
| 3. Disconnect the unit from AC (mains) power, and verify that BATT illuminates. | Pass__ Fail__ |

Pressure Test and Silence Switch Test

- 1. Press and hold [SILENCE] and verify that the VOLUME DELIVERED display indicates the correct switch setting for MIN-MID-MAX settings (i.e., MID PRES). Pass___ Fail___
- 2. Check occlusion pressure at MIN pressure setting and record. MIN: _____ (Specification = 4 ± 1.5 psig (27.6 ± 10.3 kPa)) Pass___ Fail___
- 3. Verify OCCLUDED flashes in VOLUME DELIVERED display. Pass___ Fail___
- 4. Verify that, after pressing [SILENCE], DIF PRES is displayed in the VOLUME DELIVERED display. Pass___ Fail___
- 5. After releasing [SILENCE] verify that pressure switch setting (set type A or B for micro) is displayed for one flash. Pass___ Fail___
- 6. Check occlusion at the MID and MAX pressure switch settings. MID: _____ (Specification = 8 ± 2.5 psig (55.2 ± 17.3 kPa)) Pass___ Fail___
 MAX: _____ (Specification = 12 ± 3.5 psig (82.8 ± 24.2 kPa)) Pass___ Fail___
- 7. Check absolute occlusion alarm. If VOLUME DELIVERED display indicates DIF PRES, repeat test. MAX: _____ (Specification = 15 ± 4.5 psig (103.5 ± 31.1 kPa)) Pass___ Fail___

High Flow Alarm Test

Set the delivery rate to 1 ml/hr (01.0 for micro).

Press [START], then interrupt the flow detector rapidly and observe:

- 1. The alarm tone is activated Pass___ Fail___
- 2. The FLOW message flashes Pass___ Fail___
- 3. The DELIVERY RATE display flashes 000 Pass___ Fail___

Low Flow/Audible Alarm Test

Models 4, 4H, and 4P: set the delivery rate to 300 ml/hr.

Micro: set the delivery rate to 99.9 ml/hr and select set type A.

Press [START] and verify that after five strokes:

- 1. Alarm tone is activated Pass___ Fail___
- 2. VOLUME DELIVERED display flashes FLOW and KVO Pass___ Fail___
- 3. DELIVERY RATE display flashes 004 (01.0 for Micro) Pass___ Fail___
- 4. Switch the alarm volume levels through LOW, medium, and HIGH. Verify that the volume changes. Pass___ Fail___

Delivery Accuracy Test

Deliver 20 ml into a 25 ml graduate, 0.2 graduations.

Use the following rates:

Models 4, and 4P: 400 ml/hr

Model 4H: 350 ml/hr

Micro: 99.9 ml/hr.

Delivery: _____ ml (Range = 19 to 21 ml)

Pass___ Fail___

Piggyback Test (Model 4P Only)

Set primary rate to 200 ml/hr, dose limit to 1 ml and the secondary rate to 300 ml/hr, dose limit to 1 ml.

- 1. Press [START] and verify pumping occurs, the VOLUME DELIVERED display shows SECNDRY and XXXX ML alternately, and the rotating bar is displayed. Pass___ Fail___
- 2. Verify that after a minimum of 12 seconds, the VOLUME DELIVERED display shows PRIMARY and XXXX ML alternately, and the rotating bar is displayed. Pass___ Fail___
- 3. Verify that after dose limit is met, the VOLUME DELIVERED display shows KVO and DOSE END alternately, and the DOSE LIMIT display shows 0001 ML. Pass___ Fail___

Battery Charging Test

1. With the pump disconnected from AC (mains) power, insert the accessory connector cable into the ACC. connector; connect to DMM and record the reading:

Pass___ Fail___

Battery Voltage: _____VDC.

Acceptable result is greater than or equal to 8.4 VDC.

2. Connect AC (mains) Power and record reading:

Pass___ Fail___

Charging Batt Voltage: _____VDC.

Acceptable result is greater than the reading in Step 1, but not greater than 11.0 VDC.

Malfunction Simulation Test

1. Insert the malfunction simulator plug into the ACC. connector and press [START]. Verify that MALFUNCT and 000 (Rate) flash and an audible alarm occurs.

Pass___ Fail___

2. Press [RESET]. Verify alarm continues to sound.

Pass___ Fail___

3. Press [START]. Verify pumping does not occur.

Pass___ Fail___

Electrical Safety Test

1. Record leakage current: _____

Pass___ Fail___

(Acceptable result: 2 to 50 μ A)

2. Record ground lug resistance: _____

Pass___ Fail___

(Acceptable result: < 0.1 ohm)

Performance Verification Test performed by _____ **Date** _____

Test Equipment:

Pressure Gauge # _____

Safety Analyzer # _____

DMM # _____

This page intentionally left blank.

Section 6

TROUBLESHOOTING

This section contains information on obtaining technical assistance, alarm messages and error codes, and troubleshooting the pump. The section also provides information on using the ACC. connector as a test connector.

6.1

TECHNICAL ASSISTANCE

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

1-800-241-4002

Send all authorized, prepaid returns to the following address:

Abbott Laboratories
Technical Support Operations
960 Linda Vista Avenue
Mountain View, California 94043

From outside the United States, contact the nearest Abbott Laboratories representative.

Contact an Abbott Laboratories representative or call Technical Support Operations for information about the Abbott Laboratories extended warranty program for the Model 4 Series Infusion Pumps.

6.2

AUDIBLE ALARMS

An audible alarm sounds either a continuous alarm tone, indicating a power failure, or a tone pattern of short-long-short-long. These short-long-short-long tones indicate the pump is in an alarm state. The pump automatically enters an alarm state whenever it detects an alarm condition.

6.3

ALARM CONDITIONS

When the pump enters an alarm condition, access the alarm history data screen as described in *Section 6.5, Obtaining an Alarm History*. If one or more alarm codes or conditions occur, consult one of the following tables: *Table 6-1, Alarm Codes*, details the alarm and failure codes as they appear on the VOLUME DELIVERED display during the malfunction mode and in the alarm and failure history. *Table 6-2 through Table 6-12* list failure symptoms by category and provide alarm codes, possible causes, and corrective actions for each condition. For additional information, refer to *Section 4.3.1, Modes of Operation*; *Section 4.3.1.3, Local Control Mode*; and *Section 4.3.1.6, System Failure Mode*.

6.4

ALARM CODES

A rolling history of up to 32 alarms and pump failures is available when the pump is connected to AC (mains) power or battery power. To access the alarm history screen, refer to *Section 6.5, Obtaining an Alarm History*.

Note: Loss of both AC (mains) and DC (battery) power will erase alarm and failure data.

The alarm and failure history is also available through the Dataway I/O port. Upon command from a remote terminal, the pump will transmit the last 32 alarms and failure codes in order of occurrence.

6.5

OBTAINING AN ALARM HISTORY

When the pump is in a malfunction state in either local control mode or remote control mode, press the [SILENCE] and [RESET] touchswitches simultaneously for at least 1.25 seconds to cause alarm and failure codes to appear on the VOLUME DELIVERED display. During an occlusion alarm, the message pertaining to the alarm is displayed continuously while the touchswitches are pressed; the remaining applicable messages are displayed in sequence when the touchswitches are released.

Table 6-1, Alarm Codes, describes pump alarm codes.

Alarm codes 01 through 17 are accessible through the RS-485 Dataway only.

Alarm codes 21 through 76 are accessible either by pressing the [SILENCE] and [RESET] touchswitches simultaneously, or through the RS-485 Dataway at a remote station.

Alarm codes 80 through 87 are I/O RS-485 Dataway error codes.

Table 6-1. Alarm Codes	
Code	Explanation
	OPERATION
01	High flow
02	Low flow
04	Occluded, absolute
05	Occluded, differential
06	Dose end
07	Check cassette (low algorithm)
08	Wrong cassette (interrupter detected)
10	Battery power low
11	Reset time-out
12	Flow detector inoperative
13	Dataway lost
14	Occluded, amplifier saturation pulsed at low frequency
15	Check rate
17	Check dose
	CORE
21	ROM failure
22	Critical data corrupted
23	Failure monitor does not reset processor when pulsed at high frequency
24	Failure monitor does not reset processor when pulsed at low frequency
25	Processor self-check failure
	DISPLAY
31	Message display filled, reply not received
32	Numeric (rate, dose, dose limit) display shift register failure
33	Numeric display segment failure
34	Numeric display digit driver failure
35	Numeric display data failure
	EXTERNAL CONTROL
41	External control UART framing error
42	External RAM read/write failure
43	Accessory port failure
	TOUCHSWITCH
51	Touchswitch closed longer than 164 seconds
	MECHANISM
61	Motor will not home
63	Motor slipping or stuck
64	Motor slipped 3 times in 10 cycles
65	Motor stalled
66	Volume owed too great (motor slipping)
67	Rate/flag conflict as detected by software

Table 6-1. Alarm Codes	
Code	Explanation
	MISCELLANEOUS
71	Power-up line does not go high within 160 ms
72	Software not executed within 5 ms
73	Processor failure detected by failure monitor
74	Pressure sensor amplifier saturated
75	A/D converter failure (0V, 2.5V, 5V tests)
76	Microcassette interrupter failure
	DATAWAY (RS-485 ONLY)
80	Invalid request; not in remote
81	Invalid request; not in reset
82	Invalid request; mode not correct
83	Invalid request; primary dose off
84	Invalid request; secondary dose off
85	Invalid request; not in operate
86	Transmission incorrect, checksum error
87	Illegal command

6.6

PUMP TROUBLESHOOTING

Before troubleshooting an alarm or malfunction, turn the main control switch to **LOAD/OFF RECHARGE** then to **LOCK/ON** and allow the self test to complete. If the alarm or malfunction persists, inspect the pump for signs of damage as described in *Section 5.1.1, Inspecting the Pump*, then perform the corrective action specified in this section.

Table 6-2 through Table 6-12 show failure symptoms by category, and describe their possible causes and remedies. Fault symptoms listed without an alarm code are detected by observation only, and do not cause the pump to sound an alarm or store an alarm code in memory.

Table 6-2. Troubleshooting Audible Alarms		
Symptom	Possible Cause	Corrective Action
No audible alarm	Defective piezoelectric alarm	Replace piezoelectric alarm (see Section 7.3.24)
	Defective power supply PWA	Replace power supply PWA (see Section 7.3.19.1)
Unable to change alarm volume	Defective alarm level switch	Replace alarm level switch (see Section 7.3.15)
Continuous audible alarm, all LED displays blank	Discharged battery	Recharge battery

Table 6-3. Troubleshooting Fluid Flow			
Alarm Code	LED Message or Symptom	Possible Cause	Corrective Action
01	High flow	Drip chamber forming more than one drop per fill stroke of pump	Replace IV set (see system operating manual)
		Drip chamber filled above score mark	Drain fluid from drip chamber until fluid is just below mark. Check closure of slide clamp on suspended drip chamber (see system operating manual). Press [RESET] and [START]
		Excessive agitation of drip chamber or IV line during patient ambulation	Stabilize flow detector
		Air in line (when using vented pump set and flexible containers only)	Remove filter from spike and cap off vent with sterile protective cover from spike. Reprime set and continue
		Dirty or defective flow detector	Clean or replace flow detector (see system operating manual)
		Defective flow detector circuitry	Replace power supply PWA (see Section 7.3.19.1)

Table 6-3. Troubleshooting Fluid Flow

Alarm Code	LED Message or Symptom	Possible Cause	Corrective Action
02	Low flow	Flow detector not positioned correctly on drip chamber	Position flow detector correctly (see system operating manual)
		Fluid level too high in drip chamber	Adjust fluid level to mark, check slide clamp closure
		Tilted drip chamber	Adjust drip chamber to vertical
		Empty fluid container	Replace container
		Air in cassette pumping chamber	Reprime set
		Less than one drop per fill stroke of pump	Upper line clamp closed or air in cassette pumping chamber. Open clamp or reprime set (see system operating manual)
		Dirty or defective flow detector	Clean or replace flow detector (see system operating manual)
		Defective flow detector circuitry	Replace power supply PWA (see Section 7.3.19.1)
04	Occluded, absolute	Closed clamp on IV set.	Eliminate cause of restricted flow
			Replace flow detector (see Section 7.3.9)
04	Occluded, absolute	Closed clamp on IV set.	Open clamp

Table 6-3. Troubleshooting Fluid Flow			
Alarm Code	LED Message or Symptom	Possible Cause	Corrective Action
05	Occluded, differential	Restrictions, such as pinched tubing or clogged filter	Find and remedy line restriction
		Pressure setting switch in wrong position or faulty	Set pressure switch to proper position or replace (<i>see Section 7.3.31</i>)
		Pressure sensor PWA saturated	Perform pressure sensor calibration and test (<i>see Section 7.2.4</i>)
06	Dose end	Dose delivered equals dose limit	Clear dose delivered
07	CHECK CASSETTE	Cassette not properly primed	Reprime cassette
		Set type switch in wrong position (Micro only)	Change set type switch setting
08	Wrong cassette	Wrong cassette installed	Install proper cassette

Table 6-3. Troubleshooting Fluid Flow

Alarm Code	LED Message or Symptom	Possible Cause	Corrective Action
12	Flow detector inoperative	Flow detector not connected to FLOW DET. connector at back of pump.	Connect flow detector (see system operating manual)
		Defective flow detector	Replace flow detector (see Section 7.3.9)
		Flow detector presence detection circuitry defective	Check DRPCH signal at P6, pin 43 on motor driver PWA. Signal should be less than 1 VDC when flow detector is not connected and greater than 1 VDC when flow detector is connected. If DRPCH signal is incorrect, replace power supply PWA (see Section 7.3.19.1). Repair any faulty connections
		Dirty flow detector pins or terminals	Replace flow detector connector pins (see Section 7.3.11), or flow detector plug terminals (see Section 7.3.10)
14	Occluded, amplifier failure	Misadjusted or defective pressure measuring system.	Insert primed cassette and turn pump on but do not start. Measure pressure filter output, J7, pins 1 and 5 on motherboard. Voltage should be between +0.25 and +0.97 VDC. If not, see Section 5.2.6

Table 6-3. Troubleshooting Fluid Flow			
Alarm Code	LED Message or Symptom	Possible Cause	Corrective Action
15	Check rate	Delivery rate is 000 when pump is started in single solution mode	Set delivery rate to desired value
		Secondary rate is less than primary rate in piggyback mode	Increase secondary rate to a value greater than primary rate
		Secondary or primary rate is greater than 300 ml/hr	Reset any rate over 300 ml/hr
17	Check dose	Dose limit is 0000 (000.0 for Micro)	Set dose limit to desired value
N/A	Pump delivers less fluid than setting, or consistently delivers less or more fluid than setting.	Air in cassette pumping chamber	Reprime set
		Excessive backpressure	Eliminate cause of restricted flow
		Defective set	Use another set
		Misadjusted pump mechanism	Contact Abbott Laboratories
		Incorrect MPU oscillator frequency	Check AS frequency on MPU PWA U3, pin 6. If not 1.0 MHz \pm 0.1%, replace MPU PWA (see Section 7.3.19.2)

Table 6-4. Troubleshooting Battery Operations			
Alarm Code	Symptom	Possible Cause	Corrective Action
10	Low battery	Discharged battery	Connect pump to AC (mains) power
N/A	Screen blank, pump inoperative, continuous alarm (or no alarm) on battery power	Discharged battery	Connect pump to AC (mains) power

Table 6-4. Troubleshooting Battery Operations

Alarm Code	Symptom	Possible Cause	Corrective Action
N/A	Operates on battery when connected to AC (mains) power	Blown AC (mains) power fuse	<p>Replace fuse (<i>see Section 7.3.4</i>) and measure AC (mains) current at 350 ml/hr (99.9 ml/hr, micro) with dose limit active</p> <p>For 100 to 120 VAC devices, if current exceeds 200 mA RMS (175 mA, micro), replace power supply PWA (<i>see Section 7.3.19.1</i>)</p> <p>For 220 to 240 VAC devices, if current exceeds 100 mA RMS, replace power supply PWA (<i>see Section 7.3.19.1</i>)</p>
		Loose or defective AC (mains) power cord or power cord plug	<p>Check power cord and power cord plug</p> <p>Replace power cord (<i>see Section 7.3.20</i> or <i>Section 7.3.21</i>)</p> <p>Replace power cord plug (<i>see Section 7.3.7</i>)</p>
		Defective power supply PWA	Replace power supply PWA (<i>see Section 7.3.19.1</i>)
		Defective primary circuit component	<p>AC (mains) voltage on power supply PWA P10 between pins 2 and 3 should measure between 11 and 17 VAC. Otherwise, check and replace as necessary: AC (mains) cord (<i>Section 7.3.20</i> or <i>Section 7.3.21</i>), P10 (<i>Section 7.3.25</i>), fuseholder (<i>Section 7.3.4.2</i> or <i>Section 7.3.29</i>), or power supply PWA (<i>Section 7.3.19.1</i>)</p>

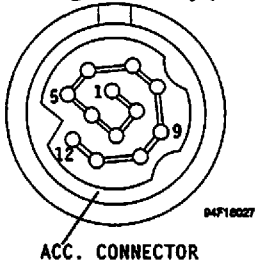
Table 6-4. Troubleshooting Battery Operations			
Alarm Code	Symptom	Possible Cause	Corrective Action
N/A	No battery operation or short operating time to low battery alarm	Defective battery pack	Whenever a defective battery pack is replaced, the battery charging circuit should be checked as described in <i>Section 5.4.4</i> Replace power supply PWA (see <i>Section 7.3.19.1</i>)
		Discharged battery pack 	Before recharging, with pump disconnected from AC (mains) power, measure battery voltage at pin 6 and ground (pin 5) of J23 (ACC. connector). If battery voltage is less than 7.2 VDC, replace the battery pack (see <i>Section 7.3.3</i>) Recharge battery pack

Table 6-5. Troubleshooting Core Failures			
Alarm Code	Symptom	Possible Cause	Corrective Action
21	ROM failure	Defective ROM, MPU PWA	Replace MPU PWA (see <i>Section 7.3.19.2</i>)
22	Critical data corrupted	Defective MPU PWA, microprocessor, read only memories	Replace MPU PWA (see <i>Section 7.3.19.2</i>)
23 24	Watchdog does not reset processor when pulsed at high frequency, or, Watchdog does not reset processor when pulsed at low frequency	Signal generated by program is significantly higher or lower than reference oscillator	Turn main control switch off and on three times. If pump still fails, replace display driver PWA (see <i>Section 7.3.19.2</i>). If pump continues to fail, replace MPU PWA (see <i>Section 7.3.19.2</i>)
		Defective display driver PWA, watchdog circuitry	
		Defective MPU PWA	Replace MPU PWA (see <i>Section 7.3.19.2</i>)

Table 6-5. Troubleshooting Core Failures			
Alarm Code	Symptom	Possible Cause	Corrective Action
25	Sanity check failure	Defective ROM, MPU PWA	Replace MPU PWA (see Section 7.3.19.2)

Table 6-6. Troubleshooting the Pump Displays			
Alarm Code	Symptom	Possible Cause	Corrective Action
31	Message display filled, reply not received	Microprocessor did not receive proper signal, indicating not all characters were written to decoder/driver	Check for proper connection; replace display PWA (see Section 7.3.19.2) if faulty
32	Numeric display shift register failure	Microprocessor failed to clear digit driver shift registers on display driver PWA	Replace display driver PWA or motor driver PWA (see Section 7.3.19.2)
33	Numeric display segment failure	Defective numeric display, segment drivers	Replace display driver PWA (see Section 7.3.19.2)
34	Numeric display digit failure	Defective numeric displays or segment drivers	Replace display driver PWA (see Section 7.3.19.2)
		Defective display driver PWA, digit drivers	Replace display driver PWA (see Section 7.3.19.2)
35	Numeric display data greater than nine failure	Defective MPU PWA	Replace MPU PWA (see Section 7.3.19.2)

Table 6-7. Troubleshooting External Controls			
Alarm Code	Symptom	Possible Cause	Corrective Action
41	External UART framing error	Defective UART	Replace motor driver PWA (<i>see Section 7.3.19.2</i>)
42	External RAM failure	Defective MPU PWA	Replace MPU PWA (<i>see Section 7.3.19.2</i>)
43	Accessory port failure	ACRT1 (RATE 1) or ACRT2 (RATE 2) shorted to ground	Both signals must be ground or high together. Check signals, clean port, or replace shorted pins as necessary
		Defective motor driver PWA, output latch circuitry	Replace motor driver PWA (<i>see Section 7.3.19.2</i>)

Table 6-8. Troubleshooting the Pump Touchswitches			
Alarm Code	Symptom	Possible Cause	Corrective Action
51	Touchswitch closed longer than 163 seconds	One or more front panel switch signals shorted to ground	Replace touchswitch or replace front panel assembly as necessary (<i>see Section 7.3.23</i>)

Table 6-9. Troubleshooting the Pump Mechanism			
Alarm Code	Symptom	Possible Cause	Corrective Action
61	Motor will not home	Misadjusted or defective motor interrupter	Contact Abbott Laboratories
		Motor flag is loose or broken	Contact Abbott Laboratories
		Defective motor voltage supply circuit	Replace power supply PWA (<i>see Section 7.3.19.1</i>)
		Defective motor driver PWA	Replace motor driver PWA (<i>see Section 7.3.19.2</i>)

Table 6-9. Troubleshooting the Pump Mechanism

Alarm Code	Symptom	Possible Cause	Corrective Action
63	Motor slipping or stuck	Defective motor transistor	Replace motor driver PWA (<i>see Section 7.3.19.2</i>)
		Motor flag interrupter defective	Contact Abbott Laboratories
		Defective motor	Contact Abbott Laboratories
64	Motor slipped three times in 10 cycles	Motor flag interrupter defective	Contact Abbott Laboratories
		Motor flag detector defective, dirty, broken, or misadjusted	Contact Abbott Laboratories
66	Volume owed too great because motor slipping	Defective power supply PWA, motor flag circuitry, motor voltage regulator	Replace power supply PWA (<i>see Section 7.3.19.1</i>), check motor flag circuitry ground of Q8 on power supply PWA, VMOT should measure 5 ± 0.2 VDC
		Motor flag interrupter not positioned correctly. Pumping mechanism binding or stuck	Remove ground for base of Q81; VMOT should measure between 0.05 and 0.20 VDC (measurements with pump in reset)
67	Rate/flag conflict as detected by software	Defective MPU PWA	Replace MPU PWA (<i>see Section 7.3.19.2</i>)
N/A	Volume owed too great because motor slipping	Defective power supply PWA, motor flag circuitry, motor voltage regulator	Replace power supply PWA (<i>see Section 7.3.19.1</i>), check motor flag circuitry ground of Q8 on power supply PWA, VMOT should measure 5 ± 0.2 VDC
		Motor flag interrupter not positioned correctly. Pumping mechanism binding or stuck	Remove ground for base of Q81; VMOT should measure between 0.05 and 0.20 VDC (measurements with pump in reset)

Table 6-9. Troubleshooting the Pump Mechanism			
Alarm Code	Symptom	Possible Cause	Corrective Action
N/A	Rate/flag conflict as detected by software	Defective MPU PWA	Replace MPU PWA (see Section 7.3.19.2)

Table 6-10. Troubleshooting the Dataway Function (RS-485 Only)			
Alarm Code	Symptom	Possible Cause	Corrective Action
13	Dataway lost	Dataway communications error Installation error in Dataway connector	Refer to <i>LifeCare Model 4 Series Infusion Pumps RS-485 Dataway Technical Specification Guide and Interface Manual</i> , P/N 430-01761-XXX
80	N/A	Invalid request; not in remote	
81	N/A	Invalid request; not in reset	
82	N/A	Invalid request; mode not correct	
83	N/A	Invalid request; primary dose off	
84	N/A	Invalid request; secondary dose off	
85	N/A	Invalid request; not in operate	
86	N/A	Transmission incorrect; checksum error	
87	N/A	Illegal command	

Table 6-11. Troubleshooting the Nurse-Call Alarm		
Symptom	Possible Cause	Corrective Action
Nurse-call does not activate during alarm or malfunction	Defective power supply PWA, nurse-call circuits	Replace power supply PWA (see Section 7.3.19.1)
	Defective main control switch	Replace main control switch. Check continuity of nurse-call circuits NCC, NC1, NC2 on power supply PWA with main control switch in both LOAD/OFF RECHARGE and LOCK/ON positions

Table 6-12. Troubleshooting Miscellaneous Conditions			
Alarm Code	Symptom	Possible Cause	Corrective Action
11	Reset more than five minutes	Pump idle in reset mode longer than five minutes	Press [START], press [RESET], or turn pump off
N/A	Screen blank, pump inoperative, continuous alarm (or no alarm) on AC (mains) power	+5 VDC power supply has failed	Replace power supply PWA (see Section 7.3.19.1) Refer to Section 4.5.6.1
		Loose PWAs	Reseat PWAs
71	Power-up line does not go high within 160 ms of power on	Defective MPU PWA, input buffer	Replace MPU PWA (see Section 7.3.19.2)
72	Software not executed within 5 ms period	Defective ROM, MPU PWA	Replace MPU PWA (see Section 7.3.19.2)
73	Watchdog has caught processor failure	One or more PWAs improperly connected or defective	Check connections of all PWAs If failure persists, contact Abbott Laboratories

Table 6-12. Troubleshooting Miscellaneous Conditions			
Alarm Code	Symptom	Possible Cause	Corrective Action
74	Pressure sensor amplifier saturated	Badly misadjusted or defective pressure measuring system	Insert primed cassette and turn pump on but do not start. Measure pressure filter output, J7, pins 1 and 5 on motherboard. Voltage should be between +0.25 and +0.97 VDC. If not, see <i>Section 5.2.6</i>
75	A/D converter failure	Defective motor driver PWA, A/D converter, improper voltages to A/D converter	Replace motor driver PWA (<i>see Section 7.3.19.2</i>)
76	Microcassette interrupter failure	Defective MPU PWA	Replace MPU PWA (<i>see Section 7.3.19.2</i>)
		Defective power supply PWA	Replace power supply PWA (<i>see Section 7.3.19.1</i>)
N/A	Main control switch assembly tight or stuck; will not rotate smoothly	Main control shaft assembly needs lubrication	Lubricate main control shaft assembly (<i>see Section 7.3.26</i>)
N/A	Pump turns off or on by itself	Worn main control shaft	Replace main control shaft (<i>see Section 7.3.26</i>)
		Main control shaft needs lubrication	Lubricate main control shaft (<i>see Section 7.3.27</i>)
N/A	Main control switch is slow to cycle power	Main control shaft needs lubrication	Lubricate main control shaft (<i>see Section 7.3.27</i>)

6.7

PVT TROUBLESHOOTING

Table 6-13 Troubleshooting with the PVT, describes failures that may be detected during the PVT (see Section 5.2, Performance Verification Test). If an error code displays, see Section 6.6, Pump Troubleshooting.

Table 6-13. Troubleshooting with the PVT

PVT Test Failure	Possible Cause	Corrective Action
Dry cassette test (Section 5.2.3)	Defective cassette	Replace test cassette
	Defective shroud assembly	Perform shroud tab check (Section 7.2.2)
Start up test (Section 5.2.5)	Blown fuse	Replace fuse (see Section 7.3.4)
	Defective main control wafer switch	Replace main control shaft assembly (see Section 7.3.26)
	Defective power supply PWA	Replace the power supply PWA (see Section 7.3.19.1)
	Defective display PWA	Replace the display PWA (see Section 7.3.19.2)
	Defective flow detector connector	Replace the flow detector connector (see Section 7.3.11)
Pressure test and silence switch test (Section 5.2.6)	Pressure Sensor PWA is out of calibration	Perform pressure sensor calibration and test (Section 7.2.4)
	Defective pressure sensor PWA	Contact Abbott Laboratories (see Section 6.1)
Low flow and high flow alarm tests (Section 5.2.7)	Dirty or defective flow detector	Clean or replace the flow detector (see Section 7.3.9)
	Defective flow detector circuitry	Replace the power supply PWA (see Section 7.3.19.1)
	Defective motherboard PWA	Replace the motherboard PWA (see Section 7.3.19.3)
Delivery accuracy test (Section 5.2.8)	Air in the cassette compression chamber	Reprime the cassette
	Defective administration set	Replace the administration set
	Inaccurate stroke length	Contact Abbott Laboratories
Piggyback test (Section 5.2.9)	Faulty touchswitch panel	Replace touchswitch panel (see Section 7.3.23)
	Faulty display driver	Replace display driver PWA (see Section 7.3.19.2)

Table 6-13. Troubleshooting with the PVT		
PVT Test Failure	Possible Cause	Corrective Action
Battery charging test (Section 5.2.10)	Defective power supply PWA	Replace power supply PWA (see Section 7.3.19.1)
	Defective or damaged battery	Replace battery pack (see Section 7.3.3)
Malfunction simulation test (Section 5.2.11)	Loose, bent, or missing pins on ACC. connector	Replace appropriate pins (see Section 7.3.17)
	Defective power supply	Replace power supply PWA (see Section 7.3.19.1)
Electrical safety test (Section 5.2.12)	Corroded prongs on AC (mains) plug	Clean the three prongs on AC (mains) plug
	Loose connection in AC (mains) plug	Tighten connections in AC (mains) plug or replace plug (see Section 7.3.7)
	Splice in AC (mains) power cord	If splice is located near plug, cut AC (mains) cord and replace plug (see Section 7.3.7); if not near plug, replace AC (mains) power cord (see Section 7.3.20 or Section 7.3.21)
	Loose grounding strap in pump	Tighten grounding strap

6.8

TEST CONNECTOR

The ACC. connector (J23) on the back of the pump can be used as a test connector to verify the system functions indicated in *Table 6-14, Test Connector (J23) Pin Assignments*. The signals listed in *Table 6-2, Troubleshooting Audible Alarms*, are taken from the power supply PWA. The ACC. connector is also used to check the battery charger.

Table 6-14. Test Connector (J23) Pin Assignments	
Pin Number	Signal Nomenclature
1	+5VDC
2	AUDIO 2
3	Not connected

Table 6-14. Test Connector (J23) Pin Assignments	
Pin Number	Signal Nomenclature
4	Not connected
5	GND
6	BATTERY MONITOR
7	Not connected
8	CYCLE*
9	RATE 1*
10	RATE 2*
11	DOSE COMPLETE*
12	ALARM*

* Indicates an active low signal.

Section 7

REPLACEABLE PARTS AND REPAIRS

This section itemizes all parts and subassemblies of the LifeCare and HomeCare Model 4 Series Infusion Pumps 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 LifeCare and HomeCare Model 4 Series infusion pump are itemized in the spare parts price list and are identified in *Figure 9-16, IPB for the Pump*. *Table 9-2, IPB for the Pump*, identifies each pump part by an index number that correlates to *Figure 9-16*.

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.

This page intentionally left blank.

7.2

ADJUSTMENT PROCEDURES

This section provides procedures for checking and adjusting the shroud tabs and for calibrating and testing the pressure sensor.

7.2.1

REQUIRED TOOLS AND MATERIALS

The following tools and materials, or equivalents, are required for the adjustment procedures described in this section:

- Primed IV set and fluid supply
- DMM, Fluke Model 77
- DPM, 0 to 50 psig, Bio-Tek DPM II
- Cassette plunger tip extracted from dry cassette, List No. 67-6254
- Relief valve assembly (P/N 561-88116-001)
- Three-way stopcock, List No. 3233-01
- Red GLPT insulating varnish (P/N 733-35029-001)
- Tab adjustment tool (P/N 561-80535-001)
- No-go tool (P/N 561-81325-105 and P/N 561-81325-115)
- Go tool (P/N 561-81325-070)
- Set of Allen wrenches
- Set of open end wrenches
- Small flat blade screwdriver

7.2.2

SHROUD TAB CHECK

The recommended tools for this procedure are as follows: a go tool and the two no-go tools.

To perform the shroud tab check for each front and rear tab guide set, refer to *Figure 7-1, Shroud Tab Check*, then proceed as follows:

1. Turn the main control switch to the LOAD/OFF RECHARGE position.
2. Position and slide the go tool tip against the front and rear tabs; check the clearance of the shroud cassette flange groove guide tabs. The go tool should just pass under the rear tabs but should be stopped by the front tabs.
3. Position and slide the no-go tool (P/N 561-81325-115) tip against the rear tab. The no-go tool should not pass under the rear tab.
4. If the no-go tool tip passes under the rear tab, proceed to *Section 7.2.3, Shroud Rear Tab Adjustment*, then repeat Step 3. If the no-go tool tip does not pass under the rear tab, proceed to Step 5.
5. Turn the main control switch to LOCK/ON and slide the no-go tool (P/N 561-81325-115) tip against the rear tab guide. The no-go tool should not pass under the rear tab.

6. If the no-go tool tip passes under the rear tab, proceed to *Section 7.2.3, Shroud Rear Tab Adjustment*, then repeat Step 5. If the no-go tool tip does not pass under the rear tab, proceed to Step 1 and perform the shroud tab check for the other front and rear tab guide set.

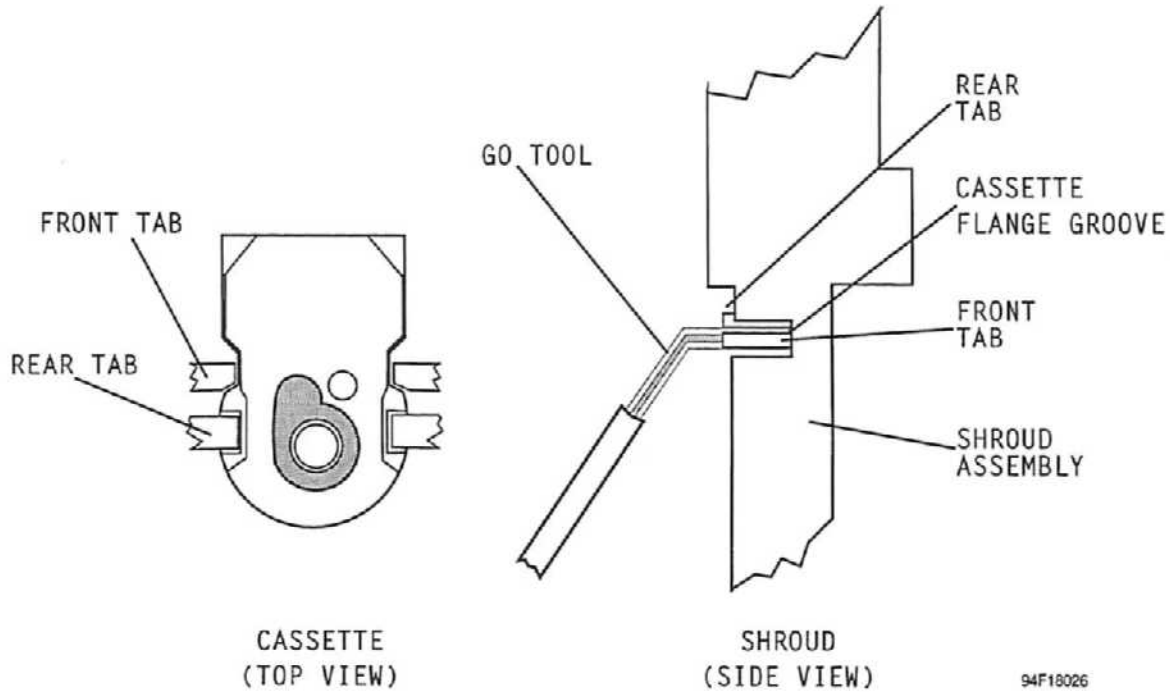


Figure 7-1. Shroud Tab Check

7.2.3

SHROUD REAR TAB ADJUSTMENT

The recommended tool for this procedure is the tab adjustment tool.

To adjust the shroud rear tabs, proceed as follows:

1. Turn the pump main control switch to LOCK/ON.
2. Using the tab adjustment tool, grasp the rear tab and bend the tab slightly up or down for proper adjustment (*see Figure 7-1, Shroud Tab Check*).
3. Repeat Step 2 with the opposite tab.
4. Turn the main control switch to LOAD/OFF RECHARGE.
5. After adjustment, perform shroud tab check for verification (*see Section 7.2.2, Shroud Tab Check*).

7.2.4

PRESSURE SENSOR CALIBRATION AND TEST

Recommended tools for this procedure are as follows: a small flat blade screwdriver, primed cassette, DMM, set of Allen wrenches, DPM, relief valve assembly, and red GLPT insulating varnish.

The pressure sensor calibration and test should be performed if the pump fails the pressure test and the problem has been isolated to the pressure sensor PWA, or if there is an occlusion alarm failure (see *Section 5.2.6, Pressure Test and Silence Switch Test*). To perform this test, disassemble the pump as described in *Section 7.3.18, Case Replacement*, and *Section 7.3.19, PWA Replacement*.

This procedure consists of a calibration procedure and a pressure sensor test. After performing the entire procedure, perform the PVT in *Section 5.2*.

7.2.4.1

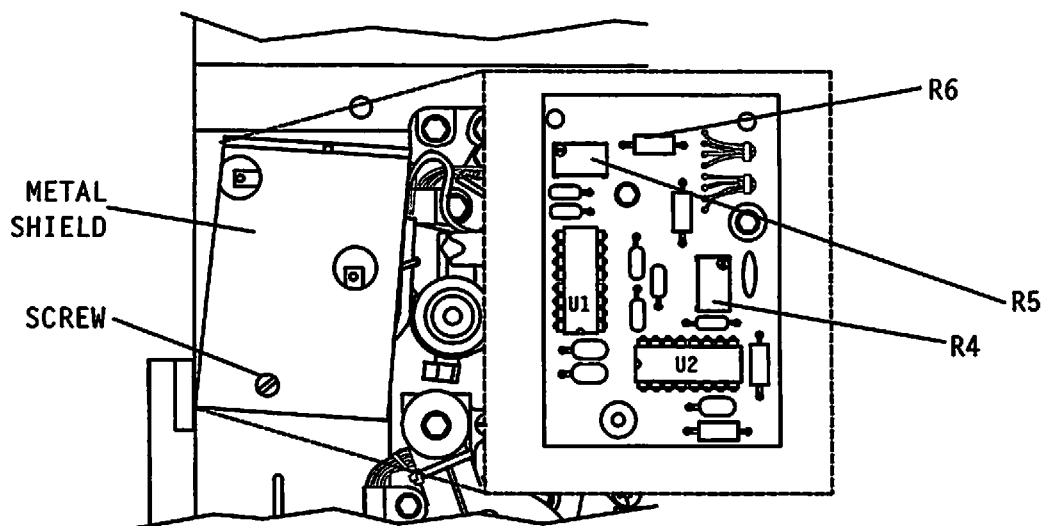
PRESSURE SENSOR CALIBRATION SETUP

There are two calibration procedures based on the final assembly number of the pressure sensor PWA. To determine the final assembly number of the pressure sensor PWA, proceed as follows:

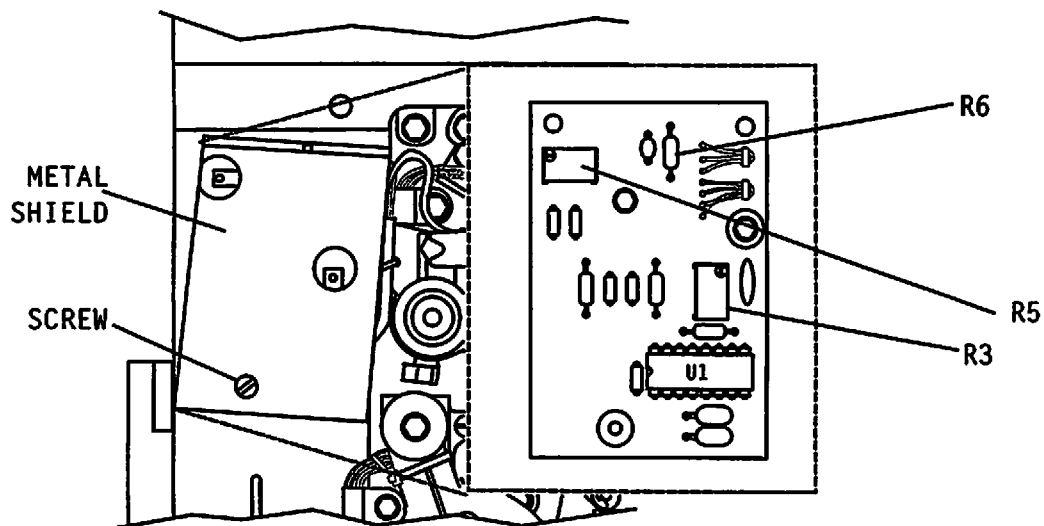
1. Using a small, flat blade screwdriver, remove the screw that secures the metal shield to the pressure sensor PWA (see *Figure 7-2, Pressure Sensor Adjustment Resistors*).
2. Connect the pump to AC (mains) power.
3. Insert a primed cassette in the pump and set the pump pressure switch to MAX.
4. Turn the main control switch to LOCK/ON.
5. Set the DMM to measure VDC, then attach the DMM leads across R6 on the pressure sensor PWA (see *Figure 7-2*).

Note: R6 is positioned horizontally on -003 and lower pressure sensor PWAs and vertically on -004 and higher pressure sensor PWAs.

6. Note the dash number inscribed on the pressure sensor PWA. If the number is -003 or lower, calibrate the pressure sensor as described in *Section 7.2.4.2, Calibration (Pressure Sensor PWA -003 and Lower)*. If the number is -004 or higher, calibrate the pressure sensor as described in *Section 7.2.4.3, Calibration (Pressure Sensor PWA -004 and Higher)*.



PRESSURE SENSOR PWA -003 AND LOWER



PRESSURE SENSOR PWA -004 AND HIGHER

94F18014

Figure 7-2. Pressure Sensor Adjustment Resistors

7.2.4.2

CALIBRATION (PRESSURE SENSOR PWA -003 AND LOWER)

To calibrate the pressure sensor, proceed as follows:

1. Perform the calibration setup procedure in *Section 7.2.4.1, Pressure Sensor Calibration Setup*.
2. Turn R5, located on the top left side of pressure sensor PWA, counterclockwise until the voltage, as observed on the DMM, stops decreasing (*see Figure 7-2, Pressure Sensor Adjustment Resistors*).
3. Adjust R4, located on the bottom right side of the pressure sensor PWA to obtain a reading of 0.75 ± 0.1 VDC on the DMM.
4. Adjust R5 clockwise to obtain a reading of 1.80 VDC on the DMM.

5. Re-adjust R4 as necessary to obtain a reading of 0.75 VDC on the DMM.
6. Set a delivery rate as follows: Models 4 and 4P to 400 ml/hr; Model 4H to 350 ml/hr; Micro to 99.9 ml/hr. Set a dose limit of 150 ml; set the pressure switch on the back of the pump to MAX.
7. Press the [START] touchswitch.
8. Press the [SILENCE] and [START] touchswitches simultaneously and read the number of bits in the VOLUME DELIVERED display.
 Stability Check: Record the number of bits. This number should not vary by more than 4 bits from one stroke to the next.
 Drift Check: Record the bits reading in 15 seconds. This number should not drift by more than 6 bits from the first reading. If the bits vary after several checks, contact Abbott Laboratories (see Section 6.1, Technical Assistance).
9. Press the [RESET] touchswitch.
10. Take the average value of the stability check and the drift check readings. If the bits vary beyond the two limits after several checks, contact Abbott Laboratories.
11. Attach the relief valve assembly and the DPM as shown in Figure 7-3, Calibration Test Setup.

Note: Do not attach the flow detector unless required for pump operation.

12. Press the [START] touchswitch. Allow 10 psig (69 kPa) to build up as read on the DPM.

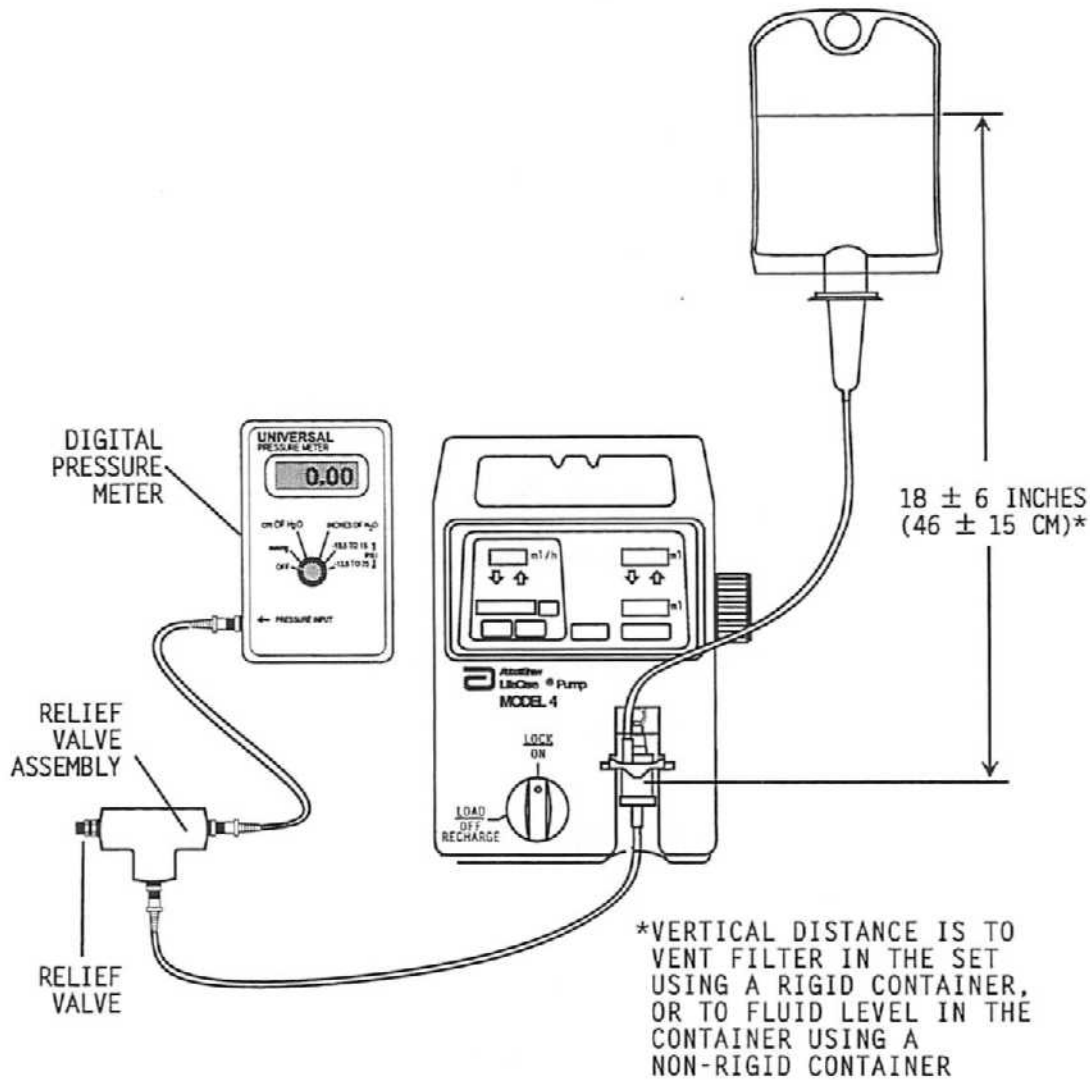
Note: If the pressure does not build and maintain at 10 ± 1 psig (69 ± 6.9 kPa), the relief valve needs to be recalibrated; proceed to Step 13. If the proper pressure is obtained and maintained, proceed to Step 17.

Note: Perform the following steps with the pump operating.

13. Hold the relief valve Allen screw with a 5/32 inch Allen wrench while loosening the outer hex head locking nut. Remove the outer hex nut only.
14. Using 5/32 inch Allen wrench, adjust the inner set screw on the relief valve so that 10 ± 1 psig (69 ± 6.9 kPa) appears on the DPM. The adjustment may need to be made to 9 psig (62.1 kPa) as the tightening of the outer locking nut may increase the value.
15. Re-insert the outer locking screw.
16. Verify that 10 ± 1 psig (69 ± 6.9 kPa) builds up and is maintained as read on the DPM. Continue this procedure until 10 ± 1 psig (69 ± 6.9 kPa) is established.

Note: If 10 ± 1 psig (69 ± 6.9 kPa) is unattainable, discontinue testing and contact Abbott Laboratories.

17. Press the [SILENCE] and [START] touchswitches simultaneously and read the number of bits in the VOLUME DELIVERED display. Turn R5 until the message display reading is 30 ± 3 bits more than the number observed in Step 10.
18. Press the [RESET] touchswitch. Turn the main control switch to LOAD/OFF RECHARGE; insert the cassette plunger tip in place of the cassette. Turn the main control switch to LOCK/ON.
19. Adjust R4 until the DMM reads 0.55 ± 0.1 VDC.
20. Disconnect the relief valve assembly.



94F18001

Figure 7-3. Calibration Test Setup

7.2.4.3

CALIBRATION (PRESSURE SENSOR PWA -004 AND HIGHER)

To calibrate the pressure sensor, proceed as follows:

1. Perform the calibration setup procedure in *Section 7.2.4.1, Pressure Sensor Calibration Setup*.
2. Turn R5, located on the top left side of pressure sensor PWA, clockwise until voltage, as observed on the DMM, stops increasing (see *Figure 7-2, Pressure Sensor Adjustment Resistors*).
3. Adjust R3, located on the bottom right side of the pressure sensor PWA, to obtain a reading of 1.83 VDC ± 20.0 mVDC on the DMM.
4. Adjust R5 counterclockwise to obtain a reading of 0.93 VDC ± 30.0 mVDC on the DMM.

5. Set the delivery rate as follows: Models 4 and 4P to 400 ml/hr; Model 4H to 350 ml/hr; Micro to 99.9 ml/hr. Set the dose limit to 150 ml; set the pressure switch on the back of the pump to MAX.
6. Press the [START] touchswitch.
7. Press the [SILENCE] and [START] touchswitches simultaneously and read the number of bits in the VOLUME DELIVERED display.

Stability Check: Record the number of bits. This number should not vary by more than 4 bits from one stroke to the next.

Drift Check: Record the bits reading in 15 seconds. This number should not drift by more than 6 bits from the first reading. If the bits vary after several checks, contact Abbott Laboratories (see Section 6.1, *Technical Assistance*).

8. Press the [RESET] touchswitch.
9. Take the average value of the stability check and the drift check readings. The average value should be between 52 and 72 bits. Record this value. If the bits vary beyond the two limits after several checks, contact Abbott Laboratories.
10. Attach the relief valve assembly and the DPM as shown in *Figure 7-3, Calibration Test Setup*.

Note: Do not attach the flow detector unless it is required for pump operation.

11. Press the [START] touchswitch. Allow 10 psig (69 kPa) to build up as read on the DPM.

Note: If the pressure does not build and maintain at 10 ± 1 psig (69 ± 6.9 kPa), the relief valve needs to be recalibrated; continue to Step 12. If the proper pressure is obtained and maintained, proceed to Step 16.

Note: Perform the following steps with the pump operating.

12. Hold the relief valve Allen screw with a 5/32 inch Allen wrench while loosening the outer hex head locking nut. Remove the outer hex nut only.
13. Using 5/32 inch Allen wrench, adjust the inner set screw on the relief valve so that 10 ± 1.0 psig (69 ± 6.9 kPa) appears on the DPM. This adjustment may need to be made to 9 psig (62.1 kPa) as the tightening of the outer locking nut may increase the value.
14. Re-insert the outer locking screw.
15. Verify that 10 ± 1 psig (69 ± 6.9 kPa) builds up and is maintained as read on the DPM. Continue this procedure until 10 ± 1 psig (69 ± 6.9 kPa) is established.

Note: If 10 ± 1 psig (69 ± 6.9 kPa) is unattainable, discontinue testing and contact Abbott Laboratories.

16. Press the [SILENCE] and [START] touchswitches simultaneously and read the number of bits in the VOLUME DELIVERED display. Turn R5 until the message display reading is 30 ± 3 bits more than the number recorded in Step 9.
17. Press the [RESET] touchswitch. Turn the main control switch to LOAD/OFF RECHARGE; insert the cassette plunger tip in place of the cassette. Turn the main control switch to LOCK/ON.
18. Adjust R3 until the DMM reads 0.82 ± 0.02 VDC.
19. Disconnect the relief valve assembly.

7.2.4.4

PRESSURE SENSOR TEST

To perform the pressure sensor test, set up the test equipment as shown in *Figure 7-3, Calibration Test Setup*. Replace the relief valve with the three-way stopcock, then proceed as follows:

1. Verify the level of the water in the container is 18 ± 6 inches (45 ± 15 cm) above the midline of the cassette. Connect the set to the container; prime and insert the cassette in the pump.
2. Connect the DPM to the patient line through a three-way stopcock. Turn the main control switch to LOCK/ON.
3. Set the pressure switch on the back of the pump to MIN. Press and hold the [SILENCE] touchswitch and read the switch position in the VOLUME DELIVERED display. Change the pressure switch setting to MID and then to MAX; observe the corresponding change in the VOLUME DELIVERED display.
4. Set the delivery rates as follows: Models 4 and 4P to 400 ml/hr; Model 4H to 350 ml/hr; Micro to 99.9 ml/hr. Set the dose limit to 150 ml.
5. With the pressure switch set to MIN, press the [START] touchswitch. After three pump strokes, press the [START] and [SILENCE] touchswitches simultaneously and record the bit count in the VOLUME DELIVERED display to use as a baseline reference; confirm a reading of 0 psig on the DPM.
6. Close the three-way stopcock. At occlusion, the pressure should read 4.0 ± 1.5 psig (27.6 ± 10.4 kPa). Release the three-way stopcock.
7. Press and hold the [SILENCE] touchswitch and confirm DIF PRES is displayed on the VOLUME DELIVERED display. Press the [SILENCE] and [START] touchswitches simultaneously and read the number of bits in the VOLUME DELIVERED display.

Note: Use the bit count recorded in Step 5 as a baseline reference.

1 psig (6.9 kPa) = 3 bits; therefore, the following values in bits above the baseline should be observed: at 4 psig (27.6 kPa), 12 bits \pm 4.5 bits; at 8.0 psig (55.2 kPa), 24 bits \pm 6 bits; at 12.0 psig (82.8 kPa), 36 bits \pm 7.5 bits.

8. Repeat Step 5 and Step 6 for the MID and MAX settings of the pressure switch. Upon completion of pressure test on the MAX setting, do not release the three-way stopcock. At the MID position of the pressure switch, the pressure should read 8 ± 2 psig (55.2 ± 13.8 kPa).

At the MAX position of the pressure switch, the pressure should read 12 ± 2 psig (82.8 ± 13.8 kPa).

Note: Due to the absolute pressure tolerance, it is possible to get an absolute pressure reading at the MAX position of the pressure switch. The pressure tolerances are 15 ± 4.5 psig (103.5 ± 31.1 kPa)

Note: Model 4, 4H, and 4 Micro pumps with pressure sensor PWA -004 and higher have 108 bits as an upper limit for differential or absolute pressure when the pump occludes. Model 4P pumps with pressure sensor PWA -004 and higher have 102 bits as the upper limit, resulting in an earlier occlusion than the other pump models.

The Model 4P occludes at a slightly lower pressure in the MIN, MID, and MAX settings than the other pumps.

9. Press the [START] touchswitch. The pump should indicate an absolute occlusion alarm at 15 ± 4.5 psig (103.5 ± 31.1 kPa).
10. Press and hold the [SILENCE] touchswitch and observe ABS PRES in the VOLUME DELIVERED display. If the pump indicates DIF PRES, repeat Step 5 through Step 7.
11. Press the [RESET] touchswitch and disconnect the DPM.
12. Apply red GLPT insulating varnish to R4 and R5 (for pressure sensor PWA -003 and lower) or to R3 and R5 (for pressure sensor PWA -004 and higher).
13. Re-assemble the pump in the exact reverse order of disassembly.

To verify successful pressure sensor calibration, perform the PVT in *Section 5.2*.

7.3

REPLACEMENT PROCEDURES

This section contains step-by-step replacement procedures for the LifeCare and HomeCare Model 4 Series Infusion Pumps. Prior to these procedures, safety and equipment precautions and required tools and materials are detailed. Unless otherwise stated, always perform the PVT after repair procedures.

7.3.1

SAFETY AND EQUIPMENT PRECAUTIONS

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

WARNING

UNLESS OTHERWISE INDICATED, DISCONNECT THE PUMP FROM AC (MAINS) POWER BEFORE PERFORMING ANY REPAIR PROCEDURE.

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

7.3.2

REQUIRED TOOLS AND MATERIALS

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

7.3.2.1

STANDARD HANDTOOLS

The following standard handtools are required for replacement procedures:

- Set of hex nutdrivers
- Set of Allen wrenches
- Set of small open end wrenches
- Set of box wrenches
- No. 2 Phillips screwdriver
- Small flat blade screwdriver
- Medium flat blade screwdriver
- Needle nose pliers
- Soldering iron
- X-acto[®] knife
- Torque wrench with 1/2 inch socket
- Wire cutters
- Wire strippers
- Electricians knife
- Wood chisel, 3/8 inch
- Heat gun (optional)

7.3.2.2

SPECIAL TOOLS

The following special tools are required for repair procedures:

- Scribe tool, List No. 76-1512
- E-type retaining ring tool (Waldes or IRC)
- Mini-pin insertion/extraction tool (AMP, Viking, Molex, or equivalent)
- External retaining ring pliers
- Crimping tool (Viking or equivalent)
- Bushing extractor tool

7.3.2.3

MATERIALS

The following materials are required for repair procedures:

- Solder, tin/lead, Sn63/Pb37 RMA-type only
- Shrink tubing, 3/32 inch, 1/8 inch, 3/8 inch, 3/4 inch, and 0.187 inch inside diameter
- Shroud Assembly Plunger Guide Repair Kit, P/N 895-01163-004
- Grease, Braycote[®] 804

- Loctite® 460 Adhesive, P/N 733-38218-001
- Loctite 712 Accelerator, P/N 733-38220-001
- Loctite retaining compound, P/N 733-35023-001
- Terminal lugs, crimp on, 12 gauge to 16 gauge, AWG
- Butt connectors, crimp on, 12 gauge to 16 gauge, AWG
- Small tie wraps
- Isopropyl alcohol
- No-lint or low-lint cloth
- Shroud assembly plunger guide repair kit, P/N 895-01163-004
- Closed entry female terminals
- Electro-Wash® 2000
- Lint-free cloth or cotton swabs
- Small brush (optional)
- 0.125 inch polyvinyl chloride (PVC) tubing

7.3.3

BATTERY PACK REPLACEMENT

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

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

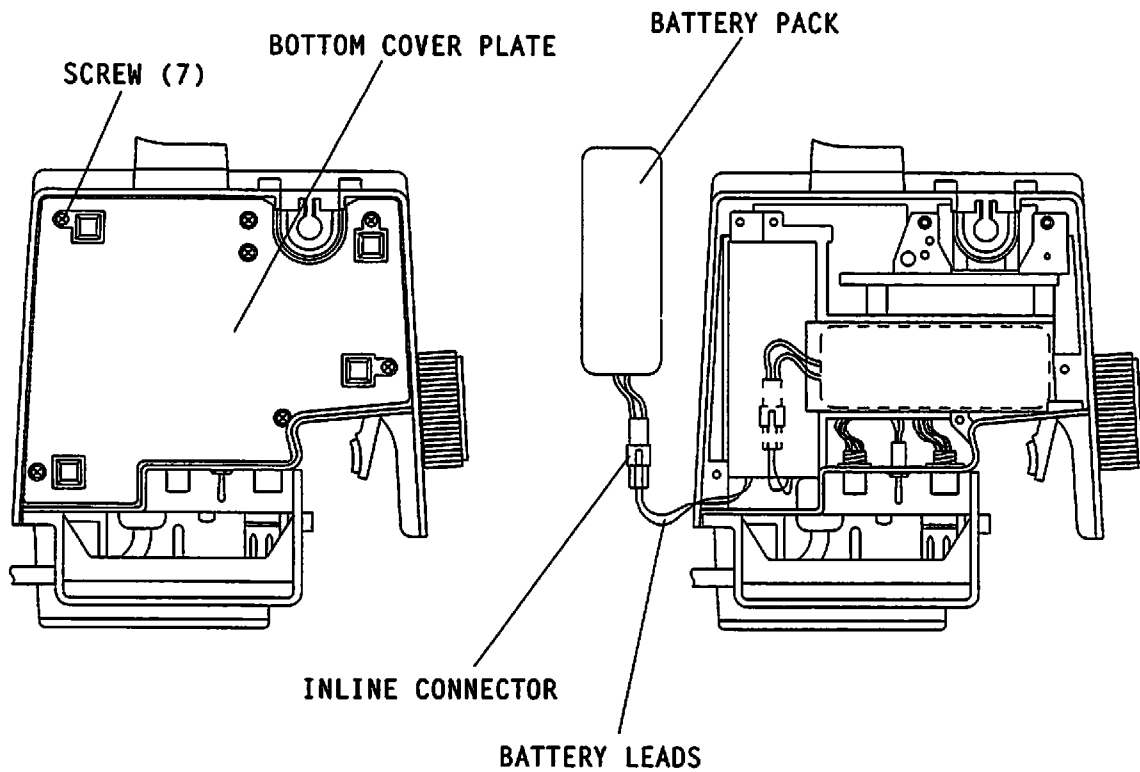
To replace the battery pack, refer to *Figure 7-4, Battery Pack Replacement*, then proceed as follows:

1. Disconnect the pump from AC (mains) power.
2. Place the pump face down on a soft surface; remove all seven Phillips screws from the bottom cover; remove the cover.
3. Grasp each side of the white inline connector and disconnect the battery pack leads.
4. Lift out the battery pack and set it beside the pump.
5. Connect the leads from the new battery pack, making certain the connection is secure.

Note: The connector is keyed to fit only one way.

6. Place the new battery pack in the housing so that the bottoms of the batteries are visible. Make certain leads are not kinked.
7. Replace the bottom cover making certain that the battery pack leads are tucked inside. Replace the screws removed in Step 2; do not overtighten.
8. With the pump disconnected from AC (mains) power, turn the main control switch to LOCK/ON. Verify that BATT is illuminated on the front panel display legend.

To verify successful battery pack replacement, perform the PVT in *Section 5.2*.



94F18031

Figure 7-4. Battery Pack Replacement

7.3.4

FUSE REPLACEMENT

The fuse replacement procedure depends on pump voltage.

7.3.4.1

FUSE REPLACEMENT



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

The recommended tool for this procedure is a Phillips screwdriver.

To replace the fuse in a 115 volt pump, proceed as follows:

1. Disconnect the pump from AC (mains) power and turn the main control switch to **LOAD/OFF RECHARGE**.
2. Open the pump case as described in *Section 7.3.18, Case Replacement*.
3. Remove the fuse by rotating the fuseholder knob counterclockwise. Pull the fuseholder from the receptacle. Remove the fuse from the fuseholder and discard according to hospital protocol.
4. Insert the new fuse in the fuseholder; press the fuse down into holder so that it is held in place.

5. Insert the fuseholder in the receptacle; note that the holder is keyed to the receptacle and can only be inserted in one way. Press the fuseholder in and twist clockwise to lock in place.
6. Re-assemble the pump in the exact reverse order of disassembly.

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

7.3.4.2

FUSE AND FUSE DRAWER REPLACEMENT



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

To replace the fuses in a 100 volt or 220 volt pump, proceed as follows:

1. Disconnect the pump from AC (mains) power and turn the main control switch to **LOAD/OFF RECHARGE**.
2. Using a small flat blade screwdriver, remove the two screws holding the protective strap over the fuseholder.
3. Using a small flat blade screwdriver, wedge the screwdriver tip between each removal tab and the side of the fuse drawer compartment; compress the removal tabs until the fuse drawer unlatches. Slide the fuse drawer from the compartment.
4. Remove the fuses from the fuse drawer. Replace the fuse drawer if defective. Replace the fuses.
5. Insert the fuse drawer into the compartment. Push the fuse drawer until it clicks securely in place.
6. Re-assemble the pump in the exact reverse order of disassembly.
7. Connect the pump to AC (mains) power. Install the cassette and turn the main control switch to **LOCK/ON**. Verify that the battery symbol is off.

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

7.3.5

VELCRO ANCHOR PAD REPLACEMENT

No tools are required for this procedure; however, isopropyl alcohol is required for removing residual adhesive.

This procedure is used to replace the Velcro anchor pad used to secure a flow detector to the pump case.

To replace the Velcro anchor pad, proceed as follows:

1. Carefully peel back the damaged or worn Velcro anchor pad on the back of the pump.
2. Remove the old adhesive with isopropyl alcohol. Clean the area where the new anchor pad is to be mounted.
3. Peel protective backing from the new anchor pad and press firmly in place.

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

7.3.6

AC POWER CORD STRAIN RELIEF BUSHING REPLACEMENT



The recommended tool for this procedure is an extractor tool for the strain relief bushing.

Note: This procedure is not applicable to pumps meeting IEC standards.

To replace the AC power cord strain relief bushing, proceed as follows:

1. Disconnect the pump from AC power.
2. Using the extractor tool, remove the damaged strain relief bushing.
3. Place the replacement strain relief bushing around the AC power cord; push it into the hole in the back of the case. Using the extractor tool, compress the bushing and push it into place in the hole in the case.

To verify successful replacement of the AC power cord strain relief bushing, perform the PVT in *Section 5.2*.

7.3.7

AC (MAINS) POWER CORD PLUG REPLACEMENT

Recommended tools for this procedure are as follows: wire strippers, screwdriver, wire cutters, and electricians knife.

In the event that the plug on the AC power cord becomes damaged, it can be replaced with a hospital grade replacement plug. The exact procedure for replacing the plug depends upon the construction of the replacement plug. This procedure is intended only as a guide and not as a specific method for plug replacement.

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

1. Disconnect the pump from AC (mains) power.
2. Using the wire cutters, remove the damaged plug by cutting the cord near the plug.
3. Disassemble the replacement plug to access the plug terminals and to estimate the amount of insulation that needs to be removed from AC (mains) power cord.
4. Using an electricians knife, remove the appropriate amount of outer insulation from the end of the power cord to expose the three individual wires in the cable; note that the two AC (mains) wires are black and white and the ground wire is green. Using the wire strippers, remove sufficient insulation (approximately 1/4 inch) from these three wires to permit connection of bare conductors to the replacement plug.
5. Using a screwdriver, connect the AC (mains) power cord wires to the replacement plug. Pay particular attention that the ground (green) wire is connected to the ground lug on the replacement plug.

6. Re-assemble the replacement plug in the exact reverse order of disassembly.

To verify successful replacement of the AC (mains) power cord plug, perform the PVT in *Section 5.2*.

7.3.8

NURSE-CALL CABLE ASSEMBLY REPLACEMENT

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

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium size flat blade screwdriver, and Allen wrenches.

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

1. Disconnect the pump from AC (mains) power and turn the main control switch to LOAD/OFF RECHARGE.
2. Open the pump case as described in *Section 7.3.18, Case Replacement*.
3. Once the nurse-call jack is accessible, disconnect the nurse-call cable assembly and connect the replacement assembly.
4. Re-assemble the pump in the exact reverse order of disassembly.

To verify successful replacement of the nurse-call cable assembly, perform the PVT in *Section 5.2*.

7.3.9

FLOW DETECTOR ASSEMBLY REPLACEMENT

No tools are required for this procedure.

The flow detector and connecting cable are replaced as one unit. If the flow detector connector (FLOW DET.) on the back of the pump is damaged, refer to *Section 7.3.10, Flow Detector Assembly Plug and Closed Entry Female Terminal Replacement*.

To replace the flow detector assembly, proceed as follows:

1. Disconnect the flow detector cable from the back of the pump.
2. Remove the flow detector from the Velcro attachment and replace with the new flow detector.
3. Connect the cable for the new flow detector assembly into the FLOW DET. connector.

To verify successful replacement of the flow detector assembly, perform the low flow alarm test and the high flow alarm test in *Section 5.2.7 High Flow Alarm and Low Flow Alarm (Simulated) and Audible Alarm Tests*.

7.3.10

FLOW DETECTOR ASSEMBLY PLUG AND CLOSED ENTRY FEMALE TERMINAL REPLACEMENT

The recommended tools for this procedure are as follows: mini-pin insertion/extraction tool, crimping tool, needle-nose pliers, soldering iron, wire cutters, wire strippers, and solder.

To replace the flow detector assembly plug, proceed as follows:

1. Disconnect the flow detector assembly from the pump FLOW DET. connector. Place flow detector assembly on a clean work surface.
2. Unscrew the cap from the flow detector assembly plug.
3. Using a mini-pin insertion/extraction tool, remove the closed entry female terminal(s) from the plug.
4. Using the needle-nose pliers, remove the rubber gasket from the plug, grasp the cable at the plug base and apply a twisting motion to remove the cable from the plug.
5. Using the wire cutters, cut the closed entry female terminal(s) from the wire end(s).
6. Using the wire strippers, remove an amount of insulation equal to the female terminal shaft length from each wire.
7. Using a soldering iron and solder, tin the stripped wire to prevent corrosion.
8. Using a crimping tool, crimp the replacement closed entry female terminal(s) to the wire(s).
9. Using a mini-pin insertion/extraction tool, insert the closed entry female terminal(s) into the specific flow detector assembly plug terminal hole, as follows, verifying that the female terminal clicks into place.
 - Red: terminal hole 1 (center)
 - Black: terminal hole 2
 - Green: terminal hole 3
 - White: terminal hole 6
10. Pull on each wire to verify that the female terminal(s) are firmly seated.
11. Verify that the closed entry female terminal(s) and cable crimp are aligned in the flow detector assembly plug. Replace the plug rubber gasket. Screw the cap to the flow detector assembly plug.
12. Connect the flow detector assembly to the pump FLOW DET. connector.

To verify successful flow detector assembly plug and closed entry female terminal replacement, perform the PVT in *Section 5.2*.

7.3.11

FLOW DETECTOR CONNECTOR HOUSING AND MALE PIN CONNECTOR(S) REPLACEMENT

The recommended tools for this procedure are as follows: mini-pin insertion/extraction tool, needle-nose pliers, external retaining ring pliers, crimping tool, soldering iron, wire cutters, wire strippers, and solder.

To replace the flow detector connector housing and male pin connector(s), proceed as follows:

1. Remove the battery as described in *Section 7.3.3, Battery Pack Replacement*.
2. Using a No. 1 Phillips screwdriver, remove the two Phillips-head screws securing the power cord shield to the pump assembly. Remove the power cord shield.
3. Using the mini-pin insertion/extraction tool, remove the male pin connector(s) from the flow detector (FLOW DET.) connector housing by pushing the hand tool on the male pin connector with enough force to free the connector.
4. Using the external retaining ring pliers, remove the connector housing retaining ring.
5. Remove the connector housing by pushing the connector housing through the pump body access.
6. Using the wire cutters, cut the male pin connector(s) from the wire end(s).
7. Using the wire strippers, remove an amount of insulation equal to the male pin connector shaft length from each wire.
8. Using a soldering iron and solder, tin the stripped wire to prevent corrosion.
9. Using a crimping tool, crimp the replacement male pin connector(s) to the wire(s).
10. Using a mini-pin insertion/extraction tool, insert the male pin connector(s) into the specific connector housing pin hole, as follows, verifying that the pin connector(s) clicks into place.

Center pin: White - brown/red tracer

Pin 2: White - violet tracer

Pin 3: White - blue tracer

Pin 6: White - brown/green tracer

11. Pull on each wire to verify that the pin connector(s) are firmly seated.
12. Replace the connector housing by pushing the connector housing through the pump body access.

Note: The retaining ring is naturally configured with a slight warp. When replacing the retaining ring, assure the convex side of the retaining ring is positioned towards the pump.

13. Using the external retaining ring pliers, replace the connector housing retaining ring.
14. Position the pump assembly rear basket. Using a No. 1 Phillips screwdriver, replace the two Phillips-head screws securing the rear basket to the pump assembly.
15. Replace the battery in the exact reverse order of removal.
16. Connect the pump to AC (mains) power.

To verify successful flow detector connector housing and male pin connector(s) replacement, perform the PVT in Section 5.2.

7.3.12

MAIN CONTROL KNOB REPLACEMENT

Recommended tools for this procedure are Allen wrenches.

To replace the main control knob, see *Figure 7-5, Main Control Knob Removal*, then proceed as follows:

1. Disconnect the pump from AC (mains) power and turn the main control switch to **LOAD/OFF RECHARGE**.
2. Loosen the two Allen screws in the main control knob. Slide the knob off the switch shaft.
3. Replace the knob on the switch shaft; confirm that the knob points to **LOAD/OFF RECHARGE**. Tighten the Allen screws, making sure that they are seated securely against the flats on the switch shaft.

Replacement of the main control knob is a routine maintenance procedure and no verification procedure is normally required. However, if the pump may have been damaged during the replacement procedure, perform the PVT in Section 5.2.

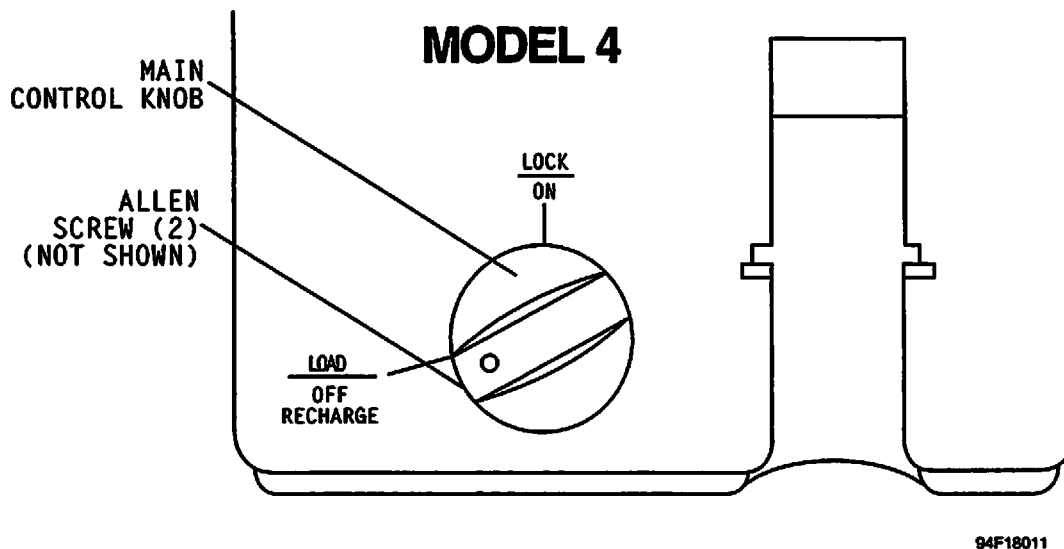


Figure 7-5. Main Control Knob Removal

7.3.13

POLE CLAMP KNOB REPLACEMENT

Recommended tools for this procedure are Allen wrenches.

To replace the pole clamp knob, see *Figure 7-6, Pole Clamp Knob Removal*, then proceed as follows:

1. Loosen the Allen screw in the pole clamp knob. Slide the knob and felt spacer off the shaft.

- Place the new pole clamp knob on the shaft and tighten the Allen screw; make sure the Allen screw fits into the hole in the switch shaft and tighten to secure.

Replacement of the pole clamp knob is a routine maintenance procedure and no verification procedure is normally required. However, if the pump may have been damaged during the replacement procedure, perform the PVT as described in Section 5.2.

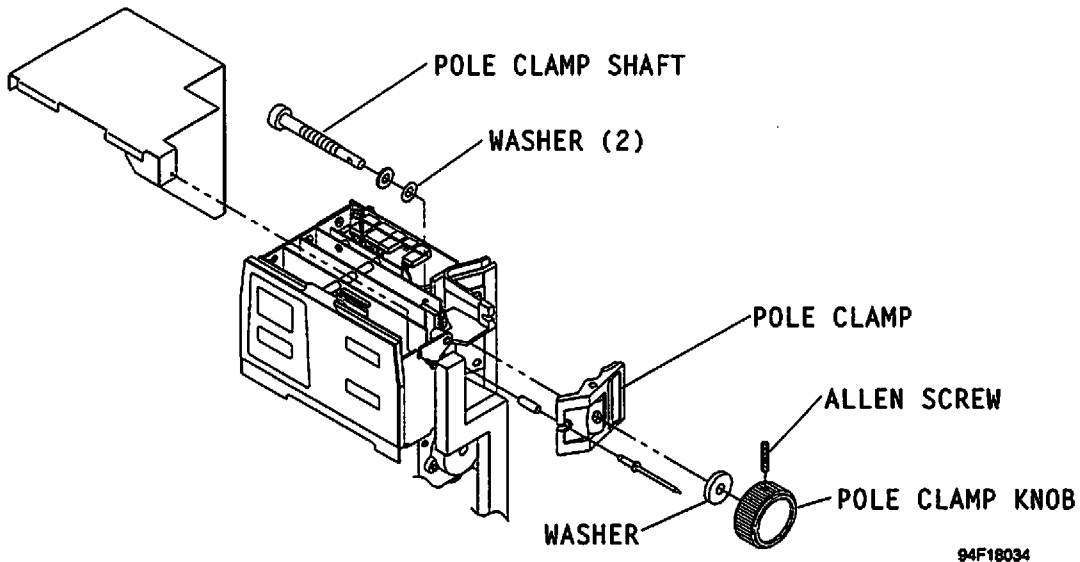


Figure 7-6. Pole Clamp Knob Removal

7.3.14

POLE CLAMP SHAFT REPLACEMENT

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

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium size flat blade screwdriver, Allen wrenches, 1/4 inch nutdriver, torque wrench with a 1/2 inch socket, grease, and retaining compound.

To replace the pole clamp shaft, proceed as follows:

- Open the pump case as described in Section 7.3.18, *Case Replacement*.
- Remove the pole clamp knob as described in Section 7.3.13, *Pole Clamp Knob Replacement*.
- Using a 1/4 inch nutdriver, loosen the three screws that secure the EMI shield to the pump. Remove the EMI shield.
- Turn the pole clamp shaft counterclockwise until the pole clamp slides off the shaft.
- Slide the pole clamp shaft through the opening in the case toward the pump interior, using care not to damage the electronic components. Remove the pole clamp shaft. If the pole clamp shaft is being replaced as an assembly, go to Step 9. If the pole clamp shaft retaining nut is being replaced, proceed as follows:
- Remove the retaining nut from the pole clamp shaft.
- Apply retaining compound to the short threads of the pole clamp shaft.

8. Install the new retaining nut within 20 minutes of applying the retaining compound to the pole clamp shaft. Using a torque wrench and a 1/2 inch socket, tighten the nut to 60 inch-pounds of torque.
9. Lubricate the long threaded portion of the pole clamp shaft and the two washers with grease.
10. Install the pole clamp shaft in the exact reverse order of removal.
11. Re-assemble the pump case in the exact reverse order of disassembly.

To verify successful replacement of the pole clamp shaft, perform the PVT in *Section 5.2*.

7.3.15

AUDIBLE ALARM LEVEL SWITCH REPLACEMENT

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, 5/16 inch box wrench, soldering iron and solder, X-acto knife, and approximately 1-1/2 inches of 3/32 inch shrink tubing.

To replace the audible alarm level switch, proceed as follows:

1. Disconnect the pump from AC (mains) power.
2. Remove the battery cover and the battery pack as described in *Section 7.3.3, Battery Pack Replacement*.
3. Using a 5/16 inch box wrench, remove the nut securing the audible alarm level switch to the panel. Set the nut aside for re-assembly. Remove the keyed flat washer, lock washer, and the switch from the panel. Remove the locknut from the switch shank.
4. Using an X-acto knife, remove the shrink tubing from the switch terminal connectors. Unsolder the wires from the terminal lugs.
5. Place a piece of 3/32 inch shrink tubing approximately 3/8 inch long over each wire. Slide the tubing down the wire so as not to interfere with the resoldering operation.
6. Resolder the three wires to the switch terminals as follows:
 - White/orange wire to switch center (OFF) terminal lug
 - White/red wire to switch (ON) terminal (opposite keyed side of switch shank)
 - White/green wire to switch (ON) terminal (on keyed side of switch shank)
7. Slide shrink tubing over each terminal connection and shrink into place.
8. Tighten the locknut on the switch shank until it is secure.
9. Install the switch through the panel hole; place the keyed flat washer and lock washer on the switch shank, verifying that the keyed flat washer is properly oriented, with the washer tab in the panel hole. Secure the switch to the panel with the nut removed in Step 3.
10. Place the audible alarm level switch in the HIGH position.
11. Connect the pump to AC (mains) power and turn the main control switch to LOCK/ON. The pump performs the self test. Verify a maximum sound level of the alarm during the self test sequence.
12. Turn the main control switch to LOAD/OFF RECHARGE. Place the audible alarm level switch in the middle position. Turn the main control switch to LOCK/ON and verify a reduced sound level of the alarm during the self test sequence.

13. Turn the main control switch to LOAD/OFF RECHARGE. Place the audible alarm level switch in the LOW position. Turn the main control switch to LOCK/ON and verify the lowest sound level of the audible alarm during the self test sequence.
14. Re-install the battery pack and replace the battery cover.

To verify successful replacement of the audible alarm level switch, perform the PVT in Section 5.2.

7.3.16

SHROUD ASSEMBLY PLUNGER GUIDE REPLACEMENT

The recommended tools for this procedure are as follows: no-lint or low-lint cloth, 1/8-inch flat-blade screwdriver, and the shroud assembly plunger guide repair kit.

Note: Verify that the adhesive and the accelerator expiration dates are current. Do not use expired materials. Always store the shroud assembly plunger guide repair kit in a cool, dry location.

WARNING

WHILE APPLYING THE ACCELERATOR AND ADHESIVE, USE GLOVES OR FINGER CAPS. DO NOT ALLOW THE ACCELERATOR OR ADHESIVE TO COME IN CONTACT WITH THE SKIN OR CLOTHING.

To replace the plunger guide, refer to *Figure 7-7, Shroud Assembly Plunger Guide Replacement*, then proceed as follows:

1. Turn the main control knob to LOAD/OFF RECHARGE.
2. Disconnect the pump from AC (mains) power.
3. Position the pump upside down with the pump front visible. Allow the pump to tilt backward on its handle.
4. Break away remnants of the existing plunger guide. Using a flat-blade screwdriver, clear any remaining plunger guide debris from the shroud assembly wall. Wipe the bonding surface area with a no-lint or low-lint cloth. The cloth may be dampened with warm water. Allow the surfaces to dry thoroughly.
5. Insert a replacement plunger guide into the shroud assembly. Confirm that the replacement plunger guide is firmly seated in the shroud assembly. Verify that there is no gap between the plunger guide and the shroud assembly wall. If a gap exists, repeat Step 4 until the plunger guide is properly seated.
6. With the plunger guide properly seated, use the applicator brush to apply the accelerator at the horseshoe-shaped junction between the plunger guide and the shroud assembly wall. Allow the accelerator to dry thoroughly (approximately two minutes).

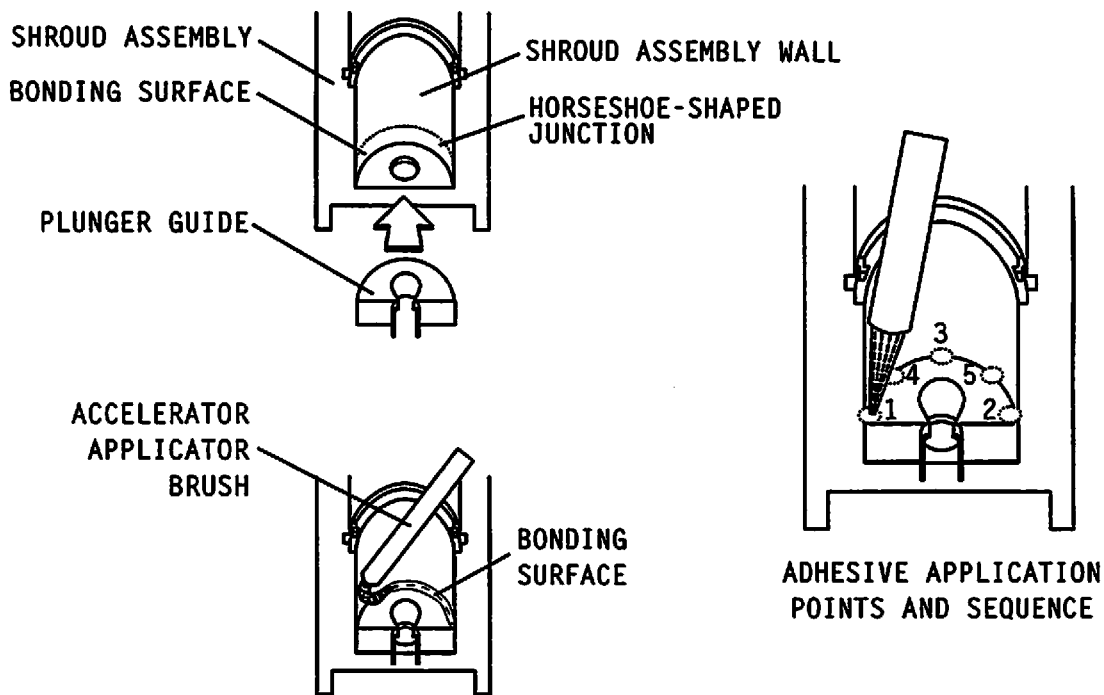
CAUTION: A white ring forming around an adhesive drop indicates that the accelerator is not completely dry. If a white ring forms around an adhesive drop during the adhesive application; cease the application of adhesive, allow the accelerator to dry thoroughly, and re-apply the adhesive adjacent to the existing drop.

7. Apply one drop of the adhesive, in numerical order, to each of the five locations on the horseshoe-shaped junction between the plunger guide and the shroud assembly, as illustrated in *Figure 7-7*.

Note: Cap the adhesive and the accelerator containers when not in use to avoid prolonged exposure to the air.

8. Allow the adhesive to set for at least five minutes. Inspect the horseshoe-shaped junction to verify that indentations are present where adhesive drops were applied. If indentations are not observed, re-apply the adhesive to the affected area and allow the re-applied adhesive to set an additional five minutes.
9. Insert a cassette into the shroud assembly. Confirm that the cassette slides freely into and out of the shroud assembly.

To verify successful plunger guide replacement, perform the *PVT* in *Section 5.2*.



95F05027

Figure 7-7. Shroud Assembly Plunger Guide Replacement

7.3.17

ACCESSORY (ACC.) CONNECTOR (OR PINS) REPLACEMENT

Recommended tools for this procedure are as follows: a mini-pin insertion/extraction tool, external retaining ring pliers, and crimping tool.

The ACC. connector must be removed to replace bent or broken pins in the connector. This procedure covers pin replacement in the accessory connector and connector replacement.

To repair bent or broken male pins in the ACC. connector and to replace the connector, proceed as follows:

1. Disconnect the pump from AC (mains) power.
2. Remove the battery pack as described in *Section 7.3.3, Battery Pack Replacement*.
3. Using the mini-pin extractor tool, remove the male pins from the ACC. connector by pushing the tool on each male pin with enough force to free the pin.
4. Using external retaining ring pliers, remove the retaining ring.
5. Remove the connector by pushing the housing into the pump body.

Note: If only the ACC. connector is to be replaced, proceed to Step 10 to complete the replacement.

6. Remove the pins; cut the wires at the end of the pins.
7. Refer to *Figure 7-8, ACC. Connector Pin Arrangement*. Using the crimping tool, crimp the new pins onto the wire ends. Place the pins into the proper connector pin holes as follows:

Pin 1: White/Gray

Pin 2: White/Orange

Pin 3: N/C

Pin 4: N/C

Pin 5: White/Black

Pin 6: White/Brown

Pin 7: N/C

Pin 8: Violet

Pin 9: Brown

Pin 10: White/Yellow

Pin 11: Gray

Pin 12: Blue

8. Using the mini-pin insertion tool, insert the new pins into the connectors. Push the pins into the connectors until they click into place.
9. Place the replacement connector in position and secure it with the retaining ring.
10. Verify appropriate voltage levels and signals with the pump operating as indicated in *Table 4-1, ACC. Connector J23 Pin Arrangement*.
11. Replace the battery pack and the battery pack cover.

To verify successful replacement of the accessory connector (or pins), Perform the PVT in *Section 5.2*.

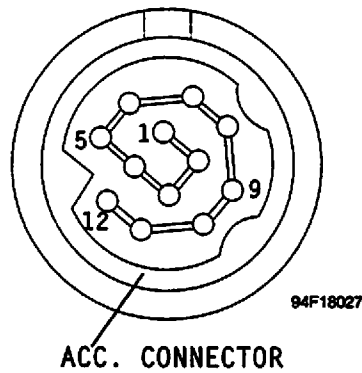


Figure 7-8. ACC. Connector Pin Arrangement

7.3.18

CASE REPLACEMENT

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

The Model 4 Series infusion pump may be housed in one of two cases (see Table 1-2, *Model 4 Series Case Types and I/O Capabilities*). The one-piece case has front and sides molded in one piece; the case is opened by removing the back cover. The clamshell case is molded in two halves that separate in the middle.

7.3.18.1

ONE-PIECE CASE REPLACEMENT

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

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium size flat blade screwdriver, and Allen wrenches.

To replace the one-piece case, proceed as follows:

1. Disconnect the pump from AC (mains) power.
2. Loosen the two Allen screws in the main control switch knob; remove the knob (see Figure 7-5, *Main Control Knob Removal*).
3. Loosen the Allen screw in the pole clamp knob; remove the knob and felt spacer (see Figure 7-6, *Pole Clamp Knob Removal*).
4. Turn the pole clamp screw fully counterclockwise and push in the pole clamp assembly so that the end clears the side of the case (see Figure 7-9, *Rear Panel Screw Removal (One-Piece Case)*).

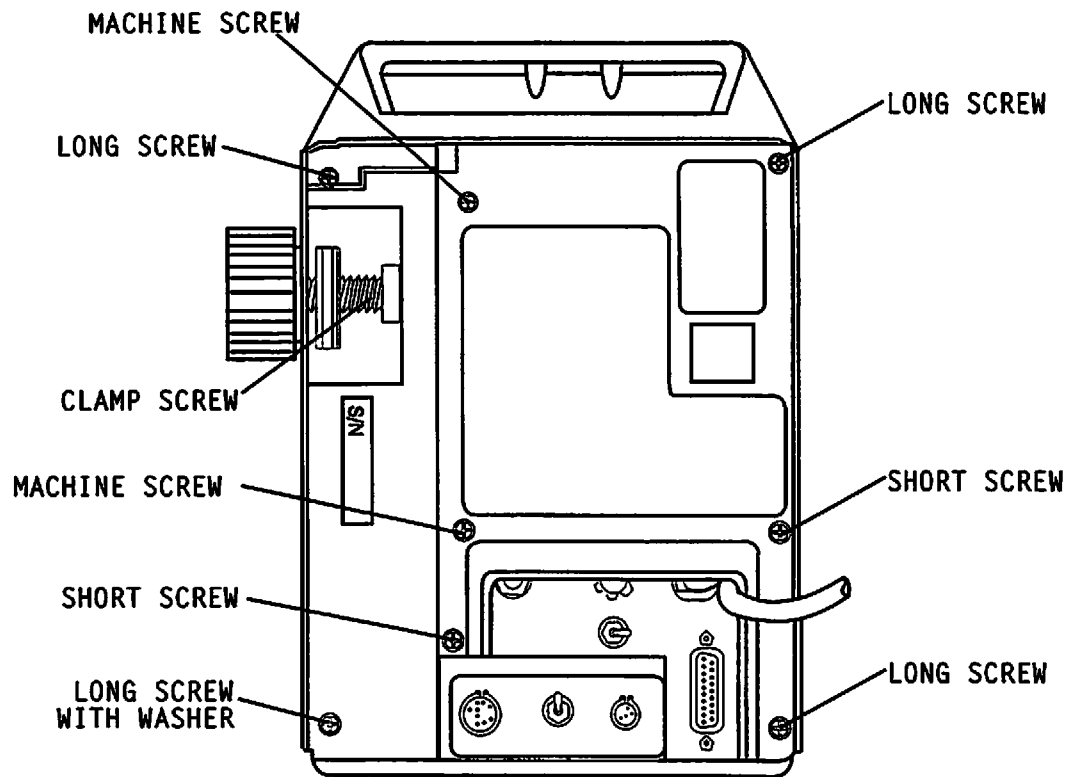
Note: Do not push the screw/shaft so far in that it drops inside the case.

- Remove the two screws in the pole clamp recess and the six screws from the back of the pump (see Figure 7-9). Lift the case off the pump (see Figure 7-10, Removing Chassis From Cover).

CAUTION: Shorter screws are used in the lower left and middle right positions of the connector shield. Re-assembly with long screws in those holes could damage the case.

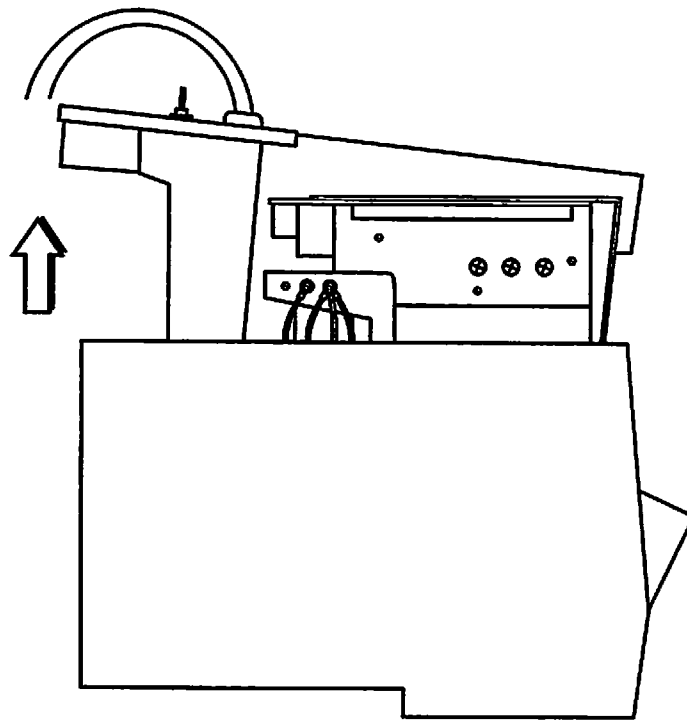
- Place the pump face down on a soft surface. Remove the seven screws from the bottom of the pump. Remove the bottom cover and battery pack. Grasp the pump body and lift the assembly out of the case. Care should be taken so that PWAs and components are not damaged during removal.
- Insert the pump into the replacement one-piece case.
- Re-assemble the pump in the exact reverse order of disassembly.

To verify successful replacement of the one-piece case, perform the PVT in Section 5.2.



94F18010

Figure 7-9. Rear Panel Screw Removal (One-Piece Case)



94F18007

Figure 7-10. Removing Chassis From Cover

7.3.18.2

CLAMSHELL CASE REPLACEMENT

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

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium size flat blade screwdriver, and Allen wrenches.

To open the clamshell case, it is not necessary to remove the pole clamp knob or move the pole clamp shaft; however, it is necessary to remove the main control switch knob.

To replace the clamshell case, proceed as follows:

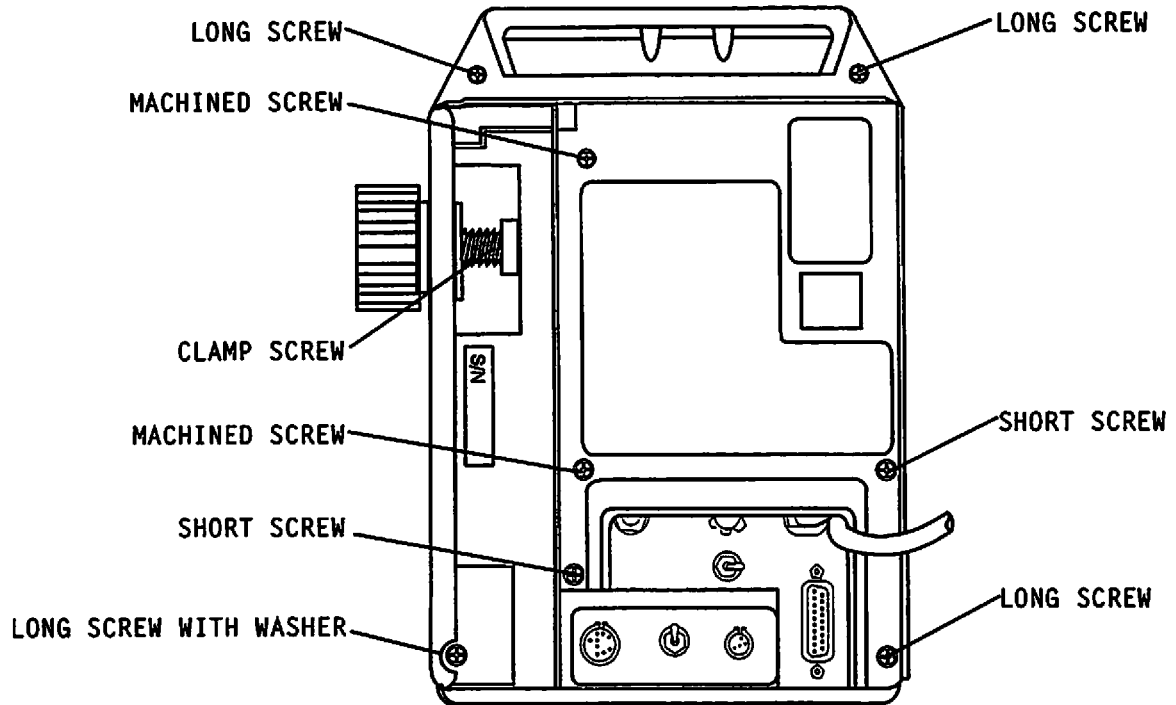
1. Disconnect the pump from AC (mains) power.
2. Loosen the two Allen head screws in the main control switch knob and remove the knob (see *Figure 7-5, Main Control Knob Removal*).
3. Place the pump on its back and remove the three Phillips screws along the front edge of the bottom panel.
4. Stand the pump upright and remove the eight Phillips screws from the back panel (see *Figure 7-11, Case Screw Removal (Clamshell Case)*).

CAUTION: The screw pattern for the clamshell case differs slightly from that of the one-piece case. Observe the correct locations for the short screws; re-assembly with long screws in those holes could damage the case.

5. With the pump standing upright and screws removed, pull the two halves of the case away from each other (see *Figure 7-12, Opening the Clamshell Case*).

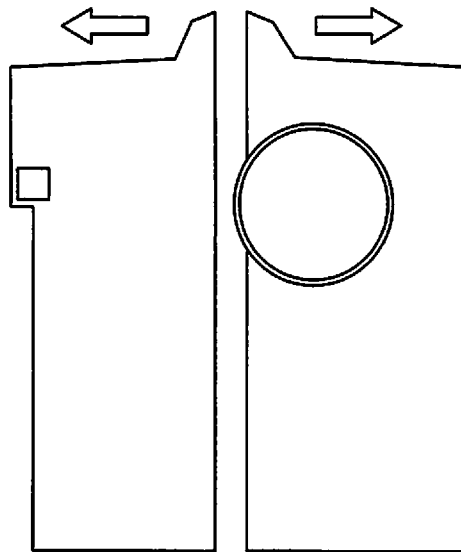
6. Insert the pump into the replacement clamshell case. Re-assemble in the exact reverse order of disassembly.

To verify successful replacement of the clamshell case, perform the PVT in *Section 5.2*.



94F18006

Figure 7-11. Case Screw Removal (Clamshell Case)



8213E017

Figure 7-12. Opening the Clamshell Case

7.3.19

PWA REPLACEMENT

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

Recommended tools for this procedure are as follows: a Phillips screwdriver and medium flat blade screwdriver.

To prepare the pump for PWA replacement, proceed as follows:

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Refer to *Figure 7-13, Shield Removal*. With the pump upright, loosen the three screws and lift the shield from the pump.

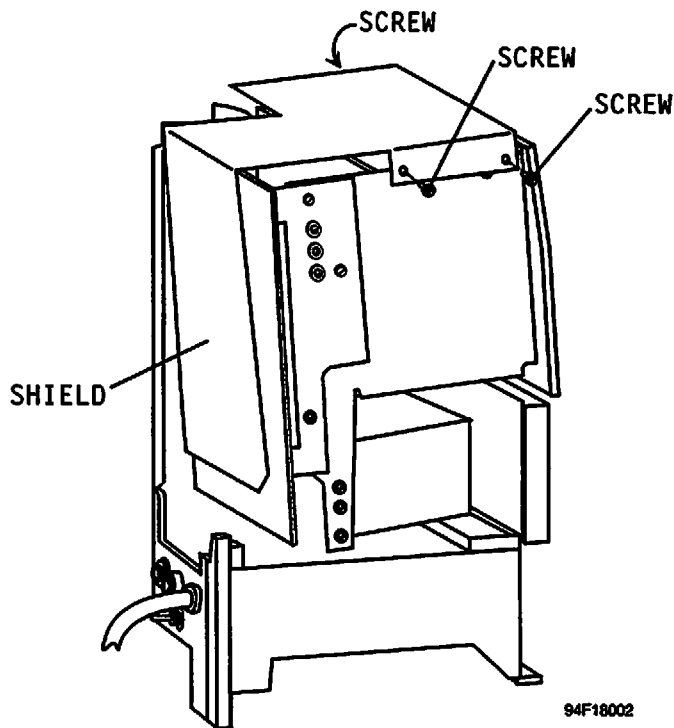


Figure 7-13. Shield Removal

7.3.19.1

POWER SUPPLY PWA REPLACEMENT

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

To replace the power supply PWA, proceed as follows:

1. Remove the three heat sink screws (see *Figure 7-14, Heat Sink Screw Removal*).
2. Remove the screw at the lower left corner of the power supply PWA.

3. Remove the connectors from the power supply PWA.
4. Remove the power supply PWA from the pump.
5. Insert the replacement power supply PWA and re-assemble the pump in the exact reverse order of disassembly.

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

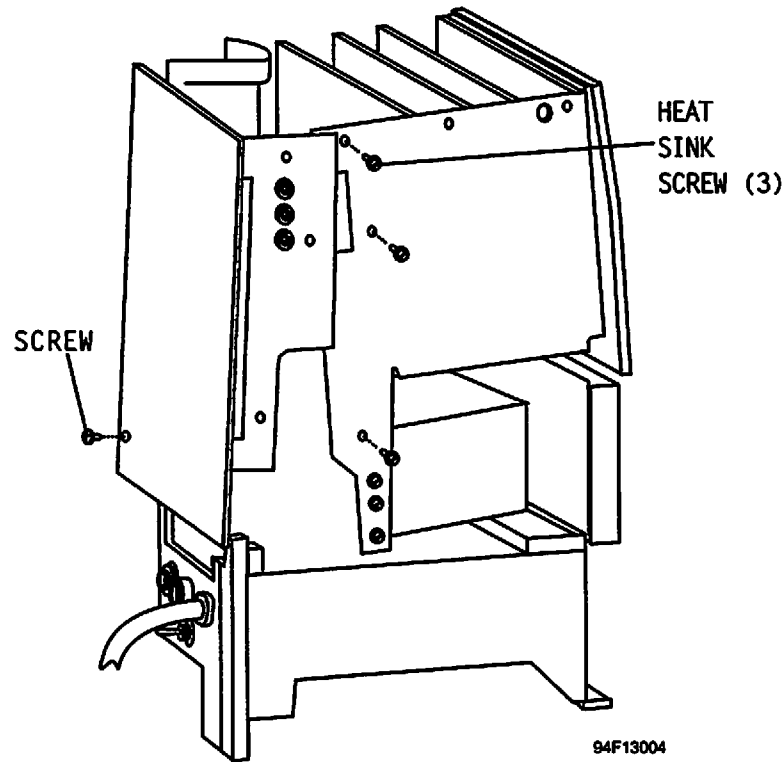


Figure 7-14. Heat Sink Screw Removal

7.3.19.2

DISPLAY PWA, DISPLAY DRIVER PWA, MPU PWA, AND MOTOR DRIVER PWA REPLACEMENT

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

To remove the display PWA, display driver PWA, MPU PWA, and motor driver PWA, refer to *Figure 7-15, PWA Removal*, then proceed as follows:

1. Remove the power supply PWA as described in *Section 7.3.19.1, Power Supply PWA Replacement*.
2. Using the Phillips screwdriver, remove the retaining screw (*see Figure 7-15*).

CAUTION: Do not let spacers fall into the mechanism.

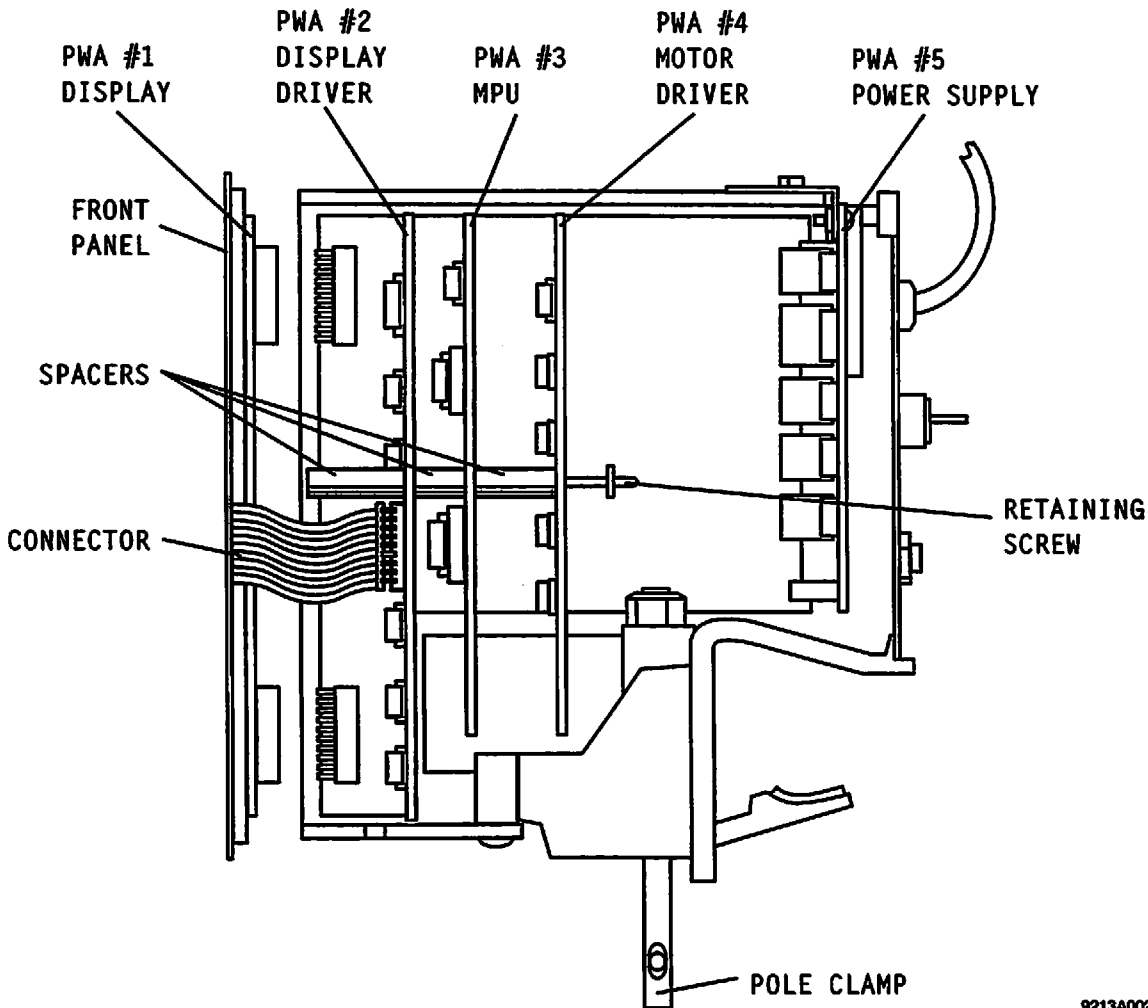
Note: The power supply PWA must be removed prior to removing the retaining screw.

3. A connector connects the front panel to the display driver PWA (PWA #2 in *Figure 7-15*). Disconnect this connector before removing the display driver PWA from the pump.
4. Remove the display PWA first (PWA #1 in *Figure 7-15*). Hold the front panel at the bottom of each side and pull. Remove the two screws from the back of the panel to separate the display PWA from the front panel.
5. Remove the display driver PWA (#2), the MPU PWA (#3), and the power supply PWA (#4) by pulling each one straight up.

CAUTION: Insert the retaining screw and make certain that all PWAs are fully seated before re-installing the power supply PWA. The retaining screw may be inserted easily only if the PWAs are properly installed.

6. Insert the replacement PWAs in the exact reverse order of removal.
7. Re-assemble the pump in the exact reverse order of disassembly.

To verify successful display PWA, display driver PWA, MPU PWA, and motor driver PWA replacement, perform the PVT in *Section 5.2*.



9213A002

Figure 7-15. PWA Removal

7.3.19.3

MOTHERBOARD PWA REPLACEMENT

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

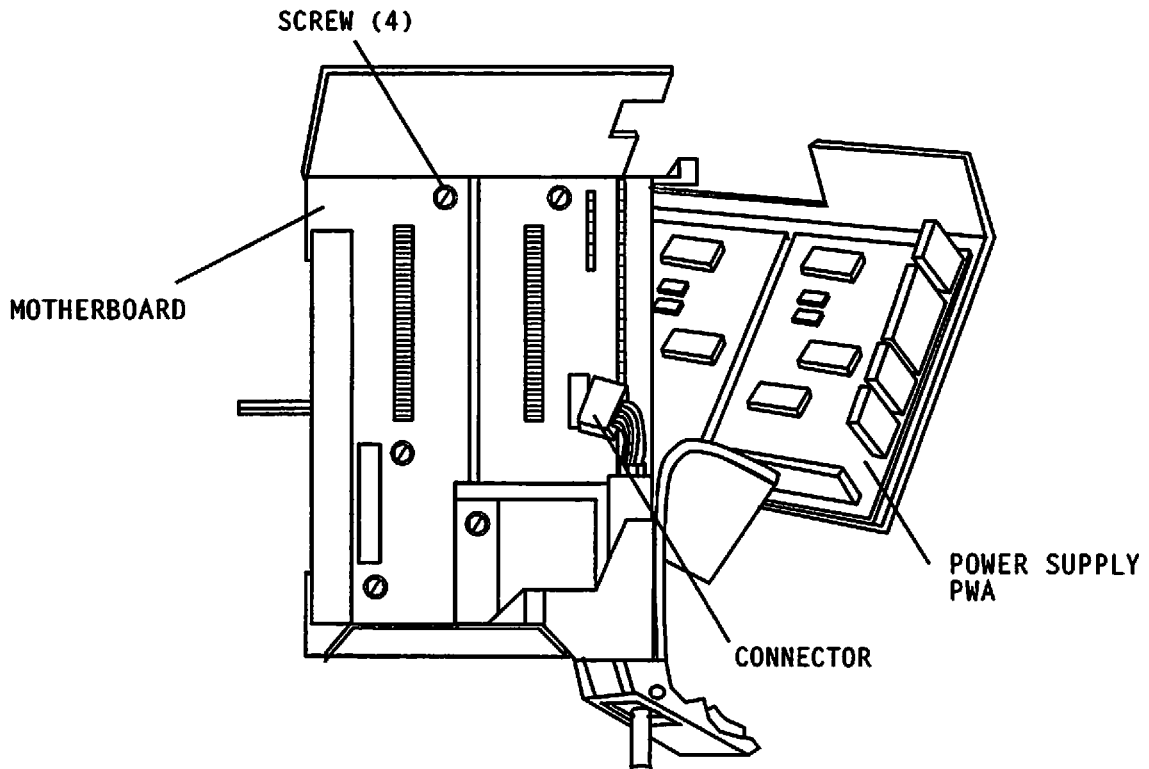
To remove the motherboard PWA, proceed as follows:

1. Remove all other PWAs as described in *Section 7.3.19.1, Power Supply PWA Replacement*, and *7.3.19.2, Display PWA, Display Driver PWA, MPU PWA, and Motor Driver PWA Replacement*.
2. Disconnect the remaining connector from the motherboard PWA (see *Figure 7-16, Motherboard PWA Removal*).
3. Remove the four screws holding the motherboard PWA in place. Lift the motherboard PWA from the chassis.

CAUTION: Insert the retaining screw and make certain that all PWAs are fully seated before re-installing the power supply PWA. The retaining screw may be inserted easily only if the PWAs are properly installed.

4. Insert the replacement motherboard PWA and re-assemble the pump in the exact reverse order of disassembly.

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



94F18013

Figure 7-16. Motherboard PWA Removal

7.3.20

AC POWER CORD REPLACEMENT



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

Recommended tools for this procedure are as follows: soldering iron, wire cutters, needle nose pliers, electricians knife, bushing extractor tool, and crimping tool. A ring terminal and a crimp-on butt connector are supplied with the replacement AC power cord assembly.

Replacement of the AC power cord on 115 volt pumps requires disassembly of the pump down to removal of the power supply PWA.

To remove the AC power cord, refer to *Figure 7-17, AC Power Cord Replacement (115 Volt)*, then proceed as follows:

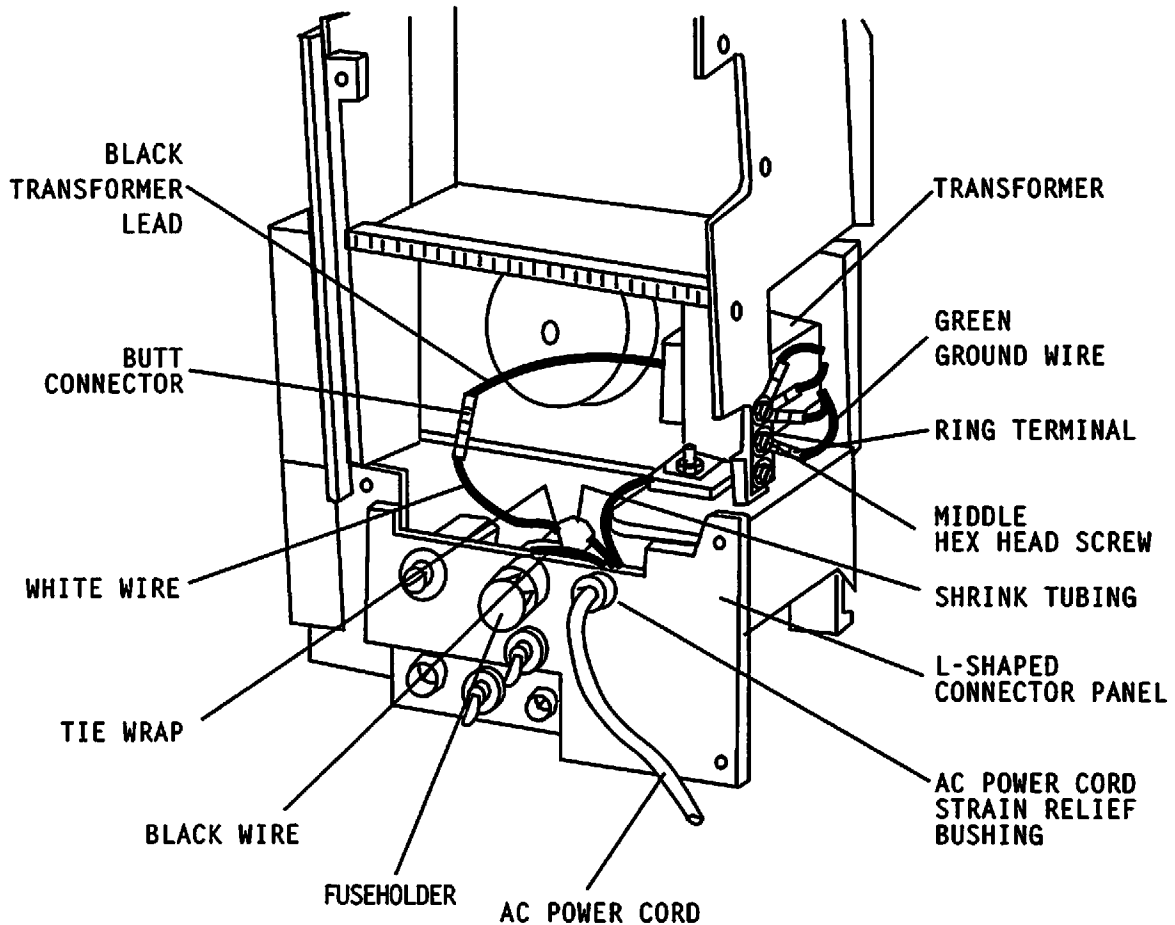
1. Remove the power supply PWA as described in *Section 7.3.19.1, Power Supply PWA Replacement*.
2. Remove the middle hex-head screw from the chassis to remove the green ground wire of the power cord from the pump shielding (*see Figure 7-17*).
3. Using needle nose pliers, remove the tie wrap from behind the fuseholder and carefully work the shrink tubing from the fuseholder.
4. Unsolder the black wire from the fuseholder.
5. Cut the white wire that is butt-spliced to the black transformer lead about 1-1/2 to 2 inches from the bottom of the butt connector (*see Figure 7-17*).

CAUTION: Do not cut the wire on the transformer side of the splice (i.e., black lead). If the wire is cut on the transformer side of the splice, the pump will have to be returned to Abbott Laboratories to replace the transformer.

6. Place the extractor tool around the strain relief bushing and work the bushing free from the pump chassis.
7. Remove the strain relief bushing from the cord and remove the cord from the pump.
8. Using the electricians knife, remove an appropriate amount of outer insulation from the end of the power cord to expose the three wires in the cable. Note that the two AC wires are black and white and the ground wire is green.
9. Run the cord assembly through the mounting hole in the chassis. The cord should be inserted far enough to assure sufficient working length.
10. Insert the black lead in the hole in the fuseholder terminal lug. Resolder to connect the lead to the terminal lug.
11. Place shrink tubing over the fuse and secure with the tie wrap.
12. Crimp a terminal ring connector to the green lead of the power cord, then feed the green lead wire under the transformer to the mounting point on the right hand shield.
13. Re-attach the ring terminal connector to the chassis using one screw with a star washer. The screw should be secure to assure a good ground connection.
14. Insert the transformer lead into the other end of the butt connector on the white lead. Crimp securely.

15. Remove the slack from the cord that remains inside the pump. Put the cord strain relief bushing around the cord. Using the extractor tool, press the bushing closed around the cord. Push the bushing into place in the cord hole.
16. Re-assemble the pump in the exact reverse order of disassembly.
17. Connect the pump to AC power. Turn the main control switch to LOCK/ON and verify the pump successfully completes the self-test.

To verify successful AC power cord installation, perform the PVT in *Section 5.2*.



94F18021

Figure 7-17. AC Power Cord Replacement (115 Volt)

7.3.21

AC (MAINS) POWER CORD REPLACEMENT



No tools are required for this procedure.

To replace the AC (mains) power cord on a 100 volt or 220 volt pump, proceed as follows:

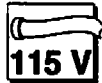
1. Disconnect the pump from AC (mains) power.
2. Disconnect the AC (mains) power cord from the pump.

3. Connect the replacement AC (mains) power cord to the pump.

Replacement of the AC (mains) power cord on a 100 volt or 220 volt pump is a routine maintenance procedure and no verification procedure is normally required. However, if the pump may have been damaged during the replacement procedure, perform the PVT in *Section 5.2*.

7.3.22

AC POWER CORD RETAINER CLIP REPLACEMENT



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

Note: This procedure is not applicable to pumps meeting IEC standards.

To replace the AC power cord retainer clip, proceed as follows:

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Remove the two Phillips screws attaching the retainer clip to the case.
3. Attach the new retainer clip using the two Phillips screws removed in Step 2.
4. Re-assemble the case in the exact reverse order of disassembly.

To verify successful replacement of the retainer clip, perform the PVT in *Section 5.2*.

7.3.23

TOUCHSWITCH PANEL REPLACEMENT

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

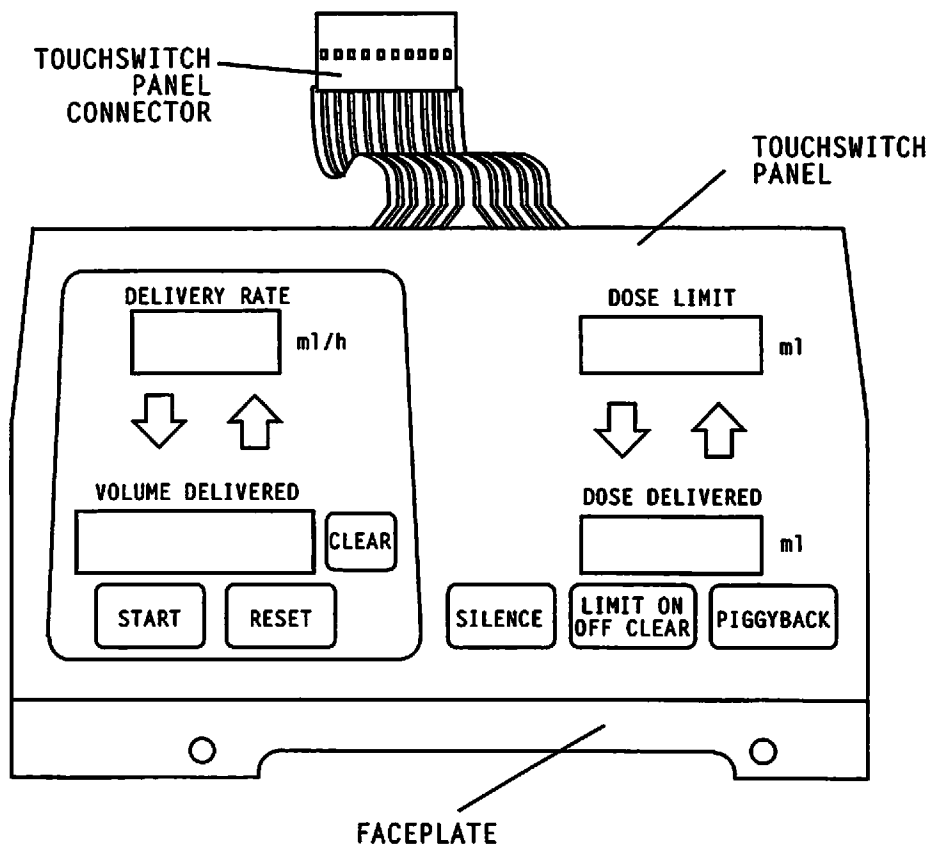
Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium screwdriver, Allen wrenches, X-acto knife, and isopropyl alcohol.

To replace the touchswitch panel, proceed as follows:

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Disconnect the touchswitch panel connector from the display driver PWA (see *Figure 7-18, Touchswitch Panel Replacement*).
3. Using an X-acto knife, carefully pry the touchswitch panel from the faceplate.
4. Clean the faceplate of any adhesive residue with isopropyl alcohol and let it dry.
5. Remove the protective backing and adhere the replacement touchswitch panel to the faceplate. Make sure the panel is centered, and that no air bubbles are trapped in the bond.
6. Re-insert the touchswitch panel connector into the display driver PWA.
7. Connect the pump to AC (mains) power and turn the main control switch to LOCK/ON.

8. Verify operation of the touchswitches by pressing them in the following order and listening for a beep:
1. DELIVERY RATE ↑
 2. DELIVERY RATE ↓
 3. DOSE LIMIT ↑
 4. DOSE LIMIT ↓
 5. START
 6. RESET
 7. CLEAR
 8. SILENCE
 9. LIMIT ON/OFF/CLEAR
 10. PIGGYBACK (Model 4P only)
9. Disconnect AC (mains) power and re-assemble the pump in the exact reverse order of disassembly.

To verify successful touchswitch panel replacement, perform the PVT in *Section 5.2*.



94F18015

Figure 7-18. Touchswitch Panel Replacement

7.3.24

PIEZOELECTRIC ALARM REPLACEMENT

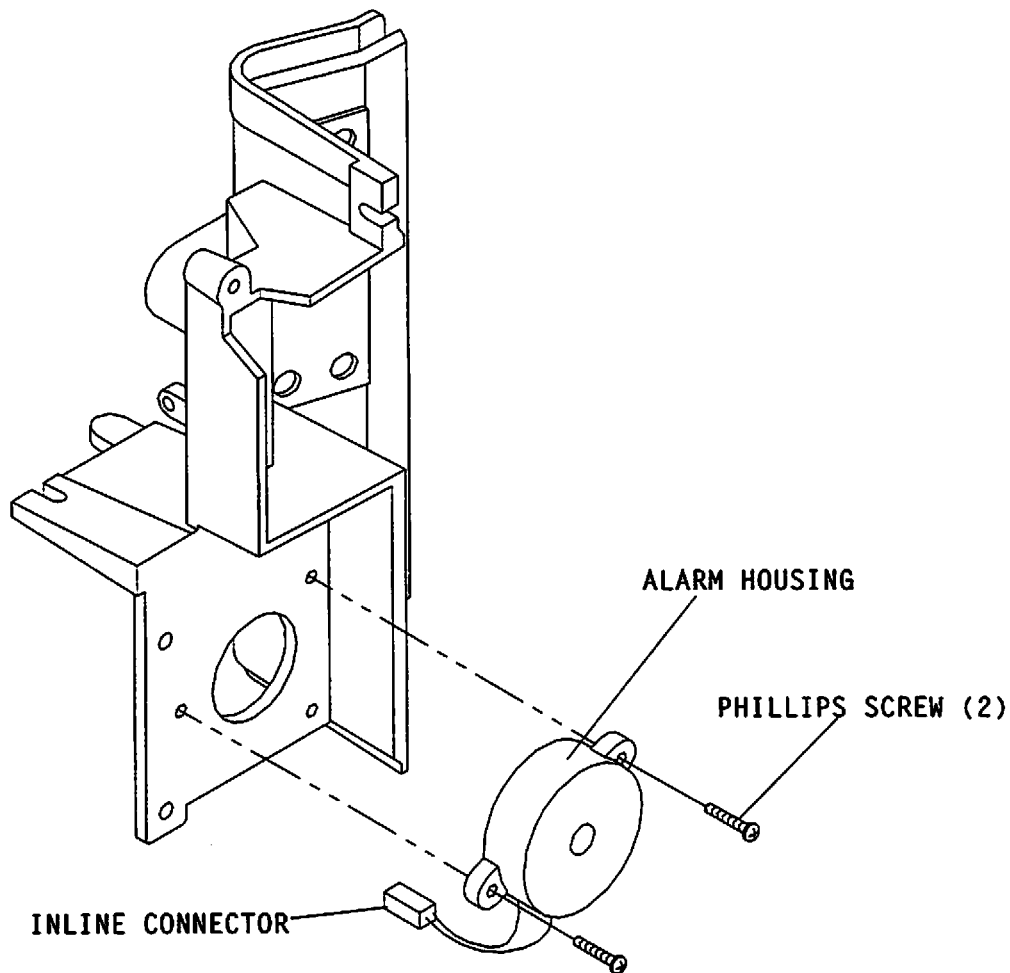
CAUTION: Use proper ESD grounding techniques when handling components. Wear an antistatic wrist strap and use an ESD-protected workstation. Store the PWA in an antistatic bag before placing it on any surface.

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium screwdriver, and Allen wrenches.

To replace the piezoelectric alarm, proceed as follows:

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Remove the two Phillips screws on either side of the alarm housing and set aside for re-assembly (*see Figure 7-19, Piezoelectric Alarm Replacement*).
3. Pull leads out of the pump far enough to disconnect the in-line connector.
4. Mount the replacement piezoelectric alarm using the Phillips screws removed in Step 2. Insert the in-line connector and wiring into the pump.
5. Turn the main control switch to LOCK/ON. Verify the alarm sounds during the self test.
6. Re-assemble the pump in the exact reverse order of disassembly.

To verify successful replacement of the piezoelectric alarm, perform the PVT in *Section 5.2*.



94F18032

Figure 7-19. Piezoelectric Alarm Replacement

7.3.25**TRANSFORMER CONNECTOR P10 AND CLOSED ENTRY FEMALE TERMINAL REPLACEMENT**

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

The recommended tools for this procedure are as follows: mini-pin insertion/extraction tool, crimping tool, needle-nose pliers, soldering iron, wire cutters, wire strippers, and solder.

1. Disconnect the pump from AC (mains) power.
2. Remove the power supply PWA as described in *Section 7.3.19.1, Power Supply PWA Replacement*.
3. Using a mini-pin insertion/extraction tool, remove the closed entry female terminal(s) from connector P10.
4. Inspect the terminals for adverse wear or damage. If adverse wear or damage is apparent, perform Steps 6 and 7; otherwise, proceed to Step 8.

5. Using the wire cutters, cut the closed entry female terminal(s) from the wire end(s).
6. Using the wire strippers, remove an amount of insulation equal to the female terminal shaft length from each wire.
7. Using a soldering iron and solder, tin the stripped wire to prevent corrosion.
8. Using a crimping tool, crimp the replacement closed entry female terminal(s) to the wire(s).
9. Using a mini-pin insertion/extraction tool, insert the closed entry female terminal(s) into the specific terminal hole.

Black: terminal hole 1

Red: terminal hole 2

Red: terminal hole 3

Yellow: terminal hole 4

10. Pull on each wire to verify that the female terminal(s) are firmly seated.
11. Re-assemble the pump in the exact reverse order of disassembly.

To verify successful flow detector assembly plug and closed entry female terminal replacement, perform the PVT in *Section 5.2*.

7.3.26

MAIN CONTROL SWITCH SHAFT ASSEMBLY REPLACEMENT

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

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium size flat blade screwdriver, Allen wrenches, retaining ring pliers, E-type retaining ring pliers, Braycote 804 grease, Electro-Wash 2000 or isopropyl alcohol, lint-free cloth or cotton swabs, small brush (optional), needle nose pliers, 1/4 inch open end wrench, small tie wraps, and wire cutters.

Note: Braycote 804 grease can be obtained from Abbott Laboratories, or may be obtained locally. Electro-Wash 2000 can be obtained locally.

To remove the main control switch shaft assembly, refer to *Figure 7-20, Main Control Switch Shaft Assembly*, *Figure 7-21, Main Control Switch Shaft Assembly With Switch Housing Removed*, and *Figure 7-22, Main Control Switch Shaft Assembly E-Ring Removal*. Set the main control switch to LOCK/ON, then proceed as follows:

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Remove the main control switch knob as described in *Section 7.3.12, Main Control Knob Replacement*.
3. Remove the battery pack as described in *Section 7.3.3, Battery Pack Replacement*.
4. Remove the power supply PWA as described in *Section 7.3.19.1, Power Supply PWA Replacement*.
5. Using retaining ring pliers, remove the retaining ring from the main control switch shaft (see *Figure 7-20*).

6. Remove the hex head screw and washer from the switch housing. Also remove the hex head screw holding the wafer switch wiring harness in place. Slide the switch housing off the main control shaft.
7. Disconnect the connector from J11 on the power supply PWA and clip off the tie wraps holding the wafer switch wiring. Remove the strain relief that holds the wiring harness located behind the motor. Carefully pull the wiring harness through the inside of the pump body.
8. Note the orientation of the shaft in the pump as the new shaft must be installed the same way.
9. Carefully turn the pump upside down to access the E-ring on the end of the shaft assembly inside the battery compartment (*see Figure 7-22*). Using E-type retaining ring pliers and needle nose pliers, remove the E-ring.
10. Pull the main control shaft through the front of the pump.
11. Using Electro-Wash 2000 or isopropyl alcohol, lint-free cloth or cotton swabs, and a small brush, remove all old grease and residue from the shaft.

Note: Isopropyl alcohol may be substituted for Electro-Wash 2000; however, if using isopropyl alcohol, use extra care to assure that all residual lubricant is removed.

12. Apply a thin coating of grease and work it into the threads along the length of the shaft. Do not fill the threads.
13. Orient the new shaft with the main control switch at LOCK/ON (*see Figure 7-22*). Lift the catch lever and slide the main control shaft into position.
14. Re-assemble the pump in the exact reverse order of disassembly.
15. Turn the main control switch to verify it is operational.

To verify successful main control switch shaft assembly replacement, perform the PVT in *Section 5.2*.

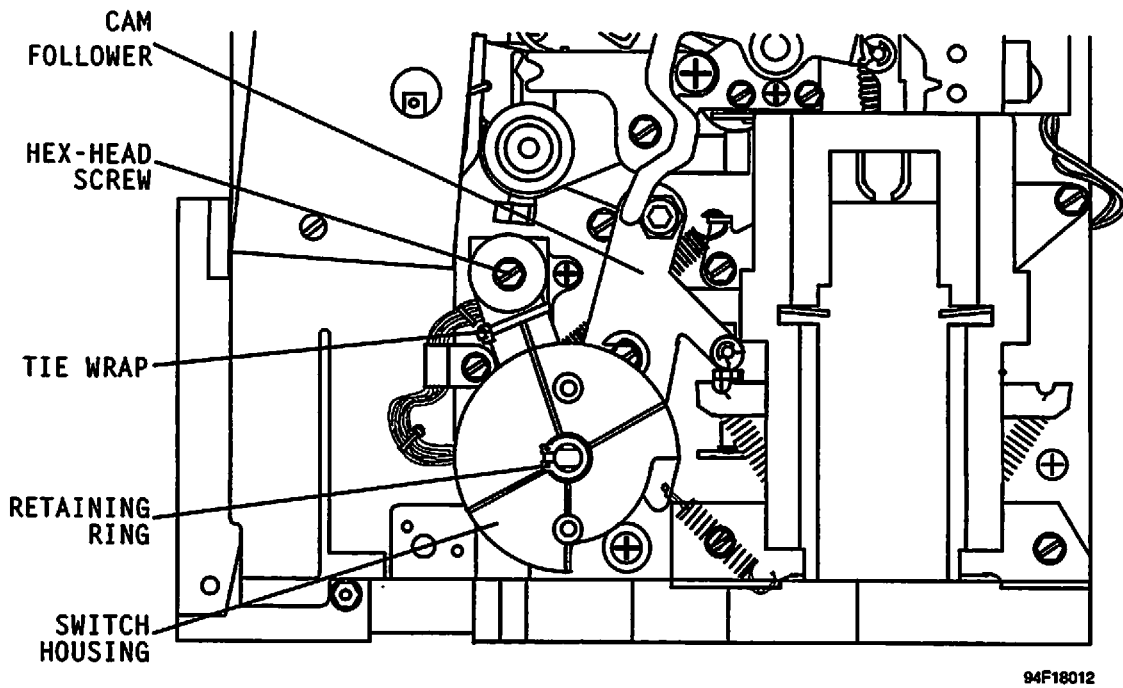


Figure 7-20. Main Control Switch Shaft Assembly

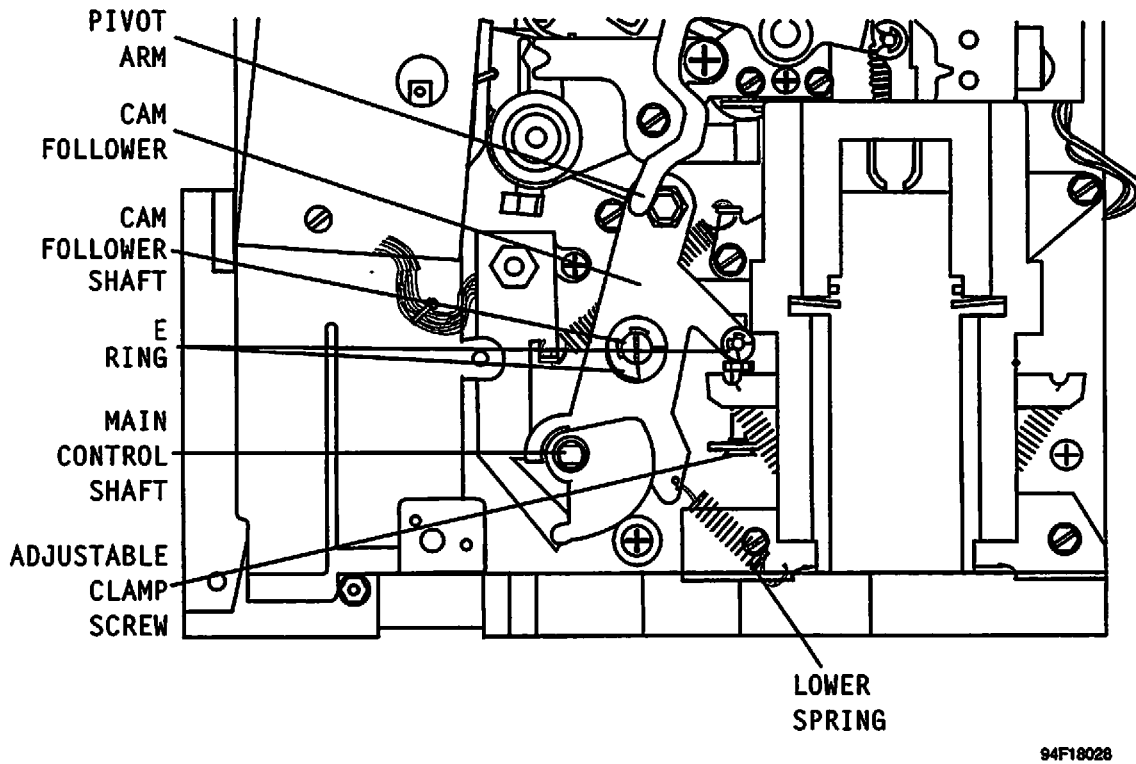


Figure 7-21. Main Control Switch Shaft Assembly with Switch Housing Removed

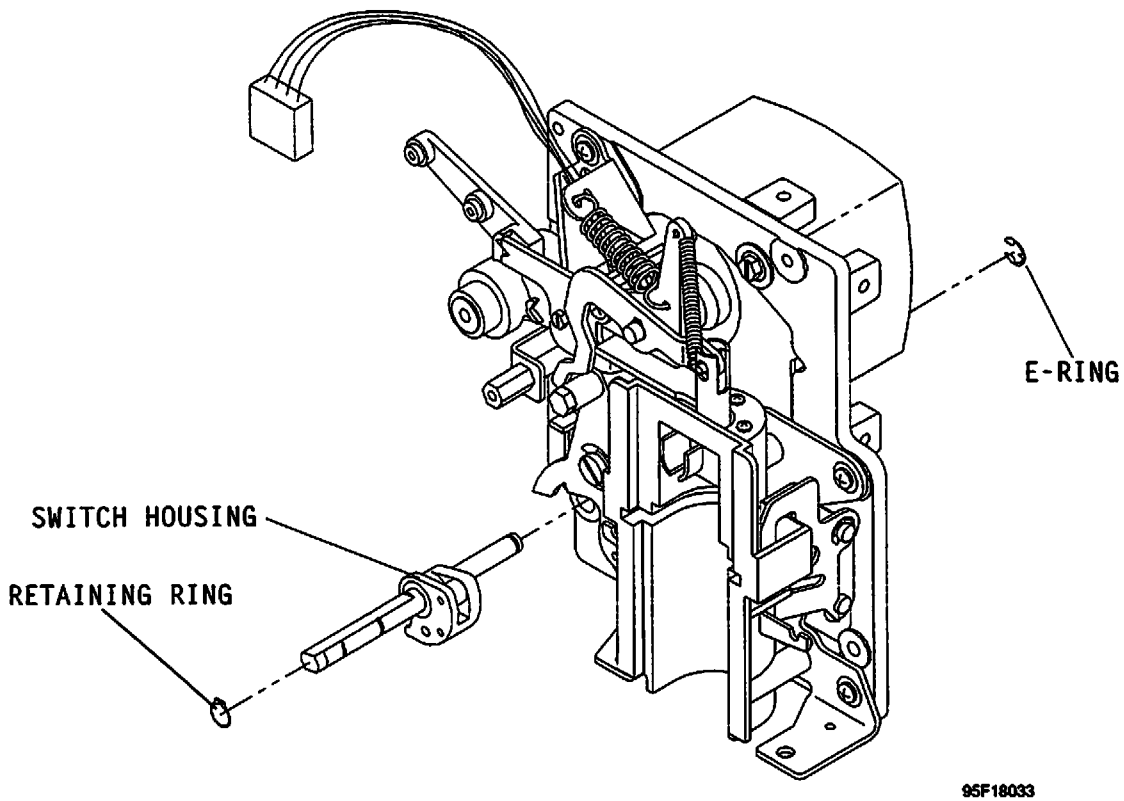


Figure 7-22. Main Control Switch Shaft Assembly E-Ring Removal

7.3.27

MAIN CONTROL SWITCH SHAFT ASSEMBLY LUBRICATION

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

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium size flat blade screwdriver, Allen wrenches, retaining ring pliers, E-type retaining ring pliers, Braycote 804 grease, Electro-Wash 2000 or isopropyl alcohol, lint-free cloth or cotton swabs, small brush (optional), needle nose pliers.

Note: Braycote 804 grease can be obtained from Abbott Laboratories, or may be obtained locally. Electro-Wash 2000 can be obtained locally.

To lubricate the main control switch shaft assembly, refer to *Figure 7-20, Main Control Switch Shaft Assembly*, *Figure 7-21, Main Control Switch Shaft Assembly With Switch Housing Removed*, and *Figure 7-22, Main Control Switch Shaft Assembly E-Ring Removal*, then proceed as follows:

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Remove the main control switch knob as described in *Section 7.3.12, Main Control Knob Replacement*.

3. Remove the main control switch shaft assembly as described in *Section 7.3.26, Main Control Switch Shaft Assembly Replacement*.
4. Remove the two E-rings and lower spring on the cam follower.
5. Slide the cam follower off the cam follower shaft (*see Figure 7-21*).

Note: When removing the cam follower be careful not to bend the pivot arm.

6. Using Electro-Wash 2000 or isopropyl alcohol, lint-free cloth or cotton swabs, and a small brush, remove all old grease and residue from the cam follower, cam follower shaft, main control shaft, adjustable clamp screw, and pivot arm.

Note: Isopropyl alcohol may be substituted for Electro-Wash 2000; however, if using isopropyl alcohol, use extra care to assure that all residual lubricant is removed.

7. Apply a thin coating of grease to all previously cleaned parts. Work the grease into the threads along the length of the shafts. Do not fill the threads.
8. Re-assemble the pump in the exact reverse order of disassembly.
9. Turn the main control switch to verify it is operational.

To verify successful main control switch shaft assembly lubrication, perform the PVT as described in *Section 5.2*.

7.3.28

MAIN CONTROL SWITCH WAFER REPLACEMENT

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

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium size flat blade screwdriver, Allen wrenches, and retaining ring pliers.

To replace the main control switch wafer, proceed as follows:

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Using the retaining ring pliers, remove the retaining ring from the main control switch shaft assembly.
3. Remove the tie wrap below the hex screw and remove the hex screw and washers.
4. Pull the switch housing off the main control switch shaft.
5. Remove the two screws that hold the main control switch in the housing. Clip the five wires from the wafer, noting the location of each color-coded wire.
6. Solder the five wires to the replacement wafer in the same locations as on the old wafer. Mount the new switch in the housing. Secure the wires with the tie wrap.
7. Mount the housing on the main control switch shaft, secure it to the chassis with the hex screw, and re-install the retaining ring.
8. Turn the main control switch shaft to the LOCK/ON position and confirm the self test performs to verify proper installation of the switch.
9. Re-assemble the pump in the exact reverse order of disassembly.

To verify successful replacement of the main control switch wafer, perform the PVT in *Section 5.2*.

7.3.29

FUSEHOLDER REPLACEMENT



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

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium size flat blade screwdriver, Allen wrenches, 11/16 inch open end wrench, 1/4 inch box wrench, X-acto knife, soldering iron and solder, tie wrap, and approximately two inches of 3/4 inch shrink tubing.

To replace the fuseholder, proceed as follows:

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Remove the power supply PWA as described in *Section 7.3.19.1, Power Supply PWA Replacement*.
3. Remove the three locknuts that secure the L-shaped connector panel to the main chassis casting. Gently pull the connector panel away from the casting to access the fuseholder (*see Figure 7-17, AC Power Cord Replacement (115 Volt)*).
4. Cut the tie wrap and remove the shrink tubing from the fuseholder. Unsolder the two black wires from the fuseholder terminal lugs.
5. Using an 11/16 inch open end wrench, remove the retaining nut from the shank of the fuseholder. Remove the fuseholder from the hole in the panel. Set aside the retaining nut and rubber insulator washer for re-assembly.
6. Place the rubber insulator washer on the shank of the replacement fuseholder. Replace the fuseholder in the hole in the L-shaped connector panel. Secure the fuseholder to the panel with the retaining nut.
7. Resolder the black wires to the fuseholder. Slip a two-inch length of 3/4 inch shrink tubing over the fuseholder. Fold the shrink tubing back over the fuseholder and secure with the tie wrap.
8. Replace the fuse.
9. Re-install the L-shaped connector panel.
10. Re-assemble the pump in the exact reverse order of disassembly.

To verify successful replacement of the fuseholder, perform the PVT in *Section 5.2*.

7.3.30

NURSE-CALL JACK REPLACEMENT

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

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, 1/2 inch open end wrench, pair of wire cutters, pair of wire strippers, soldering iron and solder, X-acto knife, and one inch of 3/8 inch shrink tubing.

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

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Remove the power supply PWA as described in *Section 7.3.19.1, Power Supply PWA Replacement*.
3. Using a 1/2 inch open end wrench, remove the nut and washer from the nurse-call jack. Push the jack through the hole in the panel and remove from the pump.
4. Using an X-acto knife, remove the shrink tubing from the terminal lugs on the jack. Unsolder and remove the wires from the terminal lugs.
5. Slip a 1/2 inch length of 3/8 inch shrink tubing over each wire.
6. Solder the orange wire to the terminal lug on the beveled corner of the jack. Solder the yellow wire to the terminal lug on the flat side of jack.
7. Slide the shrink tubing over the terminal lugs and shrink in place.
8. Re-assemble the jack on the rear panel. Secure with the washer and nut removed in Step 3.
9. Re-install the power supply PWA.
10. Re-assemble the pump in the exact reverse order of disassembly.

To verify successful replacement of the nurse-call jack, perform the PVT in *Section 5.2*.

7.3.31

PRESSURE LEVEL SELECT SWITCH REPLACEMENT

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

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium size flat blade screwdriver, Allen wrenches, 1/4 inch and 5/16 inch box wrenches, X-acto knife, soldering iron and solder, and 1/8 inch shrink tubing.

To replace the pressure level select switch, proceed as follows:

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Remove the power supply PWA as described in *Section 7.3.19.1, Power Supply PWA Replacement*.
3. Using a 1/4 inch box wrench, remove the three locknuts that secure the L-shaped connector panel to the main chassis casting. Gently pull the connector panel away

from the casting to access the switch (see *Figure 7-17, AC Power Cord Replacement (115 Volt)*).

4. Using a 5/16 inch box wrench, remove the nut from the switch shank that secures the switch to the panel. Remove the lock washer and keyed flat washer. Remove the switch from the panel.
5. Remove the locknut from the switch shank. Set aside both nuts, the lock washer, and the keyed flat washer for re-assembly.
6. Using an X-acto knife, remove the shrink tubing from the switch terminals. Unsolder the wires from the terminals.
7. Place a 3/8 to 1/2 inch length of 1/8 inch shrink tubing on each switch wire. Slide the shrink tubing down the wire so as not to interfere with resoldering.
8. Resolder the three wires to the terminals of the replacement switch as follows:
 - Red wire to switch center (OFF) terminal lug
 - Blue wire to switch (ON) terminal (opposite keyed side of switch shank)
 - Green wire to switch (ON) terminal (on keyed side of switch shank)
9. Slide shrink tubing over each terminal connection and shrink into place.
10. Screw the locknut on the shank of the replacement switch and secure against the switch for jamnut action.
11. Install the switch through the panel hole. Place the keyed flat washer and lock washer on the switch shank, making sure the keyed flat washer is properly oriented, with the washer tab in the panel hole. Secure the switch to the panel with the nut.
12. Connect the pump to AC (mains) power and turn the main control switch to LOCK/ON.
13. Place the level select switch to MIN. Press the [SILENCE] touchswitch for two seconds and verify proper switch position in the VOLUME DELIVERED display.
14. Repeat Step 13 for the MID and MAX positions of the level switch.
15. Disconnect the pump from AC (mains) power. Replace the L-shaped connector panel removed in Step 3.
16. Re-install the power supply PWA in the exact reverse order of disassembly.
17. Re-assemble the pump in the exact reverse order of disassembly.

To verify successful pressure level select switch replacement, perform the PVT in *Section 5.2*.

7.3.32

SET TYPE SWITCH REPLACEMENT (MICRO ONLY)

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

Recommended tools for this procedure are as follows: a No. 2 Phillips screwdriver, medium size flat blade screwdriver, Allen wrenches, soldering iron and solder, and 3/32 inch shrink tubing.

This procedure is for replacement of the set type switch mounted on the rear panel of the Micro pump.

To replace the set type switch, proceed as follows:

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Remove the power supply PWA as described in *Section 7.3.19.1, Power Supply PWA Replacement*.
3. Using a 1/4 inch box wrench, remove the three locknuts that secure the L-shaped connector panel to the main chassis casting. Gently pull the connector panel away from the casting to access the switch (see *Figure 7-17, AC Power Cord Replacement (115 Volt)*).
4. Using a screwdriver, remove the two screws attaching the switch to the panel.
5. Unsolder the wires from the switch. Discard the switch.
6. Place a 3/8 to 1/2 inch length of 3/32 inch shrink tubing over each wire and slide the shrink tubing down the wire so as not to interfere with resoldering.
7. Solder the brown wire to the center terminal of the new switch. Solder the green wire to one end terminal of the switch. Slide the shrink tubing down over the connections and shrink into place.
8. Re-install the switch in the panel. Make sure that the switch is oriented so the end terminal with the green wire is on the left (set type A position) when facing the back of the pump.
9. Re-attach the L-shaped connector panel to the main chassis using the three locknuts removed in Step 3.
10. Connect the pump to AC (mains) power and turn the main control switch to LOCK/ON.
11. With the set type switch in the set type A position. Press the [SILENCE] touchswitch for a minimum of 1.25 seconds and verify the switch position message appears on the VOLUME DELIVERED display.
12. Slide the set type switch to the set type B position. Press the [SILENCE] touchswitch for a minimum of 1.25 seconds and verify the switch position message appears on the VOLUME DELIVERED display.
13. Disconnect the pump from AC (mains) power. Re-install the power supply PWA and re-assemble the pump case in the exact reverse order of disassembly.

To verify successful set type switch replacement, perform the PVT in *Section 5.2*.

7.3.33

RUBBER FOOT PAD REPLACEMENT

The recommended tools for this procedure are as follows: 3/8 inch wood chisel or X-acto knife, and isopropyl alcohol.

To replace the rubber foot pad, proceed as follows:

1. Place the infuser on its side.
2. Using a 3/8 inch wood chisel or an X-acto knife, remove the rubber foot pad and scrape the enclosure recess to remove adhesive residue.

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

3. Using isopropyl alcohol, clean any adhesive residue from the enclosure recess.

4. Remove the protective backing from the self-adhesive surface of the replacement foot pad and press the pad in place.
5. After approximately five minutes, verify the foot pad is secure.

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

7.3.34

MAINS RECEPTACLE ASSEMBLY REPLACEMENT



The recommended tools for this procedure are as follows: 3/16 inch nutdriver, soldering iron and solder, X-acto knife, 0.187 inch shrink tubing, and 0.125 inch PVC tubing.

To replace the mains receptacle assembly, proceed as follows:

1. Open the pump case as described in *Section 7.3.18, Case Replacement*.
2. Using a 3/16 inch nutdriver, remove the two nuts and lockwashers securing the receptacle to the switch plate. Retain the nuts and lockwashers for re-assembly.
3. Using an X-acto knife, remove the shrink tubing from the receptacle terminal connectors. Unsolder the wires from the terminal lugs, noting the location of each wire for reconnection.
4. Place a piece of shrink tubing approximately 0.75 inch (2 cm) long over the green and yellow ground wire. Slide the tubing down the wire so as not to interfere with the soldering operation.
5. Place a piece of PVC tubing approximately 4.25 inch (11 cm) long and a piece of shrink tubing approximately 0.75 inch (2 cm) long over each of the two transformer leads. Slide the tubing down the wire so as not to interfere with the soldering operation.
6. Solder the three wires to the replacement receptacle terminals in the same locations as on the old receptacle.
7. Slide shrink tubing and PVC tubing over each terminal connection. Shrink the shrink tubing over the terminals. The shrink tubing must cover at least 0.125 inch of the PVC tubing on the transformer leads.
8. Re-install the receptacle and re-assemble the pump in the exact reverse order of disassembly.
9. Install the fuses as described in *Section 7.3.4.2, Fuse and Fuse Drawer Replacement*.

To verify successful mains receptacle replacement, perform the PVT in *Section 5.2*.

This page intentionally left blank.

Section 8

SPECIFICATIONS

Weight:	13 pounds (6 kg)
Dimensions:	8 x 11 x 9 inches (20 x 28 x 23 cm)
Mains Power Requirements:	100 V~, 50/60 Hz, 25 VA 110 to 120 V~, 50/60 Hz, 30 VA 220 to 240 V~, 50/60 Hz, 25 VA
Electrical Safety:	(100 V~ and 220 to 240 V~) meets IEC 601-1 standards, Class 1, mains supply equipment using protective earth (110 to 120 V~) meets UL 544 standards
Battery:	One 8 V, sealed, rechargeable battery. Typical operating time for a fully charged, new battery is up to four hours at a delivery rate of 125 ml/hr. Gradual degradation over extended periods of use will decrease the operating time and recharge recovery. When capacity drops to an unacceptable level, replace the battery
Mains Fuses:	100 V~, T315 mA, 250 V, 2 each 110 to 120 V~, T250 mA, 250 V 220 to 240 V~, T100 mA, 250 V, 2 each
Mains Cord:	110 to 120 V~, UL hospital grade AC power cord, 2.5 ± 0.5 meters. 100 V~ and 220 to 240 V~, IEC 601-1 approved detachable cord set, 2.5 ± 0.5 meters
Operating Range:	Primary (Models 4 and 4P): 1 to 999 ml/hr in 1 ml/hr increments Secondary (Model 4P only): 1 to 300 ml/hr in 1 ml/hr increments Primary (Model 4H): 1 to 350 ml/hr in 1 ml/hr increments Micro: 0.1 to 99.9 ml/hr in 0.1 ml/hr increments
Dose Limit Selection:	Models 4 and 4P: 1 to 9999 ml in 1 ml increments Model 4H: 1 to 5000 ml in 1 ml increments Micro: 0.1 to 999.9 ml in 0.1 ml increments
Maximum Occlusion Pressure:	20 psig (138 kPa)

Occlusion Alarm Pressure Limit:

The pump is designed to sense inline pressure at the cassette outlet valve (baseline pressure). The user may select variable pressure limits, above the baseline pressure, of either 4, 8, or 12 psi (28, 55, or 83 kPa). When either the variable pressure limit or the available operating pressure limit is sensed, the pump stops fluid delivery and an occlusion alarm sounds.

Nurse-Call System:

The pump is designed to operate with either normally open (NO) or normally closed (NC) type hospital nurse-call systems.

CAUTION: Connect pump nurse-call cable to previously tested and approved nurse-call systems only.

Note: The nurse-call alarm is factory preset for normally open (NO) systems. Only qualified hospital personnel may make an internal adjustment for normally closed (NC) type systems.

Fluids and Cleaning:

Pump not affected by fluid spills or cleaning solutions recommended in *Table 5-1, Cleaning Solutions*

ENVIRONMENT:

Operating Temperature:

10° to 40° C, 10% to 90% relative humidity

Shipping and Storage:

-20° to 60° C, 10% to 90% relative humidity

IPX1

Equipment protected against dripping water



Terminal for connection of an equipotential conductor



Attention, consult accompanying documents



Type B:

Equipment providing adequate degree of protection against electrical shock (see pump labeling to determine class of protection)



Type BF:



Type CF:

Table 9-2. IPB for the Pump		
Index Number	Nomenclature	Replacement Procedure
1	Assembly, Panel, Front	<i>Section 7.3.23</i>
2	Panel, Sub, Front	<i>Section 7.3.23</i>
3	Pad, Front Panel	As applicable
4	PWA, Display	<i>Section 7.3.19.2</i>
5	Chasis, Main	N/A
6	PWA, Display Driver, Series 4	<i>Section 7.3.19.2</i>
7	PWA, MPU, LC4 w/RS-485	<i>Section 7.3.19.2</i>
8	PWA, Motherboard, Series 4	<i>Section 7.3.19.3</i>
9	PWA, Motor Driver, Series 4	<i>Section 7.3.19.2</i>
10	Insulator, Charger, PWA	N/A
11	PWA, Boost, Charger	N/A
12	Cover, Bottom	<i>Section 7.3.3</i>
13	Clamp, Casting, Model 3/4	N/A
14	Shield, EMI	<i>Section 7.3.19</i>
15	PWA, Power Supply (International)	<i>Section 7.3.19.1</i>
16	Assembly, Casting, Clamp	<i>Section 7.3.14</i>
17	Pad, Battery	As applicable
18	Battery, 8V, 2.5 AH, E Balance	<i>Section 7.3.3</i>
19	Cover, Front	<i>Section 7.3.18.2</i>
20	Gasket, Front Cover, Foam	<i>Section 7.3.18.2</i>
21	Cover, Back	<i>Section 7.3.18.2</i>
22	Clip, Cord	<i>Section 7.3.22</i>
23	Assembly, Shaft, Knob	<i>Section 7.3.26</i>
24	Guide, Plunger, Black	<i>Section 7.3.16</i>
25	Spacer, Round, .25 OD x .140 ID x 1.0 Long	<i>Section 7.3.19.2</i>

Table 9-2. IPB for the Pump		
Index Number	Nomenclature	Replacement Procedure
26	Spacer, Round, .25 OD x .140 ID x .625 Long	<i>Section 7.3.19.2</i>
27	Spacer, #4, .25 OD x .25 ID, Nylon	<i>Section 7.3.19.2</i>
28	Spacer, #6, .25 OD x .25 ID, Nylon	<i>Section 7.3.19.2</i>
29	Knob, Main Control	<i>Section 7.3.12</i>
30	Washer, Flat, 3/8, .19 Thick, Felt	<i>Section 7.3.13</i>
31	Knob, Clamp	<i>Section 7.3.13</i>
32	Screw, Set, 8-32 NC x 3/4, ALHD, HAFIG	<i>Section 7.3.13</i>
33	Cover, Pressure Sensor, PWA	N/A
34	PWA, Pressure, Sensor	N/A
35	Washer, Flat, 3/8 ID, .060 Thick, Stainless Steel	<i>Section 7.3.14</i>
36	Washer, Flat, 3/8 ID, .010 Thick, Stainless Steel	<i>Section 7.3.14</i>
37	Shaft, Clamp, 3.98 inches Long	<i>Section 7.3.14</i>
38	Rivit, Pop, 1/8 x 5/8, GRIP, Aluminum	As applicable
39	Assembly, Alarm, Piezo	<i>Section 7.3.24</i>
40	Gasket, Side Foam	As applicable
41	Ring, Retaining, .250 SFT x .025 Thick	<i>Section 7.3.26</i>
42	Ring, Retaining, .250 SFT, EXT GR	<i>Section 7.3.26</i>
43	Screw, 6-32 x 3 Long, Round Head, Slotted	As applicable
44	Spacer, Round, .19 OD x .144 ID x .310 Long	As applicable
45	Washer, Flat, #6, .032 Thick, Steel	As applicable
46	Screw, 6-32 x 5/16, Hex Head, w/Washer	As applicable
47	Screw, 6-32 x 1/4, Hex Head, Slotted, w/Washer	As applicable
48	Screw, 4-40 x 3/8, Hex Head, Slotted, w/Washer	As applicable
49	Screw, 4-40 x 1/2, Hex Head, Slotted, w/Washer	As applicable
50	Screw, 6-19 x 1/2, Panhead, Phillips, TRI-RND	As applicable

Table 9-2. . IPB for the Pump

Index Number	Nomenclature	Replacement Procedure
51	Screw, 6-19 x 3/4, Panhead, Phillips, TRI-RND	As applicable
52	Screw, 6-32 x .375, Hex Head, Slotted, w/Washer	As applicable
53	Washer, Lock, #6, .031 Thick, SPL, C, STL	As applicable
54	Screw, 6-32 x 1/2 Long, Panhead, Phillips, TRI-RND	As applicable
55	Screw, 6-20 x 1, Phillips, Self-Tapping	As applicable
56	Mount, Black, Left	As applicable
57	Mount, Black, Right	As applicable
58	Screw, 6-32 x 1/2, Hex Head, Slotted, w/Washer	As applicable
59	Screw, 4-24 x .313, Panhead, Phillips, Type B	As applicable
60	Screw, 4-40 x 5/16, Hex Head, Slotted, w/Washer	As applicable
61	Screw 4-40 x 1/4, Machine, Panhead, Slotted	As applicable
62	Assembly, Cord Set (European)	<i>Section 7.3.21</i>
63	Assembly, Cable, Elect (Nurse Call)	<i>Section 7.3.8</i>
64	Assembly, AC Power Supply Cord	<i>Section 7.3.20</i>
65	Assembly, FNL, Drop Sensor	<i>Section 7.3.9</i>
66	Assembly, Battery, Case w/RS-485 (Domestic)	N/A
66A	Cover Rotary Switch	<i>Section 7.3.28</i>
66B	Switch, Rotary Wafer, SW 1	<i>Section 7.3.28</i>
66C	Nut 4-40, KEP, w/Conical Washer, SML	As applicable
66D	Connector, Female, D-Sub, 15 Pin	N/A
66E	Switch, Toggle, Spot, Center Off, Bright Nickel, SW 3, 2	<i>Section 7.3.15</i> <i>Section 7.3.32</i>
66F	Standoff, Assembly, 2 Nuts, 3 Washers	As applicable
66G	Strain Relief, Bushing, .325-.360"W	<i>Section 7.3.6</i>
66H	Fuse, 1/4 Amp, Slo-Blo, 250 V	<i>Section 7.3.4.1</i>

Table 9-2. IPB for the Pump		
Index Number	Nomenclature	Replacement Procedure
66J	Holder, Fuse, 20 A, 250 V	<i>Section 7.3.29</i>
66K	PL, SW	N/A
66L	Washer, Lock, #6, EXT, TTH	As applicable
66M	Nut, 6-32, KEP, w/Conical Washer, SML	As applicable
66N	Jack, Output, Nurse Call, 2 CKT, J21	<i>Section 7.3.30</i>
66P	Ring, Retaining, .406 SFT, .025 Thick, EX G	As applicable
66Q	Ring, Retaining, .50 SFT, .035 Thick, EXT	As applicable
66R	Connector Housing, Male, Panel Mounted, 7 Pin, Black, J22	<i>Section 7.3.11</i>
66S	Connector, RCPT, BHD, V-LOK, 12 Pin, Black, J23	<i>Section 7.3.17</i>
67	Assembly, Battery Case w/RS-485 (International)	N/A
67A	Nut, 4-40, Hex, Steel, CB/ZN PL	<i>Section 7.3.34</i>
67B	Washer, Lock, #4, .025 Thick, SPL, C, Steel	<i>Section 7.3.34</i>
67C	Power Module, 2 Pole, w/Ground	<i>Section 7.3.34</i>
67D	Fuse, 0.1 A, Slo-Blo, Glass	<i>Section 7.3.4.2</i>
67E	Nut, M6-1, Hex, Steel	As applicable
67F	Switch, SL, DPDT, LKG, NON-SHT, 4-40 SW 7	N/A
67G	Washer, Lock, 1/4, .025 Thick, INT, TTH	As applicable
67H	PL, SW	N/A
67J	Terminal, Equipotential	N/A
67K	Drawer, Fuse, 2 Pole	<i>Section 7.3.4.2</i>
67L	Screw, 10-32 x 3/16, Hex Head, Slotted, w/Washer	<i>Section 7.3.4.2</i>
67M	Fuse, Strap	<i>Section 7.3.4.2</i>

Section 10

INDEX

- 20-MA I/O Port, 4-5
 - 5 VDC Failure Detector Circuitry, 4-34
 - 5 VDC Regulator Circuitry, 4-33
- ### A
- A/D Converter, 4-27
 - Abbreviations and Acronyms, 1-3
 - AC
 - Power Cord Retainer Clip Replacement, 7-36
 - AC (Mains)
 - Operation, 4-35
 - Power Cord Plug Replacement, 7-16
 - Power Cord Replacement (100 Volt, 220 Volt), 7-35
 - AC Power Cord Replacement (115 Volt), 7-34
 - AC Power Cord Strain Relief Bushing Replacement, 7-16
 - ACC. Connector J23, 4-3
 - Pin Arrangement, 4-4
 - Accessory (ACC.) Connector (or Pins) Replacement, 7-24
 - Adjustment
 - Shroud Rear Tab, 7-4
 - Adjustment Procedures, 7-3
 - Alarm
 - Audible, 4-2
 - Codes, 6-2 - 6-3
 - Conditions, 6-2
 - History, Obtaining, 6-2
 - Nurse-call, 4-2
 - Nurse-Call, Troubleshooting, 6-16
 - Alarms, 4-2
 - Audible, 6-1
 - Audible, Troubleshooting, 6-4
 - Artifacts, 1-5
 - Assistance, Technical, 6-1
 - Audible Alarm Level Switch Replacement, 7-22
- ### B
- Battery
 - Charger Circuitry, 4-32
 - Charging Circuit Test, 5-12
 - Charging Test, 5-9
 - Circuit Alarm and Charger Tests, 5-11
 - Depth of Discharge, 5-10
 - Discharged Mode, 4-9
 - Low Battery Alarm Test, 5-11
 - Maintenance, 5-10
 - Monitor Circuitry, 4-34
 - Operation Overview, 4-40
 - Operations, Troubleshooting, 6-9
 - Pack, 4-31
 - Pack Replacement, 7-13
 - Recharging, 5-10
 - Shutdown Test, 5-11
 - Battery Circuit Alarm and Charger Tests Equipment Required, 5-11
- ### C
- Calibration
 - Pressure Sensor (-003 and Lower), 7-6
 - Pressure Sensor (-004 and Higher), 7-8
 - Test Setup, 7-8
 - Case Replacement, 7-26
 - Clamshell, 7-28
 - One-Piece, 7-26
 - Case Screw Removal (Clamshell Case), 7-29
 - Cassette, 4-1, 4-38
 - Circuitry
 - 5 VDC Failure Detector, 4-34
 - 5 VDC Regulator, 4-33
 - Battery Charger, 4-32
 - Battery Monitor, 4-34
 - Diode Power Switch, 4-32
 - Display Enable Stretcher & Display Protector, 4-30
 - Hardware Watchdog, 4-29
 - Malfunction Detection, 4-18
 - Memory, 4-22
 - Memory Latch, 4-22
 - Memory Protector, 4-22
 - Memory Supply, 4-35
 - Microprocessor, 4-21
 - Numeric and Bar Display Digit Drivers, 4-29
 - Power Control, 4-32
 - Unregulated DC Power Supply, 4-31
 - Clamshell Case Replacement, 7-28

Cleaning Solutions, 5-2
 Cleaning the Pump, 5-2
 Control Switches, 4-36
 Conventions of Manual, 1-2
 Core Failures, Troubleshooting, 6-11
 Current
 Amplitude Modulator, 4-14
 Boost Charger PWA, 4-35

D

Data Retention Function, 4-12
 Dataway
 RS-485 I/O Connector J101, 4-5
 RS-485 Port, 4-27
 Troubleshooting (RS-485 Only), 6-15
 DC Operation, 4-36
 Delivery Accuracy
 Test Setup, 5-5
 Delivery Accuracy Test, 5-7
 Depth of Discharge, 5-10
 Diode Power Switch Circuitry, 4-32
 Display Driver PWA, 4-29
 Replacement, 7-31
 Display Enable Stretcher and Display
 Protector Circuitry, 4-30
 Display PWA, 4-28
 Replacement, 7-31
 Display Test, 4-30
 Displays
 Numeric and Bar, 4-2
 Pump, Troubleshooting, 6-12
 Drawings, 9-1
 Drop Amplitude Threshold Detector, 4-15
 Drop Signal Processor, 4-14
 Dry Cassette Test, 5-4

E

Electrical Safety Test, 5-9
 Electronics Subsystem Principles of
 Operation, 4-20
 End of Performance Verification Test, 5-9
 Equipment Precautions, Safety and, 7-11
 Equipment and Materials Required, 5-3
 External Controls, Troubleshooting, 6-13
 External Interface Ports, 4-3

F

Features
 Series Specific, 1-6
 Flow Algorithm, 4-16
 Flow Detector, 4-2, 4-13
 Assembly Plug Replacement, 7-18

Assembly Replacement, 7-17
 Closed Entry Female Terminal
 Replacement, 7-18
 Connector Housing Replacement, 7-19
 Connector J22, 4-4
 Male Pin Connector(s) Replacement, 7-19
 Presence Detection, 4-15
 Schematic Diagram, 4-14
 Flow Monitoring System, 4-12
 Front Panel Switches, 4-36
 Functions, General, 4-1
 Fuse Replacement
 100 Volt, 7-15
 115 Volt, 7-14
 220 Volt, 7-15
 Fuseholder Replacement, 7-45

G

General Functions, 4-1

H

Hardware Watchdog, 4-19
 Circuitry, 4-29
 Test, 4-20
 Heat Sink Screw Removal, 7-31
 High Flow and Low Flow Alarm
 (Simulated) and Audible Alarm Tests, 5-7

I

I/O Address
 Decoder, 4-26
 Table, 4-24
 I/O Ports, 4-22
 Input Data Buffers, 4-27
 Inspecting the Pump, 5-1
 Inspection, 1-9, 5-4
 Instrument Installation Procedure, 1-8
 Interface, External Ports, 4-3
 Internal RAM Test, 4-18
 Introduction to Product, 1-1
 IPB for the Pump, 9-69, 9-89

L

Load Off/Recharge Mode, 4-7
 Local Control Mode, 4-8
 Lubrication, Main Control Switch Shaft
 Assembly, 7-43

M

- Main Control Knob
 - Replacement, 7-20
- Main Control Knob
 - Removal, 7-20
- Main Control Switch Shaft Assembly
 - E-Ring Removal, 7-43
 - Lubrication, 7-43
 - Replacement, 7-40
- Main Control Switch Wafer Replacement, 7-44
- Mains Receptacle Assembly Replacement, 7-49
- Maintenance
 - and Service Tests, 5-1
 - Preventive, 5-1
- Malfunction Detection Circuitry, 4-18
- Malfunction Simulation Test, 5-9
- Materials, 7-12
- Mechanical Subsystem Principles of Operation, 4-38
- Memory
 - Circuitry, 4-22
 - Latch Circuitry, 4-22
 - Protector Circuitry, 4-22
 - Supply Circuitry, 4-35
- Microprocessor
 - Circuitry, 4-21
 - Sanity Check, 4-20
- Miscellaneous Conditions
 - Troubleshooting, 6-16
- Modes of Operation, 4-6
 - Battery Discharged, 4-9
 - Load/Off Recharge Mode, 4-7
 - Local Control, 4-8
 - Remote Control, 4-9
 - Self Test, 4-8
 - System Failure, 4-10
 - User Controls and Operating Mode, 4-6
- Monitors and Detectors, 4-12
- Motherboard PWA
 - Replacement, 7-33
- Motor and Motor Drivers, 4-40
- Motor Driver PWA, 4-23
 - Replacement, 7-31
- Motor Voltage Regulator, 4-34
- MPU PWA, 4-21
 - Replacement, 7-31

N

- Numeric and Bar Display, 4-2, 4-29
 - Digit Drivers Circuitry, 4-29
 - Segment Drivers, 4-30

- Nurse-Call
 - Alarm, 4-2
 - Cable Assembly Replacement, 7-17
- Nurse-Call Jack
 - J21, 4-4
 - Replacement, 7-46

O

- Obtaining an Alarm History, 6-2
- Occlusion Alarm Algorithm, 4-17
- One-Piece Case Replacement, 7-26
- Opening Clamshell Case, 7-29
- Operating Manual
 - System, 3-1
- Operation
 - AC (Mains), 4-35
 - DC, 4-36
 - Modes of, 4-6
 - Theory of, 4-1
- Operational Description, 4-6

P

- Performance Verification Test, 5-3
 - Troubleshooting, 6-17
- Piezoelectric Alarm Replacement, 7-38
- Piggyback Test (Model 4P Only), 5-8
- Pole Clamp Knob
 - Removal, 7-21
 - Replacement, 7-20
- Pole Clamp Shaft Replacement, 7-21
- Ports
 - I/O, 4-22
- Power Control Circuitry, 4-32
- Power Supply PWA, 4-31
 - Replacement, 7-30
- Power-Up Test, 4-19
- Precautions, Safety and Equipment, 7-11
- Pressure Level Select Switch
 - Replacement, 7-46
- Pressure Measuring System, 4-16
- Pressure Sensor
 - Adjustment Resistors, 7-6
 - Calibration and Test, 7-5
 - Test, 7-10
- Pressure Sensor Calibration
 - (-003 and Lower), 7-6
 - (-004 and Higher), 7-8
 - Setup, 7-5
- Pressure Sensor PWA
 - 003 and Lower, 4-17
 - 004 and Higher, 4-17
- Pressure Test and Silence Switch Test, 5-6

Preventive Maintenance, 5-1
 Principles of Operation
 Electronic Subsystem, 4-20
 Mechanical Subsystem, 4-38
 Procedure
 Instrument Installation, 1-8
 Procedures
 Adjustment, 7-3
 Replacement, 7-11
 Pump Inspection, 5-4
 Pump Mechanism, 4-39
 Pump Troubleshooting, 6-4
 PVT Data Form, 5-13
 PVT Troubleshooting, 6-17
 PWA
 Current Boost Charger, 4-35
 Display, 4-28
 Motor Driver, 4-23
 MPU, 4-21
 Power Supply, 4-31
 Removal, 7-32
 Replacement, 7-30

R

Rear Panel
 Screw Removal (One-Piece Case), 7-27
 Switches, 4-37
 Recharging, 5-10
 Remote Control Mode, 4-9
 Removal
 PWA, 7-32
 Removing Chassis From Cover, 7-28
 Replaceable Parts
 and Repairs, 7-1
 List, 7-1
 Replacement
 AC (Mains) Power Cord (100 Volt, 220 Volt), 7-35
 AC (Mains) Power Cord Plug, 7-16
 AC Power Cord (115 Volt), 7-34
 AC Power Cord Retainer Clip, 7-36
 AC Power Cord Strain Relief Bushing, 7-16
 Accessory (ACC.) Connector (or Pins), 7-24
 Audible Alarm Level Switch, 7-22
 Battery Pack, 7-13
 Case, 7-26
 Case, Clamshell, 7-28
 Case, One-Piece, 7-26
 Closed Entry Female Terminal, 7-18
 Display Driver PWA, 7-31
 Display PWA, 7-31
 Flow Detector Assembly, 7-17
 Flow Detector Assembly Plug, 7-18
 Flow Detector Connector Housing, 7-19

Fuse (115 Volt), 7-14
 Fuse (100 Volt, 220 Volt), 7-15
 Fuseholder, 7-45
 Main Control Knob, 7-20
 Main Control Switch Shaft Assembly, 7-40
 Main Control Switch Wafer, 7-44
 Mains Receptacle Assembly, 7-49
 Male Pin Connector(s), 7-19
 Motherboard PWA, 7-33
 Motor Driver PWA, 7-31
 MPU PWA, 7-31
 Nurse-Call Cable Assembly, 7-17
 Nurse-Call Jack, 7-46
 Piezoelectric Alarm, 7-38
 Pole Clamp Knob, 7-20
 Pole Clamp Shaft, 7-21
 Power Supply PWA, 7-30
 Pressure Level Select Switch, 7-46
 Procedures, 7-11
 PWA, 7-30
 Rubber Foot Pad, 7-48
 Set Type Switch (Micro Only), 7-47
 Shroud Assembly Plunger Guide, 7-23
 Touchswitch Panel, 7-36
 Velcro Anchor Pad, 7-15
 Required Tools and Materials, 7-11
 ROM Test, 4-19
 RS-232 I/O Port, 4-5
 RS-485
 Dataway I/O Connector J101, 4-5
 Dataway Port, 4-27
 Rubber Foot Pad Replacement, 7-48

S

Safety and Equipment Precautions, 7-11
 Sanitizing the Pump, 5-3
 Scope of Manual, 1-1
 Segment Drivers
 Numeric and Bar Display, 4-30
 Self Test, 1-9
 Mode, 4-8
 Series Specific Features, 1-6
 Set Type Switch Replacement (Micro Only), 7-47
 Shield Removal, 7-30
 Shroud Assembly Plunger Guide
 Replacement, 7-23
 Shroud Rear Tab
 Adjustment, 7-4
 Shroud Tab
 Check, 7-3
 Silence/ASK Function, 4-11
 Messages, 4-11
 Software Watchdog, 4-20

Special Tools, 7-12
 Specifications, 8-1
 Standard Handtools, 7-12
 Start Up Test, 5-5
 Switches
 Control, 4-36
 Front Panel, 4-36
 Rear Panel, 4-37
 Synchronous Demodulator, 4-15
 System Failure Mode, 4-10

T

Technical Assistance, 6-1
 Test
 Audible Alarm, 5-7
 Battery Charging, 5-9
 Battery Charging Circuit, 5-12
 Battery Circuit Alarm and Charger, 5-11
 Battery Shutdown, 5-11
 Calibration, Setup, 7-8
 Delivery Accuracy, 5-7
 Delivery Accuracy, Setup, 5-5
 Display, 4-30
 Dry Cassette, 5-4
 Electrical Safety, 5-9
 Hardware Watchdog, 4-20
 High Flow and Low Flow Alarm
 (Simulated), 5-7
 Internal RAM, 4-18
 Low Battery Alarm, 5-11
 Malfunction Simulation, 5-9
 Performance Verification, 5-3
 Piggyback (Model 4P Only), 5-8
 Power-Up, 4-19
 Pressure and Silence Switch, 5-6
 Pressure Sensor, 7-10
 Pressure Sensor Calibration, 7-5
 ROM, 4-19
 Self, 1-9
 Setup, 5-4
 Start Up, 5-5
 Test Connector, 6-18
 (J23) Pin Assignments, 6-18
 Test Setup, 5-4
 Tests
 Maintenance and Service, 5-1
 Theory of Operation, 4-1
 Tools
 and Materials, Required, 7-3, 7-11
 Special, 7-12
 Standard Handtools, 7-12
 Touchswitch Panel Replacement, 7-36
 Transformer Connector P10 and Closed
 Entry Female Terminal Replacement, 7-39

Troubleshooting, 6-1
 Audible Alarms, 6-4
 Battery Operations, 6-9
 Core Failures, 6-11
 Dataway Function (RS-485 Only), 6-15
 External Controls, 6-13
 Miscellaneous Conditions, 6-16
 Nurse-Call Alarm, 6-16
 Performance Verification Test, 6-17
 Pump, 6-4
 Pump Displays, 6-12
 PVT, 6-17

U

Unpacking, 1-9
 Unregulated DC Power Supply Circuitry,
 4-31
 User Controls and Operating Modes, 4-6
 User Qualifications, 1-5

V

Velcro Anchor Pad Replacement, 7-15

W

Warranty, 2-1

1. The first step in the process is to identify the client's needs.

2. The second step is to assess the client's resources.

3. The third step is to develop a care plan.

4. The fourth step is to implement the care plan.

INDEX



1. The first step in the process is to identify the client's needs.

2. The second step is to assess the client's resources.

3. The third step is to develop a care plan.

This page intentionally left blank.

4. The fourth step is to implement the care plan.

5. The fifth step is to evaluate the care plan.

6. The sixth step is to document the care plan.

APPENDIX

7. The seventh step is to monitor the care plan.

8. The eighth step is to modify the care plan.

9. The ninth step is to terminate the care plan.

10. The tenth step is to evaluate the care plan.

11. The eleventh step is to document the care plan.

12. The twelfth step is to monitor the care plan.

13. The thirteenth step is to modify the care plan.

For technical assistance within the United States, contact:

Abbott Laboratories
Technical Support Operations
960 Linda Vista Avenue
Mountain View, California 94043

Call TOLL FREE: 1-800-241-4002

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

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

WARNING

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

Covered by the following U.S. patents: 4,336,800, 4,453,932, and 4,552,336.

LifeCare, HomeCare, and Butterfly are registered trademarks of Abbott Laboratories. Dual Rate is a trademark of Abbott Laboratories. Super Edisonite is a registered trademark of S. M. Edison Chemical Co. Velcro is a registered trademark of Velcro USA, Inc. X-acto is a registered trademark of Hunt Mfg. Braycote is a registered trademark of Castrol, Inc. Vesphene II se and Manu-Klenz are registered trademarks of Calgon Vestal Laboratories. Formula C is a trademark of Diversey Corporation, Bio-Tek is a registered trademark of Bio-Tek Instruments, Inc. Fluke is a registered trademark of John Fluke Manufacturing Company, Inc. Loctite is a registered trademark of Loctite, Inc. Dynatech Nevada is a registered trademark of Dynatech Nevada, Inc. Electro-Wash 2000 is a registered trademark of Chemtronics Inc.



CSA is a registered trademark of the Canadian Standards Association. The use of NRTL/C adjacent to the CSA mark indicates that the product has been certified by CSA to U.S. and Canadian standards. CSA has been accredited by the U.S. Occupational Safety and Health Administration (OSHA), as a Nationally Recognized Test Laboratories (NRTL). NRTL stands for Nationally Recognized Test Laboratories.

OR



Listing does not cover pump sets



RISK CLASS 2G
LR-36894
CSA STANDARD
C22.2 No. 125

IPX 1

IEC 601-1 Classification: Class 1, Drip-proof Medical Equipment



Attention, consult accompanying documents

Printed in USA

Abbott Laboratories North Chicago Illinois 60064 USA

Section 9

DRAWINGS

Figure 9-1, Block Diagram, Series 4, through Figure 9-16, IPB for the Pump, detail the pump through interconnect, schematic diagrams, and illustrated parts breakdown (IPB). Table 9-1, Drawings, lists drawings by figure number, title, and part number. Table 9-2, IPB for the Pump, identifies pump parts by index numbers that correlate to Figure 9-16. Table 9-2 follows Figure 9-16.

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

Table 9-1. Drawings		
Figure Number	Title	Drawing Number
9-1	Block Diagram, Series 4	207-01400
9-2	System Interconnect Schematic, Model 4P (2 Sheets)	249-01401
9-3	System Interconnect Schematic, Micro 4/MDL 4 (2 Sheets)	249-01400
9-4	Interconnect Schematic, Micro 4/MDL 4 (International) (2 Sheets)	249-01617
9-5	Pressure Sensor PWA Schematic, Micro 4/Model 4 (2 Sheets)	249-01394
9-6	Motherboard PWA Schematic, Series 4 (2 Sheets)	249-01390
9-7	MPU PWA Schematic, Series 4 (2 Sheets)	249-01529
9-8	MPU PWA Schematic, Micro 4, Model 4	249-01388
9-9	Motor Driver PWA Schematic, Micro 4/Model 4	249-01392
9-10	Motor Driver PWA Schematic, Series 4	249-01530
9-11	Display PWA Schematic, MDL 4 (2 Sheets)	249-01395
9-12	Display PWA Schematic, Micro 4 (2 Sheets)	249-01386
9-13	Display Driver PWA Schematic, Series 4	249-01387
9-14	Power Supply PWA Schematic, Micro 4/Model 4 (10 Sheets)	249-01389
9-15	Current Boost Charger Schematic, MDL 4/PCA (2 Sheets)	249-04469
9-16	IPB for the Pump (10 Sheets)	N/A

This page intentionally left blank