HORIZON Nxt®

Modular Infusion System

Service Manual

B. Braun
June 2000
950500 Rev E

Manual Revision History

Table 1:

Date	Rev Letter	Description of Revision
1/97	A	Initial Release
5/98	B	Change company name to B. Braun
1/00	C	Change Battery Charging Reference
4/00	D	Tighten Solenoid Gap Tolerance
6/00	E	Add caution regarding electromagnetic field exposure

CONTENTS

1.0 INTRODUCTION

1.1 DISCLAIMER

Due to the criticality of product performance, B. Braun recommends that all required service on this product be performed only by an authorized B. Braun Service Center or a qualified biomedical repair professional who has attended the B. Braun service training course. Repairs should not be attempted without a current Service Manual. Repairs should not be attempted by other than qualified personnel that are knowledgeable in the areas of microprocessor controlled electronics, digital and analog circuitry, electromechanical devices, testing, static control and soldering techniques. Repairs should not be attempted which have not specifically been identified in this Service Manual.

WARNING: If the product is partially or completely disassembled, or a component or assembly has been replaced or repaired, the unit must undergo and pass all performance checks outlined in Section 3.6 of this manual and the appropriate calibrations and or tests outlined in Sections 3.7 and 3.8 prior to use for patient care. All final performance testing and calibration of the Horizon Nxt pump must be performed with a set that is acceptable for patient use with an exception for set sterility only. Failure to do so may cause bodily harm and will void all warranties and liabilities.

CAUTION: Rework of multi-layer boards should not be attempted unless personnel have attended and passed an accredited course in soldering techniques for this type of board and express written consent has been obtained from an authorized B. Braun Representative. Failure to do so will void all warranties.

CAUTION: Individual component replacement is not recommended and will void any and all warranties unless express written consent has been obtained from an authorized B. Braun Representative. B. Braun recommends board replacement as it may not be possible to test complete circuit function to factory specifications.

CAUTION: Do not use the pump in the presence of strong electromagnetic fields. The field may permanently damage the pump. For further information consult the manufacturer of the equipment in question.

By performing any repairs with or without use of this manual as reference, you hereby acknowledge and agree that B. Braun and its distributors shall be indemnified and held harmless from and against any and all damages, liabilities, actions or causes of action, including attorney's fees, directly or indirectly arising out of or resulting from such repairs.

You also understand that neither B. Braun nor its distributors shall be liable for any incidental or consequential loss, damage, or expense directly or indirectly arising from authorized or unauthorized repair of this device since the quality of repair, and the knowledge and experience of personnel performing repairs, as well as other factors relating to matters beyond B. Braun's control, directly affect the device and the results obtained from its use.

B. Braun neither assumes, nor authorizes any other person to assume for it, any other or additional liability or responsibility in connection with repair of this device. B. Braun accepts no financial obligations for any institution's authorized or unauthorized repair during the warranty period.

The information contained in this manual is current as of the date of issue.

1.2 WARRANTY

B. Braun hereby warrants that reasonable care has been used in the manufacture of each Horizon Nxt Infusion Pump. When properly used and maintained, it shall be free from defects in material and workmanship for a period of one year after the date of shipment. Any Horizon Nxt Infusion Pump that is found not to meet these standards within this one year period will be repaired after examination by B.Braun , or, at B. Braun's option, will be replaced without charge. If the defect has been caused by misuse, unauthorized modification, or abnormal conditions of operation, repairs will be billed at B.Braun's then current charges. In this case, an estimate will be submitted before work is started, if requested. The defective device should be returned to B. Braun properly packaged, postage prepaid. Loss or damage in return shipment to B. Braun will be at the purchaser's risk. The foregoing express warranty, as conditioned and limited, is in lieu of and excludes all other warranties not expressly set forth herein, whether expressed or implied by operation of law or otherwise including, but not limited to, any implied warranties of merchantability or fitness, since handling, storage, and cleaning of these devices, as well as factors relating to other matters beyond B. Braun's control, directly affect these devices and the results obtained from their use. B. Braun shall not be liable for any incidental or consequential loss, damage or expense, directly or indirectly arising from the use of this device other than replacement of all or part of it. B. Braun neither assumes, nor authorizes any other person to assume for it, another or additional liability or responsibility in connection with this device. This warranty will not apply to any Horizon Nxt Infusion Pump or component thereof which has been:

- Repaired by anyone other than authorized B. Braun trained technician or repair facility;
- Altered in any way that, in B. Braun's judgement, affects its stability or reliability;
- Subjected to misuse, negligent handling, or accident;
- Used in any manner not according to the instructions furnished by B. Braun in the Operation Manual and/or Service Manual.

This warranty extends only to the first purchaser or lessee and does not extend to, and may not be enforced by, any other person.

1.3 INTENDED USE

This manual is intended to be used by a qualified biomedical service professional for the troubleshooting and repair of the referenced equipment. Repair of the device should only be performed by a qualified biomedical service professional. Although it is not mandatory that each service professional be certified by B. Braun prior to servicing the Horizon Nxt Pump, it is recommended, and will be made available to your institution upon the expiration of the standard Horizon Nxt Infusion Pump warranty. Please contact Customer Service (see Chapter 9) for additional information on the training classes and fee structure. B. Braun maintains the right to withhold the purchase of parts until a service professional has been certified by B. Braun.

NOTE: This manual contains information and data proprietary to B. Braun This information is provided solely for technical personnel in maintaining and servicing the Horizon Nxt Infusion Pump. None of the information contained herein may be duplicated or used in any manner other than for the maintenance and servicing of the pumps or their component parts. Any unauthorized use of the information contained herein may subject the user to substantial liability for infringement of trade secrets, copyright, and patents.

This Service Manual is organized into ten chapters as outlined in the Table of Contents. A Horizon Nxt Operation Manual is included at the end of this manual for easy reference. Please refer to Chapter 1 of the Operation Manual for the intended use of this infusion pump.

2.0 DESCRIPTION

2.1 VISUAL INDICATORS AND CONTROLS

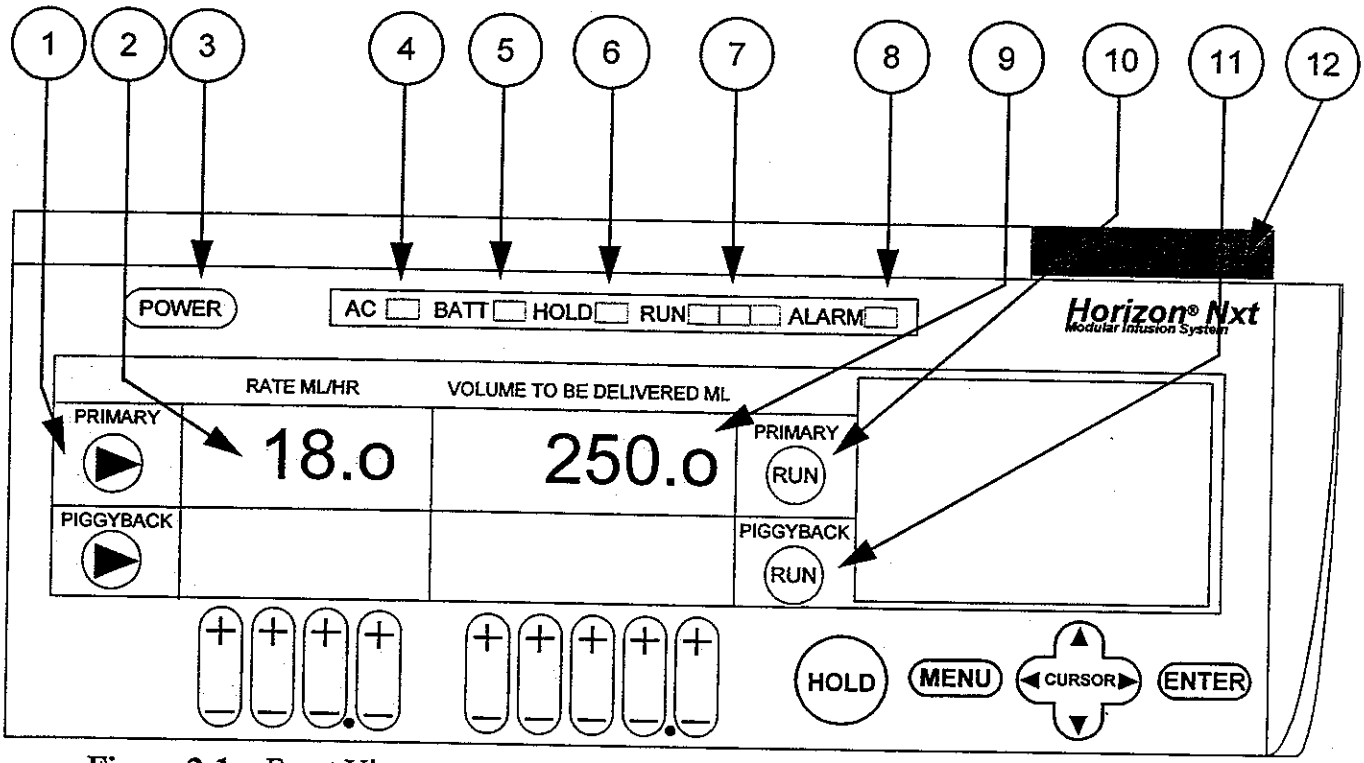
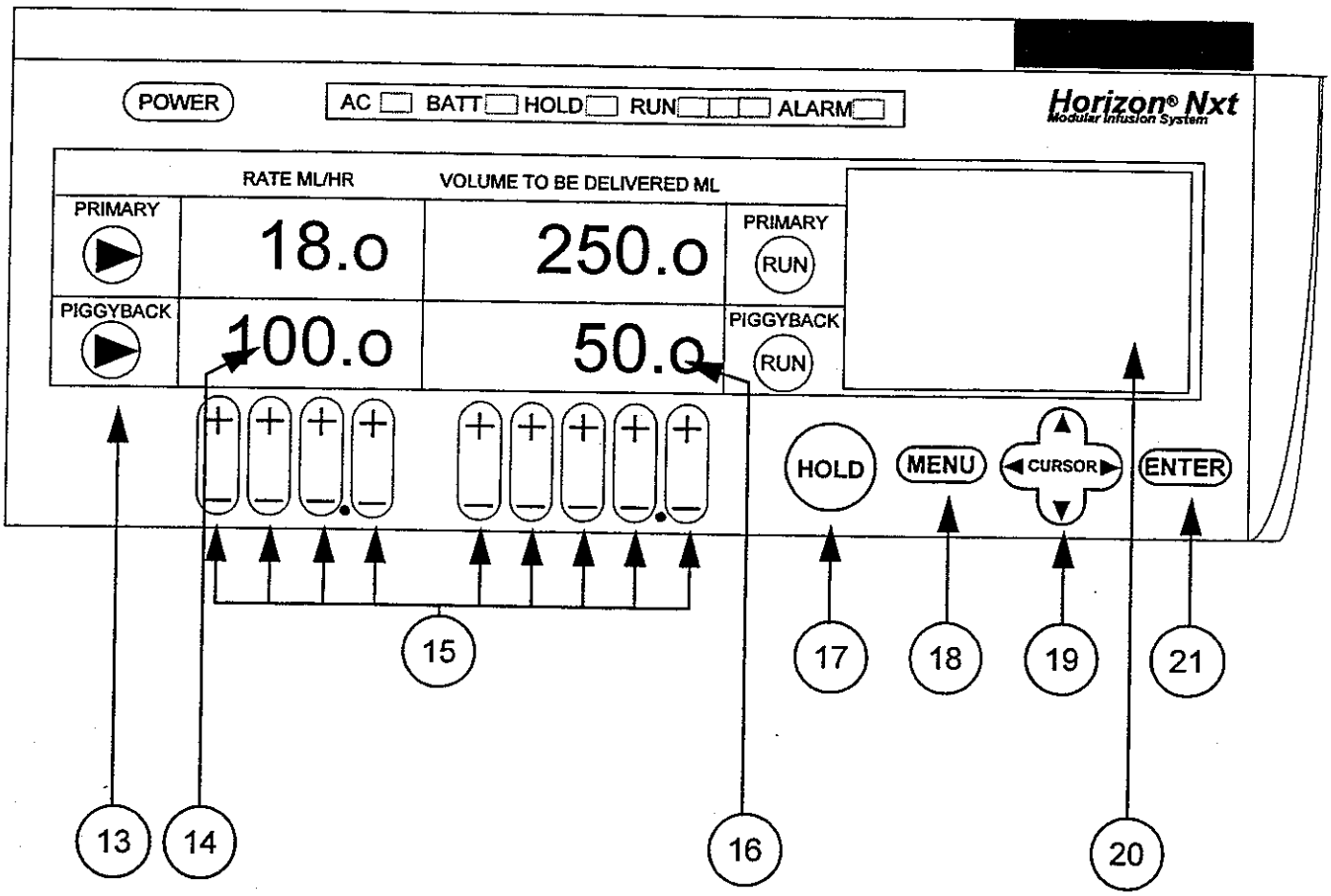


Figure 2-1: Front View

1. PRIMARY Indicator Key	7. RUN Indicator
2. Primary Rate Display	8. ALARM Indicator
3. POWER Key	9. Primary Volume Display
4. AC Use Indicator	10. PRIMARY RUN Key
5. Battery Use Indicator	11. PIGGYBACK RUN Key
6. HOLD Indicator	12. Door Lever

Figure 2-2: Front View (Cont'd.)



13. PIGGYBACK Indicator Key	18. MENU Key
14. Piggyback Rate Display	19. CURSOR Keys
15. Data Keys	20. Information (LCD) Display
16. Piggyback Volume Display	21. ENTER Key
17. HOLD Key	

Figure 2-3: Right View

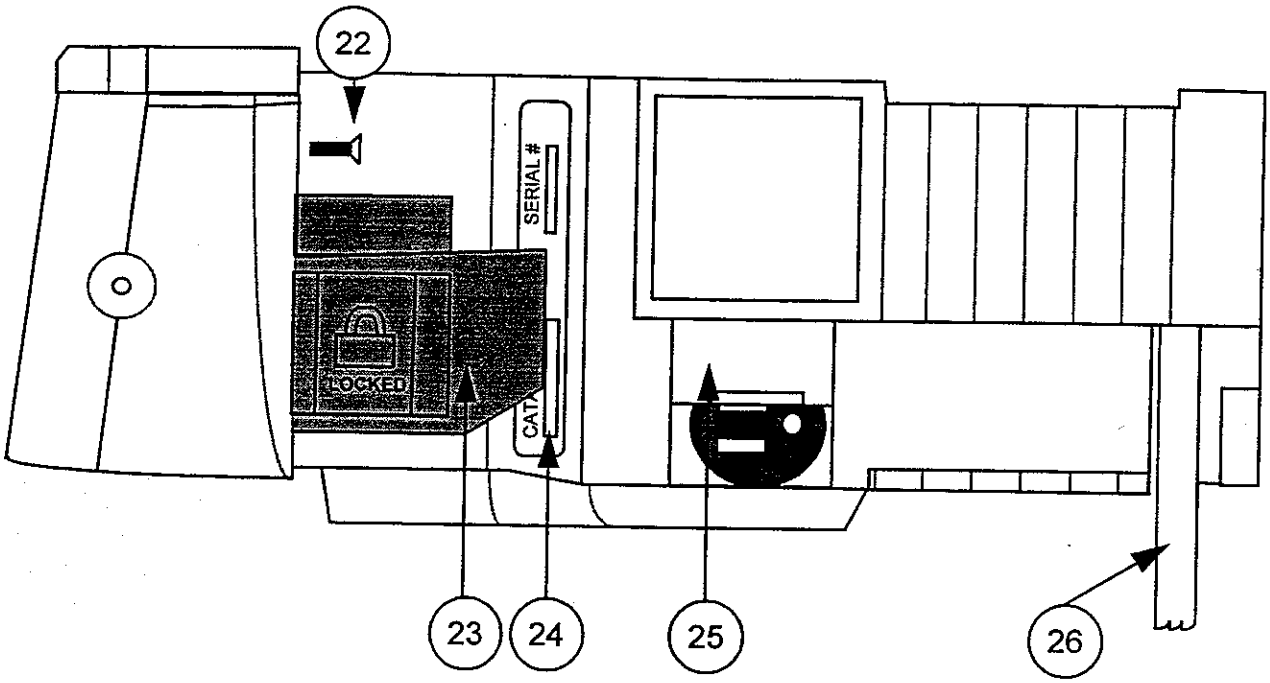
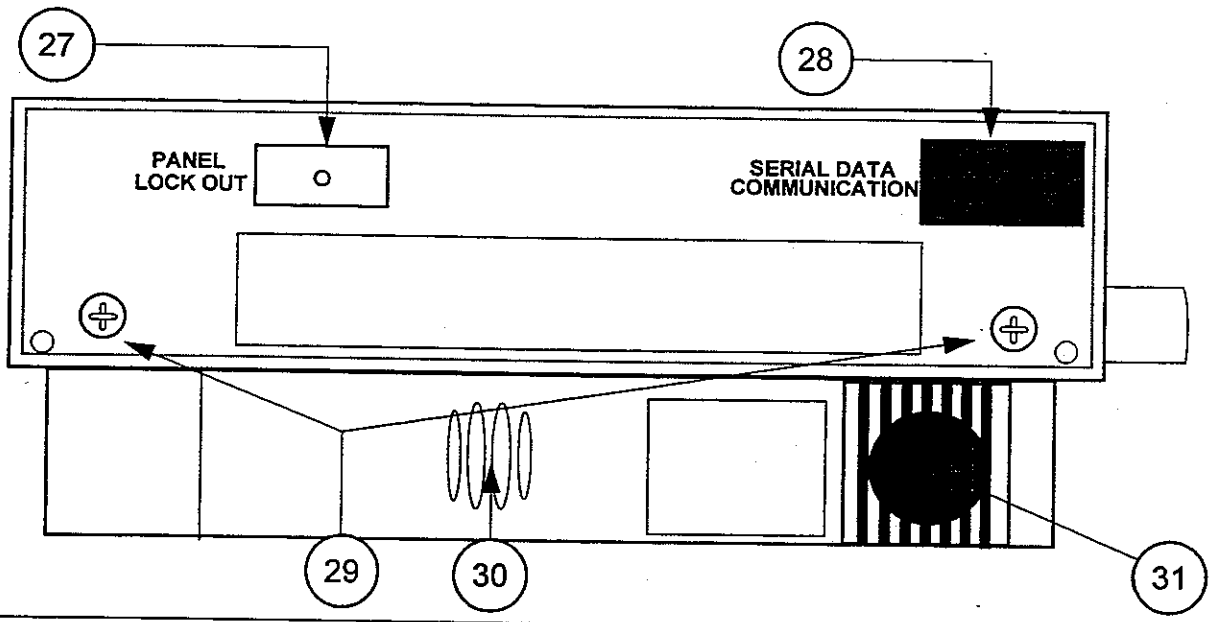
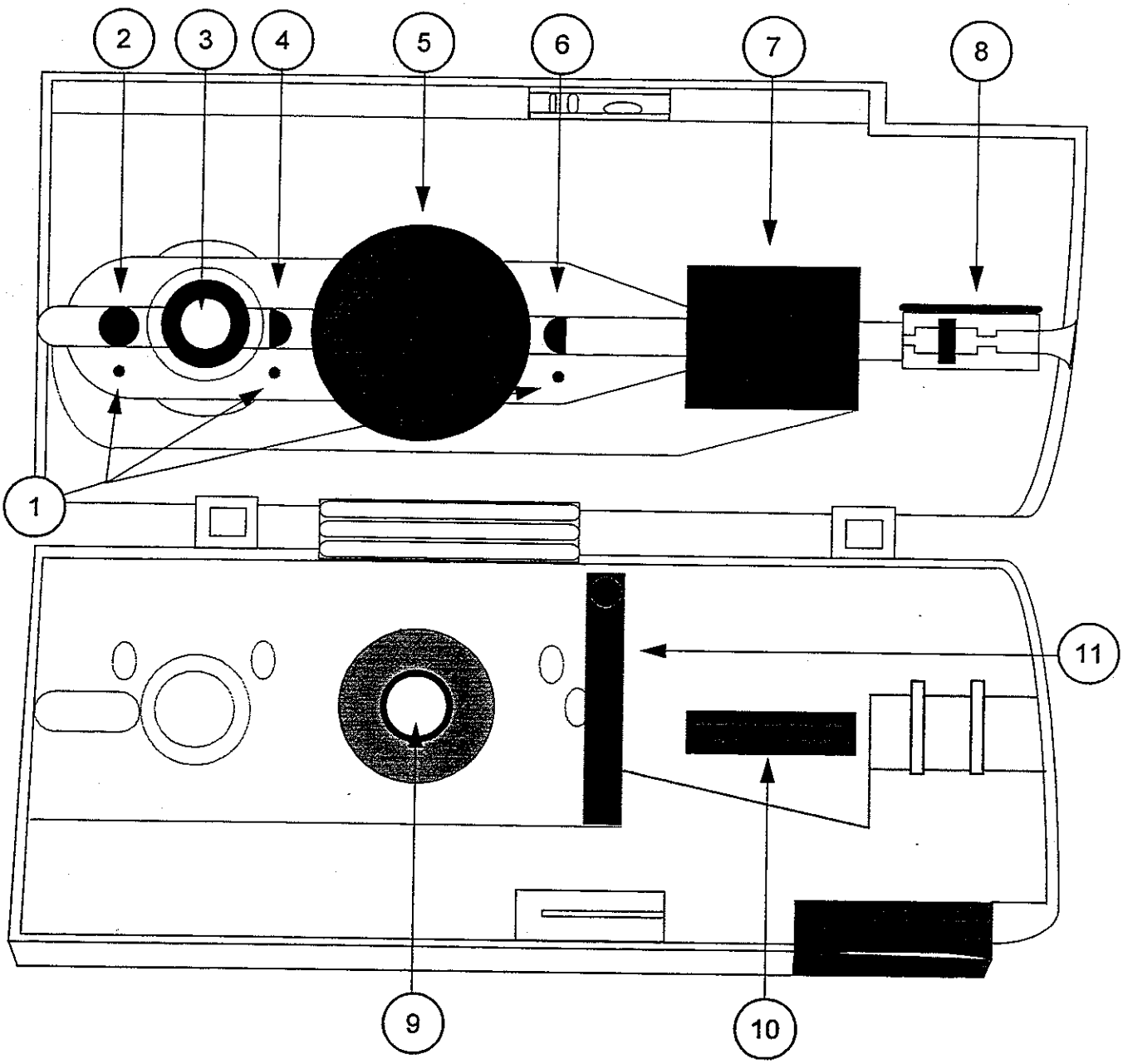


Figure 2-4: Rear View



22. Phillips Head Case Top Screw	27. PANEL LOCK OUT Switch
23. Pole Clamp	28. SERIAL DATA COMMUNICATIONPort
24. Catalog and S/N Identification	29. Quarter-turn Case Top Screws
25. Daisy Chain Outlet Door	30. Piezo Alarm Speaker (Model 610-012)
26. AC Power Cord	31. Main Speaker

Figure 2-5: Front View, Door Open



1. Cassette Alignment Pins	7. Air-In-Line Detector
2. Inlet Valve	8. Anti-Freeflow Socket
3. Refill Piston	9. Pressure Transducer
4. Transfer Valve	10. Tube Pusher
5. Petal Module Cover	11. Spring (Free Flow Prevention)
6. Restriction/Outlet Valve	

2.2 SPECIFICATIONS

Mechanism:	Volumetric (Non Drop-Counting), Positive Pressure Displacement Reservoir
Dimensions:	Width 12.4" (31.5 cm) Height 4.8" (12.2 cm) Depth 12.2" (31.0 cm)
Weight:	Approximately 11.9 lbs (5.4 kg)
Power Requirements:	90-132 VAC, 30 Watts, 47/63 Hz excluding accessories (domestic), 180-264 VAC, 30 Watts, 47/63 Hz excluding accessories (international)
Grounding Resistance:	Meets UL Standard 544
Leakage Current:	Meets or exceeds UL Standard 544, Section 27.2, and ANSI/AAMI Safe Current Limits (July 9, 1985) for each device.
Plug:	Hospital Grade (3 pin)
Pole Size Range:	0.75" to 1.25"
Battery:	12 Volt sealed lead-acid battery for ambulatory use. Run time is dependent on the state of battery charge and the rate of fluid delivery.
Rate Range:	Standard: (Primary and Piggyback) 0.1 to 999.9 ml/hr Micro: (Primary and Piggyback) 0.1 to 99.9 ml/hr
Keep Open Rate:	3 ml/hr for prescribed delivery rates of 3 to 999.9 ml/hr, or the continuation of the prescribed delivery rate for 0.1 to 2.9 ml/hr settings
Volume to be Infused:	0.1 to 9999.9 ml
Fluid Types:	All standard I.V. fluids, including lipids & TPN
Occlusion Pressure:	75, 100, 200, 300, 400, 500 and 750 mmHg. Standard Mode default is 300 mmHg. Micro Mode default is 100 mmHg. Both defaults are user adjustable.
Alarms:	Air-In-Line, Battery Very Low, Container Empty, Door Open, Downstream Occlusion, Hold Time Exceeded, Repair Instrument, Set Improperly Loaded, Set Piggyback Rate, Set Piggyback Volume, Set Primary Rate, Set Primary Volume, System Alarm, Solution Alarm
Air-In-Line Alarm:	0.09 cc

Hold Time Exceeded:	Activated after three minutes without user interaction (deactivated if the door of the pump is open)
Memory:	Permanent data retention after the pump is turned off, unless the Data Retention Defaults have been otherwise selected in the Biomed Options.

3.0 RECOMMENDED RECEIVING PROCEDURE

3.1 RECEIVING NOTICES

New Device Notice: Any new device that does not meet factory specifications during in-coming inspection will be replaced only if the device is not altered, i.e. hospital identification markings, asset control numbers, or preventative maintenance tags. If a device is used on a patient, it will not be considered an out of box failure.

WARNING: If the product is partially or completely disassembled, or a component or assembly has been replaced or repaired, the unit must undergo and pass all performance checks outlined in Section 3.6 of this manual and the appropriate calibrations and/or tests outlined in Sections 3.7 and 3.8 prior to use for patient care. All final performance testing and calibration of the Horizon Nxt must be performed with a set that is acceptable for patient use with an exception for set sterility only. Failure to do so may cause bodily harm and will void all warranties.

3.1.1 Damaged Goods

Upon receipt, count and inspect your freight before the carrier departs. Damaged merchandise should not be accepted. Identify any items that are damaged or lost, and have the extent of the damage or loss noted on the customer's copy of the delivery document by an agent of the transportation company. If damage is discovered after receipt of shipment, notify the transportation company immediately, and request that inspection be made and an inspection report rendered. B. Braun will be happy to issue a credit for the loss or damage, and file a claim with the carrier, providing your reque and the carrier's freight bill indicating the item and quantity damaged or not received are promptly forwarded to the Carrollton, Texas office (see Chapter 9), and received within ten days. The claim request must be accompanied by a delivery receipt or an inspection report upon which the transportation company has properly noted such damage or loss.

3.1.2 Goods Received in Error

Items ordered or shipped in error may be returned to the warehouse provided Customer Service is notified (see Chapter 9), and the products are returned within 14 days. Items ordered in error must be returned freight prepaid by the customer.

Credit will be issued for all returns for goods received in error provided:

1. Proper authorization has been obtained (see Chapter 9).
2. Products are in the original undamaged cases, suitable for immediate resale.
3. Products are current inventory items.
4. Merchandise has been shipped and billed to the customer by B. Braun.

Certain products are not eligible for return for credit. These are:

1. Products which have been used.
2. Products whose labels or seals have been tampered with or removed.

Except in the case of a B. Braun error, items must be returned freight prepaid by the customer.

3.1.3 Late Shipments

B. Braun shall be excused from any delay in, or impossibility of performance due to any cause beyond its or its suppliers' or subcontractors' control, including, but not limited to: acts of God, war, acts of government, acts of purchase priorities or allocations, raw material shortages, fire, flood, strike, labor trouble, sabotage or delay in obtaining labor, materials, equipment, or transportation.

3.1.4 Expedited Shipments

When expedited transportation, specialized services, or alternate transportation modes are specified by the customer, an additional charge to cover the premium expense will be added to the invoice.

3.1.5 Receiving Inspection

Each Horizon Nxt Infusion Pump is factory inspected and tested prior to its final packaging and shipment. There is, however, the possibility of in-transit damage which may or may not be obvious; therefore, the following inspection is recommended. If functional testing is required upon receipt by your (customer) policy, refer to the section in this chapter titled "CHECK-IN PROCEDURE."

1. Before opening the shipping container, inspect it carefully to assure the absence of obvious damage. If damage is present, notify the freight carrier immediately, and wait to open the container until a representative of the shipping company is present. (It is difficult to place responsibility for shipping damage after the shipping container is opened). Do not return damaged equipment to the manufacturer unless specifically authorized to do so by the company, whether or not the company is responsible for the repair.
2. Remove the pump from the shipping carton.
3. Carefully inspect the pump for dents, scratches, missing parts, or any other obvious signs of shipping damage.
4. Make sure the door of the pump opens and closes easily, without binding, and that it is properly aligned with the bezel.
5. Make sure there are no visible dents, tears or scratches on the pump membrane panel.
6. Check the Pole Clamp for ease of operation.
7. Inspect the power cord for nicks or cuts, and the plug for bent or insecure prongs.
8. Make sure the petal module cover, valve tips and pressure transducer cover are not torn or otherwise damaged.

3.2 CHECK-IN PROCEDURE

Prior to use, it is recommended that the pump be checked-in according to Sections 3.3 through 3.8 of this manual. If the pump fails to operate, contact B. Braun for a Returned Materials Authorization Number (RMA#). See Chapter 9 for information on contacting the company.

Each pump has been inspected and tested prior to shipment; however, in-transit handling or repair work may have caused some misalignment. Therefore, the procedures outlined in this chapter are intended to be used by qualified service personnel in the initial and routine checks of the Horizon Nxt Infusion Pump.

3.3 MECHANICAL INSPECTION

3.3.1 Door Alignment Inspection

1. Make sure the door of the pump opens and closes easily, without binding, and that it is properly aligned with the bezel. The door latch allows the door to close completely.
2. The gap on each side and along the top of the door is symmetrical.

3.3.2 Pole Clamp Inspection

See Table 3-2, # 1.

3.3.3 Switch Inspection

See Table 3-2, # 2.

3.3.4 Gasket and Hardware Inspection

1. All gaskets and seals are securely attached.
2. Petal module cover and valve tips are in place and in good condition.
3. The cover on the pressure transducer shall not have any rips, tears, punctures or indentation marks.
4. All screws are tight and secure.
5. No cracks are present in the bezel or inner door face.
6. Tube pusher is intact and securely mounted.
7. No cracks in the case or handle exist.
8. Inspect the power cord for nicks or cuts. Inspect the plug for bent or insecure prongs.

3.4 MAIN BATTERY CHECK AND CHARGING

All rechargeable batteries automatically discharge when not in use. The rechargeable battery used in this pump is no exception. Therefore, it is suggested that before attempting to use the pump for the first time, the battery be fully charged by connecting the power cord of the pump to a hospital grade electrical outlet. Allow at least 24 hours to fully charge the battery from a fully discharged condition. In order to maintain the battery in a fully charged condition, the pump should be plugged into a hospital grade electrical outlet whenever possible. When charging multiple devices in a storage facility, ***not in the vicinity of patients***, 12 Horizon® and/or Horizon Nxts may be Daisy Chained together for outlet conservation purposes.

3.5 DEFAULT SOFTWARE SETTINGS

1. Set all defaults according to your individual institution's needs. Use PC Docking to program the pumps. Refer to the PC Docking Operation Manual, Part No. 950441, for instructions.
2. Verify that the pump's calendar and clock are set appropriately.

A list of all the options in the Menu System, and the submenus in which they can be placed, is available by contacting Technical Support Services at (800) 627-7867.

3.6 SIMULATED USE AND PERFORMANCE CHECK

Equipment Required:

1. Horizon® Pump I.V. Set
2. Container with suitable fluid in it
3. Needle and 3ml Syringe
4. I.V. pole or equivalent
5. AC power source

3.6.1 Test Procedure: Simulated Use

Table 3-2: Simulated Use Initial Checkout

Action	Observation
1. Unlock the Pole Clamp by rotating the Pole Clamp lever clockwise toward the front of the pump 1/4 turn. Attach the pump to an I.V. pole by pressing down on the unlocked Pole Clamp lever. While holding the lever down, position the pump such that the pole is seated in the V-block of the instrument case. Release the Pole Clamp. With the pump now supported by the I.V. pole, use one hand to lightly press down on the pump. Rotate the Pole Clamp lever 1/4 turn counterclockwise towards the back of the pump to lock the Pole Clamp.	1. Verify the Pole Clamp mechanism tightens firmly onto the pole. **Note:** As the open Pole Clamp lever is snugged tighter, the pump will become more securely mounted on the I.V. pole.
2. Press the Power Key to turn on the pump.	2. The speaker will sound a tone. The BATT and HOLD LEDs will illuminate. The Rate and Volume To Be Delivered columns will display values, the LCD will illuminate and display: Load the Set and then close the Door. Total Infused = 0.0 ml Occlusion Limit = 300 mmHg **Note:** If no keys have been pressed for approximately 30 seconds, "HOLd" will be displayed in the Primary or Piggyback channel, whichever is not active. If no keys have been pressed for 3 min., "HOLd" will flash in the Primary Volume To Be Delivered column of the LED's and the alarm will sound.

Table 3-2: Simulated Use Initial Checkout

3. Individually press and hold the + and - portion of each DATA Key to verify operation. Press the PIGGYBACK INDICATOR Key and repeat. Return the Piggyback Rate and Volume To Be Delivered values to zero.	3. Key clicks are heard as the LEDs sequence. An audible tone will sound as the hundreds column of the Rate and the thousands column of the Volume To Be Delivered are advanced past 9 or if any column is decremented past 0. This same tone will sound if an attempt is made to set the rate or volume less than 0.o ml. **Note:** Whichever key is depressed, PRIMARY INDICATOR or PIGGYBACK INDICATOR, the respective display will illuminate brighter, while the other display becomes dimmer.
4. Enter a Primary rate of 900 and a Primary volume of 10. Press the PRIMARY RUN Key.	4. The audible alarm will begin to sound and repeat approximately once every three seconds. The ALARM LED will illuminate. The LEDs in the Primary Volume To Be Delivered column will flash "SEE HELP". The LCD will display: CLOSE ROLLER CLAMP Then open door. Check Placement of Secure Flow Clamp ↓ ...(picture)...
5. Press the MENU Key, then the HOLD Key.	5. The LCD will display: Load the Set and then close the Door. Total Infused = 0.o ml Occlusion Limit = 300 mmHg Flow Clamp Position HELP
6. Press the MENU Key followed by the down arrow CURSOR Key until "Alternate Menu" is highlighted. Press the ENTER Key. Press the down arrow CURSOR Key until "Set LCD Contrast" is highlighted. Press the ENTER Key.	6. The LCD will display: EXIT Adjust cursor ← → until this message is clear. Then press Enter key.
7. Cursor left and right.	7. The contrast changes from high to low and back to high again. The backlight intensity should be present and not erratic or flickering.

Table 3-2: Simulated Use Initial Checkout

8. Press the ENTER Key.	8. The LCD will display: Load the Set and then close the Door. Total Infused = 0.0 ml Occlusion Limit = 300 mmHg Flow Clamp Position HELP
9. Open the door.	9. The only display change will occur after several seconds, after which the PIGGYBACK LEDs will display "HOLd". Opening the door disables the Hold Time Exceeded alarm.
10. Spike the fluid container with the I.V. set, and prime the set with fluid. Make sure all air is removed from the set before closing the roller clamp. Load the cassette into the pump mechanism according to the instruction label inside the door. Close the door.	10. The Rate and Volume To Be Delivered columns will display those values that were present prior to opening the door. The LCD will illuminate and display: Set the Rate & Volume. Then Press RUN. Total Infused = 0.0 ml Occlusion Limit = 300 mmHg Flow Clamp Position HELP
11. Press the PIGGYBACK Indicator Key and enter a Piggyback rate and volume of 0.0.	11. The LCD will drop the last line of text. The row of PIGGYBACK LEDs will illuminate. The row of PRIMARY LEDs will become dim.
12. Close the clamp downstream from the cassette and press the PRIMARY RUN Key.	12. The "Total Infused =" value should stop increasing with a complete occlusion and an audible alarm should sound associated with a flashing LED message of "OCCL." **Note:** The amount of time will vary depending upon how far downstream the clamp is, the occlusion limit setting as well as the infusion rate. **Note:** The Occlusion Limit will automatically increase to 400 mmHg to compensate for the effect of tubing flow resistance as infusion rates exceed 399.9 ml/hr.
13. Press the HOLD Key and open the downstream clamp. Clamp the tubing upstream of the pump and press the PRIMARY RUN Key.	13. The "Total Infused =" value should stop increasing with a complete occlusion and an audible alarm should sound associated with a flashing LED message of "SOLU." **Note:** The amount of time will vary depending upon how far upstream the clamp is, the occlusion limit setting as well as the infusion rate.

Table 3-2: Simulated Use Initial Checkout

14. Press the HOLD Key and unclamp the upstream tubing. Inject an air bubble of at least 0.9 ml into the "Y" site of the tubing on the upstream side of the pump. Press the PRIMARY RUN Key.	14. The cassette chambers will be filled and pressurized. The HOLD LED will extinguish. The RUI LEDs will begin to illuminate sequentially. The LCD will display: Time Left = 0 hr 0 min Total Infused = 1.8 ml Occlusion Limit = 400 mmHg
15. When the air bubble reaches the pump, tilt the pump such that the distal (delivery end) is pointing upwards, toward the ceiling.	15. The alarm will sound as the air bubble passes into the air-in-line detector. The ALARM LED will illuminate. The RUN LEDs will extinguish. The LEDs in the Volume To Be Delivered column will flash "Air." The LCD will display: Air In Line To Silence Alarm Press MENU for help, or Press HOLD.
16. Press the MENU Key.	16. The alarm will silence. The ALARM LED will extinguish. The HOLD LED will illuminate. The LCD will display: - Air in downstream tubing - Tubing improperly inserted in Air-In-Line Detector. Press HOLD or Press RUN
17. Open the door and flush the air in the tubing. Perform the Volumetric Test as described in Section 3.7.1. Enter a Primary Volume to be Delivered of 10.0 ml. Press the RUN Key.	17. At the end of infusion, the pump will go into Keep Vein Open mode.

Table 3-2: Simulated Use Initial Checkout

18. Wait until the infusion is complete.	18. An alarm sounds, indicating a KVO state of operation. The primary rate will be 3.o ml/hr and the volume to be delivered will be 0.o, each will be flashing. The LCD will display: KVO: PRIMARY COMPLETE Total Infused = 10.o ml Occlusion Limit = 300 mmHg
19. Open the door.	19. The alarm will sound. The Alarm LED will illuminate. The LEDs in the Volume to be Delivered column will flash "door."
20. Press the HOLD Key.	20. The alarm will silence. The HOLD LED will illuminate. The Primary rate will display 900 and a Volume to be Delivered of 0.o. The LCD will display; PRIMARY COMPLETE Time Left = 0 hr 0 min Total Infused = 10.o ml Occlusion Limit = 300 mmHg
21. Press the MENU Key. Press the ENTER Key to "Clear Total Infused."	21. The LCD will display: The present Total Infused of 10.oo ml will be zeroed. Is this OK? YES NO
22. Press the ENTER Key.	22. The LCD will display: PRIMARY COMPLETE Time Left = 0 hr 0 min Total Infused = 0.o ml Occlusion Limit = 300 mmHg
23. Press the POWER Key to turn the pump off.	23. The LED's in the Volume to be delivered column will display "----" until the device has completed the power down cycle. The AC LED will remain lit while the pump is plugged into an AC power supply.

3.7 VOLUME DELIVERY ACCURACY

Equipment Required:

1. Distilled water in an I.V. fluid container
2. Horizon® Pump I.V. Set
3. Electronic Balance or Precision Collection Vessel
4. Needle or dispenser tip with a Luer lock type connector.

3.7.1 Test Procedure: Volumetric

1. Connect the fluid delivery set to the fluid container.
2. Attach the needle to the delivery end of the I.V. Set.
3. Completely prime the set with fluid so all the air is expelled from the set, and then close the roller clamp on the set.
4. Insert the cassette into the pump according to the instructions inside the door of the Horizon Nxt pump.
5. Close the door and press the POWER Key to turn on the pump.
6. Open all clamps and enter:

Table 3-3: Volumetric Test Values

Volume	Rate	Pressure	Acceptable Limit
10 ml	120 ml/hr	300 mmHg	9.5 - 10.5 ml

7. Place the collection vessel on the balance, zero the reading, and suspend the needle over the collection vessel.
8. Press the RUN Key.
9. When the pump goes into the Keep Vein Open mode, press the HOLD Key immediately. Make sure the actual volume delivered is between the acceptable limits listed in the above table.

Note: 1 ml = 1 cc = 1 g of distilled water at room temperature (70° F)

10. Zero the reading on the balance. If the actual values are not within the specifications, test the pump with additional I.V. fluid delivery sets. If the values remain outside the specifications, return the pump to an authorized B. Braun Service Center.

Note: If using other accuracy test methods, in addition to the above, be sure to compensate for the adaptive energy processing used to conserve battery power and reduce noise as described in section 5.5.7.2 "Motor Controllers." This dynamic processing of resistance to flow will cause the motor energy to rise and fall at the beginning of an infusion (each time the pump transitions from the Hold state to the Run state). This results in several (varies with the system dynamics and rate) momentary pauses of the motor as the energy is changed during the first few delivery cycles after the RUN Key is pressed. Manufacturers of biomedical test equipment will supply you with written instructions for use of their equipment when testing I.V. pumps which employ this type of energy processing. While volumetric analyzers are different, typically all that is required is that you allow 5-10 milliliters of fluid to bleed from

the system prior to starting the timer(s) or counter(s). A 3-way stopcock is very useful here. Contact the manufacturer of you volumetric analyzer to ensure proper software and testing procedures are used.

3.8 ELECTRICAL SAFETY CHECK

Equipment Required:

1. Medical equipment electrical safety analyzer
2. AC power source

3.8.1 Test Procedure: Electrical

1. Plug the analyzer into an AC outlet.
2. Make sure the analyzer is functioning properly, according to your institution's protocol.
3. Plug the pump into the AC outlet of the analyzer.
4. Attach the probe to a single lead and touch it to the aluminum plate which supports the Daisy Chain outlet on the side of the pump or any protruding metal component.

Note: If using a manual probe for your resistance checks, you will need to make contact with either the metal frame of the power supply, located next to the Daisy Chain outlet, or the stainless steel door latch. Being stainless steel, the door latch makes for a difficult contact; you may need to scratch and scrape the probe on the latch.

5. Set the grounding selection to "No Ground."
6. Set the polarity to "Normal."
7. Press the POWER Key to turn on the pump.
8. Press the Chassis Leakage button and make sure the reading does not exceed the UL 544 or the IEC 601-1 specifications as indicated below.

Note: As of the date this manual was written, the AC leakage current specifications for both UL 544 and IEC 601-1 is 100 microamps for patient vicinity equipment. When using the Daisy Chain feature on the Horizon Nxt (plugging one Horizon or Horizon Nxt into another), the chassis leakage current is cumulative. Therefore, test all units connected as one system. The number of pumps interconnected at any time should not exceed the 100 microamp limit.

9. Set the polarity to "Reverse."
10. Press the Chassis Leakage button again. Make sure the reading does not exceed the UL 544 or the IEC 601-1 specifications.
11. Press the HOLD Key.
12. Set the polarity to "Off."
13. Set the grounding selection switch to "Ground."
14. Press the Ground Wire Resistance button. Make sure the reading does not exceed the UL 544 or the IEC 601-1 specification.

Note: As of the date this manual was written, the ground wire resistance specification for a device with a non-detachable power cord for UL 544 and IEC 601-1 is 200 milliohms.

15. Press the POWER Key on the pump.
16. Repeat steps 8 - 14, skipping step 11, with the power off (optional).
17. Disconnect the pump from the analyzer. Disconnect the analyzer from the AC power source.

4.0 THEORY OF OPERATION, GENERAL DESCRIPTION

The following describes the basic theory of operation for the Horizon Nxt pump. The organization of the material follows a general to specific format. The first section, Section 4.1, gives an overall description of a few significant design features. The next section, Section 4.2, is intended to give the reader a top level functional description. The detailed descriptions have been placed in Chapter 5 for clarity. Related schematics and drawings are cross-referenced where applicable. Appendix A lists the common abbreviations and symbols used throughout this chapter.

4.1 GENERAL DESIGN FEATURES

4.1.1 Patient Safety

Patient safety was a primary concern in the development of the Horizon Nxt pump. The operation of the Horizon Nxt pump incorporates a product design with features that optimize the safety of prescribed infusions.

Alarm and troubleshooting information are clearly visible, easy to read, and provide specific directions to correct problems as well as a list of possible causes.

The **Alarm Log and Operations Log** use the Horizon Nxt's real time clock to record up to 255 separate events to assist in troubleshooting problems and documenting a specific series of events.

Automatic dose rate calculations are performed by Horizon Nxt's unique Dose Mode. Nursing convenience and dosing accuracy are enhanced by both this feature and the Drug Menus.

The Horizon Nxt's **ease of use** is one of the strongest factors contributing to patient safety. The method of operation is easy to learn. A wide variety of information provided by the data and information displays assist the user at each step of the infusion process.

Full visibility of operating parameters is accomplished with the LED data displays and the LCD information display.

Reduced cord clutter around the bed-side results from using the Horizon Nxt's Daisy Chain approach to power cord management. Multiple pumps can be Daisy Chained together, only one of which needs to be plugged into the wall.

The Horizon Nxt's **Anti-Freeflow mechanism** provides protection against inadvertent free flow when the Horizon® Pump I.V. Set is removed from the pump.

Tamperproofing of the user selected operating parameters is provided in two levels. Rate changes during operation require the operator to validate the change by pressing the ENTER Key within six seconds. Complete lock out of the front panel is available by pressing the PANEL LOCK OUT Key on the back of the pump.

User selectable variable occlusion pressure limits of 75 (approximately equal to gravity with fluid at 3.4 feet above the I.V. site), 100, 200, 300, 400, 500 and 750 mmHg settings allow the maximum occlusion pressure to be tailored to each patient's specific needs.

The innovative **Pole Clamp** design provides rapid and secure attachment to a variety of standard poles. While supporting the pump with both hands, the pump is attached to the pole, giving the u greater control of this process.

4.1.2 Ease of Operation and Repair

Ease of operation is enhanced by characteristics or features such as the Pole Clamp, stackability of pumps, Daisy Chaining of power cords, and a full array of displays that provide for optimal interaction between the pump and the user.

Ease of repair is facilitated through a modular approach to instrument design, assembly and disassembly. Rapid access to the interior of the pump is provided by a sliding case top. The alarm and operations logs provide a variety of time and date stamped information that will assist in the repair and service of the Horizon Nxt pump.

4.1.3 Upgradability

The Horizon Nxt Modular Infusion System was designed with an eye toward the future. The modular design of the housing and internal assemblies makes access for service or upgrade simple. In addition, some connections are built into every Horizon Nxt for the addition of future options and accessories.

The most likely upgrade choice adds new software to the system. The software is contained in two Erasable Programmable Read Only Memory (EPROM) integrated circuits on the main board, which can be reached by simply sliding back the top cover. The EPROMs are installed in special carrie which protect their pins. Their sockets are polarized so that the EPROMs cannot be mixed up or plugged in backwards. The Biomed Menu can be used to identify the installed software versions.

4.2 FUNCTIONAL DESCRIPTION

The Horizon Nxt Modular Infusion System is a microprocessor-controlled volumetric infusion pump designed with advanced safety and convenience features for both the operator and the service technician. The modular internal design allows for rapid removal and installation of subassemblies for ease of problem diagnosis and repair.

The major subassemblies are: Case Bottom, Power Supply, Main Battery, Half Door/Bezel, Cosmetic Bezel and Key Panel, and Main Board. Inside, the Door Subassemblies are: LED Display Board and LCD Display Module. There are three microprocessors which control most all functions. They are as follows: Door Processor (DP); Management Processor (MP); and the Pump Processor (PP).

Refer to Chapter 5 for a detailed description of items discussed in this section.

4.2.1 Case Bottom

The case bottom is the platform on which the rest of the Horizon Nxt is assembled. Attached directly to the case bottom are the fan, speaker, and the pole clamp. The fan is turned on by management software to cool the pump if its temperature rises too high or with rates >499 ml/hr. The power supply and battery attach to the case bottom with one self-locking nut. The bezel and door assembly slide into place on ribs in the case bottom, and the main board sits on posts above everything else. The case top slides onto the case bottom, locking the whole assembly together.

The case bottom and the other major case parts are painted with a conductive copper paint to provide shielding for the entire system.

4.2.2 Power Supply

The Horizon Nxt power supply board is mounted in a sheet metal chassis with a filtered, AC power inlet connector and a hospital-grade outlet for daisy chaining multiple pumps. The power supply connects to the main board and supplies 16 and 5 volts to the system. The supply is a nominal 30 watt design using switching technology which reduces weight and increases efficiency.

The supply is attached to the case bottom and shielding, with a set of tabs and slots. Once the battery is placed above the power supply, it is made secure with one self-locking nut.

4.2.3 Main Battery

The Horizon Nxt can operate from a built-in 12 volt two amp-hour sealed lead-acid battery. This battery connects to and is charged by a circuit on the main board. The battery fits into a holder which attaches to the power supply and is held in place by the same fastener nut.

4.2.4 Half Door/Bezel Assy.

The Horizon Nxt bezel is a plastic part to which is attached the pump mechanism components and the Air-In-Line block. The door and bezel become one assembly when attached together by the door hinges. The door and bezel assembly is positioned in the case bottom via gasketed tongue and groove joints. On the inside surface, it captures the cassette and tubing and holds the pressure transducer.

4.2.4.1 Half Door/Bezel Mechanism

The Half Door/Bezel Mechanism mechanically controls the flow-rate, volume, and pressure of the fluid delivered. The various important parts of the bezel mechanism are the bezel, the inlet valve, the transfer valve, the restriction valve, the petal module, the refill piston, and the pressure transducer (Figure 2-5). In the following paragraphs, the mechanism is described as it is seen from the front of the pump.

The door of the pump limits the movement of the cassette, and helps to contain the pressure required for pressurized fluid delivery. The door must be closed and securely latched for the pump to operate.

4.2.4.2 Restriction/Outlet Valve

The restriction/outlet valve, (Figure 2-5), is the right-most valve which extends through the bezel. The valve is under servo-control by the pump software and the restriction motor. The purpose of the valve is to provide the proper downstream resistance at the selected operating pressure. The restriction yoke has an optical sensor at the tip, called an optical yoke sensor, giving valve position information to the pump's system.

4.2.4.3 Petal Module

The function of the petal module is to pressurize the delivery chamber of the cassette. The petal module is located just to the left of the restriction valve and has a protective rubber cover. It is pushed forward by the main stepper motor during fluid delivery and retracts as fluid is pushed into the delivery chamber from the refill chamber during the refill operation. The pump system obtains main motor position from the main motor optical encoder.

4.2.4.4 Refill Piston

The refill piston is inversely and mechanically linked to the main motor drive. This allows the cassette to refill while the petal module is delivering. The refill piston is the large disc to the left of the petal module, (Figure 2-5). The face of the piston is a magnet of special construction. It has unusually strong magnetic properties, which allows the piston to remain attached to the metal disk, part of the refill chamber of the cassette, even when refilling from a fluid supply positioned below the inlet of the pump (a negative head height).

4.2.4.5 Transfer and Inlet Valves

The transfer valve controls the transfer of fluid from the refill chamber of the cassette to the delivery chamber and is located between the petal module and the refill piston. The inlet valve controls the flow of fluid into the refill chamber and is located to the left of the refill piston. These two valves are mechanically linked to provide inverse operation and are operated by the pump system via the transfer solenoid.

4.2.4.6 Mechanism Operational Sequence

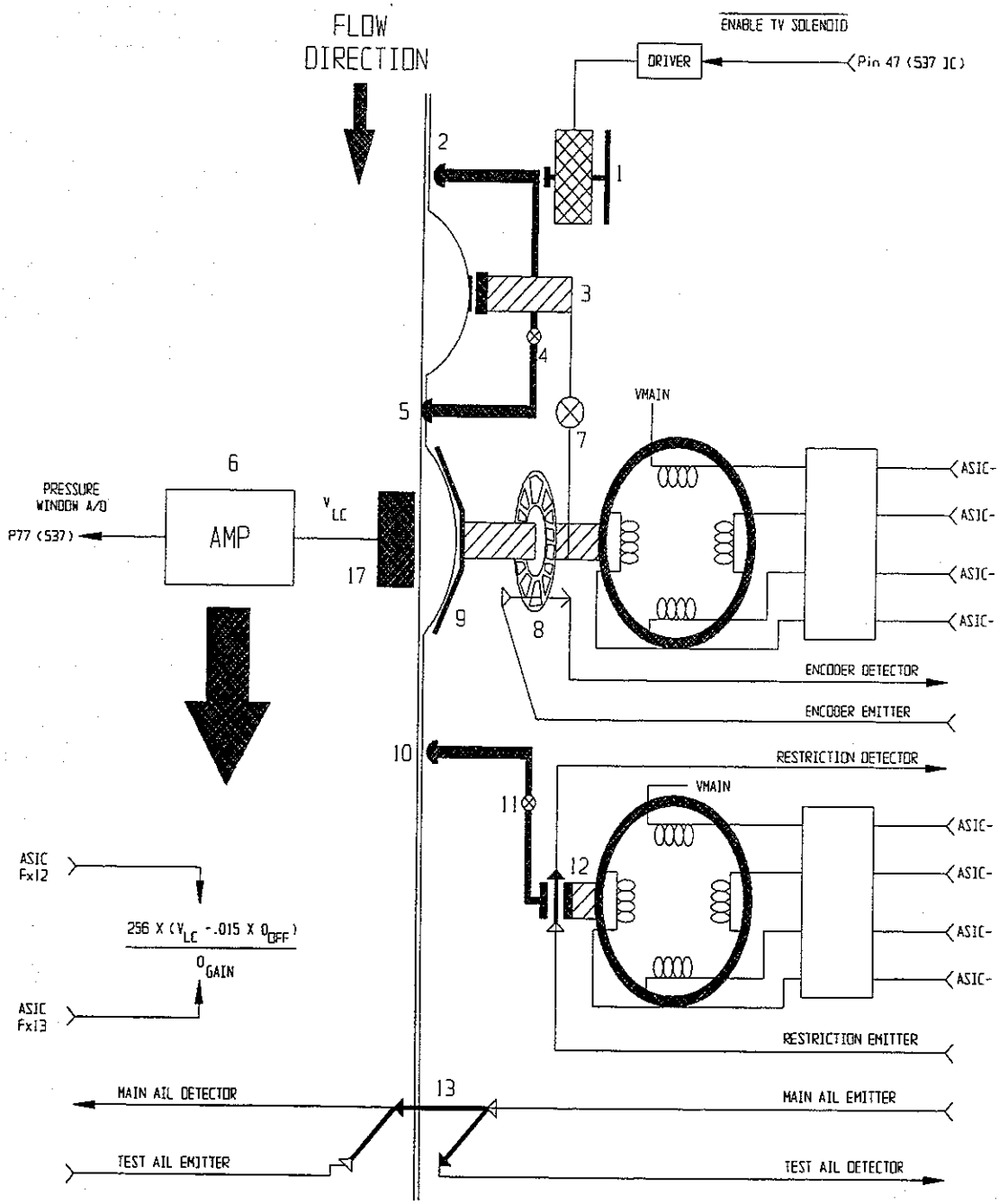


Figure 4-2: Mechanism Description and I/O Map

4.2.4.6 Mechanism Operational Sequence

The Horizon Nxt uses a cyclical volumetric displacement method to deliver fluid. At the beginning of a pumping cycle, the restriction (10) and transfer (5) valves are closed, the inlet (2) valve is open, the petal module (9) is back and the cassette delivery chamber is full (cassette portion attached to 9), the refill piston (3) is forward and the cassette refill chamber (cassette portion attached to 3) is empty.

The petal module (9) is attached to the bezel and is driven by the main stepper motor shaft via a screw thread. Once the RUN Key is pressed, the petal module assembly is driven forward until the selected delivery pressure (6) is achieved, and delivery begins. At the same time, the refill piston moves in the opposite direction, because it is mechanically connected through a pivot point (7). The main stepper motor drives the petal module forward a certain number of steps each cycle to deliver a precise amount of fluid. The delivery is approximately linear; for each main stepper motor step an equal amount of fluid is delivered. As delivery proceeds, the restriction valve opens and closes as the pump software reacts to varying fluid line conditions to maintain constant pressure in the delivery chamber.

As the petal module moves forward under stepper motor control, the refill piston moves back to allow entry of fluid from the container while the inlet valve is open. The encoder wheel (8) is optically monitored to give positive indication of motion. Pressure is monitored by a load cell (17) whose output goes to an amplifier (6). The amplifier output has separate offset and gain controls.

When the delivery cycle is complete, the restriction motor causes the restriction/outlet valve to close through a pivot point (11). The tip of the restriction motor is optically monitored to detect the point just before the valve starts to open. The transfer solenoid (1) energizes, causing the transfer valve to open and the inlet valve to close because it is mechanically connected through pivot point (4), and the petal module retracts as the refill piston moves forward to transfer fluid from the refill chamber to the delivery chamber. When the transfer is complete, the solenoid changes state and a spring forces the transfer valve to shut and the inlet valve to open and the delivery cycle is repeated.

4.2.4.7 Mechanism Interface Board

The mechanism interface board is the connection point between the main board and the bezel and door assemblies. One large connector mates with the main board and from there, connectors are provided for the main stepper motor, main motor encoder, restriction motor, restriction optical yoke, transfer solenoid, air-in-line block, and door assembly.

4.2.4.8 Air-In-Line Block

The air-in-line block is an optical bubble detector which the system uses to prevent pumping air to the patient. The set tubing is pressed tightly into the slot in the block by a spring-loaded pusher in the door. When a bubble above a certain size is detected, the pump will stop pumping and alarm.

4.2.4.9 LED Display Board

The LED display board is the largest PCB inside the door. It contains the red LED display digits and the door processor integrated circuit. The door processor software receives commands from the management processor on the main board, controls the LED displays, processes key panel inputs, controls the LCD display's visual contrast and backlight, controls the display and transducer board memories.

4.2.4.10 LCD Display Module

The LCD display module is a factory-assembled liquid crystal display module containing the actual glass display screen, a printed circuit board containing driver electronics that control the 128 x 64 screen elements, and an electroluminescent backlit panel to allow viewing in low light. This module requires the LCD controller components on the LED board to operate. In order to increase the backlight life span and reduce power consumption, the display is dimmed after three minutes if no keys have been pressed on the face of the pump.

4.2.4.11 Pressure Transducer

The transducer is essential to the operation of the pumping mechanism (Figure 2-5). It measures fluid pressure in the delivery chamber of the cassette. The circuitry amplifies this pressure signal before it is sent to the pump processor on the main board.

The face of the pressure transducer is made of a rubber compound that transmits pressure from the window in the delivery chamber of the cassette to a sensor in the body of the transducer. The transducer face is covered with a special Teflon tape to protect it and reduce friction with the cassette.

4.2.5 Main Board

The main board is the center of the Horizon Nxt electronics system. It contains the management processor, pump processor, and their associated EPROMs. The EPROMs hold the software programs which control the operation of the rest of the system. The main board mounts on four posts which are part of the case bottom, and has connections to the mechanism interface board, option board, main battery, power supply, fan, and speaker.

A switch located at the rear of the board is used to enable or lock out user access to the key panel on the front of the pump while it is running. Also, at the rear of the board is an optical transmitter/receiver pair. These devices send and receive through a plastic window in the rear of the case top, and work in concert with a Serial Data Communications Infrared Module that clips on to the rear of the assembled pump to allow communications with the Horizon Nxt software.

The main board performs all pump mechanism control functions. It has a charging circuits for the batteries, and an interface for an option board. It controls the audio alarm, and has a backup alarm beeper and battery on board. It has special sockets for the two EPROM (Erasable Programmable Read Only Memory) integrated circuits which contain the management and pump processor software programs.

The main board is locked in place by ribs in the case top when it is slid on. This eliminates fasteners, and allows convenient access to the bezel/mechanism and power supply/battery.

5.0 THEORY OF OPERATION, DETAILED DESCRIPTIONS

5.1 POWER SUPPLY BOARD ASSY.

WARNING: USE A LINE ISOLATION TRANSFORMER AND CAUTION WHENEVER WORKING ON AN ENERGIZED SUPPLY. FAILURE TO DO SO COULD RESULT IN BODILY HARM. A large portion of the Horizon Nxt power supply board is connected directly to the AC line and contains high voltages.

The Horizon Nxt power supply has two major sections: an off-line switching supply that converts AC line voltage to 16 volts DC for charging the battery and running the pump, and a DC to DC converter to change either the 16 volt supply or the 12 volt main battery voltage to 5 volts DC for all logic circuits. AC power enters the supply through an electromagnetic interference (EMI) filter with an integral input connector. From there, power is fed to the Daisy Chain outlet and to the power supply board itself. Note that the Daisy Chain outlet is not fused, which is why it should only be used for other Horizon® or Horizon Nxt pumps.

5.1.1 16 Volt Supply

WARNING: DO NOT WORK ON THIS CIRCUIT WITHOUT USING A LINE ISOLATION TRANSFORMER TO ISOLATE THE "NEUTRAL" INPUT CONDUCTOR FROM EARTH GROUND. FAILURE TO DO SO COULD RESULT IN BODILY HARM. The ground reference shown in the primary or high voltage side of the 16 volt supply is not the same as circuit ground throughout the rest of the pump, and it is different from earth ground.

The 16 volt supply section can use a nominal AC line supply of either 120 VAC or 240 VAC. Two jumpers soldered into the board must be removed for 240 VAC operation. The supply has a fuse in each input line, which is required for 240 VAC capability. The Daisy Chain outlet and power cord provided with the 120 VAC system are not applicable for 240 VAC operation. There is then a filter section for removal of electromagnetic interference (EMI). A thermistor, RT1, has a relatively high resistance when cold, which limits the inrush of current when the supply is first plugged in and the filter capacitors are uncharged. Once this happens, the thermistor warms up and its resistance does not affect supply operation. VR1 and VR2 are called Metal Oxide Varistors, or MOV. They absorb high transient voltage spikes which may occur on the line. VR2 is only effective when the 240 VAC jumper JMP1 is cut. Rectifier CR3 acts as a bridge rectifier when configured for 120 VAC and as a half-bridge when configured for 240 VAC.

The control element in this supply is integrated circuit U1. It has a built-in voltage reference and a high frequency oscillator whose frequency (about 50 KHz) is set by R4 and C4. When the AC line cord is plugged in, U1 is supplied start-up voltage through R1. As soon as its Vcc input rises above 8 volts, it begins to operate. U1 turns on field effect transistor (FED) Q1. This connects the primary (pins 1 to 10) of transformer T1 across the high voltage DC supply. Rising current through the inductance of T1 is sensed by resistor R24 until it reaches the peak set by U1, and Q1 is turned off. Two snubber circuits around diodes CR1 and CR2 absorb the high voltage inductive spikes caused by the switching of Q1. These current pulses though T1 create a voltage across the secondary #1 (pins 7 to 8) which is rectified by CR10 and filtered by C24 and L3, to build up to 16 volts. The fuse in series with T1's primary protects the transformer and primary circuits should Q1 fail in the "ON" condition.

Since T1 is the isolating component between the line voltage and the secondary circuit, there is no

direct feedback between the 16 volt output and U1. Instead, secondary #2 of T1 (pins 4 to 5) is used for control. Since secondary #2 is a part of the same transformer, its output is representative of the 16 volt secondary. The output of secondary #2 is rectified by CR3, filtered and fed to U1. As input pin 2 of U1 reaches 2.5 volts, the on-time of Q1 is reduced, and the 16 volt output stabilizes. Over-current protection is provided by the peak-current sensing at R24. Secondary #2 also is rectified by CR4 and used to keep U1 supplied with current during any sags in the high voltage supply.

This 16 volt supply output has a maximum output of approximately 1.8 amps, and is used to power the battery charger and mechanism motors and transfer solenoid in the pump mechanism. When the AC plug is disconnected, the main battery takes over this function. This voltage is distributed to the rest of the pump electronics and is referred to as VMAIN.

5.1.2 5 Volt Supply

The second part of the Horizon Nxt power supply is the 5 volt supply. The controller IC is the same type as used in the 16 volt section, and the circuit configuration is similar, with FET Q2, switching transformer T2 and CR7 rectifying the secondary to get 5 volts out. However, since this is all low voltage circuitry, the 5 volt output is regulated directly by U2. This supply section is powered either by the 16 volt output from the power supply, or the main battery. If the 16 volt supply falls below the main battery level, circuitry on the main board ensures an immediate switchover.

5.2 LED DISPLAY BOARD ASSY.

The LED display board acts as the central connection point inside the Horizon Nxt door assembly. The 34-conductor cable from the bezel assembly brings all signal and power lines to the display board, and from there some are distributed to the transducer and LCD boards.

5.2.1 Door Processor

The heart of the display board is the door processor IC. This is a single-chip microprocessor with an internal program which controls the LED displays, the interface to the membrane key panel, the inverter for the LCD display backlight, and the contrast voltage supply for the LCD display. Secondary functions it performs are reading the nonvolatile configuration memories on both the display and pressure transducer boards. Memory internal to the door processor is used to store display content and other control status information sent from the management processor. This data is lost at power-off and must be restored from the management processor when power is restored.

The door processor behaves as a slave to the management processor on the main PC board. It has a built-in crystal-controlled 5 megahertz oscillator, and is reset by a signal from the management processor. After reset, it turns on the AC indicator LED and waits for commands from the management processor. Communication with the main board is controlled by the management processor and uses four signal lines: SYNCDAT, SYNCCLK, DOORCTS, and DOORRTS. Communications use a synchronous serial format, with the synchronous clock generated by the management processor. If the management processor wishes to send a message to the door processor, it sends one or more bytes with one clock pulse for each bit. If the door processor wishes to send a message to the management processor, it uses DOORRTS to request it, and the management processor uses DOORCTS to indicate its readiness, and the message byte is then transferred by the management processor's clock pulses. These message signals can be observed even when the pump is idle, since each processor sends an "I'm O.K." message every few seconds for safety purposes.

Messages between the two processors have parity bits so that communication errors can be detecte and an alarm generated.

5.2.2 LED Displays

The primary function of the door processor is the control of the LED displays. There are 18 digits of seven segments each and seven individual indicator LEDs. Counting the four decimal points which are used, there are 137 LED segments which must be controlled by the processor. This is accomplished by using a technique called multiplexing, in which a smaller group of digits are turned on, along with the desired segments in those digits, for a short time at a higher than normal brightness. Then another group of digits and segments is turned on using the same processor pins. If this is done rapidly enough, the eye is fooled into thinking that the LEDs are on all of the time at normal brightness.

On the Horizon Nxt display board, the LED digits are divided into five groups. The seven indicator LEDs are treated as if they were another digit. Digit driver U4 is controlled from the door processor so that only one group of digits is fed power at a time. Five shift clock pulses from the door processor move the correct "ON" bit into the digit driver once each multiplex period. At the same time that the digit group is powered up, individual segment drive pins on the processor itself are turned on, so that the desired segments in that group of digits are turned on. Current flow through an individual segment travels as follows: from Vcc (5 volts) supply through transistor Q1 to digit driver U4, from one output of U4 to the LED anode, through the LED to a current limiting resistor, and then through a door processor port pin to ground.

Transistor Q1 is used by the door processor to test LED segments during the multiplexing process If Q1 is turned on by the door processor, the voltage drop across it is very low. To test a single LED segment, Q1 is turned off, and the proper digit group and segment drive pin are turned on. The current flowing through the LED segment produces a voltage drop across resistor R2, and this voltage can be measured by a door processor threshold port pin. This measurement, which can split 5 volts into 16 different levels, can detect if the LED is open. If the segment is bad, then the door processor will send a failure message to the management processor, and an alarm will result. The testing of a segment takes very little time, and is an ongoing process while the LED display is active.

The information to be shown on the LED displays is sent from the management processor and is stored in the door processor internal memory. Brightness of the LED digits is controlled by the percentage of time that the digits are on during multiplexing. The management processor sends brightness commands to the door processor, which makes one row of LEDs brighter than the other to indicate which row will be affected when the key panel is used. When an alarm occurs, the management processor commands the door processor to blink certain digits.

Contents of the door processor memory that controls the LED display contents can be sent back to the management processor for checking display integrity.

5.2.3 Key Panel Interface Assy.

The second most important function of the door processor is to interface with the switches in the membrane key panel. The key panel connects to the display board through two 7-conductor flexible tails. The POWER or on/off switch in the key panel connects straight through to the main PCB to control power-up and power-down sequences. The other key panel internal switches form a five by

six matrix which is connected to the door processor circuitry. Each switch on the panel is connected between one "row" and one "column" of this matrix, which is scanned for pressed keys during part of the display multiplexing process. During a time when they are not driving an LED segment, one of six door processor ports is held low. This pulls one of six key panel columns down to ground through a diode. The five key panel rows are each pulled up to Vcc by a resistor, and are tied to five door processor inputs. If a switch contact on that key panel column is closed when this happens, then that switch's row is pulled low so that one of the door processor's inputs is pulled low. In this way, the software can tell by scanning all six columns which switches are closed. This scanning process is very rapid and is synchronized with the LED multiplexing. If a switch is held down long enough, about $1/30^{th}$ of a second, then the door processor will send a message to the management processor saying that the key has been pressed. If the key remains held down, then a periodic "key still down" message will be sent.

A flexible circuit jumper is part of the key panel tail, and ties one of the five row lines to a special door processor pin. The processor can use this pin to tell which line the jumper is tied to, which tells it the specific key panel type. In this way, future key panels with different switch arrangements or graphics could be identified for use with special software versions.

If the door is open, the management processor will generate audio clicks if the key panel switches are pressed, but no other action will be taken. This is to prevent accidental data or status changes caused by something underneath the open door.

5.2.4 LCD Contrast Voltage

Integrated circuit U3 generates a regulated voltage that is supplied to the LCD display module, which controls the visibility, or contrast, of the display elements on the LCD screen. U3 and the surrounding circuitry takes VMAIN, which ranges from 11 to 16 volts, and generates a negative voltage supply (Vlcd). This voltage is regulated by U3, but it is influenced by two other factors. First, since LCD contrast is affected by temperature, thermistor, CT1, causes Vlcd to change with temperature to match the display. If the display is cold, the voltage should be more negative, if it is warm, the voltage should be less negative. In addition, three output pins from the door processor can shift Vlcd. These three pins can be set to eight different combinations (0-7) which can give eight different levels of Vlcd, which are controlled by software from the User Menu item "Set LCD Contrast." This setting is saved in management processor RAM memory and is restored at power-up. Vlcd has a normal adjustment range from -7 to -8.5 volts.

The door processor uses transistor Q4 to supply Vlcd to the LCD display. At power-up, it is not turned on until the LCD controller has been initialized and the management processor sends an "LCD ON" command to the door.

5.2.5 LCD Backlight Supply

CAUTION: The backlight voltage passes from the display board, through the LCD controller board, and to the LCD display module. If this connection is broken and the inverter is on, it will emit a high frequency audible noise, and it can be damaged by operating this way for any length of time.

The LCD display module contains an electroluminescent panel which is used to backlight the display so it can be viewed in dim lighting conditions. This backlight requires a power supply of 100 volts

AC at 400 Hz frequency. This voltage is generated by a DC to AC converter mounted on the back of the display board. The door processor, commanded by the management processor, controls the VMAIN supply to the inverter, which turns the backlight on and off. An electroluminescent panel has a limited operating life, over which it grows dimmer, so the management software turns off the backlight when no user interface activity is taking place.

5.2.6 LCD Module Assy.

The Liquid Crystal Display module is a combined LCD screen, driver electronics board, and electroluminescent backlight. It is supplied by Epson U.S.A. and is not repairable to the component level. It is a "transflective" type of display, with a built-in reflector for viewing in brighter light, and a transmissive backlight for viewing in dim or no light.

The LCD panel contains 1024 square elements (pixels) arranged as a 128 pixel wide by 64 pixel high array. Control signals for the display are generated by the LCD controller, and are all logic level signals. The actual voltage (Vlcd) that turns on the LCD pixels is a negative voltage (-7 to -8.5 volts) generated on the display board and adjusted (under operator control through the User Menu) by the door processor. This voltage also varies with temperature, since the behavior of the LCD is temperature sensitive. This allows the display to work over a temperature range without requiring adjustments.

The backlight is a solid-state electroluminescent (EL) sheet which glows when energized by a 100 volt AC signal generated on the display board. The glowing phosphors in this panel tend to glow less brightly as time goes on, so the backlight is turned on and off under management software control. After the pump starts running, the backlight is turned off to extend its useful life. Once the backlight is turned off, pushing any key panel key will turn it back on so that the display can be seen in dim light.

5.3 PRESSURE TRANSDUCER

5.3.1 Pressure Transducer Circuits

The pressure transducer converts the pressure applied to its surface membrane to a differential output voltage. The pressure transducer is powered by a constant current source, which is generated by op amp U2A, 2.5 volt reference CR1, and a 1.65K ohm current setting resistor, R3. Op amp U2A maintains 2.5 volts across resistor R3, which results in a constant 1.5 milliamps out of the pressure transducer supply return terminal. The differential pressure transducer output is sensed by op amp U3A, which has unity gain.

5.3.2 Offset, Gain, and Output Circuits

The sensed pressure transducer output signal is amplified and adjusted for offset errors, by means of op amp U2B. Amplifier U2B is constructed as a summing amplifier, with a signal gain of 47.5. Amplifier U2B sums the inputs from the pressure transducer sense amplifier, the 2.5 volt reference CR1, and the -2.5 volt reference CR2. The contribution from the sensed pressure signal is scaled by the ratio of feedback resistor R2 to input resistor R5, which provides a signal gain of 47.5. The contribution from the 2.5 volt reference is scaled by the ratio of feedback resistor R2 to input resistor R8. Therefore, R8 is selected to correct for negative offset errors. The contribution from the -2.5 volt reference is scaled by the ratio of feedback resistor R2 to input resistor R7. Therefore, R7 is selected

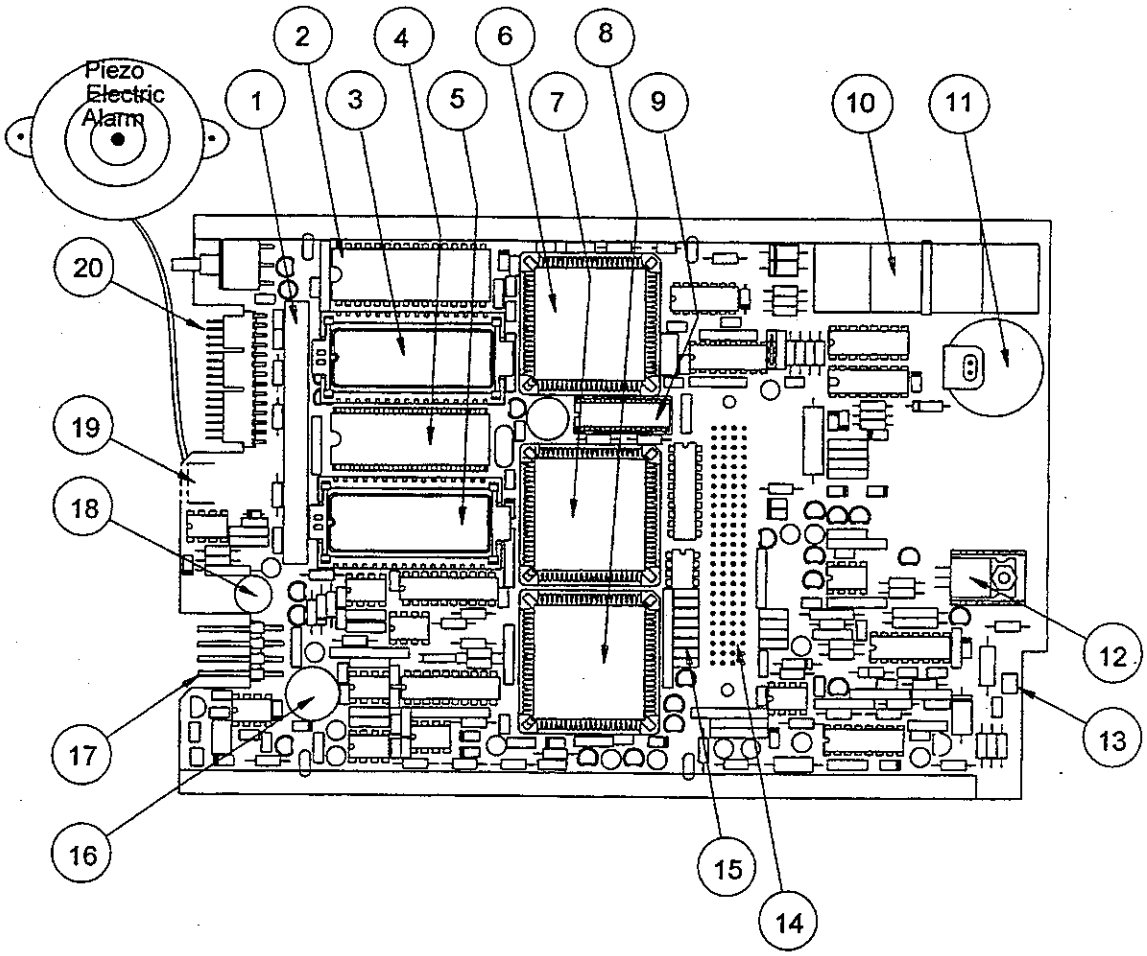
to correct for positive offset errors.

Op amp U3B inverts the offset adjusted pressure signal, to complete the formation of a differential output with maximum range.

5.4 MECHANISM INTERFACE BOARD ASSY.

The mechanism interface board is the connection point between the main board and the bezel and door assemblies. One 100-pin connector mates with the main board and from there, connectors are provided for the main stepper motor, main motor encoder, restriction motor, restriction optical yoke, transfer solenoid, air-in-line block, and door assembly. The connectors are polarized and sized so that the mechanism components cannot be plugged in incorrectly. The door cable assembly is built with special high flex-life ribbon cable to withstand the large number of door operations over the life of the pump.

Figure 5-1: Main Board Layout Description



1. Option Board Connector
2. Pump Processor memory
3. Pump Processor EPROM
4. Management Processor Memory
5. Management Processor EPROM
6. Pump Processor, 80C537
7. Management Processor, V25PLUS
8. ASIC
9. EPLD
10. 4.8 Volt NiCad Battery
11. 3.0 Volt Lithium Battery
12. Main Battery Charger
13. Touch Switch for manual turn off
14. Bezel/Door Connector
15. Motor Drivers
16. Backup Alarm
17. Main Battery Connector
18. Fuse 2, Main Battery Switching
19. Fan/Speaker Connector
20. Power Supply Connector

5.5 MAIN BOARD ASSY.

The main board utilizes a dual processor architecture, for both efficiency and reliability. One of the processors, the management processor, is primarily responsible for interpreting operator inputs, initiating fluid delivery operations, and generating display information. The other processor, the pump processor, is primarily responsible for controlling fluid delivery operations, as directed by the management processor. An application specific integrated circuit (ASIC) generates the waveforms that control the two motors during fluid delivery, as directed by the pump processor. The ASIC also provides all address decoding for the management processor, and provides the interface between the external photo-interrupter LEDs and both processors. A block diagram of the main board's major circuits and their connections to the external subsystems is shown in Figure 4-1. A picture of the main board is included to help identify selected components. See Figure 5-1.

5.5.1 Management Processor

The management processor, U11, is a V25 Plus microcomputer, which is software compatible with the 8086 microcomputer. It uses a 16 bit internal data bus and an 8 bit external data bus. The V25 Plus can directly address 1M byte of memory and 1M byte of I/O. Memory accesses are controlled by Memory Request (MREQ), Memory Strobe (MSTB), and Read/Write (R/W). I/O accesses are controlled by I/O Strobe (IOSTB) and Read/Write (R/W). The V25 has two serial channels and four multifunction I/O ports, including one 8 bit analog comparator port for discrete or analog inputs. The microprocessor operates at a clock frequency of 12 MHz, which is supplied by a crystal and an internal oscillator.

The management processor program is stored in an external 512 K byte EPROM, U13, and data is retained in an external 128K byte RAM, U10. The RAM write line is gated by Memory Strobe with a 74AC11032 NAND gate, U7A, to provide the necessary address setup time. The RAM is backed up with a 3 volt on-board battery, BT2, which is switched in or out by a 691 power supervisory integrated circuit, U5. Therefore, data will be retained in RAM even if the board is removed from the system. Pullup and pulldown resistors on the data bus ensure that an Interrupt 3 instruction will be retrieved by the microcomputer if non-existent memory is addressed.

5.5.2 Door Interface Bus

The management processor communicates with the external door processor via a bidirectional, synchronous serial bus. The management processor uses port pin P14 to transmit and receive data on the data line, and it uses port pin P17 to drive the clock line. The door processor requests permission to transmit a message by raising a flag on the DOORRTS line (management processor port pin P07). The management processor then grants permission to send by raising a flag on the DOORCTS line (management processor port pin P21). The DOORRTS and DOORCTS lines are not used when the management processor sends messages to the door processor, since the door processor is normally ready to receive. The management processor can reset the external door processor with the RESET-DOOR line (port pin 22).

5.5.3 LCD Interface

The management processor can write commands and display data to, and read status and display data from, the external LCD controller, via an 8 bit parallel data path. The 8 bit data path is buffered by a 74HC245 octal bidirectional buffer, U9. The management processor Memory Strobe is gated with

the Read/Write line by two 74AC11032 NAND gates, U7B and U7C, to produce an LCD read and an LCD write line. An LCD select line is generated by the ASIC. It is decoded from management processor memory address space, from 400 hex to 401 hex. A single address line, A0, buffered by a 74AC11032 NAND gate, U7D, provides 2 LCD read addresses and 2 LCD write addresses. This allows the management processor to write LCD commands, write LCD data, read LCD data, and read LCD status.

5.5.4 IR Link

The management processor can transmit to and receive serial data from an external host by means of a full duplex, asynchronous, infrared (IR) communications link. The infrared communication path allows a fluid tight, electrically isolated interface. One of the two serial ports in the management processor is dedicated for this purpose. Transmit data from the management processor serial port output pin is re-driven by PNP transistor Q37, and then routed to an LED, D2, which produces infrared light at 940 nM. The LED is positioned at the rear of the main board, facing a window that is transparent to infrared light. An optional external IR communications module converts the infrared transmit data to RS 232 levels, and completes the transmission to an external host. RS 232 data from the host is similarly converted to infrared light by the external IR communications module, and detected by a phototransistor, D3, located at the rear of the main board. This data is routed directly to the management processor serial port input pin. The data is sent as ASCII text using a baud rate of 9600, no parity, 8 data bits and 1 stop bit. With this format an entire log, alarm or operation, can be downloaded in approximately 90 seconds. Refer to the PC Docking Manual, Part No. 950441.

5.5.5 Pump Processor

The pump processor is an 80C537 microcontroller, U3, which is based on a superset of the 80C31 architecture. With 16 address bits, the 80C537 can directly address 64K bytes of program memory and 64K bytes of data memory. Eight output pins are dedicated to the upper eight address bits, but the lower eight address bits are multiplexed with the 8 bit data bus. Therefore, the lower eight address bits must be stored in the 74HC373 latch, U16, with the falling edge of Address Latch Enable (ALE) before the eight data bits are presented on the same lines. Program memory fetches are controlled by Program Store Enable (PSEN), data memory reads are controlled by Read (RD), and data memory writes are controlled by Write (WR).

The pump processor program is stored in an external 64K byte EPROM, U6, and data is retained in an external 128K byte RAM, U1, although only half the RAM can be accessed. Pulldown resistors on the data bus ensure that a NOP instruction will be retrieved by the microcontroller if nonexistent memory is addressed.

In addition to its address and data ports, the 80C537 has five 8 bit multifunction I/O ports, two serial channels, and 12 A/D inputs. The 80C537 operates at a clock frequency of 12 MHz, which is supplied by a crystal and an internal oscillator.

5.5.6 Interprocessor Communications Bus

The management processor and the pump processor communicate with one another through dedicated full duplex asynchronous serial ports. The management processor can transmit messages to the pump processor at any time over the V25TO537 line, and the pump processor can transmit messages to the management processor at any time over the 537TOV25 line.

5.5.7 ASIC

The ASIC, U19, interfaces with both the management processor bus and the pump processor bus. It performs all address decoding for the management processor, performs I/O address decoding for the pump processor, generates stimuli for external sensors, and generates motor drive waveforms for the main motor and restriction motor.

5.5.7.1 Address Decoding and Stimuli

The AIL LED, test AIL LED, main motor encoder LED, restriction valve LED, Anti-Freeflow Clamp LED, and the door switch can all be energized by either the management processor or the pump processor.

5.5.7.2 Motor Controller

The ASIC receives motor commands from the pump processor bus, and generates pulse width modulated (PWM) waveforms for the main motor and the restriction motor. Both motors are four phase, unipolar stepper motors. A single command from the pump processor can result in no more than a single step from a single motor, so the motors are always under strict processor control. The eight PWM motor waveforms are re-driven by eight N-channel FET's with transient suppression diodes. The resulting drive signals are then routed to the motor windings. The eight PWM motor waveforms in the ASIC can be completely inhibited by the LATALARM signal from the EPLD. See Section 5.5.12.2 "Power Controller EPLD" for a description of LATALARM.

The ASIC controls the duty cycle of the PWM waveforms, as directed by the pump processor, which in turn determines the average current through the motors. The pump processor can also command the ASIC to ramp the duty cycle of the PWM waveform up or down over a selectable period of time, at the beginning or end of a motor step. This is done to reduce the acoustical noise when a motor step is applied.

5.5.7.3 ASIC Timers

The ASIC also contains two programmable timers, one for each motor, to ensure that the motor stepping rates selected by the pump processor are accurate. Any pending main motor step command is automatically executed when the main motor timer times out. In addition, the main motor timer issues interrupts to the pump processor at three different points: when the timer times out, three timer clock periods before the timer times out, and seven timer clock periods before the timer times out. The main motor timer clock period can be programmed to be either 341 microseconds or 2.73 milliseconds. The restriction motor timer issues interrupts to the pump processor only when its timer times out. Any pending restriction motor step command is automatically executed at that time. The restriction motor timer clock period is 685 microseconds.

5.5.8 Transfer Valve Solenoid Driver

The pump processor generates the PWM waveform for the transfer valve solenoid by means of a built-in timer/comparator circuit, using port pin P4.7 . The pump processor reduces the duty cycle of the waveform after initial pull-in of the solenoid, in order to minimize power consumption. The PWM motor waveform is inverted by a P-channel FED, Q3, and driven by an N-channel FED, Q32,

with a transient suppression diode, CR30. The resulting drive signal is then routed to the solenoi winding. The other side of the solenoid is connected to VMAIN.

5.5.9 Temperature Controller

The pump processor monitors the air temperature inside the case with a thermistor, TH1, through A/D port pin P7.0. If the temperature exceeds a preset threshold, the pump processor turns on a cooling fan, through port pin P6.4. The fan signal is re-driven by an N-channel FED, Q13, with a transient suppression diode, CR24, and a 7.5 volt zener diode, CR18, before being routed to the fan motor.

5.5.10 External Sensor Interface

5.5.10.1 Panel Lock Out Switch

The panel lock out switch is a single pole, double throw, momentary switch, which is mounted on the main board. It is accessible to the user through a flexible membrane in the rear of the case. The state of the switch signal is monitored by the management processor, via port pin P05. The software toggles between the lock out mode and the non-lock out mode with each depression of the switch.

5.5.10.2 Door Switch

The door switch is a single pole, double throw, magnetically operated switch, which is mounted in the bezel. The switch is closed by means of a magnet in the door whenever the door is closed The state of the switch is monitored by the management processor, via port pin P01. The switch is directly energized by the STIM signal, which can be generated by either processor via the ASIC. Therefore, the management processor can distinguish between a switch signal that is stuck low and a real closed door condition, by toggling the STIM signal.

5.5.10.3 Encoder and Restriction Valve

The position of the main motor is determined by counting pulses from an encoder wheel mounted to the motor shaft. The motor is first initialized to a known position by retracting it to its extreme limit. The pulses are generated by a photo-interrupter assembly, which detects the alternate spokes and holes in the encoder wheel. The encoder output signal remains high for approximately four main motor steps and low for approximately six main motor steps. This output, ENCODERSEN, is received by inverting schmitt trigger U2 on the main board, and then routed to both processors.

The position of the restriction valve is determined by counting restriction motor steps. The restriction valve is first initialized to a reference position (fully closed position) by moving it to the position where the restriction motor shaft makes initial contact with the spring loaded valve linkage. At this point, the output from a photo-interrupter assembly in the valve link makes a transition in logic levels: high for contact, low for no contact. This output, RESTRSEN, is received by inverting schmitt trigger U2 on the main board, and then routed to both processors.

The LEDs in both photo-interrupter assemblies are connected in series, and energized by the STIM signal generated in the ASIC. The STIM signal is re-driven by transistor Q32 and current

limited with a 220 ohm resistor before being routed to the LED's.

5.5.10.4 Air-In-Line Block

Air bubbles in the line are detected by means of the air-in-line block. The air-in-line block printed circuit board contains two separate infrared LED/photosensor pairs, with current limiting LED resistors. One pair, the AIL pair, utilizes the different indices of refraction of air and liquids to detect air bubbles in the line. Its LED is energized by the AILLED signal generated in the ASIC. The AILLED signal is re-driven by transistor Q31 before being routed to the AIL board. The output of this pair, AILSEN, is received by comparator U4A and then routed to both processors. In normal operation, AILSEN is high for air and low for liquids.

Another LED/photosensor pair, the TESTAIL pair, is used to test the operation of the AIL LED and photosensor. The TESTAIL LED is positioned to emit infrared light directly onto the AIL photosensor. The AIL output signal is high when the TESTAIL LED is on. The TESTAIL LED is energized by the TESTAILLED signal generated in the ASIC and re-driven by transistor Q30 before being routed to the AIL board. The TESTAIL photosensor is positioned to detect infrared light emitted by the AIL LED. Its output signal, AILTESTSEN, is received by comparator U4B and then routed to both processors. AILTESTSEN is high when the AIL LED is on.

5.5.11 Power

The main board circuits are powered by the external power supply, an onboard voltage regulator, an onboard power converter, the main battery, and two onboard batteries.

5.5.11.1 VSUPPLY

When the Horizon Nxt is plugged into an AC outlet, the power supply generates 16 volts on the VSUPPLY line. The power supply then uses VSUPPLY to generate 5 volts on the VCC line. Therefore, when the Horizon Nxt is not plugged in, the power supply can generate the 5 volts. The main board provides that DC source by means of an external main battery, which can be connected to VSUPPLY under software control, through 2 amp fuse FU2, FET Q35, and diode CR31. Since the power supply also sources 16 volts through a diode, VSUPPLY will reflect the value of the higher of the two sources: 16 volts when the Horizon Nxt is plugged in, 12 volts when it is turned on but not plugged in, and zero when it is not turned on and not plugged in.

5.5.11.2 VMAIN

All of the VSUPPLY current that is used by or distributed by the main board is measured through a series .05 ohm resistor, R44, and op amp U17A. The pump processor monitors the op amp output through A/D input P7.3. The node on the load side of the .05 ohm resistor is called VMAIN.

5.5.11.3 VBATT

The external 12 volt lead-acid battery is connected to the main board through a 2 amp fuse, FU2. The node on the load side of the fuse is called VBATT. The battery voltage is measured by op amp U22A, through two sense wires provided for that purpose: BATTSEN+ and BATTSEN- . The output of the op amp is monitored by the pump processor, through A/D input P7.2.

In addition to the analog measurement of VBATT, two comparator circuits are provided to monitor the condition of the battery. The LOWBATT signal is generated by comparator U26A and a 2.5 volt reference, VR2, whenever VBATT is less than 10.5 volts. LOWBATT is connected to the management processor non-maskable interrupt input, P10, and to pump processor input P3.2. The DEADBATT signal is generated by comparator U26C and voltage reference VR2 whenever VBATT is less than 10.3 volts. DEADBATT is connected to the power controller EPLD, U8.

The main board maintains the charge on the main battery by means of a UC3906 battery charger integrated circuit, U20, which is powered by VSUPPLY. The UC3906 automatically switches between three different charge states, depending on the condition of the battery: a high current bulk-charge state, a controlled overcharge state, and a precision float-charge, or standby, state. The pump processor can disable the charger during battery operation.

5.5.11.4 V+

V+ is produced from 12 volts or 16 volts on VMAIN by an onboard 78L08 eight volt voltage regulator, VR1.

5.5.11.5 V-

-8 volts is produced from 12 volts or 16 volts on VMAIN by an onboard 1054 switched capacitor voltage converter with regulator, U24. The -8 volt regulator output is gated by FET Q33, which outputs -8 volts on the V- line. Q33 is provided to ensure that V- cannot become positive during power-up.

5.5.11.6 VMEM

A 3 volt, 280 ma-hr, nonrechargeable lithium battery, BT2, is provided on the main board, as a backup power source for VMEM. VMEM powers the management processor RAM, U10, and the time-of-day integrated circuit, U18. A 691 power supervisory integrated circuit, U5, connects either the 3 volt VCC or the 3 volt battery voltage to VMEM, whichever is higher. Therefore, information stored in the RAM and the time-of-day integrated circuit is maintained, even when the main board is removed from the Horizon Nxt.

5.5.11.7 VBKUP

A 4.8 volt battery pack, BT1, is provided on the main board, as a backup power source for VBKUP. The battery pack consists of four rechargeable, 1.2 volt, 100-110 ma-hr, nickel-cadmium batteries. VBKUP powers the backup alarm, the power controller EPLD, the power switch circuits, the 2.5 volt reference, and the main battery threshold detectors. Therefore, the backup alarm will be operable, even if the Horizon Nxt is not plugged in and the main battery is dead. The 4.8 volt battery pack is charged by diode CR3 and resistor R2 whenever power is available from VSUPPLY.

VBKUP normally obtains power from VCC, through diode CR5, whenever VCC is available. It obtains power from the 4.8 volt battery pack or VSUPPLY through diode CR6 and FET Q36 only if the Horizon Nxt has been turned on. It also obtains power from VBATT through resistor R23, diode CR17, and FET Q36 if the Horizon Nxt has been turned on.

5.5.12 Power Control Circuits

When the Horizon Nxt is turned off and not plugged into an AC power source, pressing the power switch will activate the circuits that apply main battery power to the power supply and to the main board. Then, when the power supply applies VCC to the processors, they will detect the active power switch signal, and begin normal operation. The next time the processors detect an active power switch signal, they will prepare the Horizon Nxt for power-down, and activate their battery-disconnect signals. When the power controller EPLD receives battery-disconnect signals from both processors, it will disconnect the main battery. At this point, the instrument will be unpowered again. When the Horizon Nxt is plugged into an AC power source, power-up and power-down proceeds logically the same as when it is not plugged in, except that the electronics remain powered. That is, the circuits remain powered when the Horizon Nxt is turned off, but only the main battery charger and the AC LED indicator are active.

5.5.12.1 Power Switch Circuit

The power switch is a simple membrane switch located on the front key panel, with one side connected to ground. The other side is connected through diode CR21 to the gate of FET Q36. When the power switch is pressed, Q36 immediately applies power from VSUPPLY, VBATT, or the 4.8 volt battery pack, to VBKUP. VBKUP then powers the remainder of the power control circuits, thus enabling the subsequent stages of the power-up process.

The power switch is also connected through diode CR20 to the input of comparator U26D, resistor R63, and capacitor C64. When the power switch is pressed, the comparator output, SW, is immediately asserted. When the switch is released, R63 and C64 delay the deactivation of the SW signal for approximately 500 milliseconds. Therefore, short pulses from the power switch are stretched to a usable length of time. The SW signal is routed to both processors and the power controller EPLD, U8.

5.5.12.2 Power Controller EPLD

The power controller electrically programmable logic device (EPLD), U8, performs several different functions. It controls the connection of the 12 volt battery to VSUPPLY, it controls the connection of the 4.8 volt battery pack to VBKUP, it activates the backup alarm in response to various input conditions, and it performs address decoding for the pump processor. When the EPLD detects the SW signal during the power-up process, it asserts the CONVBKUP and the CONVBATT signals. The CONVBKUP signal turns on FET Q1 after an approximate 50 millisecond delay, which is induced by resistor R12 and capacitor C6. FET Q1 then enables FET Q36, which connects the 4.8 volt battery pack to VBKUP. At this point, the operator can release the power switch, and the power-up process will continue. The CONVBATT signal is inverted by FET Q19, which enables FET Q35, which connects VBATT to VSUPPLY through diode CR31. The next press of the power switch will not normally affect the EPLD directly. However, the processors will interpret the key press as a request for power-down. After preparing the instrument for power-down, the management processor will assert the DISCONA signal via port pin P06, and the pump processor will assert the DISCONB signal via port pin P5.7. When both processors have asserted their disconnect signals, the EPLD will disconnect the 4.8 volt battery, unless the backup alarm has been activated, and it will disconnect the main battery.

The EPLD activates the backup alarm via the BKUPALARM signal whenever both CONVBK-

UP and RESET are asserted. Therefore, RESET normally causes a short beep from the backu alarm circuit, prior to the chime from the primary alarm circuit, when an unplugged instrumen is first turned on. The EPLD also activates the backup alarm whenever the EPLD latched output signal, LATALARM, is asserted. Pressing the power switch after LATALARM has been asserted will cause the EPLD to immediately silence the alarm, and disconnect both the 4.8 volt battery and the main battery. LATALARM is asserted under four different conditions, which are described below.

CONDITIONS RESULTING IN LATALARM SIGNAL

1. The pump processor issues an ALARMON signal, via port pin P5.2.
2. The management processor issues a SHUTDOWN signal, via port pin P02.
3. Comparator U26C generates a DEADBATT signal. DEADBATT also causes the EPLD to disconnect the main battery, to protect it from permanent damage.
4. An extraneous RESET signal is generated after the normal power-up RESET. The possible causes of extraneous RESET's are described in the Power Supervisory Circuit section.

The EPLD also decodes addresses for the pump processor. The single decoded output, 537RAM, is routed directly to the pump processor RAM and the ASIC, without diode protection. Therefore, the 537RAM output line is forced low by the RESET line whenever VCC is not available, to avoid the possibility of sourcing an unpowered component through an input pin when the EPLD is powered by the 4.8 volt battery.

5.5.12.3 Power Supervisory Circuit

The 691 power supervisory circuit, U5, performs several functions. It generates resets under various input conditions and controls backup power for the management processor RAM and the time-of-day circuit.

The 691 constantly monitors VCC, and generates a minimum 35 millisecond reset on the RESET line if VCC falls below 4.5 to 4.75 volts. Therefore, RESET is always asserted on initial power-up and during subsequent negative glitches on the VCC line. Reset is also generated by the overvoltage detection circuit whenever VCC exceeds 5.32 to 5.6 volts for 4-15 milliseconds. See the Section entitled "Overvoltage Detection Circuit." The 691 also asserts the RESET line whenever its watchdog circuit times out. The watchdog time-out period is 1.6 seconds. The watchdog circuit is normally prevented from timing out by pulses generated by the pump processor, via port pin P6.0. A reset can also be forced by holding the TESTRESET line from the option connector either low or high for 1.6 seconds. This normally open-circuit line is connected to the 691 watchdog input, along with the watchdog input signal from the pump processor.

Both VCC and the 3 volt battery, BT2, are connected to the 691. During normal operation, the 691 connects VCC to the VMEM line, which provides power to the management processor RAM, U10, and the time-of-day integrated circuit, U18. The 691 BATON output signal also enables a separate PNP transistor, Q5, which provides additional current from the VCC line to VMEM. However, when VCC falls below the voltage level of the 3 volt battery, the 691 asserts the RESET signal, and switches the 3 volt battery power onto the VMEM line instead. The 3 volt battery power is sufficient to maintain the data in the management processor RAM and to maintain the current time in the time-of-day integrated circuit. The RESET line is also routed to one of the management processor RAM enable inputs in order to inhibit writes when VCC is

low.

5.5.13 Voltage References

Two voltage references are supplied on the main board. A 5 volt reference voltage is generated by a 1029 integrated circuit, CR35, which is powered by V+. The source current from V+ passes through a red indicator LED, D1, and a voltage dropping resistor, R38, before reaching the 1029. Therefore, LED D1 provides an "ON" indication for service technicians without using additional power. The 5 volt reference is used by the A/D converter inside the pump processor, the analog comparators inside the management processor, the offset DAC in the pressure signal circuits, and the thermistor in the temperature control circuit.

A 2.5 volt reference voltage is generated by a 2425 precision virtual ground integrated circuit, VR2, which is powered by VBKUP. The 2.5 volt reference is used by the LOWBATT and DEADBATT comparators, U26A and U26C.

5.5.14 Pressure Signal Circuits

The pressure signal circuits receive the differential output signal from the pressure transducer, VPRESS+ and VPRESS-, and perform several processing operations before presenting the results to the A/D converter inside the pump processor. The differential input signal is first converted to a single ended signal by op amp U22B. Then the single ended signal is level shifted and amplified under control of the pump processor. The shifted and amplified signal is then routed through a diode/resistor clamping matrix, and presented to the A/D converter inside the pump processor. The software controlled level shifting and amplification allows the pump processor to examine minute details imposed on relatively large scale pressure signal waveforms with increased resolution.

5.5.15 Variable Level Shifter

The pump processor uses half of a 7528 dual DAC, U23, and op amp U21B to generate a variable offset voltage for the level shifting process. A -3.84 volt reference voltage for the DAC input is generated from the 5 volt reference voltage by op amp U25A. This allows the DAC to generate a variable offset voltage between zero and 3.84 volts, in 15 millivolt increments. The offset voltage from U21B is subtracted from the single ended pressure signal by op amp U25B.

5.5.16 Variable Gain Amplifier

The pump processor uses the other half of the 7528 dual DAC, U23, and op amp U21A to amplify the level shifted pressure signal by a variable amount. Since the DAC is inserted in the feedback path of op amp U21A instead of its input path, the gain is inversely proportional to the DAC setting. Thus, the gain can be varied from 256/255 to 256/1. The output of the variable gain amplifier is clamped by means of a diode/resistor matrix, to protect the A/D inside the pump processor from excessive voltages. Refer to Chapter 7, Section 7.7.1.1, "Testing the Pressure Transducer A/D Offset."

5.5.17 Time of Day

The main board maintains the current time by means of a 1202 serial timekeeper integrated circuit, U18, with a separate 32.768K Hz crystal. The 1202 counts seconds, minutes, hours, day, month, and year. The time-of-day select line, TOD, is generated and latched in the ASIC. It is controlled

by bit four of the command byte that is located at address 2200 hex in the management processor I/O space. The 1202 is powered by VMEM, which is backed up with a 3 volt battery when VCC is not available.

5.5.18 Audible Alarms

5.5.18.1 Primary Alarm

Both primary and backup audible alarm circuits are provided on the main board. The primary alarm uses an external 8 ohm speaker. It is driven by a 7052 full bridge speaker driver integrated circuit, U12, which is fed by a chime generator circuit. The chime generator is built around op amp U15A, which receives a software controlled volume control signal on its positive input terminal and a software controlled pitch signal on its negative input terminal. The pitch signal is a square wave transmitted from management processor port pin P15. The volume control signal is an exponentially decaying waveform derived from a 1.5 microfarad capacitor or a 10 microfarad capacitor, which are both connected to the positive terminal of op amp U15A through a diode array and a 100 K ohm input resistor. The 1.5 microfarad capacitor, C60, is used to generate short decay time volume control waveforms, for maximum chime effect. The 10 microfarad capacitor, C63, is used to generate longer decay time volume control waveforms, for a steady tone effect. C60 is charged up to a software controlled initial value by management processor port pin P03. C64 is charged up to a software controlled initial value by management processor port pin P04.

The speaker current is sensed by a series 0.2 ohm resistor, R35, and amplified by op amp U15B. The amplified speaker current signal is routed to a peak detector, consisting of series resistor R33, series diode CR33, storage capacitor C53, and drain resistor RP15-6. The peak detected speaker current signal is monitored by the management processor, via an analog comparator input, PT6.

5.5.18.2 Backup Alarm

The backup alarm uses an onboard or external piezo sound generator with built in oscillator, AL1. AL1 is driven by a 1026 voltage doubler integrated circuit, U27, which receives input power from the VBKUP line. The backup alarm is turned on by the BKUPALARM signal from the power controller EPLD, U8. See the Power Controller EPLD section for a description of the BKUPALARM signal. The BKUPALARM signal turns on FET Q23, which completes the ground circuit for voltage doubler U27 and piezo sound generator AL1. Since both the EPLD and the voltage doubler are powered by VBKUP, which is backed up with an onboard 4.8 volt battery, the backup alarm can continue to sound even if the instrument is unplugged and the main battery becomes discharged. This alarm can be turned off manually by touching the 2 contacts on the main PCB. See Figure 5-1, Item 13.

5.5.19 Overvoltage Detection Circuit

The Horizon Nxt overvoltage detection circuit utilizes comparator U4D to compare a scaled VCC against the 2.5 volt voltage reference. VCC is scaled by voltage divider R5/R6, and filtered by a 0.1 microfarad capacitor, C2. When VCC reaches the trip point voltage, comparator U4D transmits a signal to the power fail input pin of the 691 power supervisory circuit, U5. The trip point is between 5.32 volts and 5.6 volts, with a nominal value of 5.46 volts. The power fail output pin and the reset

output pin of the 691 power supervisory circuit are connected together. Therefore, any positive voltage excursion on VCC with sufficient amplitude and duration will result in a board reset, which will cause the power controller EPLD, U8, to activate the backup alarm.

The overvoltage detection circuit is designed to filter out voltage spikes shorter than 4 milliseconds, and to generate a board reset signal for voltage spikes longer than 15 milliseconds. The 2.5 volt voltage reference, the power controller EPLD, and the backup alarm are powered by VBKUP. Comparator U4D is powered by VCC, and is guaranteed to operate properly with input power from 3-15 volts.

5.6 AIR-IN-LINE BOARD ASSY.

Air bubbles in the line are detected by means of the air-in-line block. The air-in-line block PCB contains two separate infrared LED/photosensor pairs, with current limiting LED resistors. One pair, the AIL pair, utilizes the different indices of refraction of air and liquids to detect air bubbles in the line. Its LED is energized by the AILLED signal generated on the main board. The output of this pair, AILSEN, is used by the main board to determine whether air is present in the line. In normal operation, AILSEN is high for air and low for liquids.

Another LED/photosensor pair, the TESTAIL pair, is used to test the operation of the AIL LED and photosensor. The TESTAIL LED is positioned to emit infrared light directly onto the AIL photosensor. The AIL output signal is high when the TESTAIL LED is on. The TESTAIL LED is energized by the TESTAILLED signal generated on the main board. The TESTAIL photosensor is positioned to detect infrared light emitted by the AIL LED. Its output signal, AILTESTSEN, is used by the main board to determine whether the AIL LED is working. AILTESTSEN is high when the AIL LED is on.

5.7 SYSTEM OPERATION

5.7.1 Power-up

The Horizon Nxt has two powered-up conditions. If the pump is off and unplugged, and then is plugged in, the power supply powers-up the system and the microprocessor programs start running. The management and pump processors initialize their internal memories, and wait for the POWER Key on the key panel to be pressed. The pump processor continuously pulses the power supervisor circuit to prevent a watchdog reset. The management processor releases the reset line to the door, and the door processor turns on the single green AC LED indicator and waits for the first command from the management processor. The LCD contrast voltage is not turned on, so the LCD display remains blank. No messages are sent, and no other processes are active.

If the pump is not plugged in, and the POWER Key is pressed, the power control circuitry, powered by the 4.8 volt backup battery, causes the main battery to be temporarily connected to the power supply, energizing the 5 volt switching regulator and generating Vcc to the whole system. This starts up the main board processors, which both detect that the POWER Key is pressed. The EPLD, without software control, latches the main battery supply on. From this point, DC or AC power-up actions are the same.

At this point, the door processor is reset by the management processor, and the green AC LED indicator is turned on again. If the pump is actually running on the main battery, a later message from the management processor causes the LED indicators to switch to indicate BATT.

Both main board processors test internal and external RAM memories as well as the program EPROM contents. Any memory failure results in a system alarm. The management RAM is battery backed by the 3 volt battery, and stores important data from when the pump was last turned off. This data is tested to be sure that its contents have not been altered. The management processor reads the contents of the time-of-day clock and alarms if the date or time data is invalid.

Messages start to be exchanged between management and pump processors. Periodic "I'm O.K." messages detect if either software ceases to work correctly. If this happens, the management and/or pump processor will sound an alarm.

The management processor sounds the chime sound of the audible alarm. The current drawn by the alarm driver is tested, and if the current read is too low, the backup alarm is turned on and a system alarm is generated. Refer to Alarm Code number 71 in Appendix B: Troubleshooting Guide.

The pump processor initializes the pumping mechanism circuits in the ASIC device. If the pump door is closed and the air-in-line block tube detector indicates that a set is in place, the restriction motor home position is located as well. If not, then this is done at RUN time.

The management processor sends commands to the door processor to initialize the LED display digits. Data displayed is determined by the data stored in management RAM and the settings from the Biomed Menu that concern data retention and start-up values. The LCD controller is initialized by management processor commands, and LCD contrast voltage and backlight are turned on. "I'm O.K." messages start to flow between door processor and management processor, and any failure in the exchange will result in either an audible alarm or an "ERR" message on the LED displays.

Once all power-up testing has been completed and there are no alarms, the pump goes into the Hold state, and awaits operator action.

5.7.2 Hold State Operation

When the microprocessor is in the Hold state, the yellow HOLD indicator is illuminated, and the Information Display indicates the time left and volume delivered values, along with the status, setup instructions or any relevant alarm messages. The Primary and Piggyback Rate and Volume To Be Delivered displays indicate the appropriate data as determined by the software power-up defaults, and previous saved data. If either Piggyback rate or Piggyback volume data is zero, then the Piggyback display remains blank. If not, it is illuminated at a reduced brightness to indicate that the Primary display digits would be changed if the DATA Keys are operated.

The management processor uses the state of the door and the air-in-line tubing detector to determine which prompt to show on the Information Display.

If the HOLD Key has been pressed in response to an alarm condition then the appropriate alarm message will be shown at the bottom of the LCD Information Display until either RUN Key is pressed.

At any time while in the Hold state, the rate and volume to be delivered values may be changed by pressing the keys below the display digits. If a key is pressed once, the audible alarm will beep once, and the corresponding digit will increase or decrease by one, or roll over or under if the maximum or minimum value has been reached. If a key is pressed and held, the corresponding digit will continue to change and the alarm will beep, at a rate of three times per second. Normally, either rate can

be set from zero to 999.9 ml/hr, while the volume to be delivered can be set from zero to 9999.9 ml. Leading zeros are not displayed. The pump will not begin operation, however, if either the Rate or the Volume To Be Delivered display of the current row is set to zero. If two keys are pressed simultaneously there will be no response.

In the Hold state, pressing the MENU Key gives access to the Main and Alternate Menus and all of the features available there. Once the pump is running, only some Main and Alternate Menu choices are available.

During the Hold state, software internal tests are performed periodically and any problems that are detected generate an immediate alarm. After 20-30 seconds have transpired while in the Hold state without key presses, the word "HOLd" is displayed in the unused VTBD channel of the LEDs. In addition, if the door is closed, a timer is activated which causes a "Hold Time Exceeded" alarm if the pump remains on hold without key presses for more than 3 minutes, unless Hold Extender option is being utilized. (See the Horizon Nxt Operation Manual for an explanation of the Hold Extender option.) If the door is opened, the timer will be deactivated until the door is closed. Once the door is closed the timer is reset for another three minutes. Once the "Hold Time Exceeded" alarm is activated, the HOLD Key must be pressed to silence the audible alarm, return the pump to the Hold state, and reset the timer for another three minutes.

If the door is open, the power can be turned on but all other key panel switches can only cause audible clicks. This is to prevent accidental data or status changes. If the door is open, the pump is on battery power and in the Hold state, the system will automatically turn of the device after approximately 20 minutes to conserve the battery.

5.7.3 Run State Operation

When either the PRIMARY RUN or PIGGYBACK RUN Key is pressed, several tests are performed before fluid delivery begins. First, if either the Primary Rate or Volume To Be Delivered display is set to zero, or either of the Piggyback Rate or Volume To Be Delivered displays are zero and the PIGGYBACK RUN Key was pressed, the appropriate zero display digit is illuminated, a warning message is displayed, the ALARM INDICATOR is illuminated, and the audible alarm sounds. If the door is opened after a RUN Key is pressed, a "Door Open" alarm is generated. To clear the alarm close the door, press the HOLD Key, and press the RUN Key again.

The management processor then sends delivery commands to the pump processor to begin pumping.

Before it begins, the pump processor checks the air-in-line block and flow clamp detector. If it indicates that a tube is not present, a "Flow Clamp Position" alarm is generated.

The pump processor moves the restriction motor to determine its home reference position. This position is the point where the restriction valve rests upon the channel in the cassette, and the optical yoke sensor beam detects the end of the restriction motor shaft. Any mechanical or electrical problem which prevents this will generate an alarm.

The pressure transducer is read by the pump processor. If this reading is above an acceptable limit, and the door is closed, the pump processor assumes that there is high pressure caused by the loading of a full cassette. The transfer solenoid is energized several times to attempt to let the pressure be relieved back upstream. If the reading (or pressure) cannot be relieved, an "Upstream Occlusion"

alarm is generated. If there is a high transducer reading and the door is open, then a system alarm i generated.

If these tests are successful, the pump processor computes the various motor timing values required for accurate delivery and pumping begins.

Pumping is carried out in repeating cycles, at the rate selected by the operator. If the rate is 400.0 ml/hr or greater, the occlusion pressure limit is raised to 400 mmHg to compensate for dynamic pressures in the set. All events during the cycle are initiated by the pump processor. The initial conditions when the cycle starts are that the main motor is retracted to the point where delivery begins, the refill piston is fully forward, the transfer solenoid is not energized, so that the transfer valve is closed and the refill valve is open, and the restriction valve is closed.

The main motor is first moved forward at a high speed to pressurize the fluid in the delivery chamber. When the cassette is installed into the mechanism, and the door is shut, an undetermined amount of fluid is held within each of the two chambers. A full delivery chamber is required for proper pumping action, so that if the chamber does not come up to pressure in a certain number of main motor steps, the pump processor tries to fill the chamber from the refill chamber. This is accomplished by stopping the main motor and actuating the transfer solenoid, which opens the transfer valve, and closes the inlet valve. Then, the main motor draws the petal module back, which simultaneously allows the refill piston to move forward, pushing fluid from the refill chamber into the delivery chamber. When the transfer solenoid is then released, allowing the inlet and refill valves to return to their original positions, more fluid will have been captured in the delivery chamber. Up to four such attempts are made to fill up the delivery chamber. If this does not fill the chamber, a "Solution" alarm is generated, otherwise, the system is checked for leaks.

After a pause the pressure is checked and if it has dropped too far, implying that the cassette or valves are not properly seated, an alarm is generated.

The restriction motor opens the restriction valve while the transducer signal is monitored. At the point where the valve starts to open, the pressure in the delivery chamber drops, and this is when actual pumping begins. The main motor steps forward at a constant speed determined by the selected delivery rate, and the pump processor monitors the transducer signal while controlling the restriction motor, so that the internal pressure is maintained at a constant level as determined by the selected maximum occlusion pressure. If the internal pressure rises, the restriction valve is opened, and if it drops, the valve is closed. This is necessary to insure accurate fluid delivery - if the pressure in the chamber is the same at the end of pumping as it was at the start, a predictable amount (approximately 0.83 milliliters) of fluid will have been delivered. Different control methods are used at different delivery rates, but the results are the same over the range of rates and pressures. Note that the pressure in the tubing will only be at the patient's pressure, plus any dynamic pressures in the tubing caused by the fluid flow itself or other items that may be obstructing the fluid flow.

At the end of the cycle, the restriction valve is closed to prepare for refill, and the transfer solenoid is actuated. Since the refill piston was pulled back as the main motor moved forward, the refill chamber has been filled from the I.V. fluid container. As the main motor is retracted and the piston returns forward, this fluid is pushed into the delivery chamber for the next cycle. The main motor is pulled back far enough that the piston travels fully forward.

Several checks are made during pumping to assure proper delivery. First, if the main motor encoder

does not see motor movement a system alarm is generated.

If the restriction optical yoke fails to sense the restriction valve closing when expected, a system alarm is generated.

If the air-in-line sensor detects air over a certain number of pumping steps, an "Air-In-Line" alarm is generated. Also during pumping, the air-in-line sensor pair is tested by an auxiliary transmitter/ receiver pair, failure of which will generate an alarm. If during pumping the pressure in the delivery chamber reaches a preset limit (determined by the selected maximum pressure), pumping stops momentarily while the restriction valve is opened. If the pressure does not drop within a few seconds, an "Occlusion" alarm or warning is generated. In addition, if the pump repeatedly reaches the preset pressure, an "Occlusion" alarm or warning will be generated, even if the pressure is released each time.

If there is not enough fluid available to refill the delivery chamber, or there is a large amount of air collected in the delivery chamber, the start of the following cycle will not be successful, and a "Solution" alarm will be generated.

The pumping rate can be changed during the Run state by using the DATA Keys to change the rate in the Rate Display, and then pressing the ENTER Key. If the ENTER Key is not pressed within a few seconds, the audible alarm will beep and the Rate Display will revert to its previous setting. The new delivery rate does not actually change until the ENTER Key is pressed. Once the ENTER Key is pressed the pump will calculate the new delivery parameters and initiate the rate change immediately.

For safety and reliability during delivery, the management processor performs what is called a co-processor function. It tracks the operation of the pump processor and if it determines that the pump processor is not delivering fluid properly, it stops the system and generates an alarm. This prevents a single software bug, damage or temporary data loss from causing an incorrect delivery.

5.7.4 Keep Vein Open State Operation

When the Primary Volume to be Delivered display decreases to zero, the pump enters the KVO state. The ALARM INDICATOR is turned on while the RUN INDICATOR continues to operate. The audible alarm sounds periodically, and the Information Display displays the KVO message. The maximum pressure setting reverts to the preset value if it automatically was increased to compensate for 400 ml/hr or higher flow rates, and if the selected delivery rate is above 3.0 ml/hr, it is reduced to 3.0 ml/hr. The Volume Delivered value continues to be increased as fluid is delivered. This state will continue indefinitely, until either fluid runs out, giving a "Solution" alarm, or the HOLD Key is pressed to go into the Hold state. Once the instrument goes into the Hold state, the pump will not run again until the Volume To Be Delivered value has been set above zero (unless the automatic Piggyback Callback method is being used as described earlier).

5.7.5 Alarm State Operation

Whenever the microprocessor detects an alarm condition, the Alarm state begins immediately. If the pump is in the Run state when the alarm occurs, the main motor immediately retracts (as if it were the end of a pump cycle) and then stops. The ALARM Indicator is illuminated and the audible alarm chimes. At the same time, the Volume To Be Delivered and Rate displays will flash an abbreviated

alarm message, and the Information Display will display a message which indicates the cause of the alarm. The user will be given the option to display a screen suggesting steps to take to eliminate the problem. This alarm mode can continue since the NiCad backup battery on the main board will operate the backup alarm if the pump's main battery fails.

When the HOLD Key is pressed, the audible alarm is silenced and the system reverts to the Hold state. Once the cause of the alarm has been corrected, the infusion can be restarted by pressing the RUN Key. In the case of a few serious system alarms, which are indicated by the "Repair Instrument" alarm message, the instrument must be turned off and back on before RUN can be pressed.

In some cases where one or more of the processors fail or the battery is deeply discharged, the system might generate either a chiming or high-pitched tone which is the backup alarm, and the HOLD Key does not shut it off. In this case, pressing the POWER Key and possibly removing the AC power to shut off the pump will silence the alarm.

If the main PCB is removed while the backup alarm is still activated it can be deactivated by touching the two contacts on the front of the PCB as shown in Figure 5-1, Item 13.

6.0 CLEANING AND DISINFECTING

6.1 RECOMMENDATIONS

Clean the pump with a soft, lint-free cloth dampened (not saturated) or swab using any of the following recommended solutions:

Household Bleach and 90% Water

Isopropyl Alcohol

Warm Soapy Water

DO NOT allow fluids to enter the pump during cleaning and disinfecting.

Once the infusion pump is cleaned, **wipe the entire pump twice with fresh water** using a soft, lint-free cloth to remove all remaining cleaner/disinfectant. Then thoroughly dry the instrument with a soft, lint-free cloth.

To avoid mechanical damage, DO NOT use acetone, solutions containing glutaraldehyde, ammonium chlorides or abrasive cleaners on the instrument.

Please refer to the hospital's housekeeping, central service, or infection control department for further information.

WARNING: To avoid electrical shock, turn the pump off and disconnect it from the electrical outlet before cleaning.

WARNING: To avoid electrical shock, insure that the AC power connector is clean and dried thoroughly prior to connecting the power cord.

CAUTION: To avoid mechanical or electronic damage, DO NOT steam autoclave or immerse the pump in any fluids or cleaning solutions.

CAUTION: Sterilization of the pump using ethylene oxide (EtO) gas or Autoclaving is not recommended.

CAUTION: Do not clean the pump using high pressure devices.

7.0 PREVENTIVE MAINTENANCE AND REPAIR

7.1 PREVENTIVE MAINTENANCE PROCEDURES

Because preventive maintenance is preferable to waiting until an instrument fails to function, it is recommended that the procedures for preventive maintenance as described in the section titled "Procedures Not Requiring Case Disassembly" be performed every 6 months, while those procedures listed in the section titled "Procedures Requiring Case Disassembly" be performed once each year.

WARNING: Do not perform these procedures and/or tests while the Horizon Nxt is in patient vicinity or while in patient use. Failure to comply could result in bodily harm.

WARNING: If the product is partially or completely disassembled, or a component or assembly has been replaced or repaired, the unit must undergo and pass all performance checks outlined in Section 3.6 of this manual and the appropriate calibrations and or tests outlined in Sections 3.7 and 3.8 prior to use for patient care. All final performance testing and calibration of the Horizon Nxt must be performed with a set that is acceptable for patient use with an exception for set sterility only. Failure to do so may cause bodily harm and will void all warranties and liabilities.

WARNING: Shock Hazard. Prior to disassembling or performing service on the Horizon Nxt Pump, it is recommended that the pump be disconnected from the AC power source unless you feel it is specifically required for a particular test. If you find it necessary to have the device connected to an AC power source, use a line isolation transformer and caution. Failure to do so could result in bodily harm.

WARNING: Shock Hazard. The inside of the Horizon Nxt case has a conductive coating which is connected to ground through the power supply module. When servicing the Horizon Nxt, use caution to prevent accidental shorting to this coating. Failure to do so may result in component damage or even bodily harm if a line isolation transformer is not used when the AC power supply cord has not been disconnected.

7.2 EQUIPMENT REQUIRED

7.2.1 Hand Tools

Table 7-1 describes the hand tools necessary to disassemble and reassemble various parts of the Horizon Nxt Pump for checkout and repair.

Table 7-1: Hand Tools

Tool Description	Size	Application
1. Phillips Head Screwdriver	#1 and #2	General
2. Small Blade Screwdriver	1/8" and 1/4" wide	General
3. Socket Driver	3/8"	Power Supply and Main Battery Removal
4. Needle Nose Pliers		General
5. Feeler Gauge	0.008 inch, 0.016 inch	Inlet Solenoid Adjustment
6. Standard Pliers		General
7. GO - NO/GO gauge	P/N: 402069 (available in Kit #FZ0029)	Outlet Valve Yoke Adjustment

7.2.2 Test Equipment and Materials

Table 7-2 is a suggested list of test equipment and materials for checkout, calibration and troubleshooting the Horizon Nxt Pump.

Table 7-2: Test Equipment and Materials

Equipment Description	Size	Suggested Brand (or Equivalent)
1. Digital Voltmeter	n/a	Fluke
2. Burette & Support	10 ml, 50 ml	KIMAX
3. Syringe and Needle	1cc and 10cc, 20 gauge, 1 inch or less	Becton Dickinson & Co.
4. Pressure Gauge (optional)	0 - 20 psig	Dynatech Nevada 207 Digital Pressure Meter
5. Digital Scale (1 mg accuracy)	100 g capacity	Mettler PC440
6. Medical Device Electronic Safety Analyzer	n/a	Dynatech Nevada 231D Safety/ ECG analyzer

7.2.3 Consumables

Table 7-3 lists consumable materials necessary for cleaning and reassembly of the Horizon Nxt Pump.

Table 7-3: List of Consumables

Material Description	Suggested Brand (or Equivalent)
1. RTV 3140, P/N 145005	Dow Corning 3140 RTV
2. 70% Isopropyl Alcohol	n/a
3. High bond adhesive	Henkel Adhesives Corp. Sicoment 8300
4. Syringe and Needle	Becton Dickinson
5. IV solution container	B. Braun
6. Horizon IV set	B. Braun
7. Silicone Spray	CRC Heavy Duty Silicone (available at many hardware stores)
8. Clear Lithium Grease	Permatex Industrial Super Lube. Multipurpose Synthetic Lubricant with Teflon
9. Cotton swabs	Johnson & Johnson

7.2.4 Spare Parts

A spare parts kit, standardized or custom designed, is available to provide parts and assemblies routinely required to service the Horizon Nxt pump. Other non-generic Horizon Nxt parts may be ordered on an individual basis when required. These parts are listed in the Parts List in chapter 8. Common, generic parts (screws, nuts, wire, etc.) are more readily available from suppliers in your area. Therefore, these parts are not available for sale through B. Braun.

7.3 PROCEDURES NOT REQUIRING CASE DISASSEMBLY (6 MONTH)

7.3.1 Mechanical Inspection

7.3.1.1 Door Alignment Inspection

1. Make sure the door of the pump opens and closes easily, without binding, and that it is uniformly aligned with the bezel. The door latch allows the door to close completely.
2. The gap on each side and along the top of the door is symmetrical.

7.3.1.2 Switch Inspection

1. Push the POWER Key to turn the pump on.
2. Verify the functionality of all keys.
3. Make sure there are no visible punctures or distortions on the pump membrane panel.

4. Push the POWER Key again to turn the pump off.
5. Verify the key panel is securely adhered to the cosmetic bezel.

7.3.1.3 Pole Clamp Inspection

1. With the Pole Clamp in the unlocked position, it will slide easily up and down with a spring action and return to the narrow pole position. Lubricate with CRC Silicone spray as necessary.
2. Rotate the Pole Clamp lever counterclockwise to make sure the locking mechanism is intact.
3. Return any defective Pole Clamp assembly for free replacement.

7.3.1.4 Gasket and Hardware Inspection

1. All gaskets and seals are securely attached.
2. Valve tips are in place and in good condition.
3. The cover on the pressure transducer shall not have any rips, tears, punctures, or indentation marks.
4. All screws are tight and secure.
5. No cracks in the bezel or inner door face are present.
6. Air-in-line tube pusher is intact and securely mounted.
7. No cracks in the case or handle exist.
8. Inspect the power cord for nicks or cuts. Inspect the plug for bent or insecure prongs.
9. Petal covers should be routinely replaced at the 6 month PM.

7.3.2 Main Battery Capacity (optional)

CAUTION: Continuous deep discharge of the battery may cause damage to battery cells and lead to premature battery replacement.

1. To check battery capacity, charge the batteries by connecting the pump to AC power. Allow the batteries to charge continuously for at least 24 hours. The pump can be infusing during this time since the rate of charge is independent of the infusion process.
2. Once fully charged, set the pump to infuse at 125 ml/hr, a volume to be delivered of 375 ml, and a 300 mmHg occlusion pressure limit setting.
3. Begin the infusion.
4. In approximately 4 hours, verify that the "PLUG AC" warning flashes on the unused channel rate LEDs and a tone with increasing frequency, but no more frequent than approximately once every 5 seconds, activates prior to the infusion stopping.
5. Allow the pump to infuse until it stops infusing completely.

Note: Total battery operational run time is dependent on factors such as age, routine charging maintenance, and rate of infusion. As with other medical equipment, it is recommended that the main battery be replaced on a 24 month basis.

Note: We have found that sealed lead-acid batteries can occasionally be "rejuvenated" by a full discharge/charge cycle. For example, if your test results in a two hour infusion, then recharge the battery and test again. On occasion, the results can double. This assumes that

the battery is undamaged.

Note: When the pump is first powered up after having infused until the emergency backup alarm activates, a "SYS Err" message will be generated. This is normal and desirable since the pump recognized that a power down occurred without the POWER Key being pressed. Simply cycle the pump off then on again to clear the alarm. This event will be stored in the internal logs as alarm code number 123.

6. Prior to patient use, allow the pump to charge at least until the "Check Battery Level" feature in the USER MENU indicates "FULLY CHARGED." To access this feature: Connect the pump to AC power, power the pump on, press the MENU Key, press the CURSOR Key until the feature is highlighted, press the ENTER Key. At this point, the battery status will be displayed. This screen can be left up for as long as desired simply by opening the door, thereby disabling the Hold alarm. This will allow you to see when the battery status changes to "FULLY CHARGED." A "FULLY CHARGED" message indicates the battery is at least 95% charged.

7.3.3 Simulated Use and Performance Check

Test Procedure: Simulated Use and Performance Check

Please follow the steps outlined in Section 3.6.

7.3.4 Volume Delivery Accuracy

Equipment Required:

1. Distilled water in an I.V. fluid container
2. Horizon® Pump I.V. Set
3. Electronic Balance **or** Precision Collection Vessel
4. Needle or dispenser tip with a Luer Lock type connector

Test Procedure: Volumetric

1. Connect the fluid delivery set to the fluid container.
2. Attach the needle to the delivery end of the I.V. Set.
3. Completely prime the set with fluid so all the air is expelled from the set, and then close the roller clamp on the set.
4. Insert the I.V. set into the pump according to the instructions inside the door of the Horizon Nxt pump.
5. Close the door and press the POWER Key to turn on the pump.
6. Open all clamps and enter:

Table 7-4: Volumetric Test Values

Volume	Rate	Pressure	Acceptable Limit
10 ml	120 ml/hr	300 mmHg	9.5 - 10.5 ml or grams

7. Place the collection vessel on the balance (if used), zero the reading, and suspend the needle over the collection vessel.
8. Press the Run Key.
9. When the pump goes into the Keep Vein Open mode, press the HOLD Key immediately. Make sure the actual volume delivered is between the limits listed in Table 7-4.

Note: 1 ml = 1 cc = 1 g distilled water at room temperature (70° F)

10. Zero the reading on the balance. If the actual values are not within the Acceptable Limit listed above, test the pump with additional I.V. fluid delivery sets. If the values remain outside the specifications, return the pump to an authorized B. Braun Service Center.

Note: If using other accuracy test methods, in addition to the above, be sure to compensate for the adaptive energy processing used to conserve battery power and reduce noise as described in section 5.5.7.2 "Motor Controllers." This dynamic processing of resistance to flow will cause the motor energy to rise and fall at the beginning of an infusion (each time the pump transitions from the hold State to the run State). This results in several (varies with the system dynamics and rate) momentary pauses of the motor as the energy is changed during the first few delivery cycles after the RUN Key is pressed. Manufacturers of biomedical test equipment will supply you with written instructions for use of their equipment when testing I.V. pumps which employ this type of energy processing. While volumetric analyzers are different, typically all that is required is that you allow 5-10 milliliters of fluid to bleed from the system prior to starting the timer(s) or counter(s). A 3 way stopcock is very useful here. Contact the manufacturer of your volumetric analyzer to ensure proper software and testing procedures are used.

7.3.5 Electrical Safety Check

Equipment Required:

1. Medical equipment type electrical safety analyzer
2. AC power source

Test Procedure: Electrical

1. Plug the analyzer into an AC outlet.
2. Make sure the analyzer is functioning properly, according to your institution's protocol.
3. Plug the pump into the AC outlet of the analyzer.
4. Attach the probe to a single lead and touch it to the aluminum plate which supports the Daisy Chain

outlet on the side of the pump or any protruding metal component.

Note: If using a manual probe for your resistance checks you will need to make contact with either the metal frame of the power supply, located next to the Daisy Chain outlet, or the stainless steel door latch. Being stainless steel, the door latch makes for a difficult contact; you may need to scratch and scrape the probe on the latch.

5. Set the grounding selection to "No Ground."
6. Set the polarity to "Normal."
7. Press the POWER Key to turn on the pump.
8. Press the Chassis Leakage button and make sure the reading does not exceed the UL 544 or the IEC 601-1 specifications as indicated below.

Note: The measurement will be highest during the refill cycle of an infusion and will last only momentarily.

Note: As of the date this manual was written, the AC leakage current specifications for both UL 544 and IEC 601-1 is 100 microamps for patient vicinity equipment. When using the Daisy Chain feature on the Horizon Nxt (plugging one Horizon® or Horizon Nxt into another), the chassis leakage current is cumulative. Therefore, test all units connected as one system. The number of pumps interconnected at any time should not exceed the 100 microamp limit. This specification should also be considered when using extension cords with any medical electronic device. The extension cord will increase the leakage current for that device and may thereby compromise the electrical safety of that device.

9. Set the polarity to "Reverse."
10. Press the Chassis Leakage button again. Make sure the reading does not exceed the UL 544 or the IEC 601-1 specifications.
11. Press the HOLD Key.
12. Set the polarity to "Off."
13. Set the grounding selection switch to "Ground."
14. Press the Ground Wire Resistance button. Make sure the reading does not exceed the UL 544 or the IEC 601-1 specification.

Note: As of the date this manual was written, the ground wire resistance specification for a device with a non-detachable power cord for UL 544 and IEC 601-1 is 200 milliohms.

15. Press the POWER Key on the pump.
16. Repeat steps 8 - 14, skipping step 16, with the power off.
17. Disconnect the pump from the analyzer. Disconnect the analyzer from the AC power source.

7.4 PROCEDURES REQUIRING CASE DISASSEMBLY (12 MONTH)

If you have not been performing a battery capacity test during your 6 month PMs, it is recommended (but optional) that you include this test in your annual PMs. B. Braun recommends replacing any batteries older than one year. Due to the length of time required to perform the test, you may wish to test only those devices which are used in an environment that charges the batteries in an erratic and infrequent manner, allowing them to fully charge very rarely, examples of which would be the Operating Room, Emergency Room and Recovery Room. Also included should be those devices which are suspect of having limited battery life. Refer to the section titled "Main Battery Capacity" for testing instructions.

1. Remove the case top as described in Section 7.6.1.
2. Check all components on the main PCB to ensure they are securely in place and undamaged.
3. Remove the battery from its case and inspect for damage.
4. Recheck all connectors on the main PCB to ensure they are securely in place.
5. Visually inspect all hardware mechanisms on the Horizon Nxt to ensure that they are secure.
6. Reassemble the pump and perform those procedures as outlined in Section 3.6 of this manual and the appropriate calibrations and or tests outlined in Sections 3.7 and 3.8 prior to use for patient care.

7.5 REPAIR

It is the intent of B. Braun to allow the Biomedical Service Professional to repair and/or replace most of the subassemblies, which represents our present procedure with other infusion devices that we manufacture. We do, however, require the Biomedical Service Professional to be certified by attending a B. Braun Repair Training class. If you wish to repair the device yourself and have any questions regarding training classes, please contact an authorized B. Braun repair facility (see Chapter 9).

7.5.1 Biomed Menu Option

Entering the Biomed Menu on the pump:

1. Press the POWER Key.
2. Press the MENU Key.
3. Press the CURSOR Keys to select "Alternate Menu."
4. Press the ENTER Key.
5. Press the CURSOR Keys to select "Biomed Options."
6. Press the ENTER Key.
7. A screen displaying the 4-digit security code is displayed
8. The security code is dependent on pressing the correct whole number Volume to be Delivered Keys in the proper sequence. Do not use the tenths key. Each key is pressed only one time. The number is created randomly each time the screen is shown.

Note: The user is allowed three successive chances to enter the appropriate security code.

For example, the correct key press sequence for "3421" is:
Ones - 1st
Tens - 2nd
Thousands -3rd
Hundreds - 4th

7.5.1.1 Alarm and Operation Logs

The Alarm and Operation Logs are the most useful tools available for troubleshooting the Horizon Nxt Pump. The unique feature of the logs is that each time an event is stored in the log, it is time and date stamped. The Operation and Alarm Logs will each hold 255 entries (32 bytes each) which can be down-loaded to a PC as frequently as needed. The file size on the PC will be approximately 55 kilobytes once down-loaded. It is estimated that under normal use, the Operation Log will store approximately one month's worth of information and the Alarm Log will store approximately 3-4 months of information. The length of time it takes to fill the log depends upon how frequently the controls of the pump are manipulated.

Once the log is filled, the oldest event will be discarded and the new event will be appended to the end of the list, in a First In First Out (FIFO) fashion. A tremendous amount of information exists in the logs, the uses of which are limitless. Several examples will be described below, but many more exist. Once familiar with the logs, they will become an invaluable diagnostic and troubleshooting tool. It is recommended that you familiarize yourself with the pump's operations by reading the included operation manual. While reading, have a pump nearby for experimentation. Once you have familiarized yourself with the pump, download the Operation Log and note how easy it is to repaint a picture of past usage.

The Alarm Log is similar to the Operation Log in many ways. The primary difference being that it stores the last 255 alarms instead of operations and therefore will hold approximately 3-4 months of alarm history. The Alarm Log is useful for giving a quick look at the alarm history versus having to wade through all of the user operations. The Operation Log holds all events, both alarm and user operations. It offers you the ability to view the use history of the device, thereby verifying that rates and volumes had indeed been entered as intended as well as determining those sequence of events that proceeded some particular alarm. When identifying the time of an event occurrence, first verify the time of day clock has been properly set by checking the "Review Time and Date" option in the Biomed Menu. If it has not; simply adjust it accordingly and add or subtract that amount of time from the log to determine the actual time of the event.

Note: When receiving a new pump or one which has been serviced, the logs will still have entries in them. There is no method to clear the logs of information. Since the device is tested for functionality prior to leaving the service facility or factory, these alarm entries will remain in the log.

If you download the logs on a regular basis and wish to save this information for future reference, a tremendous amount of disk space can be saved if you use a file compression utility on the files. Without compression you will only be able to store approximately 200 operation logs per 10 Megabytes of disk space. File compression, can reduce the amount of disk space required by approximately 85%, from 10 Megabytes down to 1.5 Megabytes. Many varieties of compression utilities are available from your local software dealer or through shareware. Please keep in mind that a certain amount of risk is involved when you alter the files and B. Braun shall not be responsible or liable for the loss or corruption of data.

To receive the file onto your PC, you will need to obtain a communications link that attaches to the back of the Horizon Nxt which serves to translate the IR signals into standard RS-232 voltages. This link will come with a 9 pin male cable, and can be connected to any standard comm port. If you do not have a free 9 pin port, simply attach a 9 to 25 pin convertor. This will allow you to connect the

link to 25 pin ports also. Most any PC communications package can be used to receive the pump's log information. The information can also be sent directly to a printer; in this case you will need refer to the printer's manual for serial port configuration DIP switch settings. Since the information is sent at such a high BAUD rate, the speed of the printer will need to be fast and it will need to have a sizeable buffer, such as 32 Kilobytes. The entire log will be transmitted in approximately 90 seconds.

Communication settings: 9600 Baud, no parity, 8 data bits, 1 stop bit

See APPENDIX C: Operation Log for examples of Operation and Alarm Logs.

7.5.1.2 Check Configuration and Software A/D Offset

This feature allows you to check the current software revisions in the device. It is recommended that you have this information available when communicating a problem to customer service representative. A definition of the display is as follows: MP = Management Processor, PP = Pump Processor, DP = Door Processor. Each is followed by the present revision level. Each processor may have a different revision level.

To test the software A/D pressure transducer offset value, you will need to install a fully primed cassette in the pump and begin an infusion. Then press the MENU Key until at the bottom of the USER MENU. Cursor up to select "Biomed Options" and press the ENTER Key. Press the MENU Key then cursor down to select "Check Configuration," and press the ENTER Key. With the software configuration information displayed press the down arrow CURSOR Key. The value displayed should be between 0 and 50 with a typical reading of 10-12. If the value is outside of these parameters refer to Section 7.7.1.1 for additional testing instructions.

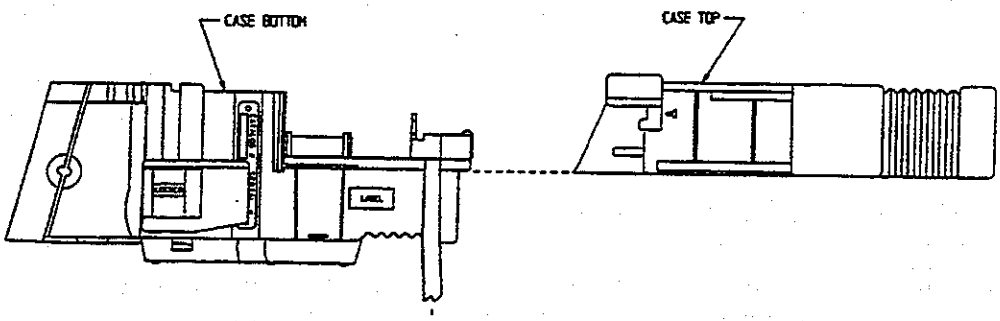
7.6 DISASSEMBLY AND REASSEMBLY INSTRUCTIONS

The pump should be tested as defined in Section 7.4 "Procedures Requiring Case Disassembly (12 month)," following calibration or adjustment of any of the following items.

Note: It is good practice to wear eye protection while servicing the pump, especially during assembly and disassembly operations.

7.6.1 Case Halves

Figure 7-1: Case Half Separation



Removal:

1. Turn the pump off and disconnect from AC power source.
2. Locate the two quarter-turn screws on the back of the device. Turn each screw one quarter turn counterclockwise.
3. Unlock the Pole Clamp lever and pull it down to the bottom most position. Lock it in the open position by simultaneously applying a light pressure against the inside portion of the outer clamp jaw and turning the clamp lever in the counterclockwise direction. The final position of the clamp should be as in Figure 7-1.
4. Locate and remove the small Phillips flat head screw on the case top near the top of the Pole Clamp mechanism. See the Figure 7-1 or Figure 2-3.
5. Check to insure the Daisy Chain AC outlet door is closed and that the AC electrical cord is pulled in the downward direction.
6. Gently, yet firmly, slide the case top toward the rear of the pump.

Installation:

1. Refer to Figure 7-1 for a side view of how to position the case halves and AC power cord prior to assembly.
2. Look at the rear of the case bottom and note the small grooves, one on each side. These grooves are the channels that the case top will slide in. Place the case bottom on your work surface with the front facing yourself. Allow plenty of clear space above and behind the pump.
3. The AC power cord should be draped down beneath the pump.
4. The Daisy Chain door should be closed.
5. The Pole Clamp should be locked in the bottom-most position.
6. The Main PCB should be mounted flush against the case bottom mounts and all connectors secure.
7. Position the case top as in Figure 7-1. Carefully engage the left groove and begin to slide the case top forward towards yourself while holding it level with the case bottom. The right groove will engage next at which point the top may hang. Make sure the AC power cord remains draped out of the way and that the right groove has properly engaged. DO NOT force the top into place! If excessive force is used, damage may occur (usually the fuses go first).
8. The next point of resistance will probably be caused by the Main PCB. Reach your thumb up underneath the rear of the case top and hold down the rear edge of the Main PCB. Slide the case top forward until past this point. Release your thumb from the Main PCB.
9. Continue to slide the case top forward until the front edge of the case top meets the gasket on the top of the bezel. While pulling the left side of the case top forward press downward and forward on the top right side of the case top. This will ensure that the right side of the case top locks into the mounting hooks on the pole clamp.
10. Tighten the two turn screws on the back of the pump and the Phillips flat head screw as indicated in Figure 2-3. If the latter Phillips flat head screw does not thread, the mounting plate may need to be resecured. To do this, slide the case top back 2 to 3 inches and locate the metal triangular shaped mounting plate on the right side near the Pole Clamp. Check that it is aligned such that the screw will thread. If not, reattach with epoxy and reinstall the case top.

7.6.2 Pole Clamp

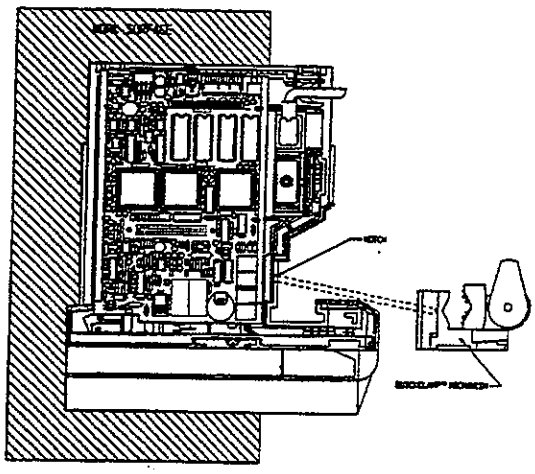
Removal:

1. Remove the case top.
2. Position the pump on your work surface as pictured. Be sure there is plenty of free space for the Pole Clamp to drop from the case bottom.
3. Locate the notched tab on the top of the Pole Clamp, see Figure 7-2. With a small flat blade screw-driver, gently clear the tab from the notch and push the Pole Clamp assembly downwards and away.

Note: It may be necessary to tap the Pole Clamp free.

4. Be sure not to lose the spring and guide wheel on the Pole Clamp mechanism as you separate it from the case bottom.

Figure 7-2: Pole Clamp Placement

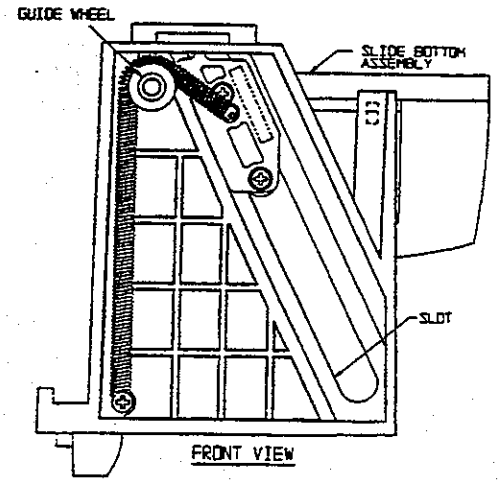


CAUTION: Actuating the Pole Clamp while detached from the pump can cause the spring's guide wheel to fly off.

Installation:

1. Be sure the spring is positioned around the guide wheel as pictured. This can be done by first attaching the spring to the screw, lower left screw in Figure 7-3, then slip the spring over the pin attached to the slide assembly.
2. Place the guide wheel against the spring and pull the wheel over the shaft.
3. Insert the Pole Clamp assembly into the case bottom by positioning the bracket such that it slides up through the bottom of the pump and locks in place.
4. Inspect the retaining tab on the top of the clamp mechanism making sure it is securely fitted and locked into the notch.

Figure 7-3: Spring Placement



7.6.3 Management and Pump Processor EPROMs and Fuses

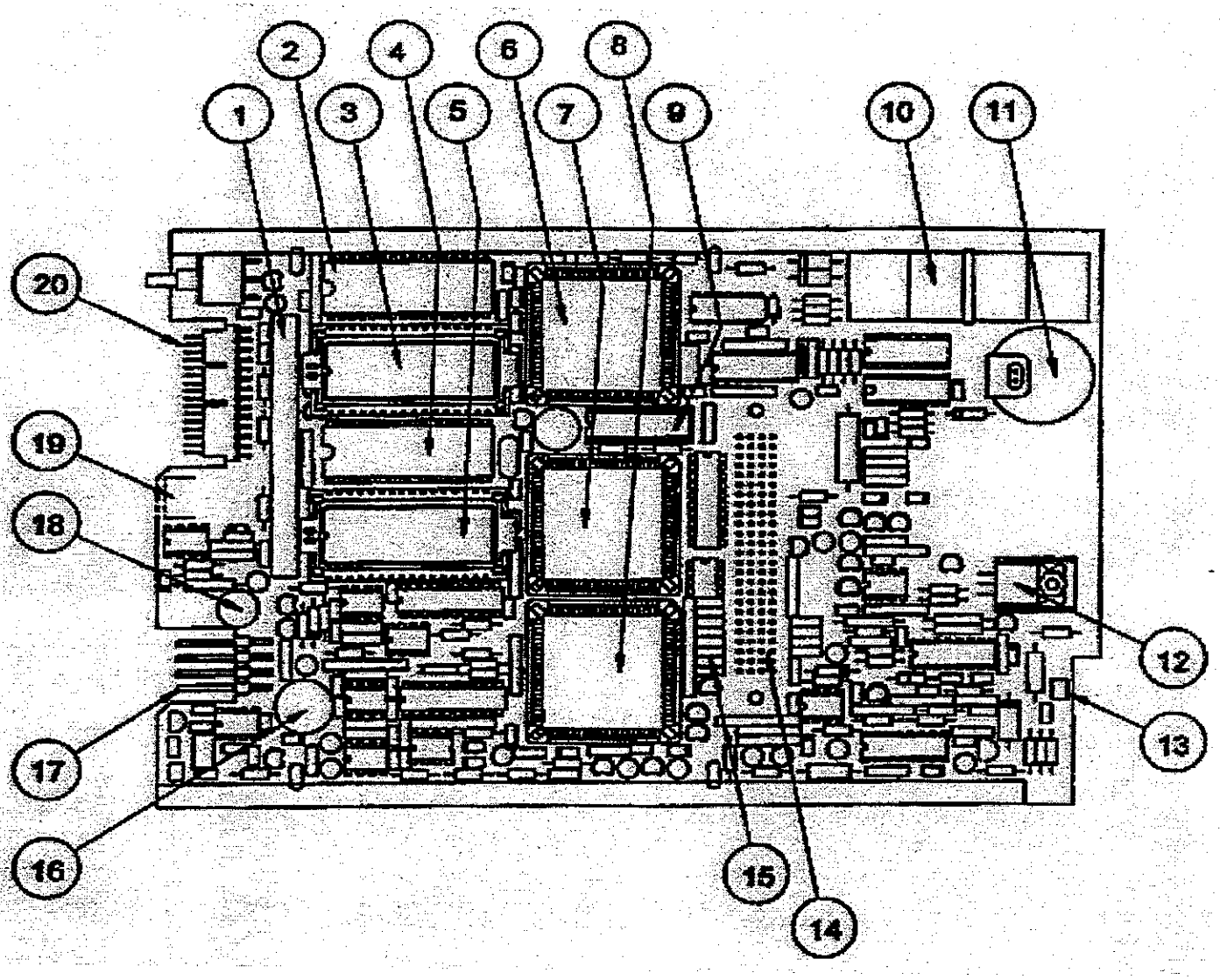


Figure 7-4: Main PCB and EPROM Removal

1. Option Board Connector
2. Pump Processor memory
3. Pump Processor EPROM
4. Management Processor Memory
5. Management Processor EPROM
6. Pump Processor, 80C537
7. Management Processor, V25PLUS
8. ASIC
9. EPLD
10. 4.8 Volt NiCad Battery
11. 3.0 Volt Lithium Battery
12. Main Battery Charger
13. Touch Switch for manual turn off
14. Bezel/Door Connector
15. Motor Drivers
16. Backup Alarm
17. Main Battery Connector
18. Fuse 2, Main Battery Switching
19. Fan/Speaker Connector
20. Power Supply Connector

Note: It is good practice to treat all ICs as if they were Static Sensitive devices. It is recommended that a static discharge device and handling methods be employed when servicing this device.

Removal:

1. Remove the case top.
2. Attach a static discharge device such as a wrist band connected to ground as per the device manufacturer's instructions. When transporting or storing the EPROMs, static free packaging is recommended.

CAUTION: If you will be working on the main board with the EPROMs removed, it is strongly recommended not to power up the Main PCB. Otherwise, the ASIC can power up with one or more of the motor windings permanently enabled, and cause them to overheat.

3. Locate the two EPROMs in the middle portion of the Main PCB, Item 3 and 5 of Figure 7-4. Using a nonconductive material, pry the chip carrier tabs away from the Main PCB and remove.
4. If the plastic IC carrier is broken, obtain a replacement from the factory.
5. The EPROMs can only be inserted one way so long as the plastic chip carrier is intact. Refer to Figure 7-4 for the location on the Main PCB.

7.6.4 Main Board

Removal:

See Figure 7-4.

1. Remove the case top.
2. Disconnect the three connectors from the rear of the Main PCB. J2 is the 15 pin power supply connector, Item 20. J4 is the 4 pin fan and speaker connector, Item19. J3 is the 4 pin battery connector, Item17.
3. Grasp each side of the Main PCB and with a firm gentle rocking motion pull the Main PCB up.

Installation:

1. Place thumbs on either side of the Main PCB and press the Main PCB onto the 100 pin mechanism connector.
2. Place the connectors onto the Main PCB as follows:
   - •Main battery connector into J3.
   - •Fan/Speaker connector into J4.
   - •Power supply connector into J2.

7.6.5 Main Battery

Removal:

1. Remove the case top and Main PCB.
2. Unfasten the self locking nut with a 3/8" nut driver.
3. Remove the nut, retaining plate, and green door latch ground wire.
4. Lift and remove the bracket and battery.

Installation:

1. The power supply should be in place. Inspect the battery for any damage.
2. Place the battery wires against the surface of the battery.
3. Slide the battery bracket over the battery.
4. Hook the battery bracket's tabs onto the power supply mounts, and lower the battery and bracket into place.
5. Place the battery bracket mounting plate (rectangular metal washer) over the threaded bolt protruding up from the power supply through the battery case.
6. Place the green door latch ground wire followed by the nylon threaded nut onto the protruding power supply bolt and tighten until secure.

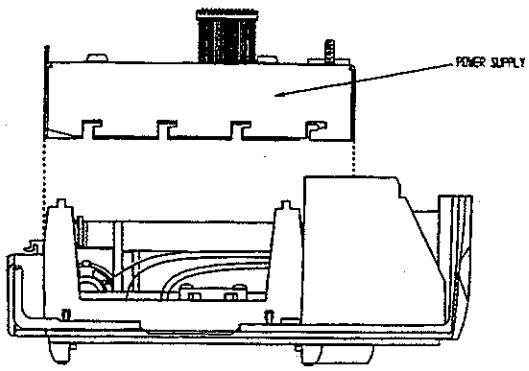
Note: It is recommended that new batteries must be charged for 24 hours prior to being used on patients for transport.

7.6.6 Power Supply

Removal:

1. Remove the case top, Main PCB, and battery.
2. Remove the AC electrical cord by pulling up on the three prong connector inside the case bottom.
3. Lift and remove the plastic Daisy Chain frame from the Daisy Chain outlet. Note its orientation.
4. Grasp the sides of the power supply and slide it sideways toward the Pole Clamp side of the instrument. This will detach it from the case bottom.
5. Lift and remove the power supply.

Figure 7-5: Power Supply Removal



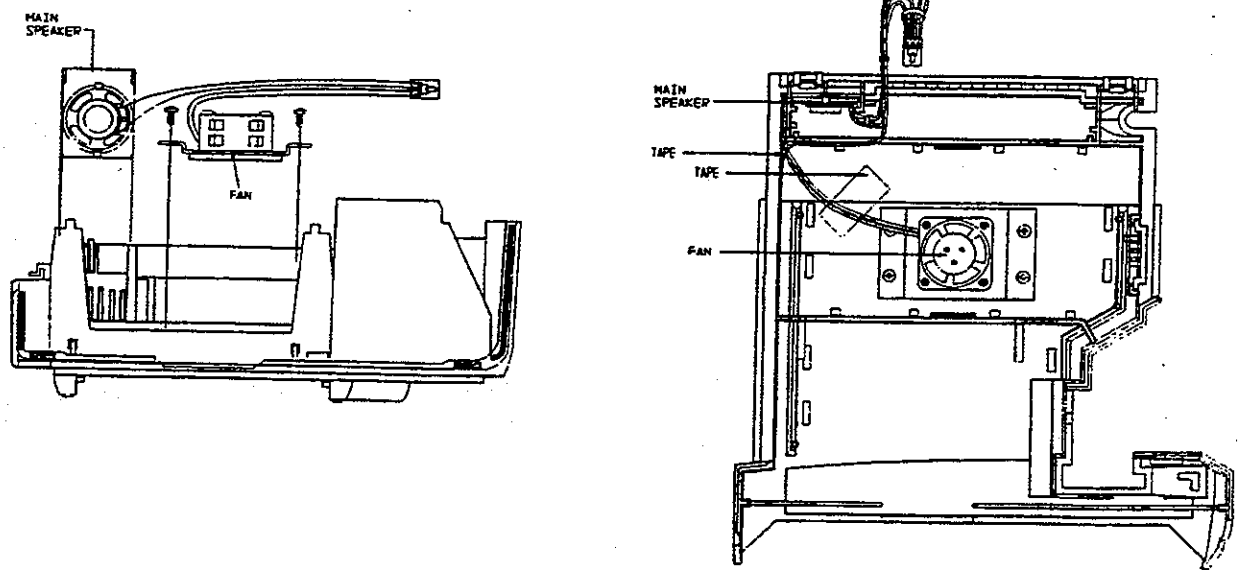
Installation:

See Figure 7-5.

1. Position the case bottom on your work surface such that the inside is visible.
2. Make sure the fan is properly positioned and secure to the case bottom.
3. Locate the eight hooks protruding from the inside of the case bottom, near the middle.
4. Locate the eight notches in the bottom of the power supply.
5. Position the power supply as in Figure 7-5 and lower it onto the hooks in the case bottom.
6. Secure the power supply by sliding it from right to left, as viewed from the front of the pump.
7. Verify the position by attempting to lift (by hand) the power supply out of the case bottom prior to disengaging it from the hooks. You should not be able to lift the power supply out by hand without first disengaging by sliding it from the left to the right.
8. If the power supply is not secure, remove and check for obstructions or broken components. Verify that the black and white wires connected to J1 inside the power supply housing are pressed against the power supply case. The open area in the middle of the board allows clearance space for the fan assembly.
9. Replace the Daisy Chain door frame clip. If the frame does not fit, engage the power supply more tightly onto the case bottom hooks by sliding it away from the Daisy Chain outlet. Do not force the frame into place.

7.6.7 Cooling Fan and Main Speaker

Figure 7-6: Fan and Speaker Placement



Removal:

1. Remove the case top, Main PCB, battery, and power supply.
2. Locate the fan in the middle of the case bottom and remove the four retaining screws that hold the fan in place.

Note: Note the location of the tape holding the fan wires in place. It is important to replace this tape and route the wires correctly to prevent the power supply case from damaging the wires.

3. Locate the Main Speaker in the rear most portion of the case bottom. Remove the plastic retainer bracket by using a small flat blade screwdriver to push up on the corner tabs.
4. Remove the fan and speaker assembly.

Installation:

See Figure 7-6.

1. Slide the speaker into the retaining bracket from the side.
2. Insert the retaining bracket into the left rear most corner of the case bottom. Make sure the right and left side tabs slide behind the case bottom ridges. Push the assembly down and check for movement of the speaker. If the speaker moves, adjust and push down the retaining clip.
3. Fasten the fan and gasket to the case bottom with four retaining screws.
4. Secure the fan wires to the case bottom with polyester tape.

7.6.8 Petal Cover

Removal:

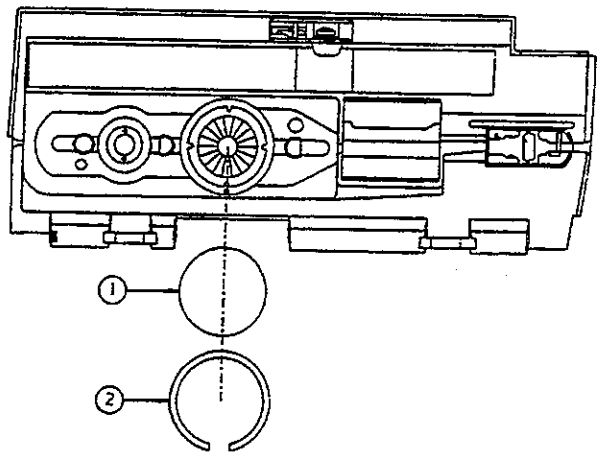
See Figure 7-7.

1. Position the pump with the door facing you. Open the door until the face is flat on the work surface.
2. Using the small flat blade screw driver, gently pry loose the black plastic snap ring (2) that holds the petal cover in position.
3. Remove the petal cover. (1)

Installation:

1. Attach the petal cover over the petal module as shown. The concave portion should be facing the petal module.
2. Snap the petal cover retaining ring in place.

Figure 7-7: Petal Cover



7.6.9 Half Door/Bezel Assembly

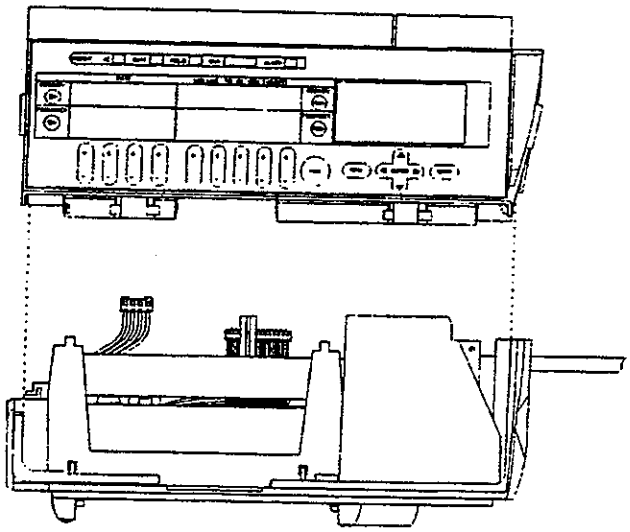
Removal:

1. Remove the case top and Main PCB.
2. Remove the green door latch grounding wire by removing the nylon threaded nut from the power supply bolt.
3. With the door closed, grasp the half door/bezel assembly near the center. Lift the half door/bezel up and out from the case bottom.

Installation:

1. Place the case bottom on your work surface such that the channel guides nearest the front of the case bottom are easily visible. Usually this is with the front facing yourself and the case feet touching the work surface.
2. Locate the grooves on each side of the half door/bezel assembly that run parallel to the face of the bezel.
3. Hold the half door/bezel assembly in both hands. Position the grooves in the half door/bezel assembly over the two channel guides in the case bottom. Allow the unit to slide down into the case bottom taking care NOT to force the fit. The fit should be snug with the top of the channel guides and flush with the top of the grooves.
4. View the assembled unit from the top making sure the half door/bezel assembly is not misaligned in the case bottom. The half door/bezel assembly grooves should fit squarely onto the channel guides. If not, remove and check for any obstruction, then reinstall.

Figure 7-8: Half Door/Bezel Assembly Removal



7.6.9.1 Air-In-Line Assy.

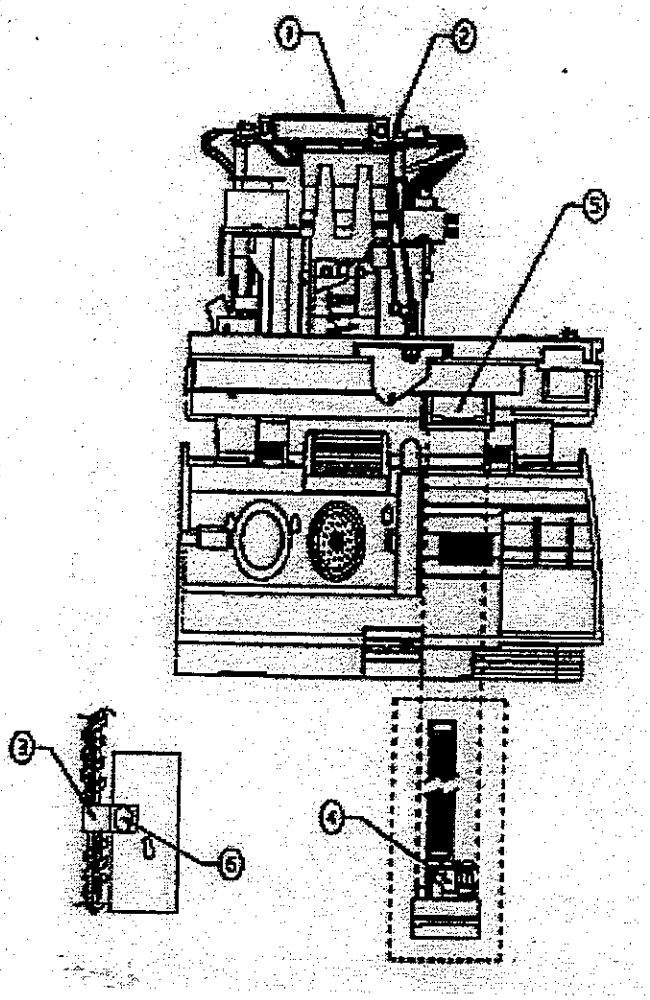
After replacing the air-in-line assembly, check out the assembly for proper operation. Refer to Section 3.6, Table 3-2, Steps 14-17.

Removal:

See Figure 7-9.

1. Disconnect J5 (Air-In-Line) 10-pin ribbon cable connector from header (1) on the Interface PCB (2).
2. Remove the cable clamp (3) from the Air-In-Line ribbon cable.
3. Open the door on the half door/bezel assembly.
4. Use a small flat head screwdriver to press on the two Air-In-Line retaining clamps (4) from the back of the bezel assembly and push the Air-In-Line assembly toward the door and remove the Air-In-Line assembly from the half door/bezel assembly.
5. Clean the RTV silicone rubber coating around the Air-In-Line area on the bezel assembly (5).

Figure 7-9: Air-In-Line



Installation:

See Figure 7-9.

1. Apply the new RTV silicone rubber coating, B. Braun P/N 145005 (Dow Corning 3140 RTV), around the opening in the bezel for the Air-In-Line assembly.
2. Install the Air-In-Line assembly into the bezel assembly. Use a small flat head screwdriver to snap the two Air-In-Line retaining clamps in place.

CAUTION: Air-in-Line retaining clamps can break with excessive force.

3. Clean excessive RTV silicone coating around the edge of the Air-In-Line area (5), if any.
4. Connect the Air-In-Line 10-pin ribbon cable connector to header J5 on the Interface PCB (1). Make

sure that pin 1 (indicated by an arrow head) on the 10-pin ribbon cable connector and pin 1 on header J5 on the Interface PCB are properly aligned.

5. Gather loose wires from the Air-In-Line assemblies and position in the cable clamp (6). Align the cable clamp with the hole in the restriction bracket and install the nylon snap rivet.

CAUTION: Take care not to allow RTV into the tubing channel of the Air-In-Line assembly.

7.6.10 Cosmetic Bezel

If you are going to simply be checking connections inside the door, or removing the cosmetic bezel or LED/LCD PCBs, do not remove the door at the hinges.

Removal:

1. With the door closed, position the pump flat on the work surface facing yourself. Rotate the pump upside down and remove the three Phillips head screws on the bottom of the door.
2. Remove the cosmetic bezel by prying the snaps along the top. Carefully disconnect the ribbon cables from the LED PCB.

Installation:

1. Connect the ribbon cable to the LED PCB.
2. Slide the cosmetic bezel over the door.
3. Install the three Phillips head screws into the bottom of the cosmetic bezel.
4. Snap the top of the cosmetic bezel into place.

7.6.11 LED Display/LCD Controller PCBs

Removal:

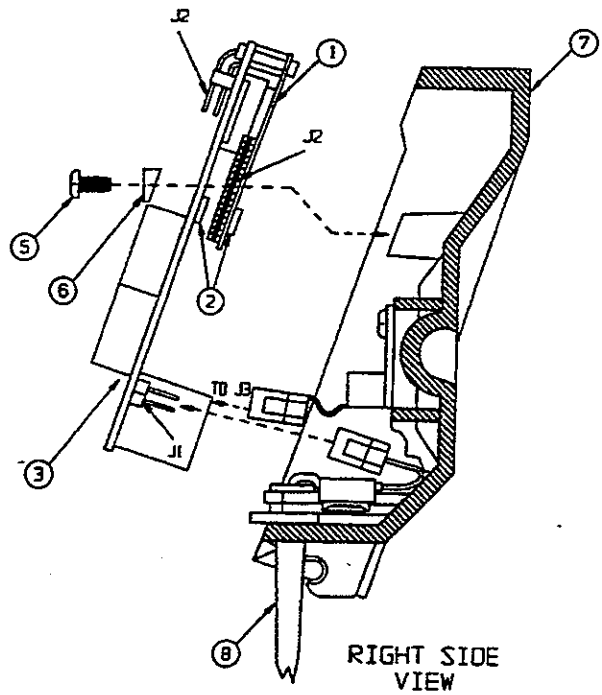
1. Remove the cosmetic bezel (see previous page).
2. Locate and remove the single Phillips screw in the center of the LED display PCB and note the orientation of the angled washer. Now pull the PCB forward.
3. Disconnect J2 (LCD) first then J3 (pressure transducer) and J1 (door cable).

Installation:

See Figure 7-13.

1. The LCD board, door cable, tube pusher, LCD controller board and pressure transducer board should already be installed.
2. Plug the cable from the LCD board into J2 of the LCD controller board (1). Visually check the top and bottom edges of the connection, making sure it is correctly attached.
3. Plug the door cable (8) into J1 on the LED display PCB.
4. Plug the pressure transducer cable onto J3 of the display board.
5. Verify that the LCD controller board (1) is firmly connected to the LED display board (3) by squeezing the two installation connections together one final time.
6. Prior to installing the mounting screw (5), align the PCB to the left, up against the two ribs inside the door. Look through the screw hole in the center of the board and verify that the board comes into firm contact with the screw mount when you press the board downward into place. If the board is not fitting into position, it is most likely caused by door cable or pressure transducer cable interference. Both of these cables need to be folded properly downwards into the door. The pressure transducer cable folds down beneath its board into the door cavity.
7. Now, while holding the LED Display board in position, snug the mounting screw tight onto its wedge washer (6).

Figure 7-13: LED Display Board



7.6.12 LCD PCB

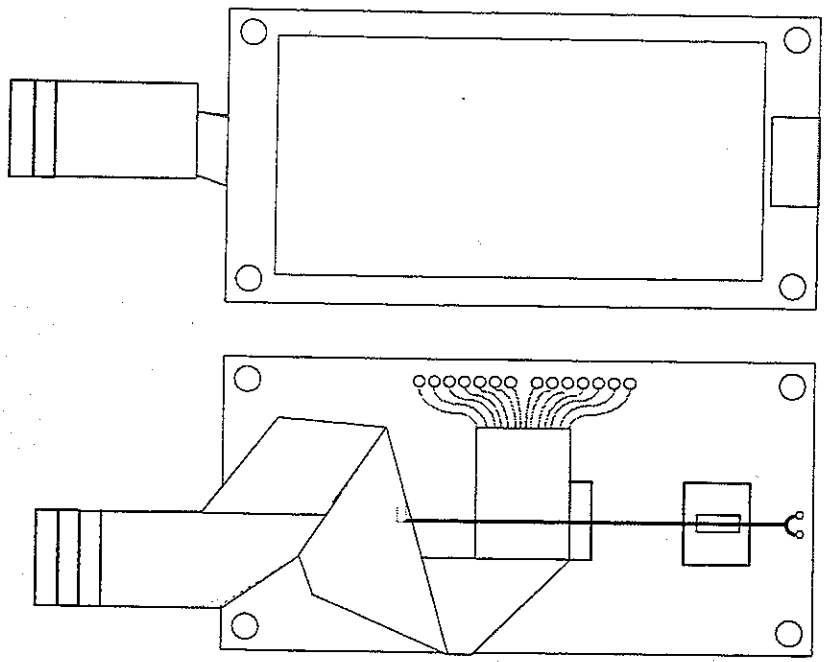
Removal:

1. Remove the cosmetic bezel.
2. Remove the LED PCB.
3. Remove the four Phillips screws located at each corner of the LCD PCB.
4. Disconnect the ribbon cable from the LCD controller PCB (J2) and remove the LCD.

Installation:

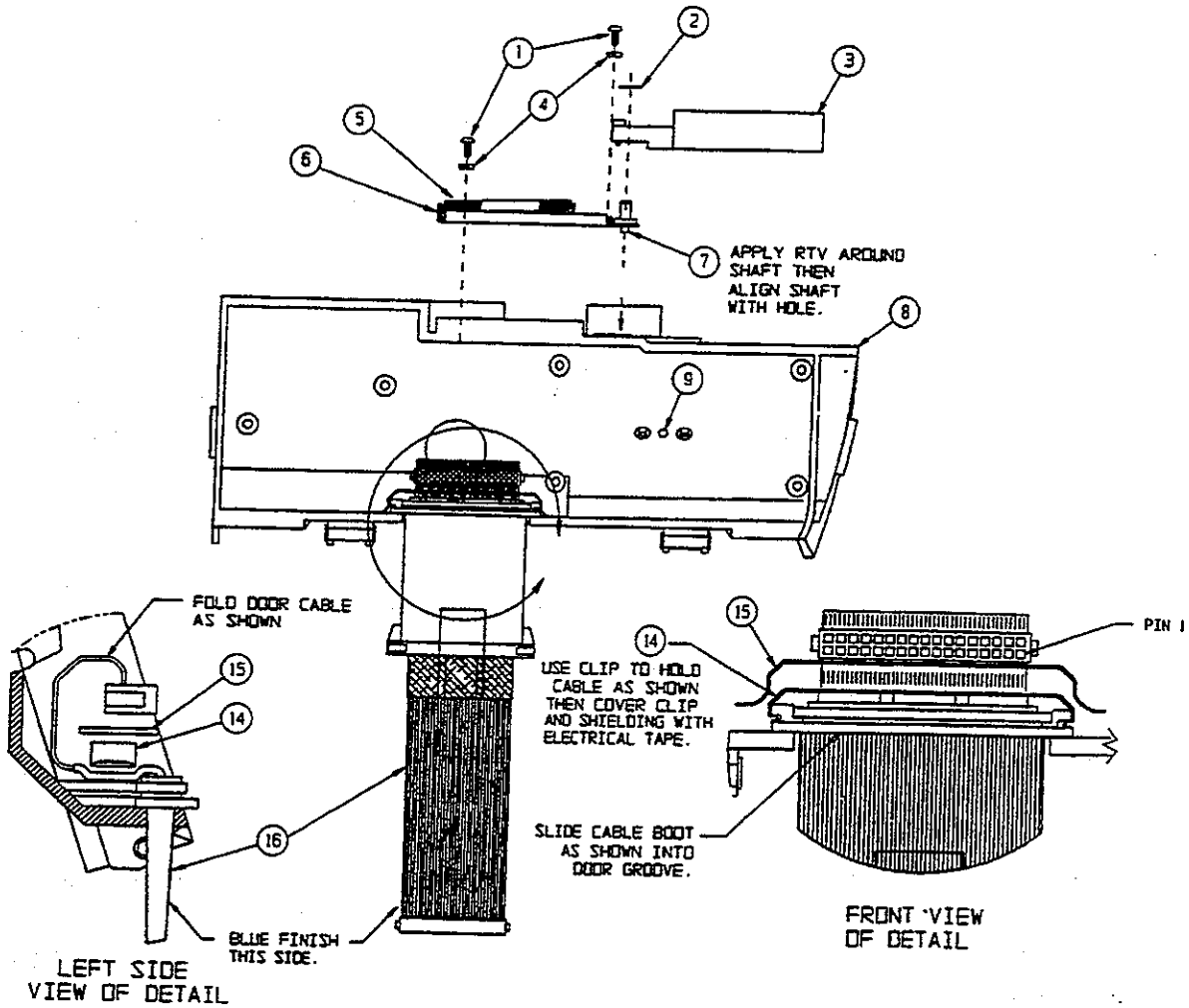
1. Be sure the tube pusher, Item 11 in Figure 2-5 is installed in the door and is functioning with a spring movement.
2. Be sure the door spring seal is properly in place.
3. Be sure the ribbon cable is not pinched between the mounting post and the PCB as the cable may short to chassis ground thus causing the LCD to function erratically.
4. Attach the LCD to the door with four screws (5) and angled washers (6) as shown. Snug the screws tight, if overtightened the PCB will crack near the screw hole.

Figure 7-14: LCD PCB, Front and Rear



7.6.13 Door Lever

Figure 7-15: Door Lever



Removal:

See Figure 7-15.

1. Remove the cosmetic bezel.
2. Remove the E-ring from the door lever shaft and lift the lever off.

Installation:

1. Slide the door lever (3) onto the door lever shaft.
2. Attach the E-Ring clip (2) into the shaft groove.
3. Move door lever back and forth to assure ease of movement.

7.7 CALIBRATION, ADJUSTMENTS, AND SPECIFIC TESTS

The pump should be tested as defined in Section 7.4 "Procedures Requiring Case Disassembly (12 month)," following calibration or adjustment of any of the following items.

7.7.1 Electronic

The circuitry of the pump has been designed without adjustable components and thus it does not require calibration.

7.7.1.1 Testing the Pressure Transducer A/D Offset (Occlusion Verification)

To test the software A/D pressure transducer offset value, you will need to install a fully primed cassette in the pump and begin an infusion. Allow the pump to run one minute minimum into the KVO mode. Then place the pump on the Hold mode. In the Menu system, use the cursor to select "Biomed Options" and press the ENTER Key. Enter the BIOMED code and press the ENTER Key. Press the MENU Key, then cursor down to select "Check Configuration." Press the ENTER Key. With the software configuration information displayed, press the down arrow CURSOR Key.

The value displayed should be between 0 and 50 with a typical reading of 10-12. If the value is outside of these parameters, continue with additional testing.

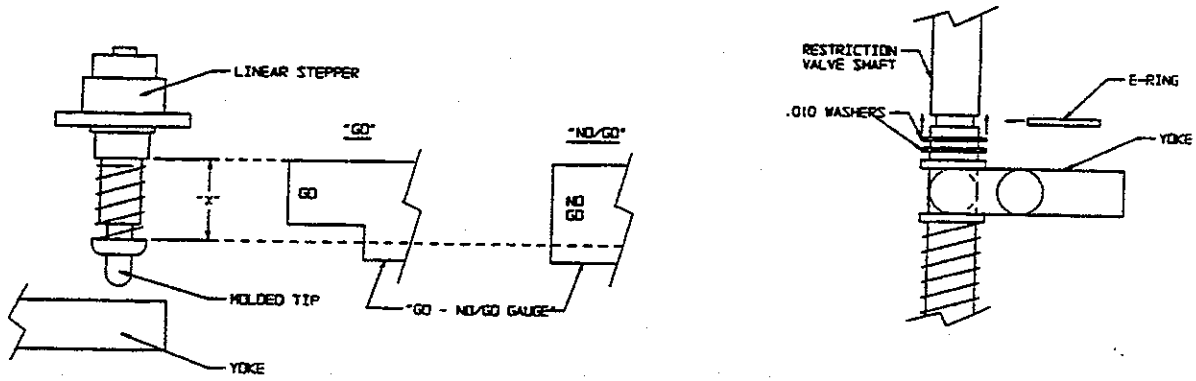
1. Disconnect from AC power and remove the case top.
2. Power the pump on.
3. Using a voltmeter, test pin 64 of J1 (mechanical interface connector) on the main PCB. With no pressure other than ambient pressure, the value should read between 50 and 600 mV. With a typical value in the 500 mV range. At higher elevations, the typical value will be less.
4. Brush your finger over the pressure transducer in the door to verify that the voltage increases as pressure is applied and returns to the previous no applied pressure value.
5. Replace the half door/bezel assembly if the voltage values or response are different from that described.

7.7.2 Mechanical

7.7.2.1 Restriction/Outlet Valve Yoke Adjustment

Perform whenever the restriction motor is exchanged. Also needed for false downstream occlusion alarms, as well as alarm codes #7 and #137.

Figure 7-16: Restriction/Outlet Valve Adjustment



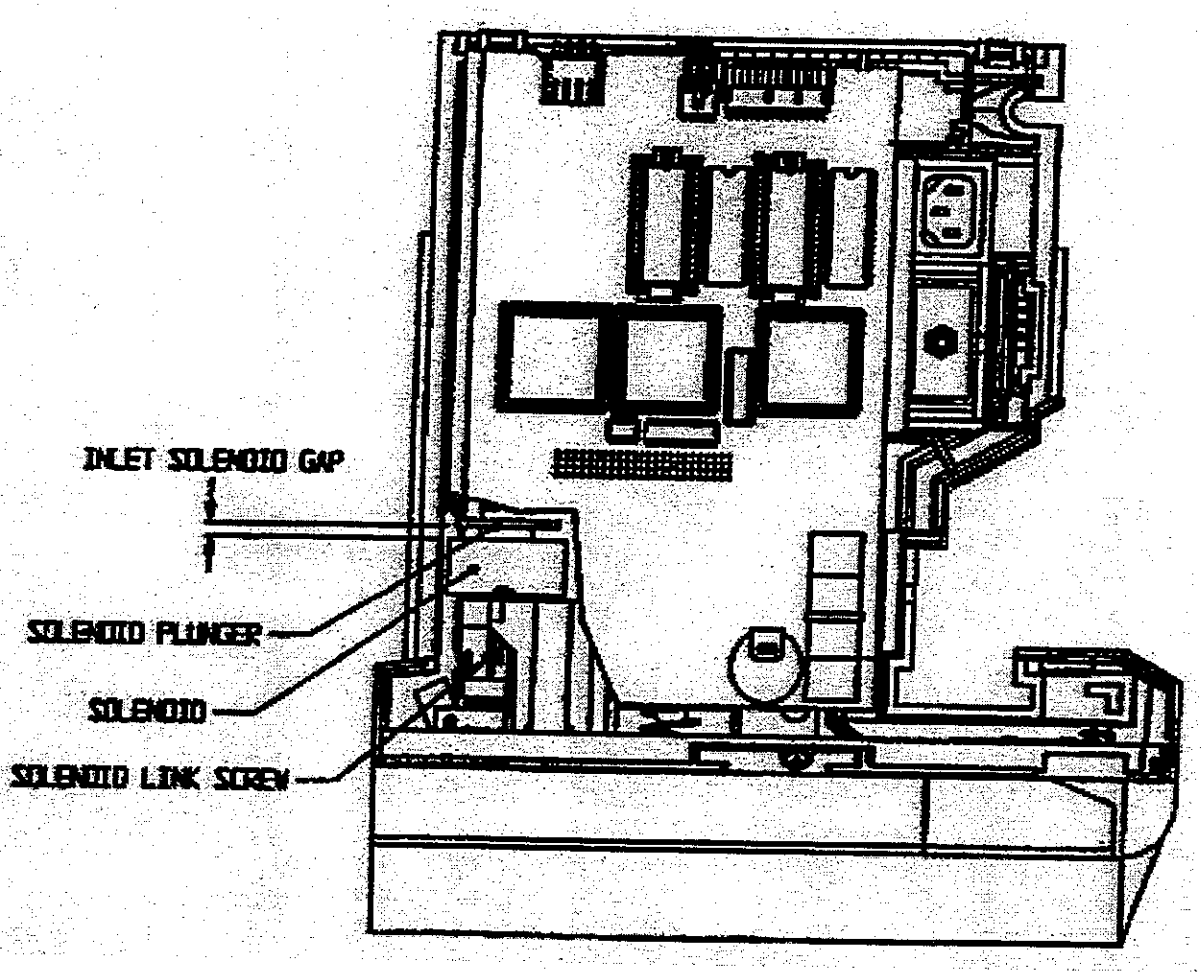
1. Remove the case top.
2. Install a fully primed new (less than 72 hours old) cassette into the pump.
3. Power on and run the pump for two cycles at a rate greater than 500 ml/hr.
4. Press the HOLD Key.
5. Do NOT open the door.
6. Power the pump off.
7. With a firm gentle rocking motion, disconnect the Main PCB from the Main PC connector. Flip it backwards out of the way.
8. Check the adjustment using tool #402069. The GO side of the gauge should fit between the shoulder on the linear motor and molded tip, marked "X" on Figure 7-16. The NO/GO side should not fit. If this is true, then no adjustment is needed. But, if the GO side does not fit, go to step 9. If the NO/GO side does fit, then adjustment is necessary; go to step 10.
9. If the GO side of the gauge will not fit then move one 0.005" nylon washer to the other side of the E-ring. This is done by removing the E-ring and moving one of the 0.005" washers above E-ring groove. Then reinstall E-ring and repeat steps 1-8.
10. If the NO/GO side of the gauge fits between the Linear/Restriction motor shoulder and molded tip, then a 0.005" washer should be moved to the other side of the E-ring. This is done by removing the E-ring and moving one of the 0.005" washers that are above the E-ring groove to below groove. Reinstall the E-ring. Then repeat steps 1-8.

Note: To relieve the spring force on the E-ring, open the door and press on the outlet valve tip.

7.7.2.2 Inlet Solenoid Adjustment

Perform whenever a half door/bezel assembly is exchanged or repaired. Also needed for false or lack of downstream occlusion (OCCL) alarms and false or lack of empty container (SOLU) alarms.

Figure 7-17: Inlet Solenoid Adjustment



1. Loosen the screw which tightens the molded solenoid link to the solenoid plunger thread, just enough so that the solenoid plunger, the circular disk on rear of solenoid, is free to turn.
2. With a primed set in place, power on the pump and begin an infusion at some rate greater than 500 ml/hr.
3. Use the inlet solenoid gap (feeler) gauge (P/N 398268 or equivalent) to verify the minimum gap between the solenoid and plunger is 0.011-0.014 inches. Measure when the plunger engages. If required, press the HOLD Key then rotate the plunger in small increments and restart the infusion. Then recheck the gap. Repeat this until the gap requirement is met.
4. Tighten the screw on the solenoid link to lock the plunger into position.

CAUTION: Overtightening the solenoid link screw can break the solenoid link. Tighten only enough to prevent the solenoid plunger from rotating.

5. The pump must now be completely tested (see Sections 3.6, 7.3.4, and 7.3.5).

8.0 PARTS LISTS, SCHEMATICS AND DRAWINGS

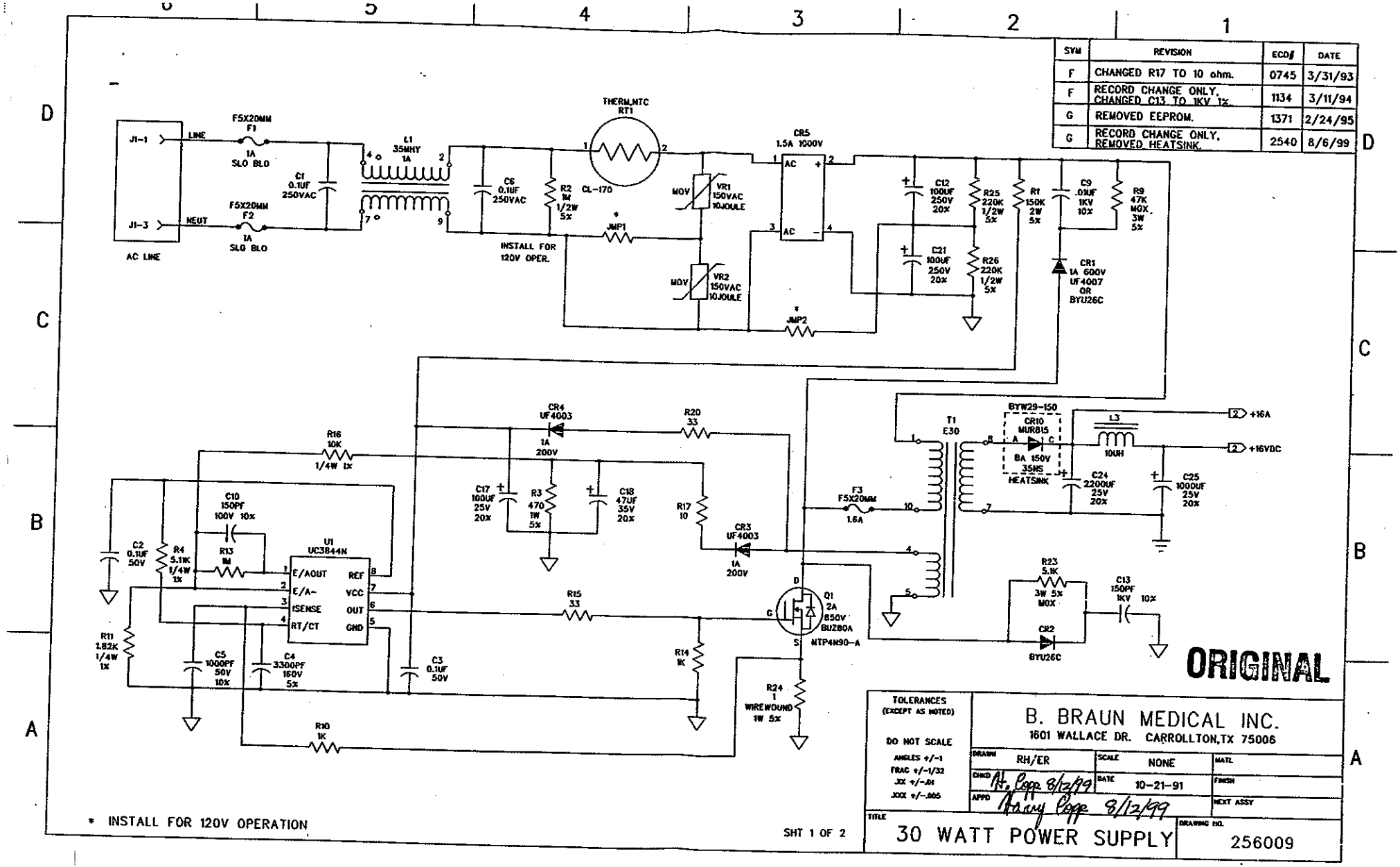
8.1 PARTS LIST

It is the intent of B. Braun to allow the Biomedical Service Professional to repair and/or replace to the PCB and component level. If you wish to repair the device yourself and have any questions, please contact Technical Support at B. Braun (see Chapter 9). The present list of replaceable subassemblies and parts will be made available to you upon request.

8.2 ELECTRICAL COMPONENTS AND SCHEMATICS

Selected engineering schematics include:

Power Supply Assy. 256009
Mechanism Interface Board Assy. 256008
NXT Main Board Assy. 256035
NXTP Main Board Assy 256038



SYM	REVISION	ECO#	DATE
F	CHANGED R17 TO 10 ohm.	0745	3/31/93
F	RECORD CHANGE ONLY, CHANGED C13 TO 1KV 1%	1134	3/11/94
G	REMOVED EEPROM.	1371	2/24/95
G	RECORD CHANGE ONLY, REMOVED HEATSINK.	2540	8/6/99

ORIGINAL

TOLERANCES (EXCEPT AS NOTED)
DO NOT SCALE
ANGLES +/-1
FRAC +/-1/32
.XX +/-.01
.XXX +/-.005

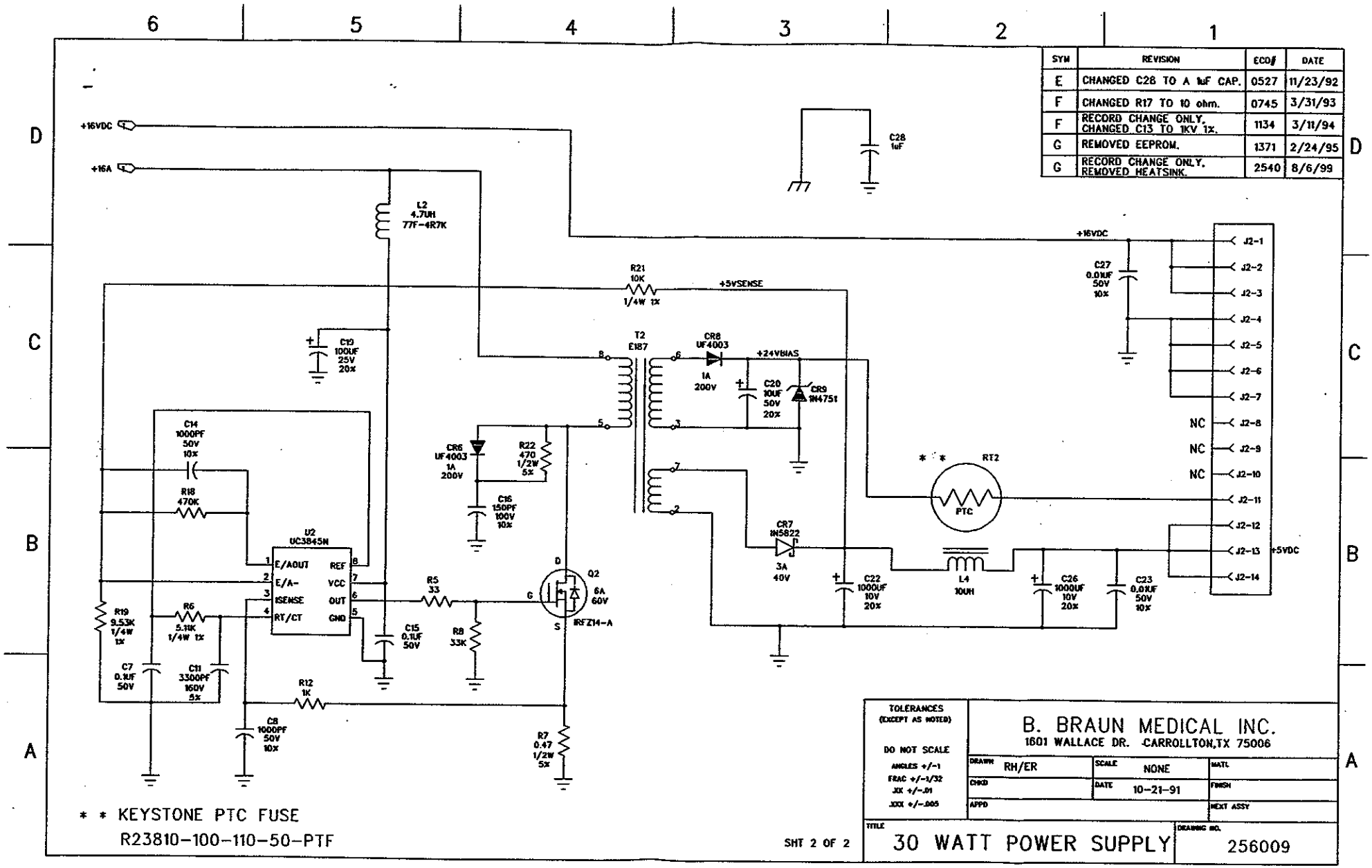
B. BRAUN MEDICAL INC.
1601 WALLACE DR. CARROLLTON,TX 75006

DRAWN	RH/ER	SCALE	NONE
CHKD	A. Copp 8/12/99	DATE	10-21-91
APPD	Tony Copp 8/12/99		

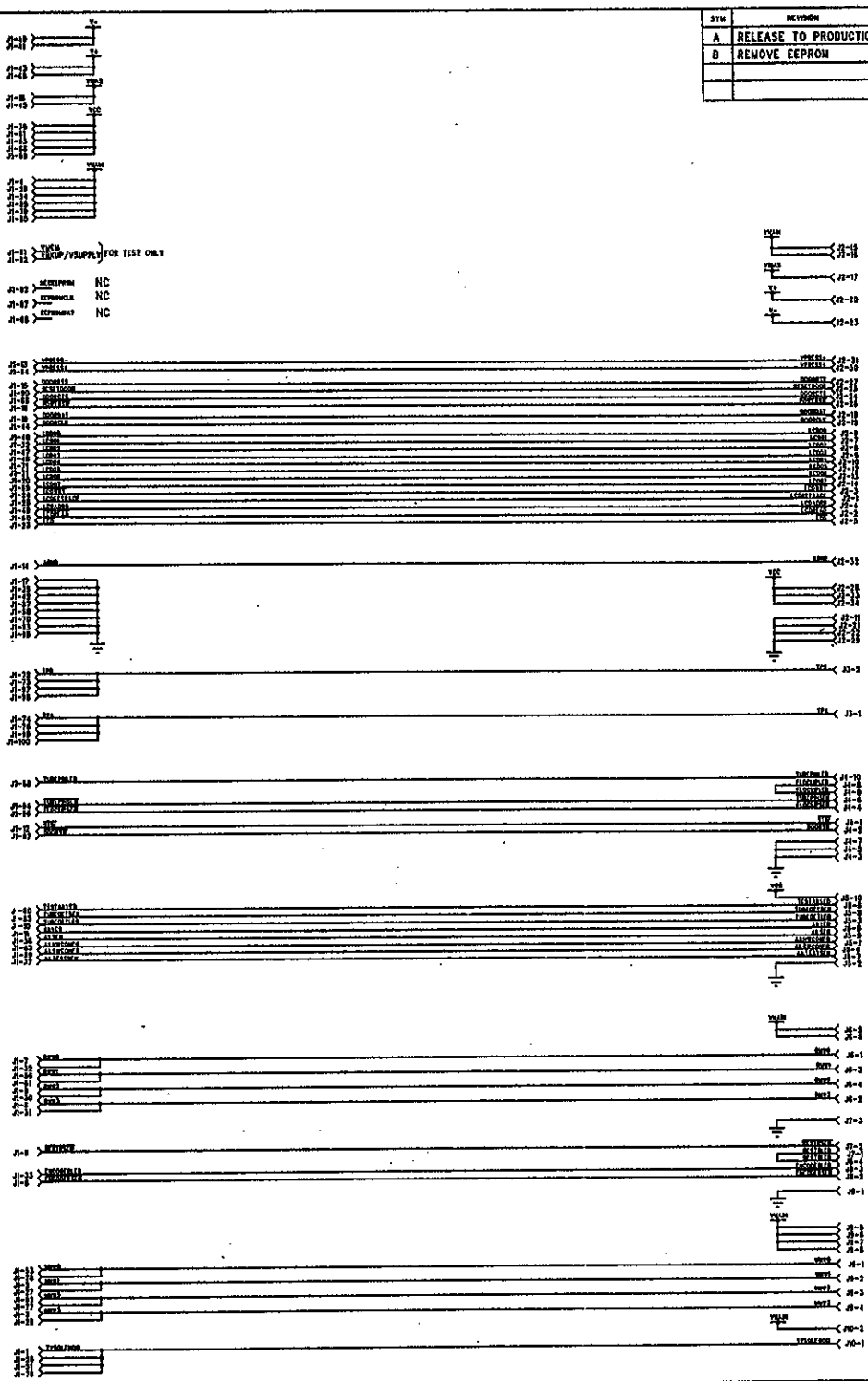
MATL
FINISH
NEXT ASSY

TITLE: 30 WATT POWER SUPPLY

DRAWING NO. 256009


6
5
4
3
2
1
D
C
B
A
SYM | REVISION | ECO# | DATE
E | CHANGED C28 TO A 1uF CAP. | 0527 | 11/23/92
F | CHANGED R17 TO 10 ohm. | 0745 | 3/31/93
F | RECORD CHANGE ONLY, CHANGED C13 TO 1KV 1%. | 1134 | 3/11/94
G | REMOVED EEPROM. | 1371 | 2/24/95
G | RECORD CHANGE ONLY, REMOVED HEATSINK. | 2540 | 8/6/99
+16VDC
+16A
C28 1uF
L2 4.7UH 77F-4R7K
R21 10K 1/4W 1%
+5VSENSE
C19 100UF 25V 20%
T2 E187
CR8 UF4003 1A 200V
+24VBIAS
C20 10UF 50V 20%
CR9 1N4751
C14 1000PF 50V 10%
R18 470K
CR6 UF4003 1A 200V
R22 470 1/2W 5%
C16 150PF 100V 10%
U2 UC3845N
E/AOUT
E/A-
ISENSE
RT/CT
REF
VCC
OUT
GND
R19 9.53K 1/4W 1%
R6 5.11K 1/4W 1%
C7 0.1UF 50V
C11 3300PF 160V 5%
R5 33
C15 0.1UF 50V
R8 33K
Q2 6A 60V IRFZ14-A
R12 1K
C8 1000PF 50V 10%
R7 0.47 1/2W 5%
CR7 1N5822 3A 40V
C22 1000UF 10V 20%
L4 10UH
C26 1000UF 10V 20%
C23 0.01UF 50V 10%
C27 0.01UF 50V 10%
* * RT2 PTC
J2-1
J2-2
J2-3
J2-4
J2-5
J2-6
J2-7
NC J2-8
NC J2-9
NC J2-10
J2-11
J2-12
J2-13 +5VDC
J2-14
* * KEYSTONE PTC FUSE
R23810-100-110-50-PTF
SHT 2 OF 2
TOLERANCES (EXCEPT AS NOTED)
DO NOT SCALE
ANGLES +/-1
FRAC +/-1/32
.XX +/-.01
.XXX +/-.005
B. BRAUN MEDICAL INC.
1601 WALLACE DR. CARROLLTON,TX 75006
DRAWN RH/ER
CHKD
APPD
SCALE NONE
DATE 10-21-91
MATL
FINISH
NEXT ASSY
TITLE 30 WATT POWER SUPPLY
DRAWING NO. 256009

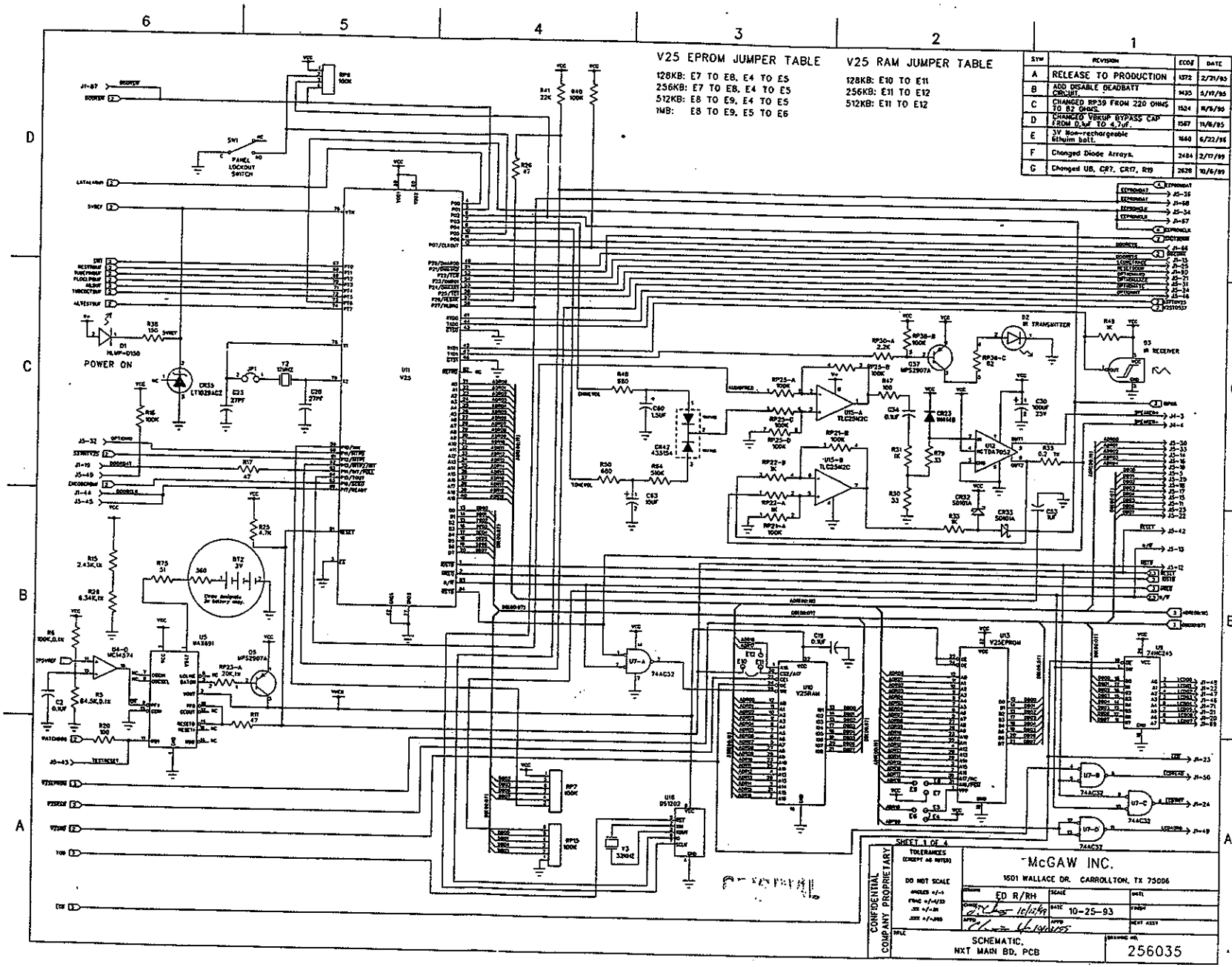
SYM	REVISION	ECO#	DATE
A	RELEASE TO PRODUCTION		
B	REMOVE EEPROM	1371	2/24/93

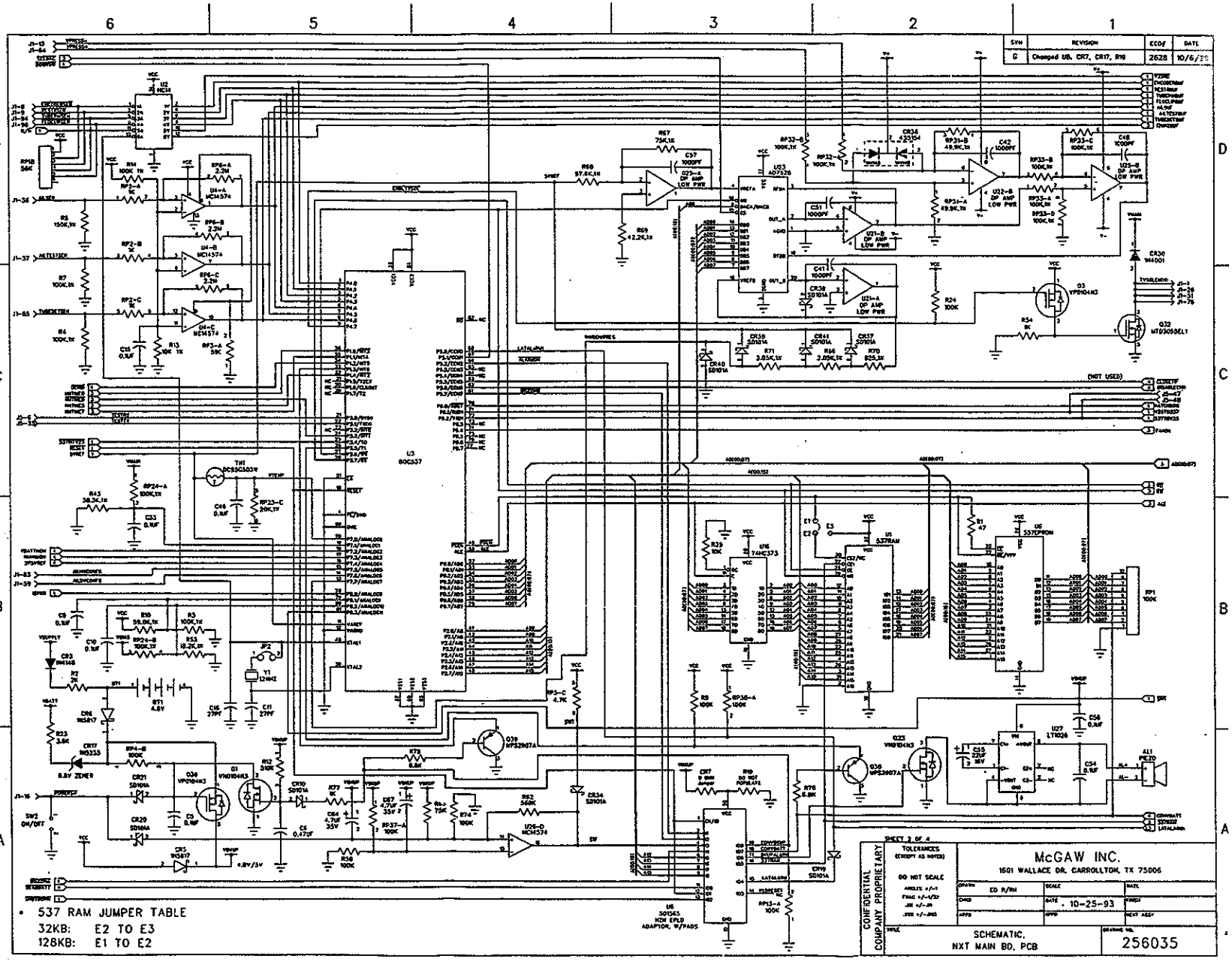


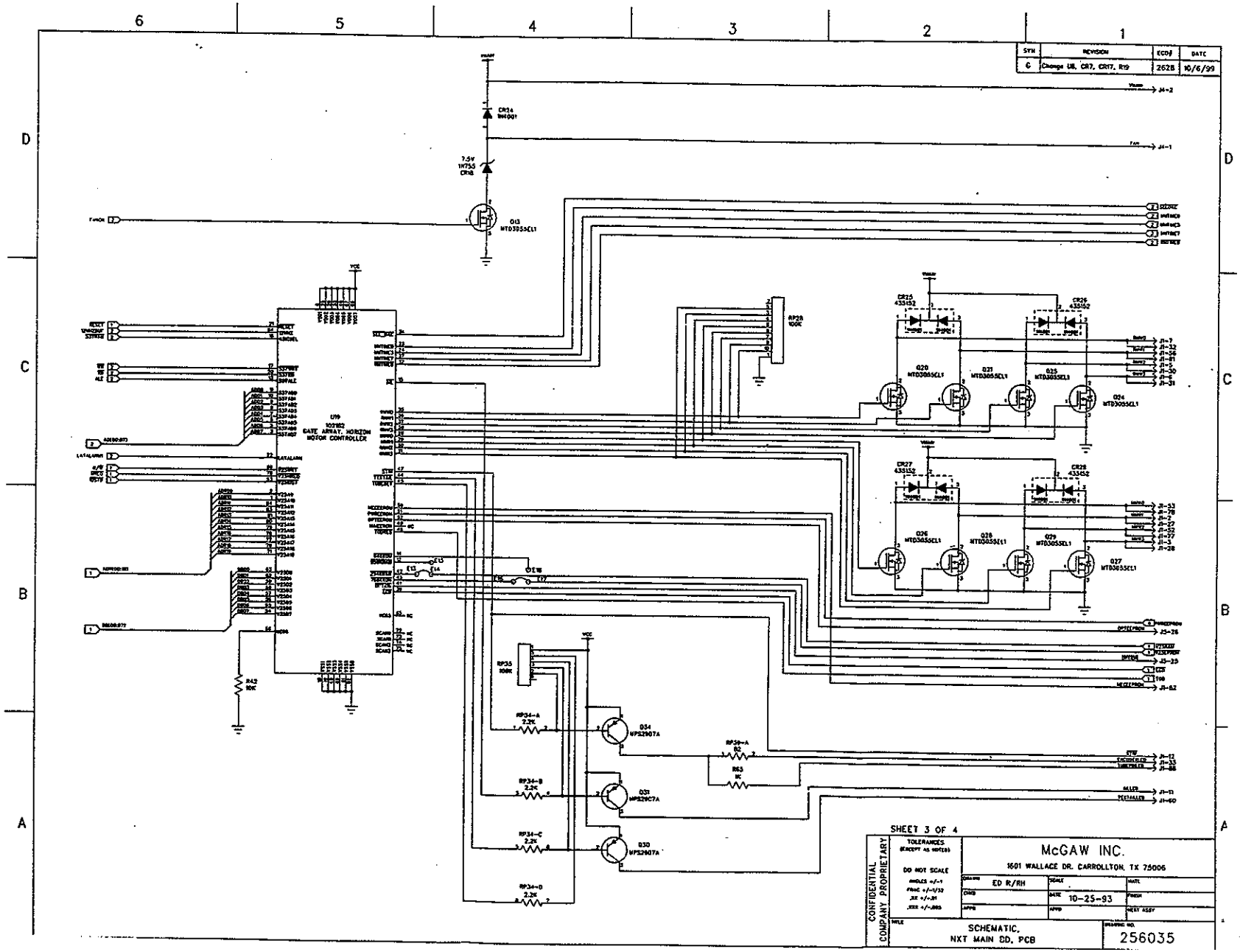
TOLERANCES (EXCEPT AS NOTED)	McGAW INC.		
	1801 WALLACE DR. CARROLLTON,TX 75006		
DO NOT SCALE	DRAWN ED R	SCALE	SHEET
ANGLES +/-1	CHKD	DATE 10-2201	FINISH
DIAM +/-1/32	APPD		NEXT ASSY
.XX +/-.01			
.XXX +/-.005			

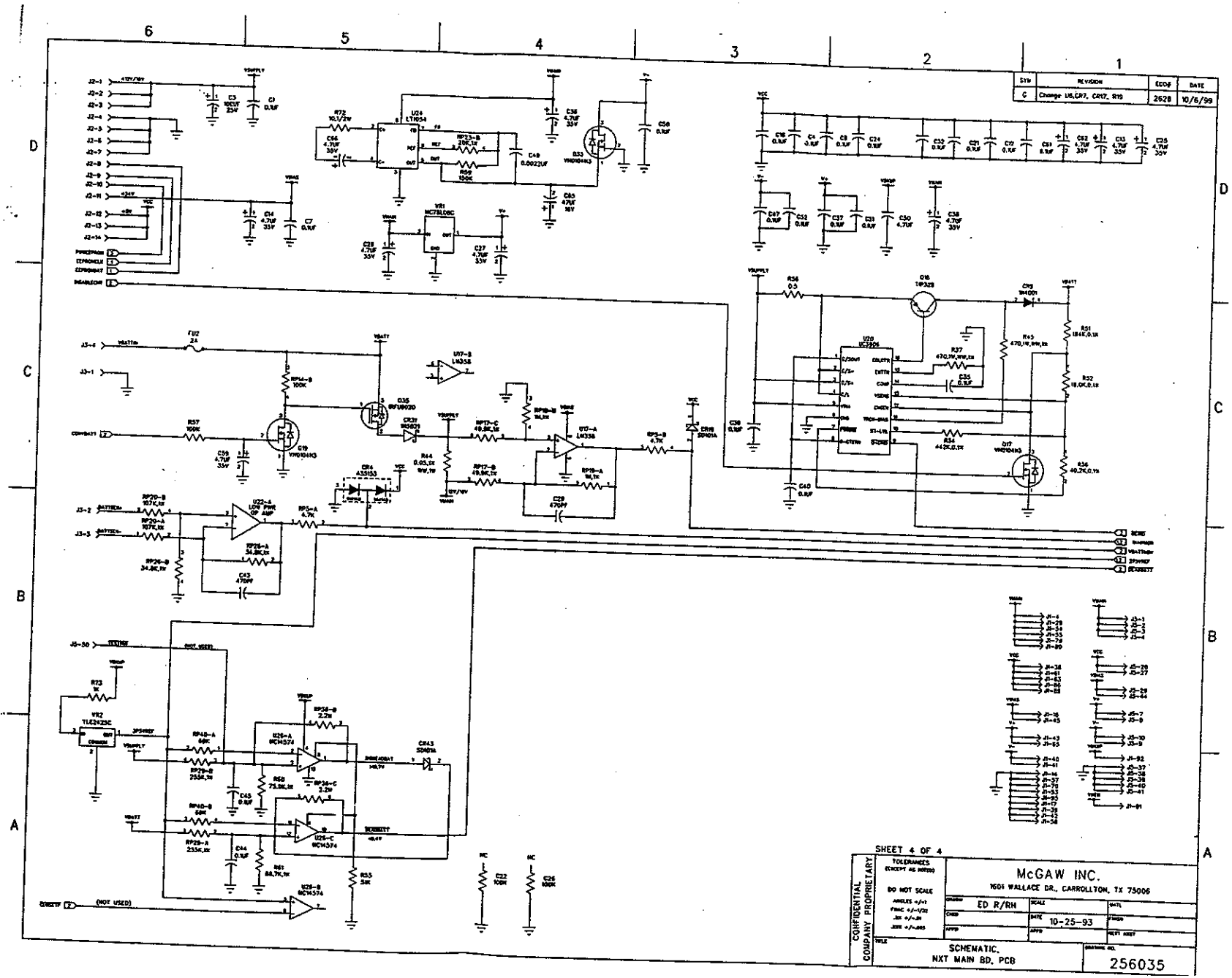
TITLE: MECHANISM INTERFACE PCB

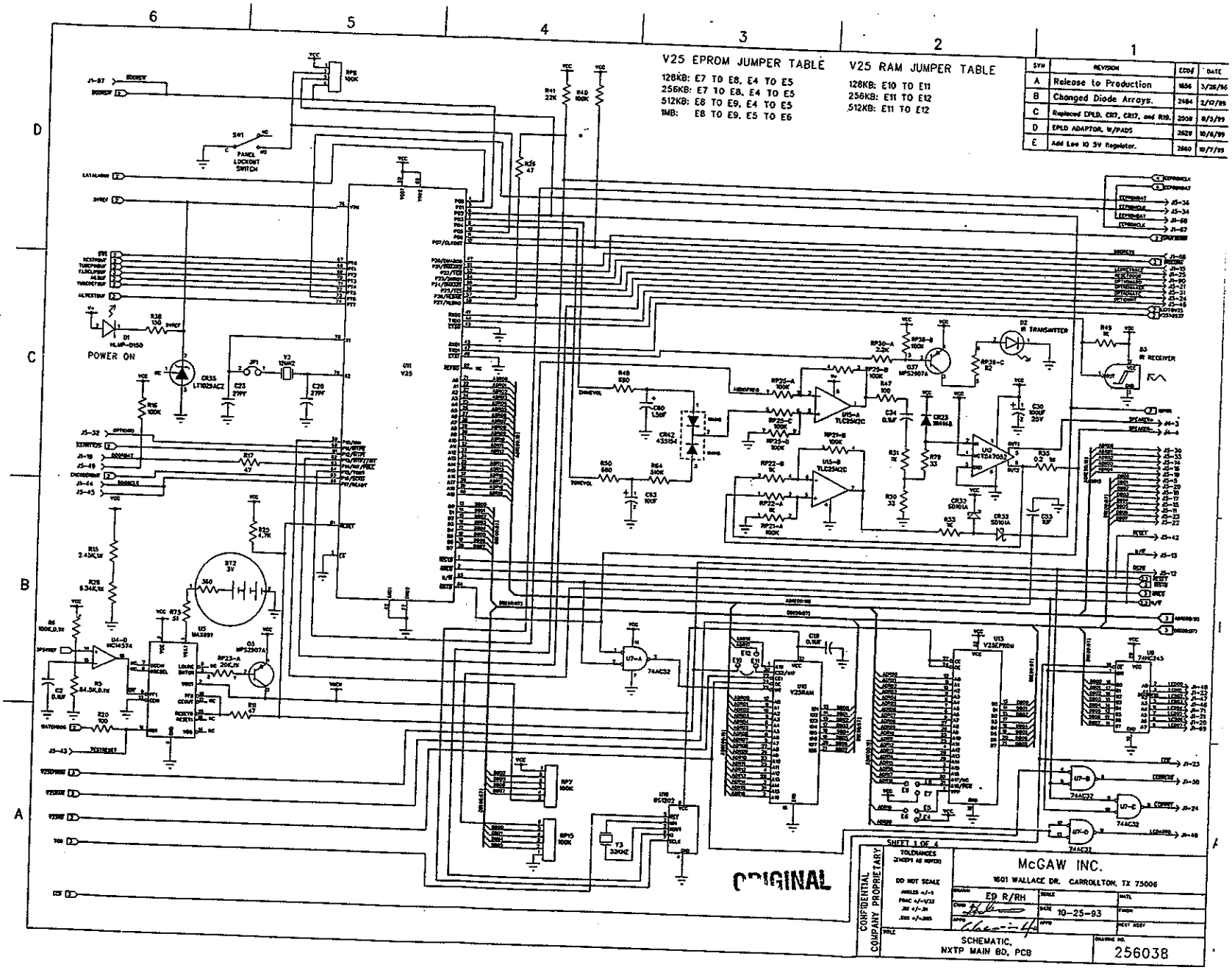
DRAWING NO.: 256008

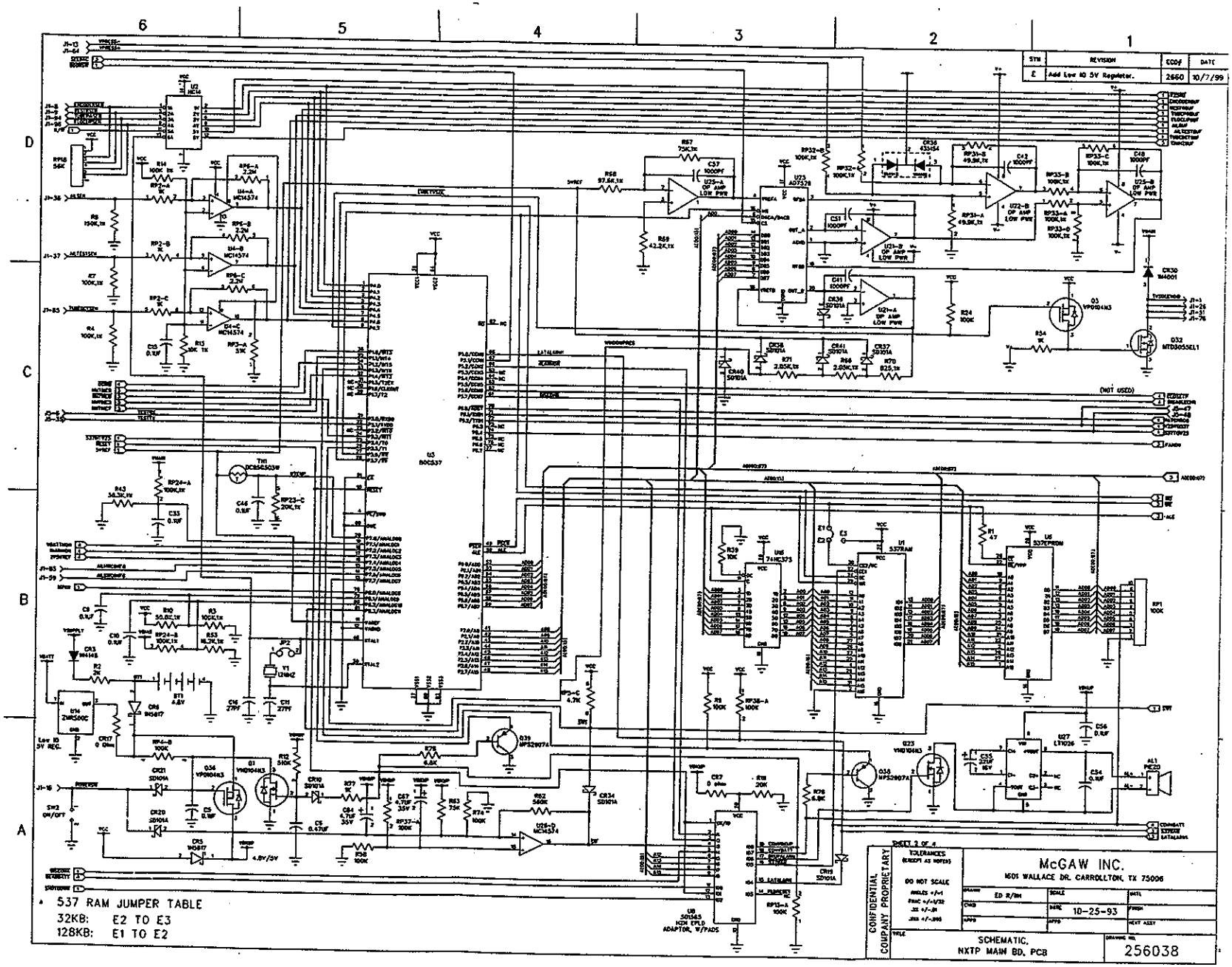

V25 EPROM JUMPER TABLE
128KB: E7 TO E8, E4 TO E5
256KB: E7 TO E8, E4 TO E5
512KB: E8 TO E9, E4 TO E5
1MB: E8 TO E9, E5 TO E6
V25 RAM JUMPER TABLE
128KB: E10 TO E11
256KB: E11 TO E12
512KB: E11 TO E12
STM | REVISION | ECO# | DATE
A | RELEASE TO PRODUCTION | 1372 | 2/29/95
B | ADD DISABLE DEADBATT CIRCUIT. | 1435 | 5/17/95
C | CHANGED RP39 FROM 220 OHMS TO 82 OHMS. | 1524 | 8/8/95
D | CHANGED VBKUP BYPASS CAP FROM 0.1uF TO 4.7uF. | 1547 | 11/8/95
E | 3V Non-rechargeable lithium batt. | 1640 | 6/22/96
F | Changed Diode Arrays. | 2484 | 2/17/99
G | Changed U8, CR7, CR17, R19 | 2628 | 10/6/99
POWER ON
SHEET 1 OF 4
CONFIDENTIAL COMPANY PROPRIETARY
DO NOT SCALE
McGAW INC.
1601 WALLACE DR. CARROLLTON, TX 75006
ED R/RH
10-25-93
SCHEMATIC, NXT MAIN BD. PCB
256035

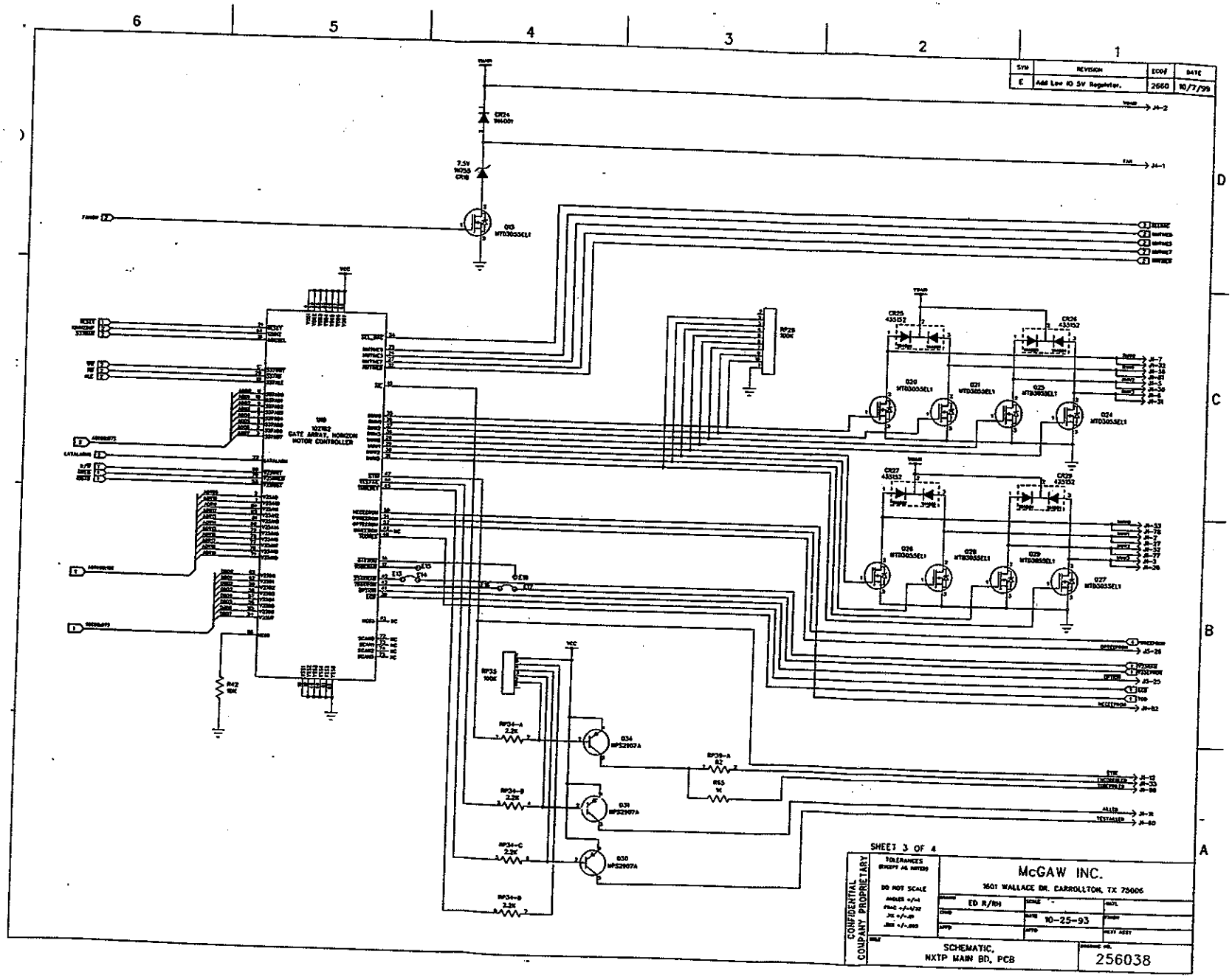

6
5
4
3
2
1
D
C
B
A
SYM
REVISION
ECO#
DATE
G
Changed U8, CR7, CR17, R16
2628
10/6/93
537 RAM JUMPER TABLE
32KB: E2 TO E3
128KB: E1 TO E2
CONFIDENTIAL COMPANY PROPRIETARY
McGAW INC.
1601 WALLACE DR, CARROLLTON, TX 75006
SCHEMATIC,
NXT MAIN BD, PCB
256035
10-25-93

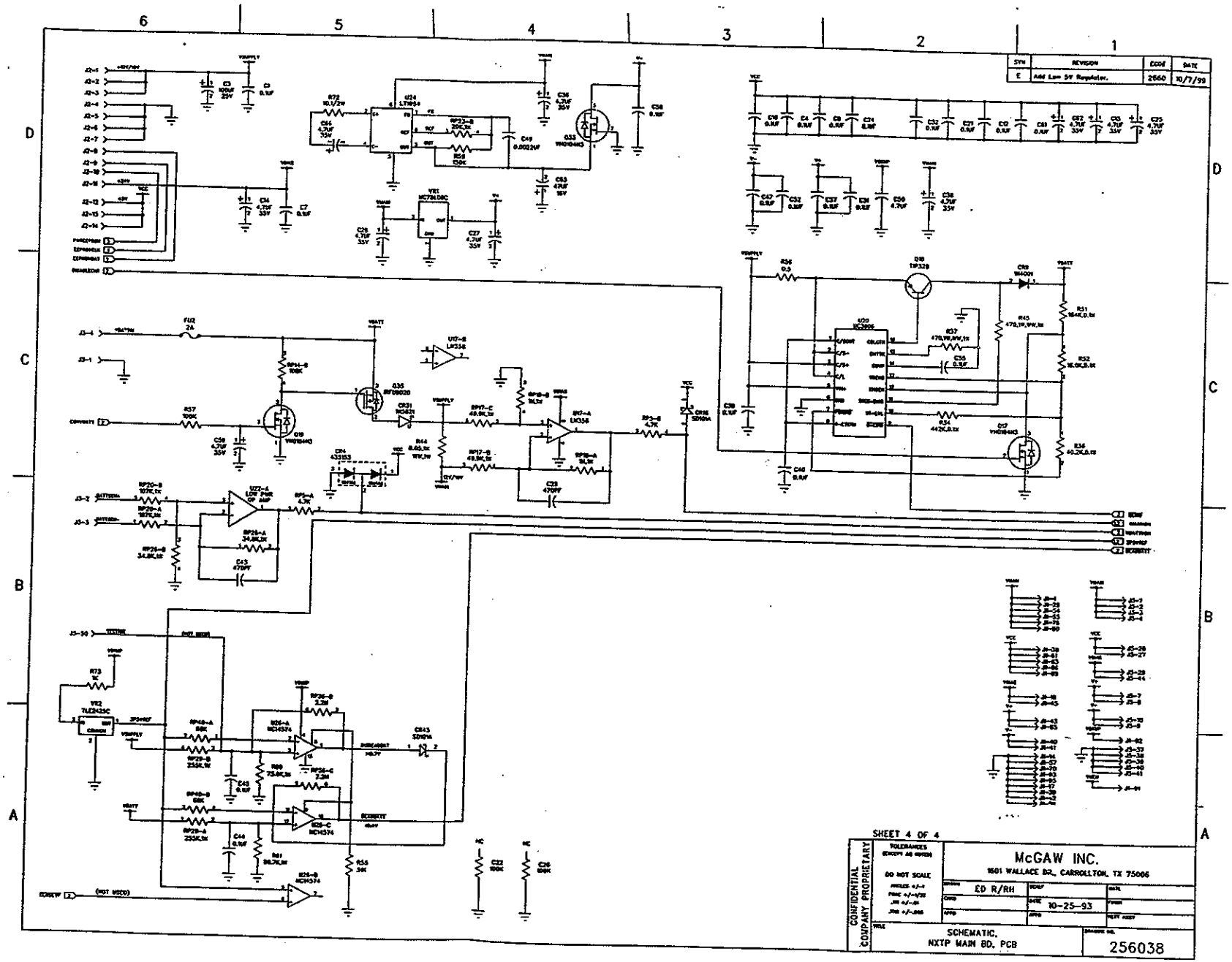

SYM
REVISION
ECO#
DATE
C
Change U8, CR7, CR17, R19
2628
10/6/99
SHEET 3 OF 4
CONFIDENTIAL COMPANY PROPRIETARY
TOLERANCES
DO NOT SCALE
McGAW INC.
1601 WALLACE DR. CARROLLTON, TX 75006
ED R/RH
10-25-93
SCHEMATIC,
NXT MAIN DD, PCB
256035


6
5
4
3
2
1
D
C
B
A
SYM
REVISION
ECO#
DATE
C
Change U6,CR7, CR17, R19
2628
10/6/99
SHEET 4 OF 4
CONFIDENTIAL
COMPANY PROPRIETARY
TOLERANCES
(EXCEPT AS NOTED)
DO NOT SCALE
McGAW INC.
1601 WALLACE DR., CARROLLTON, TX 75006
ED R/RH
10-25-93
SCHEMATIC,
NXT MAIN BD. PCB
256035


V25 EPROM JUMPER TABLE
128KB: E7 TO E8, E4 TO E5
256KB: E7 TO E8, E4 TO E5
512KB: E8 TO E9, E4 TO E5
1MB: E8 TO E9, E5 TO E6
V25 RAM JUMPER TABLE
128KB: E10 TO E11
256KB: E11 TO E12
512KB: E11 TO E12
SYM | REVISION | ECO# | DATE
A | Release to Production | 1656 | 3/26/96
B | Changed Diode Arrays. | 2484 | 2/12/98
C | Replaced EPLD, CR7, CR17, and R19. | 2558 | 8/3/99
D | EPLD ADAPTOR, W/PADS | 2629 | 10/6/99
E | Add Low IQ 5V Regulator. | 2660 | 10/7/99
POWER ON
PANEL LOCKOUT SWITCH
IR TRANSMITTER
IR RECEIVER
ORIGINAL
CONFIDENTIAL COMPANY PROPRIETARY
SHEET 1 OF 4
DO NOT SCALE
McGAW INC.
1601 WALLACE DR. CARROLLTON, Tx 75006
ED R/RH
10-25-93
SCHEMATIC, NXTP MAIN BD, PCB
256038


6
5
4
3
2
1
D
C
B
A
REVISION
ECO#
DATE
E
Add Low IQ 5V Regulator.
2660
10/7/99
* 537 RAM JUMPER TABLE
32KB: E2 TO E3
128KB: E1 TO E2
CONFIDENTIAL
COMPANY PROPRIETARY
DO NOT SCALE
McGAW INC.
1601 WALLACE DR. CARROLLTON, TX 75006
ED R/RH
10-25-93
SCHEMATIC,
NXTP MAIN BD, PCB
256038


6
5
4
3
2
1
D
C
B
A
REVISION
Add Low IO 5V Regulator.
2660
10/7/99
GATE ARRAY, HORIZON MOTOR CONTROLLER
SHEET 3 OF 4
McGAW INC.
3601 WALLACE DR. CARROLLTON, TX 75006
ED R/RH
10-25-93
SCHEMATIC,
NXTP MAIN BD, PCB
256038
CONFIDENTIAL COMPANY PROPRIETARY


6
5
4
3
2
1
D
C
B
A
REVISION
Add Low 5V Regulator.
2660
10/7/99
SHEET 4 OF 4
CONFIDENTIAL COMPANY PROPRIETARY
DO NOT SCALE
McGAW INC.
1601 WALLACE RD., CARROLLTON, TX 75006
ED R/RH
10-25-93
SCHEMATIC,
NXTP MAIN BD. PCB
256038

9.0 SERVICE AND PERFORMANCE INFORMATION

9.1 CONTACT INFORMATION

If the pump fails to respond to the operating or troubleshooting procedures listed in this manual, and the cause cannot be determined, discontinue using the pump.

Service and product performance information may be obtained from the manufacturer by contacting:

B. Braun
1601 Wallace Drive, Suite 150
Carrollton, Texas 75006
Attn: Manager of Service
Or Call: (800) 627-PUMP
(800) 627-7867

Product complaints may be sent to the Manager of Quality Assurance at the above address. With each complaint, please include the serial number or lot number of the product involved, a description of the difficulty experienced, information regarding the pressure limit and flow rate setting, the type of I.V. fluid in use, the message displayed at the time the difficulty occurred, the diagnostic code number (if applicable), and any other information which might aid in the investigation of the complaint.

Should it be necessary to return the pump to the manufacturer, carefully pack the pump (preferably in the original packing, FZ0012 Horizon Shipping Carton Kit), and ship it prepaid to the above address. The manufacturer cannot assume any responsibility for loss or damage to returned instruments while they are in transit.

Authorization to return products must be received from B. Braun prior to shipment. Please contact Customer Service at the above phone number for a Returned Materials Authorization Number.

With each question or complaint, please include:

- ☑ the pump's serial number,
- ☑ a description of the difficulty experienced,
- ☑ the pressure limit setting,
- ☑ the rate setting,
- ☑ the initial volume(s) to be infused,
- ☑ the type of fluid(s),
- ☑ the amount of time between the start of the infusion and the time the difficulty was noticed,
- ☑ the message displayed at the time the difficulty occurred, and
- ☑ the catalog and lot number of the set(s) in use.

10.0 MONITOR DOCKING

10.1 DESCRIPTION

Monitor Docking, a feature of the Horizon Nxt Modular Infusion System, provides communication from the pump to a cardiac monitor. This allows for vital infusion information, such as rate, volume to be infused, volume infused, and pump alarms, to be displayed on the patient's cardiac monitor, at the bedside and/or at a central nurses' station.

Monitor Docking reduces the amount of time used to determine the whereabouts and type of alarm. Eventually, Monitor Docking may be used as a part of overall computerized nurse charting system.

WARNING: Read this chapter before using the Monitor Docking feature. The user should become familiar with the proper use of this feature and the Horizon Nxt Infusion Pump.

For technical assistance, call
B. Braun
1-800-627-PUMP
1-800-627-7867

10.2 INSTALLATION

Note: Monitor Docking must be enabled in the pump by the Biomedical Department for this feature to be accessible. The Serial Data Communication IR Module will be connected by the Biomedical Department to the cardiac monitor.

10.2.1 System Requirements

Table 10-1 lists the equipment required for successful Monitor Docking.

Table 10-1: System Requirements

Infusion Pump:	B. Braun Horizon Nxt Infusion Pump
Cardiac Monitoring Systems:	Marquette SpaceLabs HP CareVue
Cardiac Monitoring Module:	Vendor Specific
P.C. Docking Kit:	Part No. FZ 501458

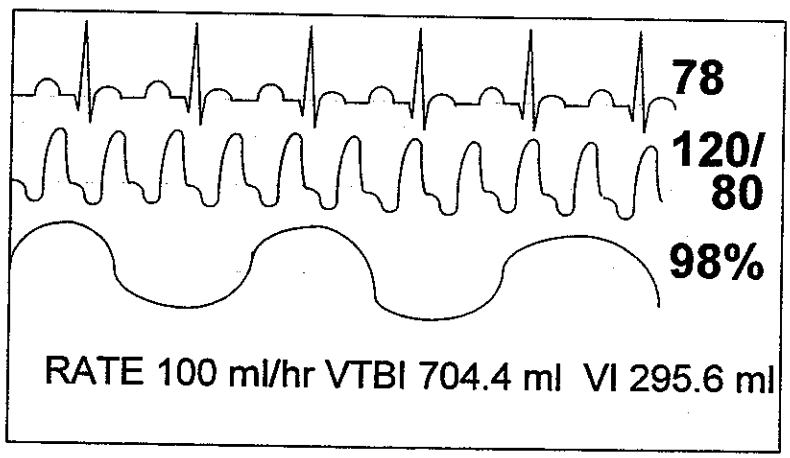
10.2.2 Docking Set Up

1. Clamp the Serial Data Communication IR Module over the Serial Data Communication fluid resistant window on the back of the Horizon Nxt Pump whose information you wish displayed.
   a. Grasp the Serial Data Communication IR Module with index finger on top and thumb on grooved surface on the bottom.
   b. Hook the top of the unit onto the pump and press with thumb to clamp the unit on the back of the pump case.

2. Enter the Biomed Menu (see Section 7.5.1 for instructions on how to enter the Biomed Menu).
3. Press the down Cursor Keys to select "Monitor Docking."

Note: Selecting Check Alarm Log, Check Operation Log, or Set Options via PC will temporarily suspend the Monitor Docking function.

4. Press the Enter Key.
5. Press the Cursor Keys to select the appropriate cardiac monitor system.
6. Press the Enter Key.
7. Press the Cursor Key to select "Exit from Menu."
8. Ensure the IR Module cable is connected securely to the back of the cardiac monitor.
9. Rate, volume to be delivered, and volume infused will now be displayed on the cardiac monitor.



10. Monitor screens may be customized. Contact your cardiac monitor manufacturer to discuss display format options.

10.2.3 Disconnecting Monitor Docking

1. Grasp the Serial Data Communication IR Module with index finger and thumb as before.
2. Press with thumb on grooved surface to release clamp.

10.3 STORAGE AND MAINTENANCE

Store the Serial Data Communication IR Module in a clean, dry area, temperatures not to exceed 90° F.

Return cable to Biomedical Department if tears, fraying, or loose cords are noted. Do not immerse in water or other fluids.

10.4 TROUBLESHOOTING

Table 10-2: Troubleshooting

If no date is displayed on the cardiac monitor once the IR module is connected...	1. Ensure cable is securely fastened to back of the cardiac monitor. 2. Clean Serial Data Communication Window on back of pump with damp cloth. Dry thoroughly. 3. Ensure sensors on IR Module are clean and free of obstruction. 4. Confirm cardiac monitor model and software revision are compatible with Horizon Nxt Monitor Docking feature.
If still no data is displayed...	1. Verify transmitting LED is not bent. If damaged, replace Main PCB.

APPENDIX A: Abbreviations and Symbols

This section lists the abbreviations, acronyms, and symbols that are used throughout the document. Many of the items have duplicates for reasons of standard usage within a respective field or industry.

A/D = analog to digital converter
AL = piezo electric alarm
AL = aluminum
ASIC = application specific integrated circuit
ASSY = assembly
AWG = american wire guage
BT = battery
C = capacitor
CAP = capacitor
CER = ceramic
CF = carbon film
COMM = communication
CONN = connector
CR = diode
CS = light detector
CT = thermistor
D = light emitting diode
DAC = digital to analog converter
DIO = diode
DIP = dual inline package
E = jumper
EEPROM = electrically erasable programmable read only memory
ELEC = electrolytic
EPLD = electrically programmable logic device
EPROM = erasable programmable read only memory
FET = field effect transistor
FPGA = field programmable gate array
FU = fuse
IC = integrated circuit
IR = infrared
J = connector
JMP = jumper
LCD = liquid crystal display
LED = light emitting diode
MF = metal film
MONCER = monolithic ceramic
MOV = metal oxide varistor
MOX = metal oxide
N-CH = n-channel
NC = no connection
NTC = negative temperature coefficient
OPTN = option
OTP = one time programmable
P = jumper

PC = personal computer
PCB = printed circuit board
PLCC = plastic leaded chip carrier
POLY = polycarbonate
PPH = Phillips pan head
PTC = positive temperature coefficient
P-CH = p-channel
Q = transistor
R = resistor
RAM = random access memory
RP = resistor package
RT = thermistor
SEC = secondary item
SIP = single in-line package
SW = switch
TH = thermistor
U = integrated circuit
VR = varistor
WW= wire wound
XSTR = transistor
XTAL = crystal
Y = crystal

APPENDIX B: Troubleshooting Guide

When troubleshooting the pump, always begin by reading the information displayed by the LCD. There will be times when the user has simply not read the LCD prior to declaring the pump at fault or out of order. Some form of instruction will always be displayed by the LCD.

This troubleshooting guide is primarily oriented to those events which cause the device to alarm. There are 117 different alarm codes in use. In the following table, if a code number is not listed, then it is not in use. Other types of malfunctions are included at the end of this list. In order for this list to be of use, it will be necessary for you to obtain the diagnostic code from the Alarm or Operation Log.

The message that is displayed on the LCD when an alarm occurs will vary depending upon the cause of the alarm. For those cases in which the pump has determined that the fault was most likely caused by or could be remedied by the user, these alarms will be defined as "user type" alarms. For user type alarms, the help message displayed will be in the form of either actions to take to remedy the alarm or a list of possible causes of the alarm. All other types of alarms will display either "System Alarm" or "Repair Instrument." System Alarm differs from Repair Instrument in that once the alarm has been silenced, pressing the RUN Key will reinitiate the infusion. Repair Instrument alarms require the pump being powered off then back on again prior to being able to reinitiate the infusion, very similar to turning your computer off and then back on again to clear a fault.

Repair or replacement of certain components can cause the configuration of the Horizon Nxt Pump to revert to factory settings. Upon completion of the repair process, ensure the device is programmed to the institution's preferred settings.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
1	SOLU	1. Fluid source is empty, or excessive air in cassette 2. Cassette not loaded properly. 3. Cassette failure. 4. Jammed refill piston. 5. Jammed inlet or transfer valves. 6. Solenoid jammed, out of adjustment or loosely mounted. 7. Mechanical failure of solenoid driving the transfer valve. 8. Petal module stuck or jammed. 9. Failure of solenoid driver circuitry on Main PCB. 10. Failure of the pressure transducer and/or its associated circuitry.	1. Re-fill the fluid source, or check cassette for air. 2. Reload the cassette (follow instructions inside door). 3. Inspect cassette for abnormalities, such as something besides fluid inside the pouches, etc. 4. Check for freedom of movement. Clean refill piston with warm water. 5. Check the inlet and transfer valve for freedom of movement by pressing on the valve tips with your finger. Clean if sticking. 6. Make sure the solenoid mounting screws are secure. Check the solenoid gap adjustment and inspect for evidence of failure such as discoloration from heat or squeaking operation. Make sure the Phillips screws used to attach the entire mechanism assembly to the bezel are secure. 7. Replace the half door/bezel assembly. 8. Remove and clean petal module with warm water. 9. Replace the Main PCB. 10. Inspect the pressure transducer for damage. Replace half door/bezel assembly.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
2	Error locating restriction/outlet valve closed position/ SYS Err	1. Optical sensor on restriction/outlet valve yoke failure or sensor is dirty. 2. Restriction/outlet valve is jammed. 3. Connector to restriction/outlet valve yoke sensor is loose or dislodged. 4. Restriction/outlet valve yoke out of adjustment. 5. Restriction motor failure. 6. Motor driver circuitry on Main PCB failure.	1. Clean the sensor surface. If problem continues, replace the half door/bezel assembly. 2. Check the restriction/outlet valve for freedom of movement by pressing on the valve tips with your finger. Clean with warm water. 3. Reseat the restriction/outlet valve yoke connector. Check for broken wire at the connector. 4. Check the restriction/outlet valve yoke adjustment and adjust as necessary (see Section 7.7.2.1). 5. Replace the restriction motor or half door/bezel assembly. 6. Replace the Main PCB.
3	Initial delivery chamber pressure too high/ SYS Err	1. Failure of pressure transducer. 2. Defective bezel assembly.	1. Inspect pressure transducer for damage. Test the pressure transducer (see Section 7.7.1.1). 2. Replace the half door/bezel assembly.
4	Main motor windings are bad/ SYS Err	1. Main motor failure. 2. Main motor connection failure. 3. Main motor circuitry on the main PCB failure.	1. Check main motor connection. 2. Replace half door/bezel assembly. 3. Replace main PCB.
5	Maximum initial retraction steps exceeded/ SYS Err	1. Main motor failure. 2. Main motor encoder assembly and/or sensor dirty, loose, or failed. 3. Main PCB failure.	1. Replace the half door/bezel assembly. 2. Inspect the main motor encoder wheel for dust or other contaminant and clean with cleaner or air blast if necessary. Encoder wheel should be centered between its sensor and rotate with moderate resistance. Return to position if necessary by sliding it into place. 3. Replace the Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
6	No more refills allowed/ SOLU	1. Fluid source is empty, or excessive air in cassette. 2. Cassette not loaded properly. 3. Cassette failure. 4. Jammed inlet or transfer valves. 5. Solenoid jammed, out of adjustment, or loosely mounted. 6. Stuck refill piston. 7. Mechanical failure of mechanism or connection through the interface PCB. 8. Failure of solenoid driver circuitry on Main PCB. 9. Failure of the pressure transducer and/or its associated circuitry. 10. Stuck or jammed petal module.	1. Re-fill the fluid source, or check cassette for air. 2. Reload the cassette (follow instructions inside door). 3. Inspect cassette for abnormalities, such as something besides fluid inside the pouches, etc. 4. Check the inlet and transfer valves for freedom of movement by pressing on the valve tips with your finger. Clean and or lubricate the valve shaft with silicon spray as needed. Do not spray the valve tips. 5. Make sure the solenoid mounting screws are secure. Check the solenoid adjustment and inspect for evidence of failure such as discoloration from heat or squeaking operation. Make sure the Phillips screws used to attach the entire mechanism assembly to the bezel are secure. 6. Clean piston area with warm water. 7. Replace the solenoid or half door/bezel assembly. 8. Replace the Main PCB. 9. Inspect the pressure transducer for damage. Replace half door/bezel assembly. 10. Remove and clean petal module with warm water.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
7	Outlet valve cannot close/ SYS Err	1. Cassette not loaded properly. 2. Cassette failure. 3. Jammed restriction/outlet valve. 4. Restriction/outlet valve yoke out of adjustment. 5. Optical sensor on restriction/outlet valve yoke failure or sensor surface is contaminated. 6. Restriction motor driver circuitry on Main PCB failure. 7. Restriction motor failure.	1. Reload the cassette (follow instructions inside door). 2. Inspect cassette for abnormalities, such as something besides fluid inside the pouches, etc. 3. Check the restriction/outlet valve for freedom of movement by pressing on the valve tips with your finger. 4. Check the restriction/outlet valve yoke adjustment (see Section 7.7.2.1). 5. Clean the optical sensor and check connections then retry operation. If this fails to correct the problem, replace the half door/bezel assembly. 6. Replace the Main PCB. 7. Replace the restriction motor assembly.
8	Outlet valve cannot open/ SYS Err	1. Jammed restriction/outlet valve. 2. Restriction/outlet valve yoke out of adjustment. 3. Optical sensor on restriction/outlet valve yoke failure or sensor surface is contaminated. 4. Restriction Motor driver circuitry on Main PCB failure. 5. Restriction motor failure.	1. Check the restriction/outlet valve for freedom of movement by pressing on the valve tips with your finger. 2. Check the restriction/outlet valve yoke adjustment (see Section 7.7.2.1). 3. Clean the optical sensor and check connections, then retry operation. 4. Replace the Main PCB. 5. Replace the restriction motor or half door/bezel assembly.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
9	Outlet valve leaking/ SYS Err	1. Cassette not loaded properly. 2. Cassette failure. 3. Jammed restriction/outlet valve. 4. Restriction/outlet valve yoke out of adjustment. 5. Optical sensor on restriction/outlet valve yoke failure or sensor surface is contaminated. 6. Restriction motor driver circuitry on Main PCB failure. 7. Restriction motor failure.	1. Reload the cassette (follow instructions inside door). 2. Inspect cassette for abnormalities, such as something besides fluid inside the pouches, etc. 3. Check the restriction/outlet valve for freedom of movement by pressing on the valve tips with your finger. 4. Check the restriction/outlet valve yoke adjustment (see Section 7.7.2.1). 5. Clean the optical sensor and check connections, then retry operation. If this fails to correct the problem, replace the half door/bezel assembly. 6. Replace the Main PCB. 7. Replace restriction motor or half door/bezel assembly.
10	Outlet valve motor windings bad/ SYS Err	1. Restriction motor failure. 2. Restriction motor connection failure. 3. Restriction motor driver circuitry on main PCB failure.	1. Replace the restriction motor. 2. Check the restriction motor connection. 3. Replace the half door/bezel assembly. 4. Replace the main PCB.
11	Outlet valve and main motor windings bad/ SYS Err	1. Restriction motor connection failure. 2. Restriction motor failure. 3. Main motor connection failure. 4. Motor driver circuitry on main PCB failure.	1. Check the restriction motor connection. 2. Replace restriction motor. 3. Check main motor connection. 4. Replace main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
12	Transfer valve leaking/ SYS Err	1. Cassette not loaded properly. 2. Cassette failure. 3. Jammed transfer valve. 4. Solenoid jammed, out of adjustment or loosely mounted. 5. Mechanical failure of solenoid driving the transfer valve. 6. Failure of solenoid driver circuitry on Main PCB.	1. Reload the cassette (follow instructions inside door). 2. Inspect cassette for abnormalities, such as something besides fluid inside the pouches, etc. 3. Check the inlet and transfer valves for freedom of movement by pressing on the valve tips with your finger. Clean or lubricate the valve shaft with silicon spray as needed. Do not spray the valve tips. 4. Make sure the solenoid mounting screws are secure. Check the solenoid adjustment and inspect for evidence of failure such as discoloration from heat or squeaking operation. Make sure the Phillips screws used to attach the entire mechanism assembly to the bezel are secure. 5. Replace the half door/bezel assembly. 6. Replace the Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
14	Upstream occlusion detected/ UP OCCL	1. Tube obstruction proximal to the pump. 2. Fluid source is empty, or excessive air in cassette. 3. Cassette not loaded properly. 4. Cassette failure. 5. Damaged pressure transducer. 6. Jammed inlet or transfer valves. 7. Solenoid jammed, out of adjustment or loosely mounted. 8. Mechanical failure of solenoid driving the transfer valve, or failure of refill piston. 9. Failure of solenoid driver circuitry on Main PCB.	1. Check tubing between the fluid source and the pump. 2. Check the cassette for excessive air in the pouches. 3. Reload the cassette (follow instructions inside door). 4. Inspect cassette for abnormalities, such as something besides fluid inside the pouches, etc. 5. Inspect the pressure transducer for damage. Replace half door/bezel assembly (see Section 7.7.1.1). 6. Check the inlet and transfer valves for freedom of movement by pressing on the valve tips with your finger. 7. Make sure the solenoid mounting screws are secure. Check the solenoid adjustment and inspect for evidence of failure such as discoloration from heat or squeaking operation. Make sure the Phillips screws used to attach the entire mechanism assembly to the bezel are secure. 8. Replace the half door/bezel assembly. 9. Replace the Main PCB.
15	Backfills allowed should not be 0/ SYS Err	1. Software failure.	1. Retry operation and if error continues, reseat the EPROMs. 2. Replace Main PCB.
16	Gross cycle timer error/ SYS Err	1. Software failure.	1. Retry operation and if error continues, reseat the EPROMs. 2. Replace Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
17	Maximum restriction/outlet valve position exceeded/ SYS Err	1. Restriction/outlet valve yoke out of adjustment. 2. Restriction motor failure. 3. Optical sensor on restriction/outlet valve yoke failure or sensor surface is contaminated. 4. Restriction motor driver circuitry on Main PCB failure.	1. Check the restriction/outlet valve yoke adjustment (see Section 7.7.2.1). 2. Replace restriction motor or half door/bezel assembly. 3. Clean the optical sensor and check connections, then retry operation. If this fails to correct the problem, replace the half door/bezel assembly. 4. Replace the Main PCB.
19	Main motor slipped on pressurization step/ If on AC - SYS Err IF on DC - PLUG AC	1. Low battery condition. 2. Main motor carriage driver needs lubrication or is loose. 3. Pressure transducer and/or associated circuitry failure. 4. Main motor failure. 5. Main motor encoder assembly and/or sensor dirty, loose or failed.	1. Plug the pump in and allow it to recharge before operating on battery. 2. Check for rotation of main motor and lubricate carriage driver with B. Braun approved silicon spray only, other lubricants will worsen the problem over time. If loose, replace carriage driver. 3. Inspect the pressure transducer for damage. Replace half door/bezel assembly. 4. Replace the half door/bezel assembly. 5. Inspect the main motor encoder wheel for dust or other contaminant and clean with cleaner or air blast if necessary. The encoder wheel should be centered between its sensor and rotate with moderate resistance. Return to position if necessary by sliding it into place.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
20	Main motor slipped on retraction step/ SYS Err	1. Low battery condition. 2. Main motor carriage driver needs lubrication or is loose. 3. Pressure transducer and/or associated circuitry failure. 4. Main motor failure. 5. Main motor encoder assembly and/or sensor dirty, loose or failed.	1. Plug the pump in and allow it to recharge before operating on battery. 2. Check for rotation of main motor and lubricate carriage driver with B. Braun approved silicon spray only, other lubricants will worsen the problem over time. If loose, replace carriage driver. 3. Inspect the pressure transducer for damage. Replace half door/bezel assembly. 4. Replace the half door/bezel assembly. 5. Inspect the main motor encoder wheel for dust or other contaminant and clean with cleaner or air blast if necessary. The encoder wheel should be centered between its sensor and rotate with moderate resistance. Return to position if necessary by sliding it into place.
21	Main motor slipped on delivery step/ If on AC - SYS Err If on DC - PLUG AC	1. Low battery condition. 2. Main motor carriage driver needs lubrication or is loose. 3. Pressure transducer and/or associated circuitry failure. 4. Main motor failure. 5. Main motor encoder assembly and/or sensor dirty, loose or failed.	1. Plug the pump in and allow it to recharge before operating on battery. 2. Check for rotation of main motor and lubricate carriage driver with B. Braun approved silicon spray only, other lubricants will worsen the problem over time. If loose, replace carriage driver. 3. Inspect the pressure transducer for damage. Replace half door/bezel assembly. 4. Replace the half door/bezel assembly. 5. Inspect the main motor encoder wheel for dust or other contaminant and clean with cleaner or air blast if necessary. The encoder wheel should be centered between its sensor and rotate with moderate resistance. Return to position if necessary by sliding it into place.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
22	Air in the line/ Air	1. Air is trapped in the tubing. 2. The Air-In-Line sensors are contaminated. 3. Air-In-Line block failure.	1. Remove air from the tubing and continue operation. 2. Inspect the tubing channel in the Air-In-Line block for contamination or fluid and clean with a cotton swab and rubbing alcohol if necessary. 3. Replace the Air-In-Line block assembly.
23	Pump processor software error/ SYS Err	1. Pump processor has malfunctioned 2. Pressure transducer and/or associated circuitry damaged or failed.	1. Replace the pump processor. If problem persists, replace the Main PCB. 2. Inspect the pressure transducer for damage. Replace half door/bezel assembly.
24	Downstream occlusion detected/ OCCL	1. Tube obstruction distal to the pump. 2. Restriction/outlet valve sticking or out of adjustment. 3. Restriction motor failure, or mechanism interface PCB. 4. Pressure transducer and/or associated circuitry damaged or failed. 5. Main PCB failure.	1. Check tubing for a closed clamp or kinks in the tubing between the pump and the patient and continue operation. 2. Check the restriction/outlet valve for freedom of movement by pressing on the valve tip with your finger, valve should depress inward against spring resistance. Check the restriction/outlet valve adjustment. 3. Replace restriction motor or half door/bezel assembly (see Section 7.7.2.1). 4. Inspect the pressure transducer for damage. Replace half door/bezel assembly. 5. Replace the Main PCB.
25	Analog to Digital offset value out of specification/ SYS Err	1. Cassette damaged. 2. Pressure transducer and/or associated circuitry failure. 3. Main PCB failure.	1. Replace cassette and retry operation. 2. Inspect the pressure transducer for damage. Test pressure transducer (see Section 7.7.1.1). 3. Inspect the petal module for fluid or any obstruction.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
26	UTL message checksum error/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
27	UTL message invalid length/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
28	UTL message contains invalid destination address/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
29	UTL message queue overrun/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
30	Over temperature alarm/ SYS Err	1. Temperature sensor indicates an over temperature condition. 2. Temperature sensor failure on the Main PCB, or other Main PCB failure. 3. Fan failure.	1. Verify the fan inlet on the bottom of the pump is not obstructed. 2. Replace the Main PCB. 3. Apply power to the fan and replace if it will not operate.
31	Semaphore ID not valid/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
32	Semaphore queue full/ SYS Err	1. Internal software failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
33	Too many "shut down" messages/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
34	Too many "start delivery messages"/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
35	Not ready to start delivery/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
36	Too many "start ramp delivery" messages/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
37	Too many "enter KVO" messages/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
38	Total volume not yet delivered/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
39	Not ready for KVO/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
42	Invalid message type received/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
43	Door open while pump operating/ door	1. Door was opened during fluid delivery. 2. Door sensor failure. 3. Door magnet failure.	1. Verify that the pump door is securely closed. Restart operation. 2. Replace the half door/bezel assembly. 3. Replace the door lever.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
44	DMA (memory transfer) test failure/ SYS Err	1. Microprocessor failure. 2. Main PCB failure.	1. Retry operation and if the error continues, reseat or replace the V25 microprocessor. 2. Replace the Main PCB.
45	RAM (memory) test failure/ SYS Err	1. Microprocessor failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
47	Invalid PRAM (protected memory) element operation/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
48	Primary Rate not set/ 0.0 primary rate	1. PRIMARY RUN Key was pressed with a rate of zero.	1. Enter a valid rate and restart operation.
49	Primary volume not set/ 0.0 primary vtbd	1. PRIMARY RUN Key was pressed with a volume to be delivered of zero.	1. Enter a valid volume to be delivered and restart operation.
50	Piggyback Rate not set/ 0.0 piggyback rate	1. PIGGYBACK RUN Key was pressed with a rate of zero.	1. Either enter a valid piggyback rate, or press the PRIMARY RUN Key.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
51	Piggyback Volume not set/ 0.0 piggyback vtbd	1. PIGGYBACK RUN Key was pressed with a volume to be delivered of zero.	1. Either enter a valid piggyback volume to be delivered, or press the PRIMARY RUN Key.
52	Hold time exceeded/ HOLD	1. Pump has remained in the HOLD state with door closed for too long.	1. Resume operation or press the HOLD Key again.
53	Invalid Op Log Event/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
54	Bad Light Emitting Diode (LED) on the front panel/ SYS Err	1. An LED on the front panel is failing to draw current, or is drawing current when it should not.	1. Replace the LED display PCB.
55	Invalid parity on Door Processor message/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
56	Invalid Door Processor message command/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Check all cable connections inside the door. 4. Retry operation and if error continues, replace the Main PCB.
57	Invalid Door Processor message digit/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.
58	Initial bit not set on Door Processor message/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable: Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.
59	No watchdog OK message from Door Processor/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Faulty door connector on mechanism interface PCB. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
60	Stack error on Door Processor message/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.
61	Invalid group in Door Processor message/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.
62	Invalid parity on Door Processor to Management Processor (Main Processor) message/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.
63	Direction bit failure/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
64	Unknown Door Processor command/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.
65	Door Processor message queue full/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable: Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.
66	Invalid Door Processor get state/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.
67	System Initialization: timer initialization test failure/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
68	System Initialization: pump communication failure/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.
69	System Initialization: Door Processor communication failure/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.
70	System Initialization: Pump Rx Time-out/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
71	System Initialization: primary alarm failure/ SYS Err	1. Speaker failing to draw current or the speaker connector has come loose. 2. Main board failure.	1. Reseat the connector and if the problem continues, replace the speaker assembly or speaker/fan assembly. 2. Replace the Main PCB
72	Pump Processor OK message not received/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
73	Door Processor OK message not received/ SYS Err	1. Faulty door connector on mechanism interface PCB. 2. Faulty ground shielding on cosmetic bezel. 3. Faulty LED display PCB. 4. Faulty main processor (on the Main PCB).	1. Reseat the door connector on the mechanism interface board. 2. Check grounding clips on each end of door cable. Check copper grounding springs on the case bottom and mechanism. 3. Replace the LED display PCB and check all cable connections inside the door. 4. Replace the Main PCB.
74	Main Processor OK message not received/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, then replace the Main PCB or return the pump for service.
75	PRAM (protected memory) failure/loss of memory configuration SYS Err	1. Processor EPROMs were just installed. 2. Discharged 3V battery. 3. Main PCB failure. 4. Device returned to Service Center for repair.	1. This is normal and expected when the EPROMs are changed. Cycle the pump off then on again. 2. Test 3V lithium battery with a voltmeter and the device turned off and unplugged. Replace if less than 1.5V DC. 3. Replace the Main PCB. 4. All devices returned to Service Center will be set to factory defaults.
76	Battery very low/ USE AC	1. Battery charge is nearly depleted. 2. Damaged battery. 3. Main PCB failure.	1. Plug the pump in and allow it to recharge. Then perform a battery capacity check. 2. Remove battery and inspect for obvious damage. Even if no damage is visible, the battery may still be bad. Charge and test. 3. Replace the Main PCB.
77	Dose Menu Error/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
78	Send Door Processor message failure/ SYS Err	1. Internal software communication failure. 2. Display board PCB failure or the connector between the display board and the Main PCB has come loose.	1. Retry operation and if error continues, replace Main PCB or return the pump for service. 2. Reseat the connector and if the problem continues, replace the LED PCB assembly.
79	Test Air in Line detector malfunction/ SYS Err	1. Failure of the test Air-In-Line sensors. 2. Failure of port input pin on the 80C537 microprocessor on the main board.	1. Check Air-In-Line cable for proper connection. 2. Check the Air-In-Line PCB for cold solder joint or fluid. 3. Replace the Air-In-Line block. 4. Replace the Main PCB.
80	Main Air in Line detector malfunction/ SYS Err	1. Failure of the main Air-In-Line sensors. 2. Failure of port input pin on the 80C537 microprocessor on the main board.	1. Clean the Air-In-Line detector PCB and retry operation if problem persists replace the Air-In-Line block. 2. Replace the Main PCB.
81	Main Processor message checksum error/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat the EPROMs. 2. Replace Main PCB.
82	Main Processor message invalid length/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat the EPROMs. 2. Replace Main PCB.
83	Main Processor message invalid destination/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat the EPROMs. 2. Replace Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
84	Main Processor message queue overrun/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat the EPROMs. 2. Replace Main PCB.
85	Set not present/ CASS	1. The RUN Key was pressed with the tubing detector indicating that no set was present.	1. Install a set in the pump prior to activating the RUN Key.
86	Time of Day time invalid/ SYS Err	1. Internal real-time clock contents corrupted. 2. Main PCB failure.	1. 3 V lithium battery (disc shaped) discharged. Test with a voltmeter with device turned off and unplugged. Replace if less than 1.5 V. 2. Replace the Main PCB.
87	Time of Day initialization failure/ SYS Err	1. Internal real-time clock fails initialization process. 2. Power supply failure.	1. Replace the Main PCB or return the pump for service. 2. Replace the power supply.
89	Pump Processor receive interrupt service routine contains invalid destination address/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
90	Pump Processor receive character not synchronized/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
91	System Integrity Check: Main Processor bad EPROM checksum/ SYS Err	1. Internal software communication failure. 2. Failure of the Main Processor EPROM.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
92	Start up message failure/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
93	System Integrity Check: Pump Processor bad EPROM checksum/ SYS Err	1. Internal software communication failure. 2. Failure of the Pump Processor or ACTEL ICs.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
94	System Integrity Check: Main Processor invalid program sequence/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
95	System Integrity Check: Pump Processor invalid program sequence/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
96	System Integrity Check: Main Processor stack overflow/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
97	System Integrity Check: Pump Processor stack overflow/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
98	System Integrity Check: Main Processor Invalid Special Function Register state/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
99	System Integrity Check: Pump Processor Invalid Special Function Register state/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
100	System Integrity Check: Main Processor unexpected interrupt/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
101	Membrane key stuck/ SYS Err	1. Key panel failure. 2. Door processor PCB failure, or the connector between the door assembly and the Main PCB has come loose. 3. Main PCB failure.	1. Replace the key panel. 2. Reseat the connector and if the problem continues, replace the LED display PCB. 3. Replace the Main PCB.
102	Coprocessor enter KVO time-out/ SYS Err	1. Failure to enter KVO within specified time limit.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace main PCB.
103	Coprocessor start delivery time-out/ SYS Err	1. Failure to initiate motor motion within 10 seconds.	1. Retry operation and if error continues, reseat or replace the EPROMs.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
104	Coprocessor parameters change time-out/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
105	Coprocessor shutdown time-out/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
106	Coprocessor start ramp time-out/ SYS Err	1. Failure to begin delivery of fluid after start of ramped delivery.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
108	Coprocessor over infusion failure/ SYS Err	1. Fluid continued to be delivered after volume to be delivered goes to zero. 2. Main motor encoder wheel and sensor damaged. 3. Main PCB failure.	1. Inspect the main motor encoder wheel and sensor for dust or other contamination or damage. Clean if necessary. 2. Replace half door/bezel assembly. 3. Replace the Main PCB.
110	Coprocessor under infusion failure/ SYS Err	1. Main motor encoder wheel and sensor damaged. 2. Failure to perform as many delivery steps as required for initial volume to be delivered.	1. Inspect the main motor encoder wheel and sensor for dust or other contamination or damage. Clean if necessary. 2. Replace the Main PCB.
111	Coprocessor rate ramped time-out/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
112	Coprocessor test air in line test failure/ SYS Err	1. Air in the set or contaminated sensor. 2. Air-In-Line block failure. 3. Pump processor failure to activate Air-In-Line emitters.	1. Remove the air and clean the sensor with alcohol and a cotton swab. 2. Replace the Air-In-Line block assembly. 3. Replace the Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
113	Coprocessor main air in line test failure/ SYS Err	1. Air in the set or contaminated sensor. 2. Air-In-Line block failure. 3. Pump processor failure to report air in line.	1. Remove the air and clean the sensor with alcohol and a cotton swab. 2. Replace the Air-In-Line block assembly. 3. Replace the Main PCB.
114	Coprocessor solenoid test failure/ SYS Err	1. Pump processor activated transfer valve solenoid during delivery. 2. Solenoid failure.	1. Check for good connection between the Main PCB and mechanism interface board then replace the Main PCB if connection OK. 2. Replace the solenoid or half door/ bezel assembly.
115	Coprocessor main backward test failure/ SYS Err	1. Pump processor takes reverse steps during delivery.	1. Check for good connection between the Main PCB and mechanism interface board then replace the Main PCB if connection OK.
116	Coprocessor main forward test failure/ SYS Err	1. Pump processor is stepping forward during over pressurization condition. 2. Main PCB failure. 3. Pressure transducer and/or associated circuitry failure.	1. Inspect the main motor encoder wheel for dust or other contaminant and clean with cleaner or air blast if necessary. The encoder wheel should be centered between its sensor and rotate with moderate resistance. Return to position if necessary by sliding it into place. 2. Check for good connection between the Main PCB and mechanism interface board then replace the Main PCB if connection OK. 3. Inspect the pressure transducer for damage.
117	Coprocessor restriction/outlet valve closed test failure/ SYS Err	1. Restriction/outlet valve closed during over pressurization.	1. Check for good connection between the Main PCB and mechanism interface board then replace the Main PCB if connection OK.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
118	Coprocessor main motor stepping fast/ SYS Err	1. Pump processor forward delivery steps are occurring too fast. The main motor encoder wheel and sensor are contaminated or damaged. 2. Poor connections. 3. Main PCB failure. 4. Pressure transducer and/or associated circuitry failure.	1. Inspect the main motor encoder wheel for dust or other contaminant and clean with cleaner or air blast if necessary. The encoder wheel should be centered between its sensor and rotate with moderate resistance. Return to position if necessary by sliding it into place. 2. Check for good connection between the Main PCB and mechanism interface board then replace the Main PCB if connection OK. 3. Replace the Main PCB. 4. Inspect the pressure transducer for damage.
119	Coprocessor main motor stepping slow/ SYS ERR	1. Pump processor forward delivery steps are occurring too slow. The main motor encoder wheel and sensor are contaminated or damaged. 2. Poor connections. 3. Main PCB failure.	1. Inspect the main motor encoder wheel for dust or other contaminant and clean with cleaner or air blast if necessary. The encoder wheel should be centered between its sensor and rotate with moderate resistance. Return to position if necessary by sliding it into place. 2. Check for good connection between the Main PCB and mechanism interface board then replace the Main PCB if connection OK. 3. Replace the Main PCB.
120	Coprocessor main motor not stepping/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
121	Coprocessor restriction motor not stepping/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
122	Coprocessor no logical interrupt/ SYS Err	1. Pump processor is not causing step signals during delivery.	1. Check for good connection between the Main PCB and mechanism interface board then replace the Main PCB if connection OK.
123	Power glitch encountered/ If on AC - SYS Err If on DC - PLUG AC	1. Discharged battery. 2. Fuse 2 on Main PCB damaged or missing. 3. Damaged battery. 4. Main PCB failure.	1. This is normal and expected when the pump is allowed to infuse until the emergency backup alarm comes on. Plug the pump in and allow it to recharge. Then perform a battery capacity check. 2. Check Fuse 2 for continuity. 3. Remove battery and inspect for obvious damage. Even if no damage is visible the battery may still be bad. Replace and retest. 4. Replace the Main PCB.
124	Receive message buffer overrun/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat the EPROMs. 2. Replace Main PCB.
126	AD offset not zero/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
127	Coprocessor occlusion test failure/ SYS Err	1. Delivery chamber has remained over pressure for too long without an occlusion alarm. Pressure transducer and/or associated circuitry failure. 2. Main PCB failure.	1. Check for obstruction in the tubing. Retry operation and if error continues, inspect the pressure transducer for damage. 2. Replace the Main PCB.
128	System Integrity Check: no ambient light message/ SYS Err	1. LED display PCB failure. 2. Main PCB failure.	1. Retry operation and if error continues, replace the LED display PCB. 2. Replace the Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
129	OPM software error/ SYS Err	1. Internal software failure.	1. Retry operation and if error continues, reseat the EPROMs. 2. Replace Main PCB.
130	Coprocessor over rate test/ SYS Err	1. Pump processor delivery rate (during ramped delivery) is too high.	1. Retry operation and if error continues, reseat the EPROMs. 2. Replace Main PCB.
131	Coprocessor under rate test/ SYS Err	1. Pump processor delivery rate (during ramped delivery) is too low.	1. Retry operation and if error continues, reseat the EPROMs. 2. Replace Main PCB.
132	Coprocessor invalid rate test/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat the EPROMs. 2. Replace Main PCB.
133	Coprocessor next delivery step test/ SYS Err	1. Pump processor stopped delivering fluid. 2. Main motor damaged.	1. Replace the Main PCB. 2. Replace the half door/bezel assembly.
134	Flow clamp out of position/ SEE HELP (help is displayed on the LCD)	1. The RUN Key was pressed with the flow clamp out of position. 2. Attempting to use tubing without an Anti-Freeflow device. 3. The optical sensor in the flow clip receptacle assembly is wet or failed. 4. Main PCB failure.	1. Verify that the set tubing is properly installed in the pump. 2. Verify proper tubing is being used. 3. Allow to dry then retry. If reoccurs, then replace the flow clip receptacle assembly. 4. Replace the Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
135	Main motor slip during forward non- pressurization step/ If on AC - SYS Err If on DC - PLUG AC	1. Low battery condition. 2. Black, negative sensor wire connecting the battery to the Main PCB has a poor connection. 3. The main motor encoder wheel and sensor are contaminated or damaged. 4. Main motor failure. 5. Main PCB failure.	1. Plug the pump in and allow it to recharge. 2. Verify continuity between the main battery ground wires and the Main PCB. Break may be hidden by shrink wrap at the battery connection side. Resolder or replace wires if needed. 3. Inspect the main motor encoder wheel for dust or other contaminant and clean with cleaner or air blast if necessary. Encoder wheel should be centered between its sensor and should rotate with moderate resistance. If jammed, it may need some force to rotate free. Return to position if necessary by sliding it into place. 4. Replace the half door/bezel assembly. 5. Replace the Main PCB.
136	DMA (memory) process time-out/ LCD Err	1. Failure of the Liquid Crystal Display (LCD) driver circuitry on the LCD controller PCB. 2. Internal software communication failure.	1. Replace the LCD controller PCB. 2. Retry operation and if error continues, replace Main PCB or return the pump for service.
137	Optical Yoke adjustment measurement out of specification/ SYS Err	1. Restriction/outlet valve yoke sticking or out of adjustment. 2. Faulty restriction motor in mechanism. 3. Faulty motor drive circuitry on Main PCB	1. Check the restriction/outlet valve for freedom of movement by pressing on the valve tip with your finger, valve should depress inward against spring resistance. Check the restriction/outlet valve yoke adjustment. 2. Replace the restriction motor or half door/bezel assembly. 3. Replace the Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
138	Backup alarm unexpectedly activated/ SYS Err	1. Fuse 2 is damaged or missing. 2. Low battery condition. 3. Damaged battery. 4. Hardware failure on Main PCB.	1. Check Fuse 2 for continuity . Check all connections to Main PCB. 2. Plug the pump in and allow it to recharge. Then perform a battery capacity check. 3. Remove battery and inspect for obvious damage. Even if no damage is visible, the battery may still be bad. Replace and retest. 4. Replace the Main PCB.
139	Batteries Improperly Connected/ SYS Err	1. Batteries are not properly connected. 2. Low battery condition. 3. Damaged battery. 4. Main PCB failure.	1. Verify all batteries have good connections. 2. Plug the pump in and allow it to recharge. Then perform a battery capacity check. 3. Remove battery and inspect for obvious damage. Even if no damage is visible the battery may still be bad, replace and retest. 4. Replace the Main PCB.
140	Battery sense wire broken/ SYS Err	1. Pump is on DC operation and battery voltage reads less than main voltage. The ground wires connecting the main battery to the Main PCB have a poor connection. 2. Analog to Digital measurement error on Main PCB.	1. Verify continuity between the main battery ground wires and the Main PCB. Break may be hidden by shrink wrap at the battery connection side. Resolder or replace wires if needed. 2. Check the Analog to Digital offset and replace the Main PCB if abnormal. See Section 7.7.1.1.
141	Unexpected power down message/ SYS Err	1. A power-down message was received without an associated POWER Key press.	1. Visually inspect Main PCB for disconnected wires or improperly seated ICs. If problem persists, replace the Main PCB.
142	Pressure Transducer EEPROM error/ SYS Err	1. The pressure transducer EEPROM is faulty. 2. The EEPROM drivers on the Main PCB are faulty.	1. Check cables and connectors to door and pressure transducer. Replace the half door/bezel assembly. 2. Replace the Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
143	Door Display EEPROM error/ SYS Err	1. The display EEPROM is faulty. 2. The EEPROM drivers on the Main PCB are faulty.	1. Check cables and connectors to door. Replace the LED PCB assembly. 2. Replace the Main PCB.
144	Door LED power low/ SYS Err	1. LED test power circuit failure. Note: This alarm differs from 54 in that it tests for power supplied to the PCB, not a LED segment failure.	1. Check door cable and connectors. Replace the LED PCB assembly.
145	FP Math Error/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
146	Qx Overlap error/ SYS Err	1. Internal software communication failure.	1. Retry operation and if error continues, reseat or replace the EPROMs. 2. Replace Main PCB.
147	PRAM corruption SYS Err	1. Corruption of control data for PRAM.	1. PRAM will automatically re-initialize. 2. Power cycle the pump and redock.
148	PRAM corruption SYS Err	1. Corruption of index of PRAM.	1. PRAM will automatically re-initialize. 2. Power cycle the pump and redock.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
	Pump will not operate on AC	1. Power cord cut or loose. 2. Power supply failure. 3. Main PCB failure. 4. Key panel failure. 5. Door processor or LED PCB failure. 6. Fluid intrusion.	1. Check the cord for continuity and placement. 2. Remove power supply and inspect for damage, loose wires or components. If fuses open, test Q1 on the power supply PCB. If FU1 or FU2 open, replace Q1 and U1 and the fuses on the power supply PCB. Q1 is the crowbar transistor intended to fail prior to other component failure. Replace fuses or power supply as necessary. 3. Replace the Main PCB. 4. Replace the key panel. 5. Replace the LED PCB assembly. 6. Open pump and look for evidence of fluid intrusion. If found, wipe off all damp components and allow to dry thoroughly before attempting operation again. If unsuccessful, return the pump for service.
	Pump does not power off with door closed	1. Key panel failure. 2. Main PCB failure. 3. Door processor or LED PCB failure. 4. Fluid intrusion.	1. Replace the key panel. 2. Test main board by shorting the on/off pads on the front of the main board. Replace the Main PCB. 3. Replace the LED PCB. 4. Open pump and look for evidence of fluid intrusion. If found, wipe off all damp components and allow to dry thoroughly before attempting operation again. If unsuccessful, return the pump for service.
	Pump emits continuous high pitched sounding alarm and will not turn on	1. Low battery condition. 2. Defective power supply. 3. Main PCB failure. 4. Short in additional subassemblies.	1. Plug the pump in and cycle the power on and off then allow it to recharge. 2. Replace power supply. 3. Replace the Main PCB. 4. Isolate defective subassembly(ies).

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
	Pump slips down pole	1. Pump improperly mounted on pole. 2. Foreign material on pole such as a lubricant. 3. QuickClamp™ mechanism failure. 4. Check that I.V. pole is within specifications (0.75" to 1.25")	1. The clamp may have been locked before it was tightened. 2. Clean the pole of all foreign materials. 3. Check to ensure that the rubber material is firmly in place and reapply with an approved adhesive material. 4. Check for cracks in QuickClamp plastic assembly and replace the clamp mechanism if any are found.
	LCD has no backlight	1. LED Display PCB failure 2. Short between the right side of the LCD PCB and the inside of the cosmetic bezel, when pressure is applied the that portion of the cosmetic bezel.	1. Replace the LED Display PCB. 2. Verify that the insulating tape is properly covering the right side of the LCD PCB and the metal clip inside the right edge of the cosmetic bezel.
	LCD flickers erratically or goes blank	1. Low battery condition. 2. Cable between the door and the mechanism has dislodged. 3. LCD assembly failure. 4. LED PCB failure. 5. Bent pin on the 100 pin main board connector.	1. Plug the pump in and verify that the LCD works correctly. 2. Reseat the connector. 3. Replace the LCD assembly. 4. Replace the LED PCB assembly. 5. Straighten the pin and re-connect.
	Pump will not operate on battery	1. Battery has completely discharged. 2. Battery cables may be damaged. 3. Fuse number 2 on Main PCB has been damaged or loose. 4. Main PCB failure.	1. Plug the pump in and allow it to fully recharge before attempting battery operation. 2. Check battery cables and connectors for damage. 3. Inspect the fuse and replace as needed. 4. Replace the Main PCB.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
	Unable to download operation, alarm log, or configuration	1. Pump not placed in proper mode. 2. Monitor Communications set to "Monitor." 3. Cables and/or connectors are not properly seated. 4. Cable not in serial port. 5. Misalignment of the infrared (IR) transceivers, or the IR window is dirty. 6. Cables and/or connectors are damaged. 7. Transmitting LEDs are damaged or bent.	1. Put pump in Biomed menu. Access operation or alarm log and select transmit with P.C. in Docking Program, receive operation log. 2. Monitor Communications must be set to either "Disabled" or "Demo." 3. Check cable connections. 4. Ensure cable is in serial port (9 pin). 5. Verify that the transceiver box is properly mounted on the pump. Clean the IR window. 6. Ensure that the connectors between the pump and the computer are not damaged. Try an alternate cable. 7. Verify that the transmitting LED is not bent. If damaged, replace the Main PCB. Remove case top and visually align receiver LEDs with main board LEDs; hold and retry.
	Unable to perform panel lockout.	1. Pump not infusing. 2. Panel lock out switch failure. 3. Main PCB failure.	1. Pump must be infusing to activate lock out. 2. Verify that the switch is being depressed properly, is not bent or damaged. 3. Replace the Main PCB.
	No audible alarm.	1. Main alarm speaker has failed. 2. Connector to the speaker has dislodged. 3. Main PCB failure.	1. Replace the speaker assembly. 2. Reseat the connector. 3. Replace the Main PCB.
	Pump makes a grinding or ratcheting noise upon power up or down. Immediately gives SYS Err	1. Main motor is jammed.	1. Remove main motor from mechanism. Unscrew carriage driver from shaft of main motor. Lubricate with CRC brand silicone spray and re-assemble.

Table 1: Troubleshooting Guide

Code	Error Description/Message on LED's	Probable Cause	Corrective Action
	LCD scrolling	1. LED board failure. 2. LCD failure. 3. Main PCB failure.	1. Examine for poor or misaligned connections. Replace LED PCB or replace the LED display board. 2. Replace the LCD display if necessary. 3. Replace the Main PCB.
	Displays flash on and off	1. Pump processor EPROM failure. 2. Pump processor failure. 3. Main PCB failure.	1. Replace or reseat the pump processor EPROM. 2. Replace or reseat pump processor. 3. Replace the Main PCB.
	LED displays Err 5	1. LED display PCB failure. 2. Main PCB failure.	1. Replace the LED display PCB. 2. Replace Main PCB.
	Short operating time to LOW BATT alarm	1. Main battery in a low condition. 2. Main battery no longer accepts a charge. 3. Main PCB failure.	1. Plug the pump in and allow it to fully recharge. Inspect Fuse 2 on the Main PCB. 2. Replace the battery (recommended at 2-year intervals). 3. Replace the Main PCB.

APPENDIX C: Operation Log

Below is an example of a portion of an Operation Log as will be seen when viewing the file on your computer. If the log is full, the print out will be approximately 20-24 pages long, with the most recent event placed at the end of the printout:

VERSION C C B
B. Braun
Horizon Nxt Operation Log

ACH = active channel
ALM = alarm
ALV = alarm volume
APG = allow program
ATV = allow time & vol
CDU = dose concentration units
DDA = dose drug amount
DOS = dosage
DPW = dose patient weight
DSV = dose solution vol
DVL = dose volume
GCV = program current vol
GSR = program set rate
IDS = initial data start-up
IPT = pressure start-up type
IST = infusion status
LCN = lcd contrast
MKC =key click signal
MMD = micro mode
PCR = profile current rate
PDV = ramp down vol
PLR = profile level rate
PRR = profile ramp rate
PTT = profile total time
PUT = profile ramp up time
PVL = profile volume
QXS = qx start time
QXR = qx rate
QXV = qx total volume
REM = time remaining
SBR = STD piggyback rate
SPR = STD primary rate
STRT= start time

AFL = allow flush
ALT = alternate alarm
APF = allow profile
APY = allow piggyback
BLV = battery level
CMD = current mode
DDU = dose drug units
DPU = dose patient unit
DRT =dose rate
DTU = dose time units
FLV = flush volume
GPD =program period
GSV = program set volume
IPR = infusion pressure
IPV =initial pressure
KOR = KVO rate
LST = line status

MTS = transition signal
PDT =ramp down time
PHU =patient height unit
PMR =profile max rate
PST = profile stage
PTV = profile total volume
PUV =profile ramp up vol
PWU = patient weight unit
QXI = QX interval
QXD = QX dose volume

SLV =STD last volume
SBV =STD piggyback volume
SPV = STD primary volume

TDY = day
TI = total infused
TMO = month
VTD = volume to deliver
THR = hour
TMN = minute
UPR = user pressure
ZTM = pause time

STANDARD POWER UP
ACH = PRIMARY SPR = 0.0 SPV = 0.0 SBR = 0.0 SBV = 0.0
UPR = 300 TI = 0.0 REM =10 hours 0 minutes
TMO = 11 TDY = 5 THR = 10 TMN = 4 LST =Uninitialized BLV = 0

MENU SETTINGS
ALV = HIGH LCN = 7 IDS = POWER UP IN STANDARD MODE
MMD = Adult IPT = FIXED IPV = 300
APF = Profile Enabled APG = Program Disabled
ATV = Time Vol Disabled APY = Piggyback Enabled
MTS = Disabled ALT= Off MKC = Enabled
TMO = 11 TDY = 5 THR = 10 TMN = 4

PRIMARY START
ACH = PRIMARY SPR = 100.0 SPV = 100.0 SBR = 0.0 SBV 0.0
UPR = 300 TI = 0.0 REM = 1 hours 0minutes
TMO = 11 TDY = 5 THR = 10 TMN = 5 LST = Battery BLV = 95

STANDARD ALARM
ALM = 24 Downstream Occlusion
ACH = PRIMARY SPR = 100.0 SPV = 98.7 SBR = 0.0 SBV 0.0
UPR = 300 TI = 1.3 REM = 0 hours 58 minutes
TMO = 11 TDY = 5 THR = 10 TMN = 7 LST = Battery BLV = 78

STANDARD HOLD
ACH = PRIMARY SPR = 100.0 SPV = 98.7 SBR = 0.0 SBV 0.0
UPR = 300 TI = 1.3 REM = 1 hours 0minutes
TMO = 11 TDY = 5 THR = 10 TMN = 7 LST = Battery BLV = 78

PRIMARY START
ACH = PRIMARY SPR = 100.0 SPV = 98.7 SBR = 0.0 SBV 0.0
UPR = 300 TI = 1.3 REM = 0 hours 58 minutes
TMO = 11 TDY = 5 THR = 10 TMN = 7 LST = Battery BLV = 78

KVO START
CMD = Standard KOR = 3.0 UPR = 300 TI = 100.0
TMO = 11 TDY = 4 THR = 11 TMN = 5 LST = Battery BLV = 75

STANDARD HOLD
ACH = PRIMARY SPR = 100.0 SPV = 0.0 SBR = 0.0 SBV 0.0
UPR = 300 TI = 100.0 REM = 0 hours 0 minutes
TMO = 11 TDY = 5 THR = 11 TMN = 7 LST = Battery BLV = 65

HOLD EXTEND START
CMD = Standard ZTM = 0 hr 3 min 0 sec
TMO = 11 TDY = 5 THR = 11 TMN = 7 LST = AC

HOLD EXTEND END
CMD = Standard ZTM = 0 hr 2 min 54 sec
TMO = 11 TDY = 5 THR = 11 TMN = 7 LST = AC

PRIMARY START
ACH = PRIMARY SPR = 100.0 SPV = 20.0 SBR = 0.0 SBV = 0.0
UPR = 300 TI = 100.0 REM = 0 hours 12 minutes
TMO = 11 TDY = 5 THR = 11 TMN = 8 LST = AC BLV = 0

STANDARD ALARM
ALM = 9 System Alarm
ACH = PRIMARY SPR = 100.0 SPV = 20.0 SBR = 0.0 SBV = 0.0
UPR = 300 TI = 100.0 REM = 0 hours 12 minutes
TMO = 11 TDY = 5 THR = 11 TMN = 8 LST = AC BLV = 0

STANDARD HOLD
ACH = PRIMARY SPR = 100.0 SPV = 20.0 SBR = 0.0 SBV = 0.0
UPR = 300 TI = 100.0 REM = 0 hours 12 minutes
TMO = 11 TDY = 5 THR = 11 TMN = 8 LST = AC BLV = 0

PRIMARY START
ACH = PRIMARY SPR = 80.0 SPV = 20.0 SBR = 0.0 SBV = 0.0
UPR = 300 TI = 0.0 REM = 0 hours 15 minutes
TMO = 11 TDY = 5 THR = 11 TMN = 8 LST = AC BLV = 0

STANDARD ALARM
ALM = 22 Air-in-Line
ACH = PRIMARY SPR = 80.0 SPV = 7.0 SBR = 0.0 SBV = 0.0
UPR = 300 TI = 13.0 REM = 0 hours 5 minutes
TMO = 11 TDY = 5 THR = 11 TMN = 8 LST = AC BLV = 0