Cut and insert into label holder on spine of binder

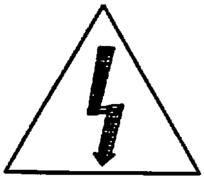
960A/
965A

WARNINGS, CAUTIONS AND NOTICES

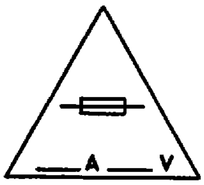
USE ONLY HOSPITAL GRADE POWER SUPPLY CORD TO INSURE PROPER GROUNDING. GROUNDING RELIABILITY CAN ONLY BE ACHIEVED BY CONNECTION TO A RECEPTACLE MARKED "HOSPITAL GRADE".

DANGER: EXPLOSION HAZARD, DO NOT USE IN THE PRESENCE OF FLAMMABLE ANESTHETICS.

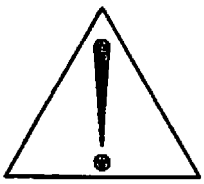
DANGER: RISQUE D'EXPLOSION, NE PAS EMPLOYER EN PRESENCE D'ANESTHESIQUES INFLAMMABLES.



CAUTION: TO REDUCE RISK OF ELECTRICAL SHOCK, DO NOT REMOVE COVER OR BACK. REFER SERVICING TO QUALIFIED SERVICE PERSONNEL.



WARNING: REPLACE FUSE AS MARKED.



CAUTION: BEFORE CONNECTING "REFER TO MANUAL"

NOTE
TO MAXIMIZE THE SERVICE LIFE OF THE INSTALLED BATTERY, IT IS RECOMMENDED THAT THIS INSTRUMENT BE STORED AND OPERATED IN AN ENVIRONMENT THAT IS TEMPERATURE CONTROLLED BETWEEN 68°F (20°C) AND 77°F (25°C).

WARNING
IN THE EVENT THE INSTRUMENT IS DROPPED AT ANY TIME, IT MUST BE CHECKED BY A BIOMEDICAL TECHNICIAN PRIOR TO USE FOR PATIENT CARE.

NOTICE

Product design and/or specifications are subject to change without notice. The information contained in this manual is current as of the date of issue.

This publication contains IMED proprietary data provided solely for the use of technical personnel in repairing IMED infusion pump/controllers.

None of the information contained herein may be duplicated nor may it be utilized in any manner other than for the repair and maintenance of IMED infusion pump/controllers and the component parts thereof. Any unauthorized use of the information contained herein may subject the user to substantial liability.

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U.S. Patents 3,985,133
Other Patents Pending

PREFACE

This manual contains operation and maintenance instructions for the IMED Model 960A/*965A* series of Volumetric/Microvolumetric Infusion Pumps. These instruments are grouped into three configurations which are defined in the following figure:

CONFIGURATION	REFERENCE	SOFTWARE DISPLAY
Foster	F	None
Hightower	HT	P0.6/P1.4/P1.5
Product Inprovement	PIP	P4.xx

Technical information that is unique to a particular configuration is identified by the reference code and/or the software version displayed during initialization.

The information provided herein is intended for use by technical personnel responsible for servicing these products. The material is divided into six sections and is presented as follows: Section 1 - Descriptive Information; Section 2 - Preparation for Use; Section 3 - Operating Instructions; Section 4 - Functional Description and Schematic Diagrams; Section 5 - Maintenance Instructions; Section 6 - Parts Lists and Assembly Drawings.

This manual supersedes IMED P/N 960-9010-00.

Additional copies of this manual may be obtained by contacting IMED's Customer Service Department and ordering IMED Part No. 960-9200-00.

The 960A/*965A* International Addendum P/N 960-9208 supplements this manual for support of the 220V versions of these instruments.

RECORD OF CHANGES

Date	Description of Change	By
05/01/90	Initial Issue	JD/MOW

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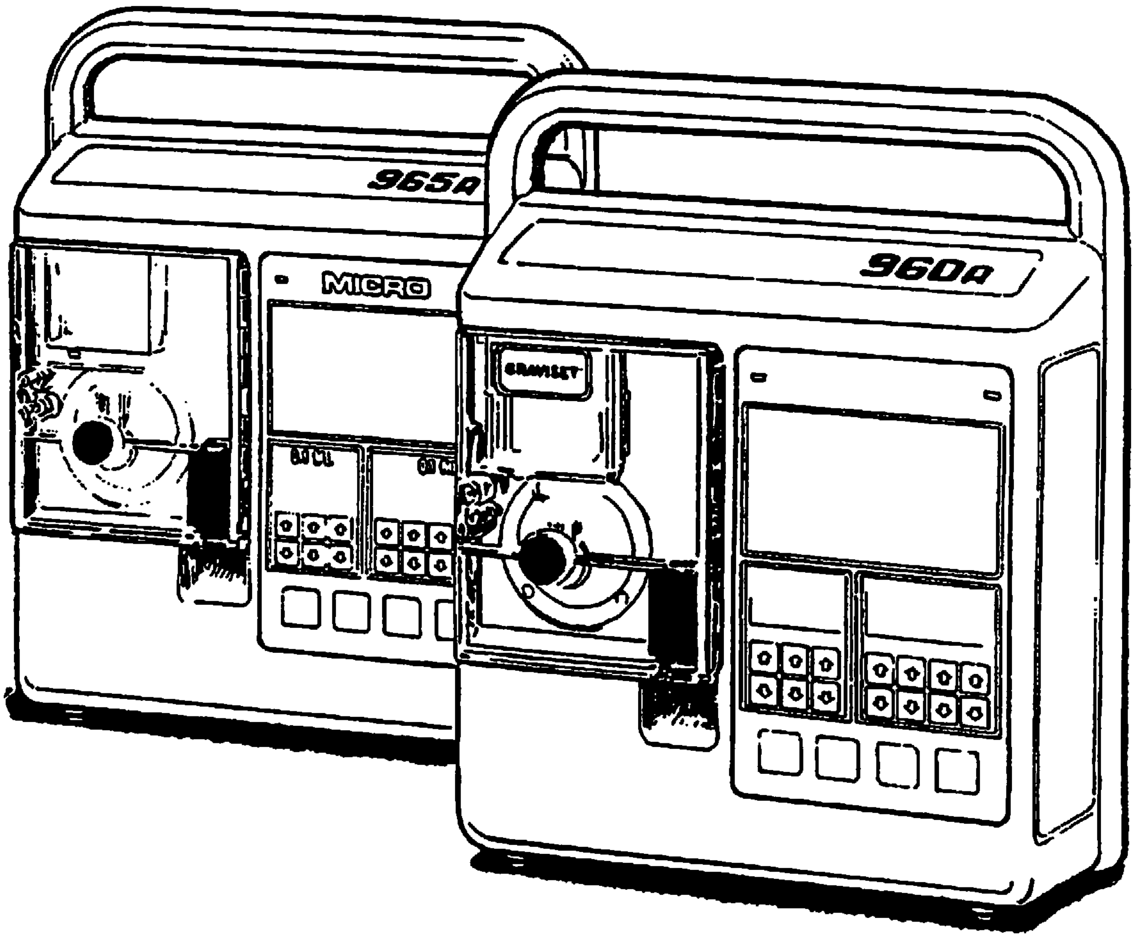


Figure 1-1. IMED 960A/*965A* Volumetric Infusion Pump

SECTION 1 - DESCRIPTION

1.0 INTRODUCTION

This section contains a description of the operating and physical characteristics plus the operating requirements and performance specifications for the IMED 960A Volumetric and *965A* Micro Volumetric Infusion Pumps. IMED administration sets compatible with each of these instruments are listed at the end of this section. The physical and operational characteristics of the 960A and *965A* are identical in most respects. Those characteristics of the *965A* that differ from the 960A will be identified by bold face italic print.

1.1 OPERATING CHARACTERISTICS

The IMED Model 960A & *965A* Volumetric Infusion devices are electronically controlled, electro-mechanically driven, piston (syringe) type pumps. The 960A is designed primarily for the delivery of drugs and fluids to adult patients. The *965A* is designed for pediatric/neonatal applications. Both instruments utilize administration sets configured with a snap-in cassette pump. An automatic priming feature is incorporated to facilitate preparing the administration set. A tactile keypad allows the user to enter infusion rate and volume to be infused (VTBI). The selected rate and VTBI are shown on seven-segment LED displays. A backlighted LCD panel displays Volume Infused, operator prompts and alarm messages. Table 1-1 defines the operating range of the rate and VTBI parameters for each instrument. Once set up and started, both instruments operate on a semi-automatic basis. While an infusion is in progress, the instrument's microprocessor monitors the fluid column for air-in-line and occlusion pressure. When the selected volume has been infused, the instrument automatically changes over to the "keep vein open (KVO)" rate and initiates an audio and visual INFUSION COMPLETE alarm.

In addition to controlling and monitoring the infusion, the instrument's microprocessor diagnostic program will detect and initiate appropriate action in the event of an open door, the battery not charging or either a hardware or software system malfunction.

The instruments can be operated on battery power for a limited period of time. The length of operating time available on battery power is dependent upon the delivery rate used. While operating on AC power the battery charger is recharging or maintaining the battery at full charge.

NOTE:

Although the IMED Models 960A/*965A* are built and tested to exacting specifications and standards, they are not intended to replace the supervision by medical personnel of IV infusions. We urge the user to exercise a professional standard of care in the use of this equipment.

1.2 PHYSICAL CHARACTERISTICS

The 960A/*965A* instruments have the following physical characteristics:

Height:	11.75 inches (29.6 cm)
Width:	10.00 inches (25.4 cm)
Depth:	6.00 inches (15.2 cm)

Weight	≈14.75 pounds (6.7 kg)

The case is molded from a high-impact, flame retardant plastic material and provides the housing and support for the internally mounted components and pole clamp assembly. The case is molded in two pieces which form the front and rear case assemblies.

FRONT CASE ASSEMBLY

Software Release P-0.x/1.x Instruments
The front case assembly contains the front panel assembly, main logic board, invertor, angle plate assembly, cassette nest, shuttle boot assembly, air in line detector and door assembly.

Software Release P-4.x Instruments
The front case assembly contains the keypad, power and display boards, angle plate assembly, shuttle boot, cassette nest, air-in-line detector assembly and door assembly.

REAR CASE ASSEMBLY

Software Release P-0.x/1.x Instruments
The rear case assembly contains the battery, AC power input module, sonalert, audio control switch, nurse call connector, pole clamp assembly, power supply board, transformer and line cord clip.

Software Release P-4.x Instruments
The rear case assembly contains the battery, AC power input module, sonalert, audio control switch, battery backup board, transformer, pole clamp assembly and line cord clip.

1.3 USER INTERFACE

The 960A/*965A* user interface includes the front panel assembly, the administration set installation area and the rear panel assembly.

FRONT PANEL

The front panel assembly employs four controls to operate the instrument. The ON/STOP control is an alternate action type switch used to turn the instrument On and Off. The PRIME ON/OFF control initiates operation of the pumping mechanism for approximately 1 minute, if the rate is set to "000". The VOL INF RESET control will clear the volume infused register and the LCD panel display to "0", if actuated when the VTBI is set to "0000". The START control initiates operation of the pumping mechanism, if the rate and VTBI are set to a value >0.

Fourteen arrow controls are used to program the instrument for a specific infusion. Six arrow controls are used to input the infusion rate which displays in three seven-segment LED windows. Eight arrow controls are used to input the VTBI which displays in four seven-segment LED windows. An amber backlighted "PRESS" indicator (above the START control) illuminates with an accompanying audio alarm if the START control is not pressed following a change in rate and/or VTBI while an infusion is in progress.

The backlighted LCD panel displays the "VOLUME INFUSED" since the last reset or "0" after the power has been off for 4 hours. While the instrument is operating a series of 5 dashes sequence across the LCD panel. Eleven visual messages are displayed on the panel in response to instrument alarm conditions or to prompt the operator. In addition to the LCD panel a green LED indicator flashes when the instrument is OPERATING and a red LED indicator flashes when the instrument is in ALARM.

ADMINISTRATION SET INSTALLATION AREA

The set installation area is behind the clear plastic door and includes the cassette nest, shuttle arm and air in line detector. The cassette must be properly seated in the nest and plunger fitting engaged to the shuttle arm before the door will close. The set tubing must be inserted into the air in line detector to enable starting the pump. The pump will stop and alarm if the door is opened during an infusion.

REAR PANEL

The rear panel controls include the AUDIO silence switch. When permitted the audio alarm can be silenced temporarily by pressing the AUDIO switch.

Software Release P-0.x/1.x instruments
A NURSE CALL connector is provided. When an external Nurse Call system is connected to the instrument, the 960A/*965A* will activate the facility's Nurse Call system if the instrument enters an alarm condition.

1.4 OPERATING SPECIFICATIONS

The operating specifications for the 960A & *965A* are divided into operating requirements and performance specifications. These requirements and specifications are delineated in Tables 1-1 and 1-2 respectively.

Table 1-1. Operating Requirements

Parameter	Specification
Power Required:	108-132 VAC, 0.3 Amps nominal, Fused at 0.4A (primary) 5.0A (secondary), 50-60 Hz, Single ϕ, 2 wire plus Ground
Battery:	Sealed Lead-Acid, 6 VDC, 10 Amp-Hr
Nurse Call System Power Limitations: (P-0.x/1.x Software Instruments ONLY)	Maximum recommended Voltage/Current 24 VDC/500 mA (Leakage current 100 µA maximum)
Operating Temperature Range:	40°F (5°C) to 104°F (40°C)
Operating Humidity Range:	40% to 95% Relative Humidity, non condensing
Storage Temperature: *	-40°F (-40°C) to 158°F (70°C)
Storage Humidity:	40% to 95% Relative Humidity, non condensing

* See NOTE on Warning, Caution and Notice page inside of the front cover.

Table 1-2. Performance Specifications

Parameter	Specification
Operating Principle:	Electronically controlled, electro-mechanically driven piston/cylinder type pump
Operating RATE range:	1-999 mL/hr in 1 mL/hr increments
	0.1-99.9 mL/hr in 0.1 mL/hr increments
VOLUME TO BE INFUSED range:	1-9999 mL in 1 mL increments
	0.1-999.9 mL in 0.1 mL increments
Keep Vein Open (KVO) rate:	1 mL/hr
	0.1 mL/hr
Occlusion Pressure:	18 psi nominal
Air In Line Detection:	<u>Software Release P-0.x/1.x Instruments</u> Optical (5 Elements)
	<u>Software Release P-4.x Instruments</u> Ultrasonic
Battery Operation:	10 hours at 125 mL/hr (with new, fully charged battery)
	10 hours at 50 mL/hr (with new, fully charged battery)

Battery Charging:

Instrument Operating at 125 mL/hr:	20 hours
Instrument - Off:	7 hours

Automatic Prime: Stops after approximately 1 minute; manual stop capability with second press of PRIME ON/OFF control

ALARMS/PROMPTS: AIR IN LINE, OCCLUSION, INFUSION COMPLETE, LOW BATTERY, DOOR OPEN, NOT OPERATING, RATE NOT 000, RATE 000, NOT CHARGING, SET 0000 VOLUME, SET VOLUME, AUDIO OFF and PRESS

Audio Characteristics:

AUDIO TYPE	AUDIBLE SOUND	AUDIO SILENCE
MALFUNCTION	CONTINUOUS WARBLE	NO
ALARM PROMPT (F) PROMPT (HT)	INTERMITTENT WARBLE	YES
WALKAWAY	CONTINUOUS WARBLE	YES
"PRESS" ADVISORY	CONTINUOUS BEEP	YES

NOTE

The 960A and *965A* Volumetric Infusion Pumps comply with the Underwriter Laboratory's 544, Medical and Dental Equipment (Second Edition, as amended) and the Canadian Standard Association's C22.2 No. 125-M1984, Electromedical Equipment specifications.

1.5 ADMINISTRATION SETS

The following administration sets available for use with the 960A Volumetric Infusion Pump and *965A* Micro Volumetric Infusion Pump are listed in Table 1-3.

Table 1-3. Administration Sets

Reorder Number	Description
	960A
9200	ACCUSET™ Administration Set with Microbore Patient Extension
9201	ACCUSET Administration Set with Microbore Patient Extension and 0.22 Micron Filter
9205	ACCUSET Administration Set with Macrobore Patient Extension
9210	ACCUSET Closed System Vented Administration Set
9211	ACCUSET Closed System Vented Administration Set with 0.22 Micron Filter
9214	ACCUSET Closed System Nonvented Administration Set with 2 Injection Sites
9215	ACCUSET Closed System Nonvented Administration Set
9216	ACCUSET Closed System Nonvented Administration Set with 0.22 Micron Filter
9219	ACCUSET Closed System Vented Administration Set with Metered Chamber and Drip Chamber
9224	ACCUSET Closed System Nonvented Administration Set with Metered Chamber and Drip Chamber
9230	ACCUSET Closed System Vented Quick Spike (without Drip Chamber) Administration Set
9235	ACCUSET Closed System Nonvented Quick spike (without Drip Chamber) Administration Set
9251	ACCUSET Closed System ADD-i-MED™ Vented Administration Set
9252	ACCUSET Closed System ADD-i-MED Nonvented Administration Set
9381	SECONDARY 20 Vented Secondary Administration Set
9382	SECONDARY 20 Nonvented Secondary Administration Set
9510	GRAVISET™ 20 Vented Primary Administration Set
9512	GRAVISET 20 Nonvented Primary Administration Set
9515	GRAVISET 20 Vented Primary with 0.22 Micron Filter Administration Set
9517	GRAVISET 20 Nonvented Primary with 0.22 Micron Filter Administration Set

9550	GRAVISET 20 Vented ADD-i-MED Primary with Check Valve Administration Set
9552	GRAVISET 20 Nonvented ADD-i-MED Primary with Check Valve Administration Set
9555	GRAVISET 20 Vented ADD-i-MED Primary with Check Valve and 0.22 Micron Filter Administration Set
9557	GRAVISET 20 Nonvented ADD-i-MED Primary with Check Valve and 0.22 Micron Filter Administration Set
9630	ACCUSET Closed System NON-PVC Vented Quick Spike (without Drip Chamber) Administration Set
9635	ACCUSET Closed System NON-PVC Nonvented Quick Spike (without Drip Chamber) Administration Set
	965A
9260	*MICROSET™ Administration Set with Patient Extension*
9261	*MICROSET Administration Set with Patient Extension and 0.22 Micron Filter*
9269	*MICROSET Closed System Vented Administration Set with Metered Chamber and Drip Chamber*
9271	*MICROSET Closed system Vented Administration Set with Metered Chamber and 0.22 Micron filter*
9274	*MICROSET Closed System Nonvented Administration Set with Metered Chamber and Drip Chamber*
9276	*MICROSET Closed System Nonvented Administration Set with Metered Chamber and 0.22 Micron Filter*

SECTION 2 - PREPARATION FOR USE

2.1 INTRODUCTION

This section contains information relative to the initial inspection and pre-operational checkout of the IMED 960A Volumetric Infusion Pump and the *965A* Micro Volumetric Infusion Pump. These procedures include a mechanical inspection, electrical inspection, pre-operational battery charge and a performance check to ensure that the instrument operates properly and has not been damaged during shipment or storage.

2.2 PRE-OPERATIONAL MECHANICAL INSPECTION

The 960A/*965A* instruments have undergone thorough production control and quality assurance testing prior to shipment from the factory. The shipping container has been designed to protect the instrument against damage under normal shipping conditions; nevertheless, internal physical and/or electronic component damage could have occurred without leaving a visible signature. Therefore, it is recommended that the following inspection procedure be performed upon receipt of the instrument at the user's facility.

1. Carefully remove the instrument from the shipping container. (It is recommended the shipping material be saved in the event the instrument has been damaged and must be returned to the factory for service or repair.)
2. Inspect the exterior case, front and rear, for holes, cracks, scratches, broken or damaged controls, missing components and/or screws.
3. Inspect the green tinted Lexan® windows covering the Rate and VTBI displays and the clear window on the LCD panel for scratches or cracks.
4. Ensure the door fits flush with the case at the top, bottom, and side.
5. Check the cassette nest for damage or distortion.
6. Inspect the shuttle boot for cuts or tears and proper installation.
7. Inspect the Air-in-line detector for damage.
8. Install an approved administration set for the instrument to ensure the cassette seats correctly and the door closes.
9. Actuate each of the keypad controls on the front panel and the Audio silence switch on the rear panel to ensure proper operation (see Figure 2-1 for location of controls).
10. Inspect the power cord for damage, bent prongs or deformed connector.
11. Exercise the pole clamp mechanism to ensure freedom of movement.

NOTE

In the event the instrument shows evidence of shipping damage, notify the carrier's agent immediately. Do not return a damaged instrument to the factory before the carrier's agent has authorized repairs. Contact IMED for authorization to return the instrument for repair regardless of liability for repair costs.

2.3 OPERATIONAL PERFORMANCE CHECK

Prior to the first operational use and following any routine maintenance or servicing of the 960A/*965A*, it is strongly recommended that an operational performance check be performed. The operational performance check consists of two phases; a Pre-operational Electrical Inspection to check the electrical integrity of the instrument for compliance with regulatory agency

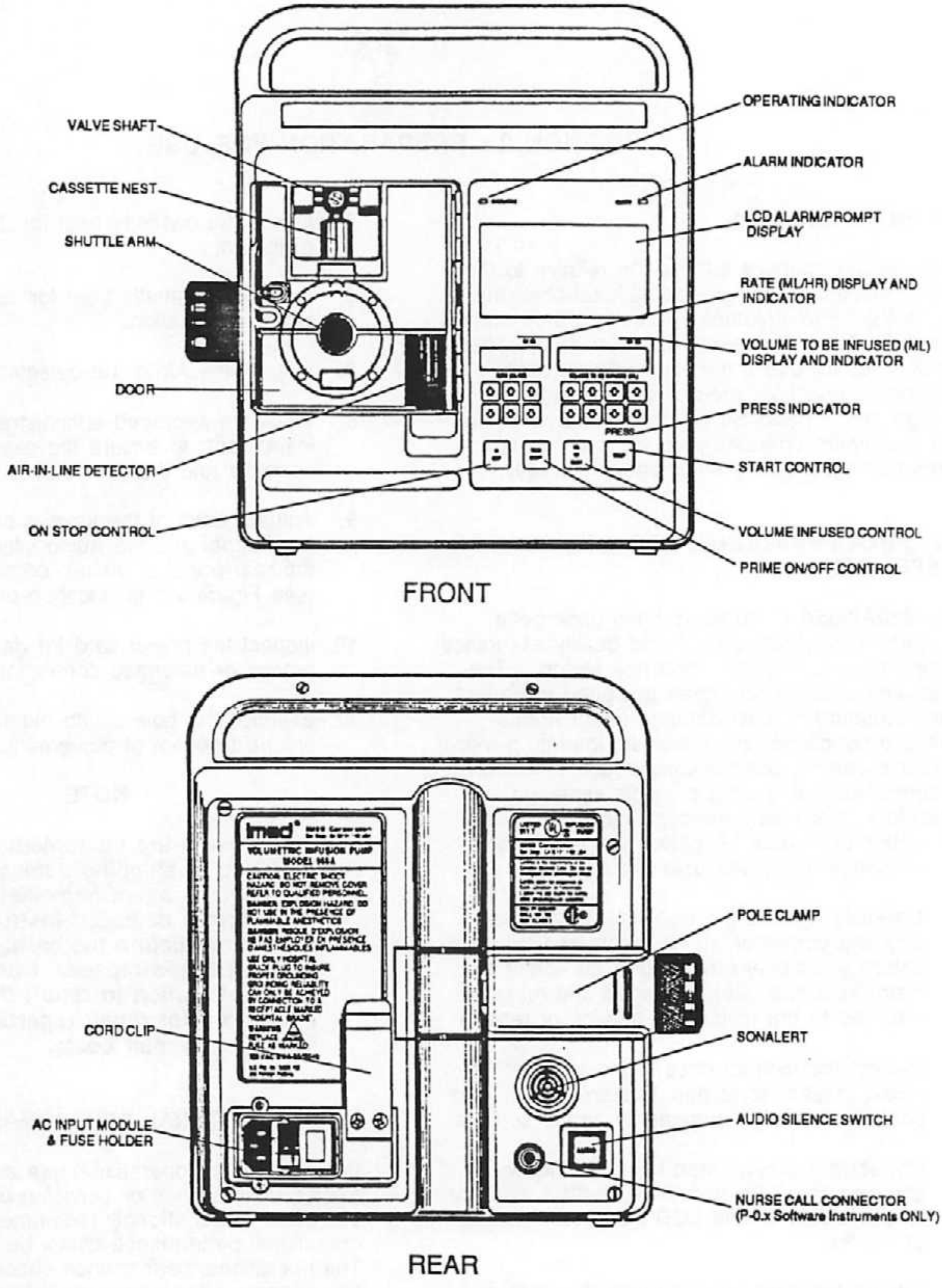


Figure 2-1. 960A/*965A* Front and Rear Operating Features

requirements and an operational performance test to verify instrument performance.

2.3.1 Pre-operational Check Battery Charge

The instrument is shipped with the battery in a fully charged condition. However, since considerable time could elapse between shipping and first use, a pre-operational battery charge is recommended. Connect the AC power cord to a suitable AC outlet and allow the battery to charge for 24 hours.

2.3.2 Pre-operational Electrical Inspection

The pre-operational electrical inspection includes an electrical leakage test, a ground continuity check and a dielectric test.

CAUTION

Some of these tests are inherently hazardous. Safeguards for personnel and property should be employed when conducting such tests. Tests should only be performed by qualified personnel.

2.3.2.1 Electrical Leakage Test

Perform an electrical leakage current measurement in compliance with Underwriters Laboratories (UL) 544 for Patient Care Equipment and/or Canadian Standards Association (CSA) Standard C22.2 No. 125 for Risk Class 2 Equipment. Leakage currents are to be less than 100 microamperes.

2.3.2.2 Electrical Ground Test

Perform an electrical ground impedance measurement in compliance with UL 544 for Patient Care Equipment and/or CSA Standard C22.2 No. 125 for Risk Class 2 Equipment. The impedance between the grounding pin on the power cord plug and the grounding point on the rear case should not exceed 100 milliohms.

2.3.2.3 Dielectric Test

Perform a dielectric withstand test in compliance with UL 544 for Patient Care Equipment and/or CSA Standard C22.2 No. 125 for Risk Class 2 Equipment.

2.3.3 Abbreviated Operational Performance Test

The following operational performance test is designed to ensure each of the 960A/*965A* controls and indicators is functioning properly and check the operability of all the features available in the normal operating modes.

2.3.3.1 Test Requirements

The following items of laboratory equipment and supplies are required to conduct the operational performance tests:

1. ACCUSET Closed System ADD-i-MED administrative set
2. IV Solution Container
3. Standard IV Pole
4. Nurse Call Test Light (see figure 2-2) (Software Release P-0.x/1.x ONLY)
5. Hemostat
6. Empty fluid container
7. Gas tight syringe: 100 microliter capacity
8. Fluid simulator, clear fluid
9. Fluid simulator, opaque fluid
10. Test magnet (door alarm override).

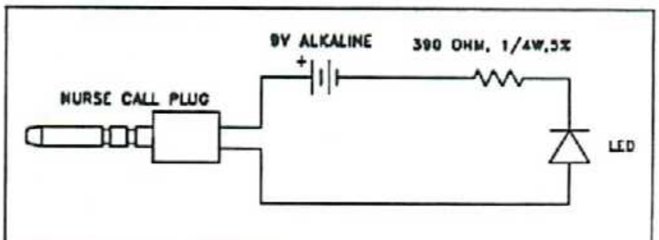


Figure 2-2. Nurse Call Test Light

2.3.3.2 Test Procedures

The following tests and associated procedures are presented in a sequence that provides an efficient, qualitative check of instrument operability.

INITIAL SETUP

1. Mount pump on IV pole (leave AC power cord unplugged).
2. Spike and hang IV fluid container above the instrument, then fill drip chamber 2/3 full.
3. Install Nurse Call Test Light in the Nurse Call connector. (Software Release P-0.x/1.x ONLY)

NOTE

Test procedures that refer to operation of the Nurse Call Test Light are applicable ONLY to instruments with Software Release P-0.x installed.

TEST SEQUENCE

1. Press ON/STOP key and check:
   - The valve shaft will home to the 10 o'clock position and the shuttle arm will home to the down position
   - LCD Panel - "VOLUME INFUSED" "8888"/*"888.8"* illuminates for 3 seconds, then reverts to "VOLUME INFUSED" and last volume infused value or "0"/*"0.0"*, if the power has been off for more than 4 hours
   - Operating/Rate graphics - illuminate steadily for 3 seconds, then go blank
   - Alarm/Prompt messages display for 3 seconds, then go blank except for "NOT OPERATING" and "NOT CHARGING" which display steadily and "AIR IN LINE" which flashes. The red ALARM LED indicator flashes and the alarm audio sounds. The Nurse Call test light illuminates
   - RATE and VTBI Displays show "888"/*"88.8"* and "8888"/*"888.8"* momentarily, then display "96.0" or *"96.5"* in the Rate and "P-X.X" (X.X refers to the installed software revision) in the VTBI for ≈2 seconds followed by reversion to the last confirmed infusion parameters or "000"/*"00.0"* and "0000"/*"000.0"*, if the power has been off for >4 hours.

NOTE

The "PRESS" and OPERATING LED indicators do not flash during the self-test check.

2. Plug the AC power cord into a suitable wall outlet and check:
   - The "NOT CHARGING" message extinguishes
   - The LCD panel backlight illuminates.
3. If rate not "000"/*"00.0"*, set to "000"/*"00.0"*.
4. If VTBI not "0000"/*"000.0"*, set to "0000"/*"000.0"*.
5. If "VOLUME INFUSED" is not "0"/*"0.0"*, press VOL INF RESET.
6. Open the door. "DOOR OPEN" message will display on the LCD panel (red ALARM indicator and alarm audio will remain active). Nurse Call test light remains illuminated.
7. Install cassette in the nest and affix plunger to shuttle arm. Press tubing into the Air In Line detector. Close the door.

WARNING

Do not prime with the administration set connected to a patient.

8. Ensure all clamps are open.
9. Press PRIME ON/OFF key once to initiate priming.
   - "AIR IN LINE" message will flash and "NOT OPERATING" message will display steadily on the LCD panel and the audio and visual alarm indications will continue.
   - Rate and VTBI displays will show ---/--.- and ----/---.- respectively for 960A/*965A*.
10. Check to ensure all air is cleared from the tubing set. Allow the auto-prime cycle to finish.

11. Check walk away alarm (operator alert) by allowing instrument to remain idle and observe:

    - After 45/*80* seconds red "ALARM" indicator flashes, "NOT OPERATING" message flashes, the audio alarm sounds and the Nurse Call test light illuminates.

12. Set rate to 125/*50.0* mL/hr and VTBI to 25/*10.0* mL, then press START and check:

    - All indicators reflect normal operation.

13. Place hemostat on the distal tubing and check:

    - ALARM indicator flashes
    - OPERATING indicator extinguishes
    - Operating/Rate graphics extinguish
    - "OCCLUSION" message flashes and "NOT OPERATING" displays steadily on the LCD panel
    - Audio Alarm sounds
    - Nurse Call test light illuminates
    - Pumping mechanism stops.

14. Remove the hemostat, press START and check:

    - All indicators reflect normal operation.

15. Place hemostat on the proximal tubing and check:

    - ALARM indicator flashes
    - OPERATING indicator extinguishes
    - Operating/Rate graphics extinguish
    - "OCCLUSION" message flashes and "NOT OPERATING" displays steadily on the LCD panel
    - Audio Alarm sounds
    - Nurse Call test light illuminates
    - Pumping mechanism stops.

16. Remove the hemostat, press START and check:

    - All indicators reflect normal operation.

17. Set VTBI to 5/*2.0* mL, press START and await Infusion Complete alarm, then check:

    - ALARM indicator flashes
    - OPERATING indicator extinguishes
    - "INFUSION COMPLETE" message flashes on the LCD
    - Operating/Rate graphics sequence at KVO rate
    - Audio Alarm sounds
    - Nurse Call test light illuminates
    - Rate display alternates between "125"/*"50.0"* and "1"/*"0.1"* mL/hr.

18. Press AUDIO Silence switch and check:
    - Audio alarm silences
    - "AUDIO OFF" message appears on the LCD panel.

19. Press ON/STOP to shut down the instrument.

20. Open the door, remove the administration set, install the test magnet over the door sensor and put the filled portion of the clear fluid simulator in the AIL detector.

OPTICAL AIR IN LINE TEST (If instrument is configured with Ultrasonic AIL detector proceed to step #32).

21. Press ON/STOP, set VTBI to 100/*40.0*, press START and check:

    - All indicators reflect normal operation.

22. Slide the clear fluid simulator down to expose the first sensor to air and check:

    - All indicators reflect normal operation.

23. Slide the clear fluid simulator down to expose the second sensor to air and check:

    - All indicators reflect normal operation.

24. Expose the third sensor to air and check:

    - ALARM indicator flashes
    - OPERATING indicator extinguishes
    - Audio Alarm sounds
    - Operating/Rate graphic extinguishes
    - "AIR IN LINE" message flashes and "NOT OPERATING" message displays steadily
    - Nurse Call test light illuminates
    - Pumping mechanism stops.

25. Remove and invert simulator then install so all sensors see fluid, press START and check:

    - All indicators reflect normal operation.

26. Slide simulator up to expose the lower 3 sensors to air and check:

    - All indicators reflect normal operation.

27. Slide simulator up to expose the lower 4 sensors to air and check:

    - ALARM indicator flashes
    - OPERATING indicator extinguishes
    - Audio Alarm sounds
    - Operating/Rate graphic extinguishes
    - "AIR IN LINE" message flashes and "NOT OPERATING" message displays steadily
    - Nurse Call test light illuminates
    - Pumping mechanism stops.

28. Press ON/STOP, remove the clear fluid simulator and replace with the opaque simulator so all sensors see fluid, then press START and check:

    - All indicators reflect normal operation.

29. Slide the simulator up to expose the lower 2 sensors to air and check:

    - ALARM indicator flashes
    - OPERATING indicator extinguishes
    - Audio Alarm sounds
    - Operating/Rate graphic extinguishes
    - "AIR IN LINE" message flashes and "NOT OPERATING" message displays steadily
    - Nurse Call test light illuminates
    - Pumping mechanism stops.

30. Press ON/STOP, reposition the opaque simulator so all sensors see fluid, then press START and check:

    - All indicators reflect normal operation.

31. Slide the simulator down to expose the upper 4 sensors to air and check:

    - ALARM indicator flashes
    - OPERATING indicator extinguishes
    - Audio Alarm sounds
    - Operating/Rate graphic extinguishes
    - "AIR IN LINE" message flashes and "NOT OPERATING" message displays steadily
    - Nurse Call test light illuminates
    - Pumping mechanism stops.

ULTRASONIC AIR IN LINE TEST

32. Press ON/STOP, set VTBI to 100/*40.0*, press START and check:

    - All indicators reflect normal operation.

33. Slide the fluid simulator down to expose sensor to air and check:

    - ALARM indicator flashes
    - OPERATING indicator extinguishes
    - Audio Alarm sounds
    - Operating/Rate graphic extinguishes
    - "AIR IN LINE" message flashes and "NOT OPERATING" message displays steadily
    - Pumping mechanism stops
    - Nurse Call test light illuminates.

34. Reposition fluid simulator so sensor will see liquid, press START and check:

    - All indicators reflect normal operation.

35. Press ON/STOP and check:

    - Instrument shuts down.

36. Remove the test magnet from the door sensor and the fluid simulator from the AIL detector. Remove the Nurse Call Test Light δ from the Nurse Call receptacle, if appropriate.

The instrument is now ready for patient care service. See Section 3 - OPERATION for standard operating procedures.

SECTION 3 - OPERATION

3.1 INTRODUCTION

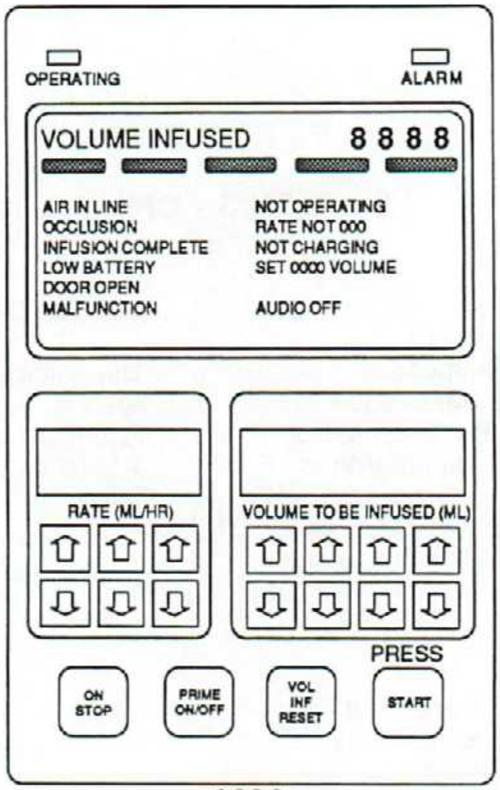
This section describes the recommended procedures for operation of the IMED 960A Volumetric Infusion Pump and the *965A* Micro Volumetric Infusion Pump. The information is intended to provide maintenance technicians with a basic understanding of instrument operation including the audio and visual alarm/prompt system.

NOTE

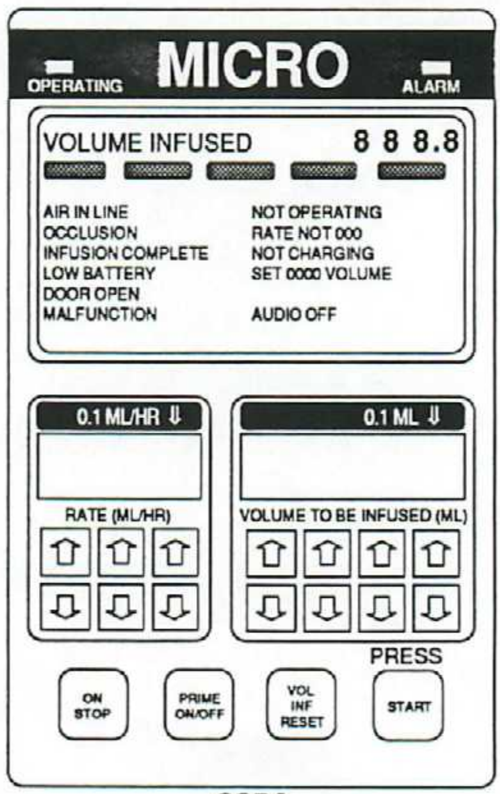
Although the 960A & *965A* are built and tested to exacting specifications, the instrument is not intended to replace the role of medical personnel in the supervision of IV infusions. The user is urged to exercise professional standards of care in the utilization of the instruments.

3.2 CONTROLS AND INDICATORS

The controls and indicators used to set up and operate the 960A and *965A* are illustrated in Figure 3-1 and listed with descriptions in Table 3-1. Items unique to the *965A* are presented in italics.



960A



965A

Figure 3-1. 960A/*965A* Controls and Indicators

Table 3-1. 960A/*965A* Controls and Indicators - Functional Description

Control/Indicator	Functional Description
OPERATING Indicator	Green LED that flashes when the instrument is infusing.
ALARM Indicator	Red LED that flashes when the instrument is in an alarm condition.
ALARM/PROMPT Display	Backlighted LCD panel that displays: "VOLUME INFUSED" message whenever the instrument power is on and either the last Volume Infused value or "0"; Operating/Rate sequencing graphics; and eleven alarm/prompt messages, when appropriate.
RATE (ML/HR) Controls/Display	Six arrow ⊡⊡ controls used to input an infusion rate into the three RATE digit displays. Each digit is separately controlled. Digits do not rollover.
VOLUME TO BE INFUSED (ML) Controls/Displays	Eight arrow ⊡⊡ controls used to input a volume to be infused into the four VTBI digit displays. Each digit is separately controlled. Digits do not rollover.
ON/STOP Control.	Applies system power to the pump when in the ON mode. When in the STOP mode, the instrument is powered down except for the microprocessor which remains powered for 4 hours.
PRIME ON/OFF Control	Operates the pumping mechanism for 63 ±3 seconds *(72 ±3)* when the rate is set to 000 *(00.0)*. Priming can be manually stopped by actuating the PRIME ON/OFF control during the automatic priming sequence.
START Control	Initiates operation of the pumping mechanism, confirms rate and/or VTBI changes input during an infusion and restarts an infusion following clearing of an alarm condition.
VOLUME INFUSED RESET (VOL INF RESET) Control	Clears the Volume Infused register and "VOLUME INFUSED" display, when actuated with the VTBI set to "0000"/*"000.0"*.
"PRESS" Indicator	Illuminates if the START control has not been actuated within 10 seconds following the changing of rate and/or VTBI during an infusion.
AUDIO Switch (Rear Panel)	Temporarily silences the audio alarm when permitted. **NOTE** **When silencing is invoked, subsequent alarm conditions will be sounded upon occurrence.**

3.3 NORMAL OPERATION

The following procedures describe in detail the steps necessary to operate the 960A Volumetric and the *965A* Micro Volumetric Infusion Pumps. Operating instructions are also provided in the Operator's Manual.

3.3.1 Setup Procedure

1. Attach the 960A/*965A* to the IV pole.
2. Plug the AC power cord into a suitable AC power outlet.
3. Spike and hang the IV fluid container in accordance with accepted hospital procedures.
4. Press the ON/STOP control to turn on the instrument, then check:
    - LCD Panel - "VOLUME INFUSED" "8888"/"*888.8*" illuminates for 3 seconds, then reverts to "VOLUME INFUSED" and last volume infused value or 0/0.0, if the power has been off for more than 4 hours
    - Operating/Rate graphics - illuminates steadily for 3 seconds, then goes blank
    - Alarm/Prompt messages display for 3 seconds, then go blank except for "NOT OPERATING" which displays steadily and "AIR IN LINE" which flashes. The red ALARM LED indicator flashes and the alarm audio sounds
    - RATE and VTBI Displays show "888"/"*88.8*" and "8888"/"*888.8*" momentarily, then display "96.0"/"*96.5*" in the Rate and "P-X.X" (where X.X refers to the installed software revision) in the VTBI for ≈2 seconds followed by reversion to the last set values or "000"/"*00.0*" and "0000"/"*000.0*", if the power has been off for >4 hours.

    NOTE

    The "PRESS" and OPERATING LED indicators do not flash during the self-test check.

5. If Rate not "000"/"*00.0*", set to "000"/"*00.0*".
6. If VTBI not "0000"/"*000.0*", set to "0000"/"*000.0*".
7. If "VOLUME INFUSED" is not "0", press VOL INF RESET.
8. Open the door. "DOOR OPEN" message will display on the LCD panel (red ALARM indicator and alarm audio will remain active).
9. Install cassette in the nest and affix plunger to shuttle arm. Press tubing into the Air-In-Line detector. Close the door.

    WARNING

    Do not prime with the administration set connected to a patient.

10. Ensure all clamps are open.
11. Press PRIME ON/OFF control once to initiate priming.
    - "AIR IN LINE" message will flash, "NOT OPERATING" message will display steadily and the operating/rate graphic will flash on the LCD panel. The audio and visual alarm indications will continue.
    - Rate and VTBI displays will show ---/--.- and ----/---.- respectively.
12. Check to ensure all air is cleared from the tubing set, then press PRIME ON/OFF to manually stop priming or allow automatic cycle to complete.
13. Attach administration set to the patient's indwelling venipuncture device.
14. Use RATE arrow controls to set RATE.
15. Use VTBI arrow controls to set VTBI.

3.3.2 Starting an Infusion

1. Press START to begin the infusion, then check:
    - The OPERATING LED indicator flashes
    - The Operating/Rate graphic begins sequencing

- The "NOT OPERATING" message extinguishes.

NOTE

If START is not pressed, the "NOT OPERATING" message will remain illuminated. Within ten seconds of the last Rate and/or VTBI entry the "PRESS" indicator plus the Rate and/or VTBI display(s) will flash, as appropriate, and an audio prompt will sound. If START is not pressed within 5 minutes of the last data entry, the pump will shut down.

3.3.3 During the Infusion

1. The VOLUME INFUSED value will increment.
2. The OPERATING LED and Delivery/Rate graphic will flash and sequence respectively.
3. Various alarm conditions may arise which will require operator attention. An alarm message will be displayed on the LCD panel, the red ALARM LED will flash and the alarm audio will sound. See Table 3-2 for a listing of the Alarm/Prompt messages and the recommended actions.

3.3.4 Infusion Complete

1. When the programmed volume to be infused has been delivered, the instrument will initiate an INFUSION COMPLETE alarm and begin a KVO infusion.
   - The "INFUSION COMPLETE" message will *flash on* the LCD panel, the red ALARM LED will flash and an audio alarm will sound.
   - The infusion rate will change to KVO (1 mL/hr or *0.1 mL/hr)* and "1" or *"0.1"* will flash alternately with the programmed rate on the Rate display.

3.3.5 Stopping an Infusion

1. Press the ON/STOP control:
   - Pumping mechanism will stop
   - All indicators and displays will extinguish
   - LCD panel will remain backlighted and battery will continue to charge as long as the AC power cord is connected to an AC power source.

3.3.6 Changing Rate or VTBI during an Infusion

1. Use the arrow ⊡⊡ controls to input a new rate and/or VTBI.
   - New rate and/or VTBI value will appear in the respective display.
2. Press the START control to confirm and initiate the new parameter(s).
   - If START is not pressed within 10 seconds, the "PRESS" indicator will flash, an audio prompt will sound and the rate and/or VTBI display will flash.

NOTE

The instrument will continue to infuse at the previous rate and/or VTBI until the START control is pressed.

3.3.7 Resetting Volume Infused

1. Use the arrow ⊡⊡ controls to set the VTBI display to "0000" or *"000.0"*.
2. Press VOL INF RESET control:
   - "VOLUME INFUSED" value will reset to "0" or *"0.0"*
   - "INFUSION COMPLETE" message will display
   - "OPERATING" LED indicator will stop flashing
   - Operating/Rate graphic will reflect KVO rate
   - ALARM LED indicator will flash and the audio alarm will sound.
3. Use the arrow ⊡⊡ controls to set the VTBI display to the desired value.
4. Press the START control:
   - "OPERATING" LED indicator will flash
   - "INFUSION COMPLETE" message will extinguish

- "ALARM" LED indicator will extinguish and alarm audio will silence
- Operating/Rate graphic will reflect programmed delivery rate.

NOTE

If the instrument is stopped during an infusion, the valve shaft will stop at its present position. To load a new cassette, first turn the instrument on. The valve shaft will "home" to the loading position.

3.3.8 Clearing Alarms

1. Refer to Table 3-2. Alarm/Prompt Message and Response Procedures.

Table 3-2. Alarm/Prompt Messages

NOTE

Alarm responses that refer to operation of the Nurse Call feature are applicable ONLY to instruments with Software Release P-0.x/1.x installed.

Message/Presentation	Cause	Response
VOLUME INFUSED XXXX Visual - Continuous Audio - None	Normal display of value in volume infused register.	None. Reset to "0" as required.
AIR IN LINE Visual - Flashing Audio - Alarm Nurse Call - On	Air bolus detected by the AIL sensor. Pumping stops.	Clear air from tubing; Press START.
OCCLUSION Visual - Flashing Audio - Alarm Nurse Call - On	Tubing in line pressure exceeds occlusion pressure limit. Pumping stops. Can occur during priming or normal operation.	Clear occlusion; Press START.
INFUSION COMPLETE Visual - Flashing Audio - Alarm Nurse Call - On	Volume Infused equals VTBI. Pump switches to KVO delivery rate.	Set up another infusion or turn instrument off.
LOW BATTERY Visual - Flashing Audio - Alarm Nurse Call - On	Battery charge has dropped to 5.8 V threshold. Pumping continues. If voltage drops to 5.4 V, a MALFUNCTION alarm will activate and pumping will stop.	Plug instrument AC power cord into a suitable AC power source.
DOOR OPEN Visual - Flashing Audio - Alarm Nurse Call - On	Door is opened while priming or during an infusion. Pumping stops.	If priming, close door and press PRIME ON/OFF twice. If infusing, close door and press START.
MALFUNCTION Visual - Flashing Audio - Alarm Nurse Call - On	Malfunction detected in any one of the monitored parameters. Pumping stops (except LOW BATTERY). Malfunction code displays in Volume Infused quantity.	Instrument must be repaired by biomedical technician before returning to *service. If LOW* BATTERY, plug AC power cord into AC outlet.

Table 3-2. Alarm/Prompt Messages

Message/Presentation	Cause	Response
NOT OPERATING Visual - Steady Audio - None Nurse Call - On	Instrument power on, but START has not pressed. After ≈45 seconds, message flashes and alarm audio sounds.	Press START, or turn instrument power off.
RATE NOT 000 Visual - Flashes twice Audio - Prompt	PRIME ON/OFF control pressed with Rate set >000 *(00.0)*.	Set Rate to 000 *(00.0)*, then press PRIME ON/OFF.
RATE 000 Visual - Flashes twice Audio - Prompt	START control pressed with the Rate set to 000 *(00.0)*. If START pressed again, "PRESS" and "ALARM" indicators flash and alarm audio sounds; otherwise, after 45 seconds "ALARM" indicator & "NOT OPERATING" message flash and alarm audio sounds.	Set Rate to a value >000 (00.0), then press START.
NOT CHARGING Visual - steady Audio - None	Instrument power on, with the AC power cord not connected to an AC power source.	Plug AC power cord into an AC power outlet.
SET 0000 VOLUME Visual - flashes twice Audio - Prompt	VOL INF RESET control pressed with VTBI set >0000 *(000.0)*.	Set VTBI to 0000 *(000.0)*, then press VOL INF RESET.
SET VOLUME Visual - flashes twice Audio - Prompt	START control pressed with VTBI set to 0000 *(000.0)*. If START pressed again, "PRESS" and "ALARM" indicators flash and alarm audio sounds; otherwise, after 45 seconds "ALARM" indicator and "NOT OPERATING" message flash and audio alarm sounds.	Set VTBI to a value >0000 *(000.0)*, then press START.
AUDIO OFF Visual - Steady Audio - Silenced temporarily	AUDIO switch (rear panel) pressed while an audio alert is sounding.	After temporary delay, audio will resume. May be silenced again, if permissible.
PRESS Visual - Flashes Audio - Prompt	Rate and/or VTBI changed during an infusion, 10 seconds have elapsed and START control not actuated or START control pressed twice with rate and/or VTBI set to 000 *(00.0)*/0000 *(000.0)*.	Press START, or set rate and/or VTBI to a value >0, then press START.

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SECTION 4 - PRINCIPLES OF OPERATION

4.1 INTRODUCTION

This section describes the functional operation of the mechanical and electrical/electronic subsystems of the 960A Volumetric and the *965A* Micro Volumetric Infusion Pumps. The information is presented in a manner and format that is complementary to the troubleshooting routines delineated in Section 5 - MAINTENANCE. The technical descriptions are referenced to the electrical schematics and illustrated parts breakdowns presented in Sections 4 and 6.

The 960A/*965A* instrument population includes pumps with display panels provided by two different manufacturers. Subsystems that are affected by display panel differences are described as either a Foster or Hightower system. Documentation related to the 960A/*965A* instruments resulting from IMED's product improvement program is identified with a PIP/P4.x designator. Functionality unique to the PIP/P4.x instruments is described in Section 4.4.

The functional descriptions presented in this section are divided into two subsections. The *first* addresses the mechanical system operation and the second describes the electrical/electronic system and operation. The electrical/electronic theory of operation is described in relation to the Functional Block Diagrams depicted in Figures 4-1(F) and 4-1a(HT). Understanding the electrical/electronic theory of operation will be facilitated by analyzing the functional block diagrams and circuit schematics in conjunction with reading the subsystem detailed circuit descriptions.

4.2 MECHANICAL OPERATION

The following material is presented in a manner that presumes the reader has a basic understanding of the information provided in Sections 1 through 3 of this manual and in addition has hands-on experience in setting up and operating the 960A and/or *965A* instrument. Direct observation of the mechanical sequence of events that take place during pumping mechanism operation is not possible when the instrument is configured for normal operation. However, by reading the following text and referring to the appropriate figures, a thorough understanding of the instrument's mechanical operation can be acquired.

4.2.1 Physical Description

4.2.1.1 Pumping Mechanism

The mechanical components of the pumping mechanism are attached to the angle plate assembly and include the valve shaft motor, the shuttle drive motor and shuttle assembly. The vertical movement of the cassette plunger is provided through the linear movement of the shuttle arm. The shuttle drive motor turns a lead screw which moves the shuttle along the shuttle guide. The upper and lower limits of travel are set by the shuttle flags.

The valve shaft motor positions the cassette valve to allow the cylinder to fill with IV solution during the plunger's down stroke then rotates the valve allowing the fluid to be expelled into the administration set's distal tubing during the upstroke. Valve shaft positioning is controlled by the valve shaft flag. An encoder wheel on the shuttle drive motor shaft provides a cross check on motor pulses required to complete a vertical movement.

4.2.2 Functional Operation

4.2.2.1 Pumping Mechanism

When the ON/STOP switch is actuated to turn on the instrument, the shuttle homes to the down position and the valve shaft homes to the 10 o'clock position. The valve lugs on the cassette are factory set to the 2 o'clock position so as to mate with the valve shaft slot when the cassette is positioned for installation in the cassette nest. The plunger may have to be positioned to mate with the shuttle arm. With a cassette installed in the nest and the extension tubing threaded through the air in line detector block, the set can be primed. All tubing clamps must be open and the rate set to 000/*00.0*. The auto prime cycle initiates when the PRIME ON/OFF key is pressed. The shuttle drive motor will operate at maximum speed for ≈62/*72* seconds moving the cassette plunger through 8/*13* cycles. The auto prime cycle may be interrupted at any time by pressing the PRIME ON/OFF key.

WARNING

Do NOT prime with the administration set connected to a patient.

During normal instrument operation, downward shuttle movement (fill stroke) is always performed at the maximum motor speed. Shuttle down-travel is terminated when the lower shuttle flag interrupts the light path in the reverse limit stop photo-interrupter. This action in turn activates the valve shaft motor which rotates the valve shaft until the valve shaft flag interrupts the light path of the valve shaft photo-interrupter. The nominal rate of upward shuttle movement (delivery stroke) is determined by the infusion rate programmed by the operator. Up stroke travel, even at the maximum programmed rate of 999/*99.9* mL/hr, is always at a rate less than maximum motor speed. Shuttle up travel is terminated by the forward limit stop photo-interrupter which in turn activates the valve shaft motor to reposition the valve for the fill stroke. The ≈720 programmed half-steps applied to the shuttle drive lead screw, with 20 threads per inch, will generate ≈0.375 inches of shuttle travel which will deliver ≈3.5/*1.5* mL of IV fluid per cycle.

4.3 ELECTRICAL/ELECTRONIC OPERATION

4.3.1 Functional Description

The electronic circuit descriptions are presented in two parts. The first is a functional description referenced to the respective block diagrams, Figure 4-1 (F) and 4-1a (HT), which provide an overview of system operation. These logic diagrams should be studied prior to attempting to understand the detailed circuit diagrams presented in the subsequent sections.

4.3.1.1 Microprocessor System

The microprocessor system consists of a 8035 microcontroller (Z1), a 8755 EPROM (Z2) and a 8243 I/O Expander (Z3). A crystal (Y1) external to the microcontroller operates at 3.0 MHz to provide the master clock signal. The operating program is stored in the programmable read-only memory (EPROM). This device has two 8-bit input/output (I/O) ports which are utilized solely for output. The microcontroller and ROM together provide the central control for all system functions. The I/O expander provides four additional 4-bit input/output ports which are used to output data to peripheral devices. The microcontroller communicates with the EPROM, I/O's and data multiplexer (MUX) using one data bus and two I/O ports. The design of the 8035 allows the busses to function bi-directionally, transmitting data to and from the microcontroller. In the 960A/*965A*, only the 8-bit bus between the microprocessor and the EPROM is used in a bi-directional mode. In addition to functioning as a data bus, it also serves as an address bus working in combination with the lower four-bits of port 2 which is connected between the microcontroller and the ROM. Data is input to the microprocessor via port 1 (P10-P17) which is connected directly to the peripheral devices and over the bi-directional 8-bit data bus (DB0-DB7). Input data is also applied to the 8-bit data bus through the multiplexer. The multiplexer consists of buffers that are enabled by the microcontroller at appropriate times. The microprocessor system generates a series of strobes, of 1 ms duration, at the 8755 output port A. These strobes energize the photo-interrupters, control, switches and other peripheral devices in sequence and cause the output of the selected device to be placed on one of the microprocessor input ports or data bus. After generating a strobe, and prior to its termination, the microprocessor reads the return from the queried peripheral. If the microprocessor senses a need for action, e.g. AIL detector indicates air in the line, the microprocessor will execute the necessary output. Should the return signal indicate a normal condition, the system will advance to the next strobe in the sampling sequence. The microprocessor timing sequence requires 20 ms to complete and is repeated continuously.

4.3.1.2 Prime Mode Logic.

The PRIME ON/OFF control is strobe enabled. Closure of its contacts is communicated to the microprocessor through the multiplexer. The microprocessor will continue its sampling of peripheral device outputs. If conditions for initiating the prime mode are not satisfactory (rate not at 000/*00.0*, for example), the microprocessor generates an alarm, places the alarm data on the bus via the 8755 on port B and latches it, via the 8755 on port A, to the LCD, to the audible alarm driver and the alarm LED driver. If conditions are normal, the microprocessor, through the 8243 I/O expander and circuits on the angle plate assembly, develops motor drive pulses and valve motor drive signals at rates and times appropriate to the prime mode.

4.3.1.3 Operate Logic.

The operate mode is initiated by pressing the START control which is strobe enabled. The microprocessor will continue sampling the outputs of the peripheral devices. If conditions required to initiate 'Operate' are not satisfied, the instrument will generate an alarm, place the alarm data on the bus via the 8755 on port B and latch it, via the 8755 on port A, to the LCD, audible alarm drive and alarm LED driver. If conditions are satisfied, the microprocessor, through the 8243 I/O expander and circuits on the angle plate assembly, generates motor drive pulses and valve drive signals appropriate to the selected rate. The microprocessor system totals the number of motor drive pulses generated during each delivery stroke, and for every 194 forward (delivery) pulses, the microprocessor updates the VOLUME INFUSED display by 1/*0.1* mL. It places the volume infused display data on the output of port B on the 8755, digit by digit. While each digit is on the output port, a strobe activates a latch to store the data. Seven-segment decoder/drivers then convert the latched BCD data to a digit on the LCD. The microprocessor periodically compares the accumulated volume infused data with the volume to be infused setting. When the two are equal, the microprocessor generates an INFUSION COMPLETE alarm and places the alarm data on the 8755's output port B. Port A strobes latch it to the LCD, the audible alarm driver and the alarm LED driver. It also outputs motor drive pulses to the KVO delivery rate of 1/*0.1* mL/hr .

4.3.1.4 Photosensor System.

The photo-interrupters on the angle plate assembly plus the LED's and photo-transistors in the air-in-line (embolism) detector comprise the photosensor system. These sensors are strobe enabled. The air-in-line detector LEDs are enabled simultaneously by a strobe independent of that which enables the photo- interrupters on the angle plate assembly. The air-in-line photo-transistors are connected to microprocessor port #1. The microprocessor responds to any change in the state of the angle plate photo-interrupters or air-in-line detector photo transistors. For example, when the shuttle reaches the top of the delivery stroke, the change of state of the forward limit stop photo-interrupter output will produce a valve motor drive signal to rotate the valve motor shaft and the cassette valve to the fill position. In the case of the air-in-line detector, there are certain combinations of low and high phototransistor collectors that indicate detection of air in the tubing. The microprocessor responds by stopping the output of motor drive pulses and activates the AIR IN LINE alarm. Though not detailed in the Figure 4-1 Block Diagram, the current paths for the air-in-line detector LED's are also connected to port #1 and are sampled sequentially with those of the photo- transistors. Should one of these paths be open, the system will generate a malfunction alarm, shut down the pump, and provide visual and audible alarms.

4.3.1.5 Alarm System.

As discussed in Section 4.3.1.3, when an alarm is activated, the nature of the alarm appears on the LCD, an audible alarm is sounded, the alarm LED flashes and the nurse call relay contacts are closed. The alarm messages are a permanent feature of the LCD. Each is connected to a single line of the LCD driver. The alarm data is placed on the output port once every 20 milliseconds. Therefore, the alarms are updated every 20 milliseconds. The audible alarm driver is activated by one output (P70) of the 8243 I/O expander (Z3), if the AUDIO silence switch has not been recently closed. Closing the AUDIO silence switch permits a strobe to appear on a data line through the multiplexer which is read by the microprocessor. This disables the audible alarm and causes the microprocessor to latch the "AUDIO OFF" display in the LCD. After this temporary delay, the "AUDIO OFF" message is cleared and the audio alarm enabled. The circuit conditions that activate processor commands the LCD driver (U5) to turn off the "NOT CHARGING" message, if displayed.

If CHG is low while operating on battery power, PB4 goes low signaling the display processor (U1) to display the "NOT CHARGING" LCD message.

The NOT CHARGING alarm is not displayed in the presence of other alarms (except LOW BATTERY) to eliminate confusion.

MALFUNCTION Alarm Logic.

The program stored in the EPROM (Z2 Figure 4-5) directs the microprocessor to continually monitor a number of electrical parameters to verify normal operation. If one of these should malfunction, the malfunction alarm will be activated. A malfunction is indicated by "MALFUNCTION" flashing on and off in the LCD and the VOLUME INFUSED XXXX display alternating with a number code which indicates the cause of the malfunction alarm. The audio alarm also sounds irrespective of the AUDIO OFF display condition. Table 5-2 lists the cause of the malfunction alarm associated with a discrete number. Malfunctions 10 and 11 are detected by the microprocessor without external malfunction detecting circuits. The collector of each photo-transistor in the air-in-line detector is connected through a 33K ohm resistor (R12 through R16) to +5V. If any one of these is low without a strobe, it indicates a shorted photo-transistor. This produces malfunction code 4. The same resistors are in the collector circuits of the valve motor, shuttle and stall sensors on the angle plate assembly (see Figure 4-7). The microprocessor can then detect if one of the signal lines connected to these resistors is high when it should not be. Such a case is both valve motor stop sensor collectors being high simultaneously. These conditions produce malfunction codes 5 and 6. As discussed under Air-in-line alarm, the returns for CR1, CR4 and CR5 in the air-in-line detector are 100 ohm resistors. If there is a voltage drop across any one of these resistors in the absence of the strobe for the three LED's, malfunction code 7 is displayed. If there is no drop across any one of these resistors in the presence of a strobe, there is either a broken connection or one of the LED's is open. This produces malfunction code 9. If the ground connection for the air-in-line detector opens, a voltage drop is produced across R11 at strobe time resulting in display of malfunction code 8. If the battery is allowed to discharge to a level of 5.4 volts, LB2 at P7 goes high. This sets the malfunction alarm with code 14 displayed. Refer to the main logic board schematic, Figure 4-5. A second oscillator comprised of two invertors, Z6-2 and Z6-4, operates at approximately 2.0 KHz and clocks counter Z4 setting the Q7 output high at 36 milliseconds after being reset by the P26 output of Z1. The microprocessor completes the loop in approximately 5 milliseconds. It looks for the Q7 output of Z4 at its T1 output every five milliseconds. If it sees a rising edge before the 6th loop (30 milliseconds), an underrate condition is indicated which sets the malfunction alarm with code 13 displayed. If it sees a rising edge after 6 loops but before the 8th loop (40 milliseconds) is entered, things are normal and continues operation. If it sees a rising edge after 8 loops (40 milliseconds) are completed, an overrate condition is indicated, which sets the malfunction alarm with code 12 displayed. Counter Z4 is reset by the P26 output of Z1 whenever Z1 detects a rising edge from the Q7 output of Z4. If the microprocessor does not reset Z4, Z4 will be clocked until its Q12 output goes high which will turn on Q14 to sound the audible alarm. The Q12 output will alternate between high and low once every two seconds producing an audible alarm every two seconds. When Q12 goes high, it also turns on Q11 which turns off Q12. Q12, in turn, turns off Q2 in the power supply (see Figure 4-8). This prevents the pump from continuing its four-hour powered down operation in the event of a microprocessor malfunction.

FOSTER

The state of PB4 is latched into U21, pin #9 when ST32 goes high (see Figure 4-6), thereby, causing the "MALFUNCTION" LCD message to appear.

HIGHTOWER

The state of PB4 is read at port PA4 of the PIO chip (U2).When a high is detected on port P1.3 (ST3) of the display processor concurrently with a high at the PIO chip, the display processor (U1) commands the display driver (U5) to display the "MALFUNCTION" message (see Figure 4-6a).

4.3.1.2 Prime Mode Logic.

The PRIME ON/OFF control is strobe enabled. Closure of its contacts is communicated to the microprocessor through the multiplexer. The microprocessor will continue its sampling of peripheral device outputs. If conditions for initiating the prime mode are not satisfactory (rate not at 000/*00.0*, for example), the microprocessor generates an alarm, places the alarm data on the bus via the 8755 on port B and latches it, via the 8755 on port A, to the LCD, to the audible alarm driver and the alarm LED driver. If conditions are normal, the microprocessor, through the 8243 I/O expander and circuits on the angle plate assembly, develops motor drive pulses and valve motor drive signals at rates and times appropriate to the prime mode.

4.3.1.3 Operate Logic.

The operate mode is initiated by pressing the START control which is strobe enabled. The microprocessor will continue sampling the outputs of the peripheral devices. If conditions required to initiate 'Operate' are not satisfied, the instrument will generate an alarm, place the alarm data on the bus via the 8755 on port B and latch it, via the 8755 on port A, to the LCD, audible alarm drive and alarm LED driver. If conditions are satisfied, the microprocessor, through the 8243 I/O expander and circuits on the angle plate assembly, generates motor drive pulses and valve drive signals appropriate to the selected rate. The microprocessor system totals the number of motor drive pulses generated during each delivery stroke, and for every 194 forward (delivery) pulses, the microprocessor updates the VOLUME INFUSED display by 1/*0.1* mL. It places the volume infused display data on the output of port B on the 8755, digit by digit. While each digit is on the output port, a strobe activates a latch to store the data. Seven-segment decoder/drivers then convert the latched BCD data to a digit on the LCD. The microprocessor periodically compares the accumulated volume infused data with the volume to be infused setting. When the two are equal, the microprocessor generates an INFUSION COMPLETE alarm and places the alarm data on the 8755's output port B. Port A strobes latch it to the LCD, the audible alarm driver and the alarm LED driver. It also outputs motor drive pulses to the KVO delivery rate of 1/*0.1* mL/hr .

4.3.1.4 Photosensor System.

The photo-interrupters on the angle plate assembly plus the LED's and photo-transistors in the air-in-line (embolism) detector comprise the photosensor system. These sensors are strobe enabled. The air-in-line detector LEDs are enabled simultaneously by a strobe independent of that which enables the photo- interrupters on the angle plate assembly. The air-in-line photo-transistors are connected to microprocessor port #1. The microprocessor responds to any change in the state of the angle plate photo-interrupters or air-in-line detector photo transistors. For example, when the shuttle reaches the top of the delivery stroke, the change of state of the forward limit stop photo-interrupter output will produce a valve motor drive signal to rotate the valve motor shaft and the cassette valve to the fill position. In the case of the air-in-line detector, there are certain combinations of low and high phototrans-istor collectors that indicate detection of air in the tubing. The microprocessor responds by stopping the output of motor drive pulses and activates the AIR IN LINE alarm. Though not detailed in the Figure 4-1 Block Diagram, the current paths for the air-in-line detector LED's are also connected to port #1 and are sampled sequentially with those of the photo- transistors. Should one of these paths be open, the system will generate a malfunction alarm, shut down the pump, and provide visual and audible alarms.

4.3.1.5 Alarm System.

As discussed in Section 4.3.1.3, when an alarm is activated, the nature of the alarm appears on the LCD, an audible alarm is sounded, the alarm LED flashes and the nurse call relay contacts are closed. The alarm messages are a permanent feature of the LCD. Each is connected to a single line of the LCD driver. The alarm data is placed on the output port once every 20 milliseconds. Therefore, the alarms are updated every 20 milli-seconds. The audible alarm driver is activated by one output (P70) of the 8243 I/O expander (Z3), if the AUDIO silence switch has not been recently closed. Closing the AUDIO silence switch permits a strobe to appear on a data line through the multiplexer which is read by the microprocessor. This disables the audible alarm and causes the microprocessor to latch the "AUDIO OFF" display in the LCD. After this temporary delay, the "AUDIO OFF" message is cleared and the audio alarm enabled. The circuit conditions that activate the alarms are covered as part of the detailed circuit descriptions subsection.

4.3.1.6 Volume and Rate Inputs.

In addition to the PRIME ON/OFF and START control inputs discussed above, the operator provides volume-to-be-infused and rate inputs through the front panel controls which are also strobe enabled. Four strobe signals input all of the front panel control and switch data. This data is placed on the bi-directional data bus through the multiplexer, which is enabled concurrently with each of the four strobes. As with all other information, the states of the controls and switches are sampled every 20 milliseconds so that a rate change introduced by the operator will produce an immediate response. As previously mentioned, the volume infused data is accumulated by the microprocessor and displayed on the LCD. This data is retained in memory for 4 hours after the pump is turned off and will redisplay if the instrument is turned on again within 4 hours. This allows the pump to be turned off for reconfiguration without losing the existing data. THe VOLUME INFUSED display can be reset to "0" by setting the volume to be infused to 0000/*000.0* then pressing the VOL INF RESET control. This control is also strobe enabled and read by the microprocessor through the multiplexer.

4.3.1.7 Malfunction Alarm.

The monitor system consists of an oscillator driven counter that provides an input to the microprocessor. The microprocessor periodically resets the counter. The interval between a counter reset and subsequent counter output to the microprocessor establishes a timebase for checking master and monitor oscillator performance. If the input to the microprocessor occurs too soon or too late, an underrate or overrate conditions is indicated. The microprocessor then activates the malfunction alarm which stops the pump and displays a distinctive malfunction code on the LCD. Should the microprocessor fail to reset the counter, indicating a microprocessor system failure, the monitor system will activate the audible alarm. The microprocessor monitors a number of electrical parameters such as the presence of certain strobe signals. If any one of the monitored parameters shows an abnormal state, the microprocessor interrupts the output of motor drive pulses, activates the malfunction alarm and causes a discrete numerical code for the type of malfunction to be displayed on the LCD.

4.3.1.8 Power Supply.

The power supply circuit includes an integral battery charger and battery. A voltage regulator controls the 5.4 to 7.2 volt battery input to provide a constant 5 volt output. Sensors within the power supply provide input signals that allow the microprocessor to activate the low battery alarm when battery voltage drops to 5.8 or to activate a malfunction alarm and stop the pump if the battery drops to 5.4 volts. Before the instrument is turned off, the microprocessor activates a transistor that is in parallel with the ON/STOP key which allows the processor to continue operating for 4 hours. The volume infused information is retained for use if the instrument is re-activated during the 4 hour period. After 4 hours or if a low battery state of 5.4 volts is detected, the monitor system turns off the parallel transistor, removing power from the electronics and resulting in the loss of any preset information.

4.3.2 Detailed Circuit Description

Microprocessor control makes possible the unique operating features, enhances the overall reliability of the 960A/*965A* instruments and minimizes the number of logic devices required to perform all of the complex functions. Microprocessor programming is necessarily detailed and since equipment for testing such systems is generally not available at user facilities field testing of the microprocessor and its peripheral devices is not practical nor recommended. Accordingly, the ensuing discussion of the microprocessor system is general in nature. This is appropriate since field maintenance and repair is intended to be at the board replacement level. In addition to the general microprocessor discussion, the paragraphs of this section will provide detailed descriptions of the discrete circuits that are controlled by the microprocessor input/output (I/O) ports. Further insight into microprocessor system operation may be acquired through reference to material provided by component manufacturers such as Intel, supplier of the 8035 microprocessor used in the 960A/*965A*. Rather than detailing the operation of circuits on a board-by-board basis, these circuit descriptions are organized on a functional basis. Circuits that comprise a functional subsystem, such as the AIR IN LINE alarm, are discussed in a single subsection irrespective of their physical location within the instrument. Although this format may require reference to multiple schematics, that inconvenience is offset by the logical development of the resultant discussion. In the following detailed circuit descriptions, the component reference designations are those depicted in the circuit board logic diagrams at the end of this section and used in the part identification figures in Section 6. Separate schematics are provided for each circuit board and Figure 4-1 depicts the logic flow between the circuit boards and chassis mounted components. The discrete logic devices, in some cases, contain a number of identical circuits. These are usually drawn individually and may be located in widely separated areas of the diagram, but will carry the reference designator of the composite device. For convenience, the individual circuits are identified by the complete reference designator followed by a hyphen and a suffix number corresponding to the terminal. For example, the Hex Invertor Z6, in Figure 4-5, that has an output on pin 2 is identified in the text as Z6-2, if more than one pin on the device is referenced, commas separate the pin numbers, i.e. Z3-5,6.

4.3.2.1 Main Circuit Board Logic.

The main logic board contains the microprocessor, erasable, programmable read-only memory (EPROM), input/ output (I/O) expander, bus buffers and a number of transistors that provide the necessary current to drive devices located on other boards. The circuits of this board are shown in Figure 4-5. To some extent, these circuits will be covered in the paragraphs of this subsection, particularly as they relate to the microprocessor system. For the most part, those circuits that interface the microprocessor system to circuits off the main logic board are more logically explained in the discussion of those specific circuits.

4.3.2.2 Microprocessor System.

The 8035 microprocessor (Z1) communicates with the EPROM (*Z2/Z2*), the I/O expander (Z3) and the other circuit boards through three busses. The principle bus, DB0 through DB7, is both the address and data bus and is fully bi-directional. It outputs addresses and data to the EPROM and receives data from the EPROM plus the other boards through the multiplexer. There are two other 8-bit busses that are uni-directional in the 960A/965A instruments. Z1, P10 through P17, constitute port 1 and P20 through P27 constitute port 2. Only P20 through P23 of port 2 are used to communicate with the I/O expander. P27 is used only as an input to Z1. In addition to the data bus, ports 1 and 2, there are input and output lines that provide control to peripheral devices. Those that are essential to an understanding of the system operation are depicted in Figure 4-1. Table 4-1 lists the microprocessor signal functions. The microprocessor timing waveforms are shown in Figure 4-2. The microprocessor contains a 64-word random access memory (RAM), an 8-bit timer/event counter and an 8-bit central processing unit (CPU). These devices enable it to perform arithmetical functions in response to inputs from the read-only memory and from external devices that feed data through the bi-directional data bus. *Z2/Z2* contains 2048 8-bit words of program memory and two latchable, 8-bit I/O ports used only as output ports in the 960A/*965A*. The pins connected to DB0 through DB7 are tri-state and will be at a high impedance except when /CE and /PSEN, or /RD, are low. The memory is programmed to IMED specifications at time of manufacture and contains all the instructions for operation of the 960A/*965A*. Z3 is an 8243 I/O expander with four 4-bit ports that communicate with Z1 through a fifth 4-bit input/output port. The port that connects to Z1 is also tri-state and is in the high impedance state except when data is being received from Z1. Although Z3 is compatible with I/O operation, it is employed only as an output device in the 960A/*965A*. A general explanation of how these 3 devices interact with each another is contained in the following paragraphs.

On power up, /RESET at pin 4 of Z1 is momentarily held low to reset the microprocessor internal program counter to its initial address and to clear the internal RAM. Crystal Y1 provides the basic timing control for the system. The 3 MHz at Y1 is divided within the microprocessor, resulting in a cycle time of five microseconds. The lower order bits of the address to *Z2/Z2* appear on DB0 to DB7. The four high order bits appear on P20-P23. An address is latched into *Z2/Z2* when /PSEN is high, the P23 output of Z1 is low and coincident with the trailing edge of the ALE pulse, as shown in Figure 4-5. The addressed instruction from *Z2/Z2* will be placed on the same bus during the low state of the /PSEN pulse and will be read by Z1. Some instructions require more than one 8-bit byte. In those cases, the necessary instructions will be fetched from *Z2/Z2*

Table 4-1. Microprocessor Signal Functions

Designation	Abbreviation	Function
INTERRUPT	$\overline{INT}$	Input. Provided to enable external devices to interrupt microprocessor. Not used on 960A/*965A*. Low active.
PROGRAM STORE ENABLE	$\overline{PSEN}$	Low Active to fetch instruction from program memory (ROM).
WRITE	$\overline{WR}$	Low Active to cause data to be written to output devices.
ADDRESS LATCH ENABLE	$\overline{ALE}$	High Active to latch the lower 8-bit address to the EPROM.
READ	$\overline{RD}$	Low Active to enable data from external source onto the data bus.
TO	TO	Test input. Used in 960A/*965A* to verify presence of ST0 or ST1.
T1	T1	Test input. Monitor system input to microprocessor.
RESET	$\overline{RESET}$	Low Active. Initializes microprocessor at turn-on.
PROGRAM PIN	$\overline{PROG}$	Programming pin for internal EPROM. Also used as a read/write strobe for the I/O Expander. (Note: 960A/*965A* does not use an internal EPROM).

before data is output. After fetching an instruction, the microcontroller (Z1) may be commanded by that instruction to read data from the data bus or processor port #1 (P10-P17), or to write data to EPROM (Z2) ports (PA0-PA7 or PB0-PB7) or to the I/O expander (Z3). The instruction could also require the microcontroller to perform an internal logic function (e.g. wait, add or subtract, branch to another address, etc.). If data is to be output on DB0-DB7, it will be to one of the two ports of Z2/*Z2*. If it is output on P20-P23, it will be to one of the four ports of Z3. If data is to be read, it will require that data from one of the external boards be placed on the data bus or port 1. If the data from Z1 is to be latched to one of the outputs of Z2/*Z2*, the state of DB0 will determine which port and /WR will cause the data to be written to that port. If the data is to be latched to one of the output ports of Z3, the instruction will be first placed on P20-P23 and latched to its internal instruction decoder by the leading edge of /PROG. This determines which port will receive the data. The data is then placed on P20 through P23 and latched to the selected port at the trailing edge of /PROG. Data from the controls and switches and power supply are read by Z1 when P23 and /RD are both low, enabling buffers Z9 and Z10. The microprocessor, in response to the instructions fetched from Z2/*Z2*, sequentially steps through a program which requires it to output data to various devices in the system, sample data on the buses and respond to any change in the condition of any input that has occurred since the last sampling. The entire process requires 20 milliseconds. In the following sections, the manner in which the sampling occurs and the responses generated are covered.

4.3.2.3 Keypad Entry and 7-Segment Display Logic

The control keys, RATE and VOLUME Data Entry keys are electronically read by the display board logic. The display board also generates the key 'echo' on the RATE and VTBI LED displays and drives the KR-BUS to inform the logic board microcontroller of key actuation. The following explanation refers to figures 4-5, 4-6 and 4-6a.

FOSTER

With the exception of the ON/STOP key, all keys are read by a keyboard decoder chip (U6) and are latched into (U5). The display processor (U7) periodically scans latch (U5). If D7 (bit #7) is high, the display processor assumes a key has been recently pressed and enters the key value into an internal register. If the key detected was a RATE or VTBI entry, the display processor updates the 7-segment display memory to reflect the entered key. U7 addresses and writes to latches U11 and U13. The latch outputs to drive segment/digit drivers U12 and U14, which in turn illuminate the selected LED segments on displays DS1 through DS7. U7 operates in a program loop which continually refreshes the 7-segment information. When any key is pressed, U7 also drives its ports PB0 through PB7 (KR-BUS) and reads ports PA0 through PA3 (strobes ST0-ST3) to communicate with the main processor on the logic board.

HIGHTOWER

All keys, except the ON/STOP key, are read by the display board processor (U1). A program loop in U1 periodically scans the keyboard by driving ports PC0 through PC4 on U2 (RAM and two 8-bit ports) while scanning processor ports P20 through P23. If a key closure is detected while scanning, U1 loads the key value into an internal register. If the key detected was a RATE or VTBI entry, the display processor updates the 7-segment display by commanding the LED driver chip (U4) to modify one of the 7-segment readouts. U4 has it's own internal RAM, segment/digit drivers , and a scan oscillator. When the display processor writes a new digit (over the data bus), U4 changes one of these RAM locations. The new digit shows on the 7-segment displays (DS1 through DS7) on the next scan. When any key is pressed, the display processor (U1) also drives U2 ports PB0 through PB7 (KR-BUS) and reads its own ports P10 through P13 (strobes ST0-ST3) to communicate with the main processor (Z1) on the logic board.

The ON/STOP key is processed differently. Since it interrupts power, a hardware driver is used to sense closure of this key (see Section 4.3.2.5).

4.3.2.4 Circuit Enabling.

Most of the circuits in the 960A/*965A* instruments that provide control or alarm signals to the microprocessor input require a voltage and/or current source. Since much of this output is sent paralleled on the data bus, it is not possible to have all of these circuits enabled simultaneously. Accordingly, these circuits are software enabled, read by the microprocessor and then disabled by turning off the enabling current and/or voltage. When current requirements are greater than can be obtained from the I/O ports, the port output drives a buffer and/or a transistor to supply the required current. The relationship between the enabling signal and current/voltage source is discussed in the following sections.

4.3.2.5 Power Supply.

The schematic diagram for the power supply circuit card is shown in Figure 4-8. The power supply includes its own battery charger operating on 120 VAC, 50-60 Hz input power. A stepdown transformer reduces the AC to approximately 14.5 volts which is rectified by Z1 and filtered by C1. Z2 is a voltage regulator that is adjusted with R1 to produce ≈7.2 volts DC when the current to the battery is approximately 50 milliamperes. CR1 prevents current from the battery from flowing through R1, R2 and R8 when the battery charger is not in operation. R8 holds CHG at pin 7 of P7 high when the battery charger is operating. This provides a status signal for the Low Battery alarm circuit.

FOSTER

The ON/STOP control, when pressed to turn on the pump, applies a signal to J4 pin #5 on the display board forcing U6 pin #14 to go high. This signal is then communicated to U7 through U5 via the data bus. The relay control signal applied holds the base of Q3 high resulting in turning K1 on and supplying SWBATT to the rest of the system. When the ON/STOP control is pressed to turn the pump off, a signal is transmitted to U7 via U6 and U5. The microprocessor then outputs a signal t hold /SV, pin 4 of P7 on the power supply board low. This turns on Q2 and maintains power to the system while the relay control line is pulled low, turning K1 off.

HIGHTOWER

The ON/STOP control, when actuated to turn on the instrument, applies a signal via J4 pin #6 to power the base of Q4. The processor reads the ON/STOP switch signal and sends a signal to the base of Q5 to apply SWBATT to power the system. When the ON/STOP switch is pressed again the processor reads the signal and turns off the displays, but retains power to the system for 4 hours after which the power to the base of Q5 is interrupted and the instrument powers down.

Thus, power to the microprocessor is maintained although it appears, externally, that power has been turned off. This enables the pump to be turned off without loss of the volume infused data. When the pump is turned on, the volume infused data will reappear in the display. After approximately four hours, output P51 of Z3 on the main logic board (see Figure 4-5) goes low, turning off Q12, also on the main logic board, and Q2 in the power supply. With Q2 turned off, the unit is completely unpowered. Z4-2 provides a reference voltage of 2.5V for Z3-9, which drives the series regulator transistor, Q1, and for the low battery reference amplifier, Z3-5,12. There are two battery voltage sense circuits. The first, comprised of Z3-5 and Z3-6, is adjusted so that the output of Z3-7 goes high when the battery voltage drops to 5.8 volts. The second, comprised of Z3-12 and Z3-13, forces the output of Z3-14 high when the battery voltage drops to 5.4 volts. The voltage across R18 is held constant by the output of Z4-2 irrespective of battery voltage within the limits of 5.2 to 7.2 volts. The outputs are used to set the low battery alarm when the battery voltage drops to 5.8 volts and to set the malfunction alarm when the voltage drops to 5.4 volts. The outputs of the battery voltage sense circuits are prevented from being forced high at power turn-on by C5 and C6. C5/R12 have a shorter time constant which releases the inputs of Z3-6,13 high sooner in respect to Z3-5,12, suppressing the battery alarm during power up.

4.3.2.6 Prime Mode Logic.

When the PRIME ON/OFF control is pressed to enter the prime mode, the display processor supplies prime status via the KR1 data bus of the microprocessor (Z1) on the main logic board (refer to Section 4.3.2.3 for a discussion of key processing). This, in conjunction with when /RD and P23 of Z1 are low, buffers Z9-11, Z9-13 and the buffers of Z10 are enabled. Strobe ST4, at the collector of Q6, goes high every 20 milliseconds, enabling the PRIME ON/OFF control. When the microprocessor receives data from the display board indicating the RATE parameter is set to 000, the stored program in *Z2/Z2* on the main logic board causes the microprocessor to output the necessary signals to drive the stepper motor at prime speed. If the rate is set at something other than zero, the microprocessor program will inhibit the prime mode. The P70 output of Z3 (see Figure 4-5) will be set low to sound the audible alarm;the PB0 and PB1 outputs of *Z2/Z2* will be set high and will be sent to the LCD (see Figure 4-6 or 4-6a) to display the RATE NOT 000 message.

4.3.2.7 Operate Logic.

The enabling strobe for the START control is ST5 which is generated at the collector of Q5 on the main logic board. START control status is fed back by the display processor via data line KR0 through J6. ST5 goes high every 20 milliseconds, detects START control actuation via the display board and pulls data line KR0 high. This is read by the microprocessor and initiates the operate mode. The stored program in Z2 then causes the microprocessor, during the times of ST0 and ST1, to read the states of data lines KR0 through KR7 which provide the rate input. These data lines are connected to the display processor through J2 (see Figure 4-6). ST1 is the enabling strobe for the two least significant digits of the RATE display and ST0 is the strobe for the most significant digit. In response to sensing actuation of the START control and reading the proper states of KR0 through KR7 (rate not '000'), the microprocessor system will output the necessary signals to cause the stepper motor to operate at the speed appropriate to the selected rate. If the

RATE data input is all set to zero (high=0) the operate mode will be inhibited. The microprocessor will set P70 of Z3 (see Figure 4-5) low to sound the audible alarm through Z6-6 and Q14. It will also set the PB1 output of Z2 high which will be latched to the LCD (see Figure 4-6 or 4-6a) and cause the "RATE 000" message to display. The microprocessor system, through Z2 (see Figure 4-5), outputs data that is latched into the display drivers of the LCD (Figure 4-6 or 4-6a) by strobe ST4. The outputs of these drivers are connected to segments of the LCD moving bars. These are energized in sequence by data on the bus so that they move at a rate relative to the selected infusion rate. When the pump is in the operate mode, the microprocessor alternately sets the P71 output of Z3 (see Figure 4-5) low, then high, to turn Q15 on and off, causing the green LED indicator to flash at a two-second rate.

4.3.2.8 Rate Compensation.

The time required to complete a fill stroke is not proportional to the delivery rate. Also, it may vary slightly. Therefore, the microprocessor will accumulate data in the random access memory (RAM) during the fill stroke which is proportional to the selected rate. During the subsequent delivery stroke, it outputs this data as additional stepper motor pulses to compensate for the delivery interruption caused by the fill stroke. This function is completely controlled by the stored program. It is mentioned here since it may be apparent during the tests of Section 5 that the stepper motor runs faster during the early part of the upstroke than during the latter part.

4.3.2.9 Volume To Be Infused Logic.

ST2 is the enabling strobe for the two most significant digits of the VOLUME TO BE INFUSED display and ST3 is the enabling strobe for the two least significant digits (see Figure 4-6). During the period of ST2 and ST3, which occurs every 20 milliseconds, the microprocessor reads the states of data lines KR0 through KR7 (see Figure 4-5) which provide the volume to be infused input. The volume infused data is stored in the microprocessor RAM. This data is incremented 1 mL for approximately every 194 stepper motor pulses (for 960A), or *0.1* mL for approximately every *46.2* pulses (for *965A*). When the stored data is equal to or greater than the VOLUME TO BE INFUSED display, the stored program of Z2 sets up a 1 mL/hr (for 960A) or a *0.1* mL/hr (for *965A*) KVO rate and activates the Infusion Complete visual and audible alarms. The total volume infused data is continually generated by the microprocessor system and stored in the RAM. Every 20 milliseconds, data lines PB0 through PB7 are updated. The data is latched into LCD decoder/drivers by the display drivers (see Figure 4-6 or 4-6a) by strobes ST0 and ST1. ST0 is the strobe for the two most significant digits of the VOLUME INFUSED display and ST1 is the strobe for the two least significant digits. The display board converts the BCD data on the data bus to output signals that drive the seven-segment digits of the display, and retains the data between one strobe and the next.

4.3.2.10 Motor Direction Control.

Motor speed and direction are completely under microprocessor control. The microprocessor outputs signals M, $\overline{M}$, N and $\overline{N}$ through Z3 (see Figure 4-5). The phasing of these signals is shown in Figure 4-3, for the delivery stroke and the fill stroke. These are approximately 20 millisecond pulses that occur at a rate appropriate to the selected infusion rate. During the fill stroke, they occur at a rate of 100 per second (for 960A), or *65.1* per second (for *965A*). Limiting the pulse length during the delivery stroke maximizes battery life between charges since only the power necessary to move the motor rotor from one position to the next is required. The sequencing of the stepper motor pulses to achieve rotation is shown in Figure 4-4.

4.3.2.11 Forward/Reverse Logic.

The forward/reverse logic determines the direction of rotation of the shuttle drive (stepper) motor and the position of the valve motor drive shaft. The photo-interrupters shown in the schematic of the angle plate assembly, Figure 4-7, are enabled by strobe SS DRIVE (SSD) which is generated at the collector of Q4 (see Figure 4-5) every 20 milliseconds. The microprocessor, simultaneously, reads the states of the collectors of the photo-interrupters A1 through A5. When the shuttle reaches its upper limit, a flag on the shuttle interrupts the light path of the TSS (TOP SHUTTLE STOP) photo-interrupter, A5. This holds the collector at a high state during the strobe time. In response to this input, signals M, $\overline{M}$, N and $\overline{N}$ are interrupted by Z1, stopping the stepper motor. VFD is set low and VDO is set high. Through invertor Z2-12 and gate Z1- 3 (Figure 4-7), transistors Q2, Q3 and Q7 are turned on, energizing the valve drive motor (B1). When B1 reaches its reverse fill limit, a flag on its shaft interrupts the light path of photo-interrupter A3. The collector of A3 will be held high when strobed. In response to this input, the microprocessor sets VDO low, removing power from the valve drive motor. When VDO goes low, it produces a positive going pulse at the output of AND gate Z1-4 that turns on Q1, Q4 and Q7. Both motor terminals are brought to ground through Q4 and Q7. This provides dynamic braking to bring the valve motor to an immediate halt. The microprocessor then resumes the output of M, $\overline{M}$, N and $\overline{N}$, but with relative phases that produce stepper motor reversal, and delivered at a rate that provides high motor speed to rapidly fill the cassette. When the shuttle reaches its lower limit, the flag interrupts the light path of photo-interrupter BSS A4. The collector of BSS A4 will beheld high when SSD strobes the photo-interrupters. This input causes the microprocessor to interrupt the output of M, $\overline{M}$, N and $\overline{N}$ and to set VFD and VDO high. This forces the output of gate Z1-11 high, turning on Q5, Q4 and Q6, applying opposite polarity to the valve motor causing it to rotate from the fill to the delivery (forward) position. When it reaches the delivery position, its flag interrupts the light path of photo-interrupter FVS A2. The collector of FVS A2 will be held high when the photo-interrupters are strobed. This input causes the microprocessor to set VDO low. VDO going low again turns on Q1, Q4 and Q7. Dynamic braking of the valve motor is achieved through Q4 and Q7 as described earlier. The output of M, $\overline{M}$, N and $\overline{N}$ is resumed with the relative phase that produces forward rotation and at a rate appropriate to the setting of the rate and the commanded rate compensation. When the shuttle reaches its upper limit TSS, the entire process is repeated.

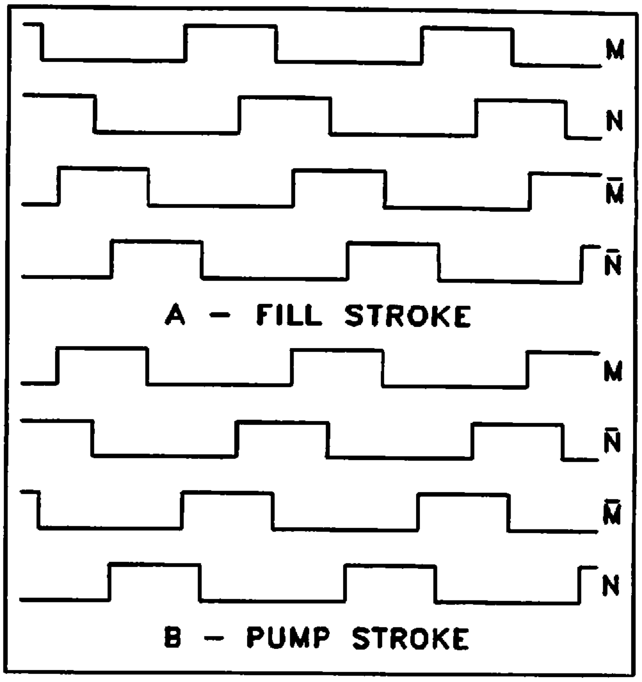

Figure 4-2. Stepper Motor Pulse Phasing

4.3.2.12 Alarm Systems.

The 960A/*965A* is configured with an alarm system that will alert the operator to an unsafe condition. Each alarm is identified by a unique message on the LCD panel and is accompanied by an audible alarm. The alarm audio can be temporarily silenced, when permitted. When the audio is silenced, the "AUDIO OFF" message appears on the LCD. The audio silence feature is overridden if an infusion is not initiated within 45 seconds after turning the instrument on or upon completion of a priming cycle. A malfunction in the system will also override the audio silence time-out. An active alarm condition will cause the P72 output of Z3 on the main logic board to go alternately high and low, switching the base of Q16 on and off which causes the ALARM indicator to flash. An electrical or mechanical malfunction will cause the ALARM indicator to illuminate steadily and override the audio silence feature, if envoked.

AIR IN LINE Alarm

The AIR IN LINE (AIL) alarm is activated when a bolus of air ≈0.375 (3/8) inch long (≈50µL), or longer, is detected by the air-in-line sensor during instrument operation. The AIL alarm will also activate if the tubing in not properly routed through the air-in-line detector when the START control is pressed. The 960A/965A instruments are configured with a 5 element, optical air-in-line detector that will detect air in either clear or opaque fluids. The AIL detector LEDs are strobe enabled. The strobe emanates from the collector of Q2 on the main logic board and is actuated by EPROM (Z2) output at port PA7. There are three 100 ohm resistors connected between lines EB6, EB7, EB8 and ground on the main logic board.

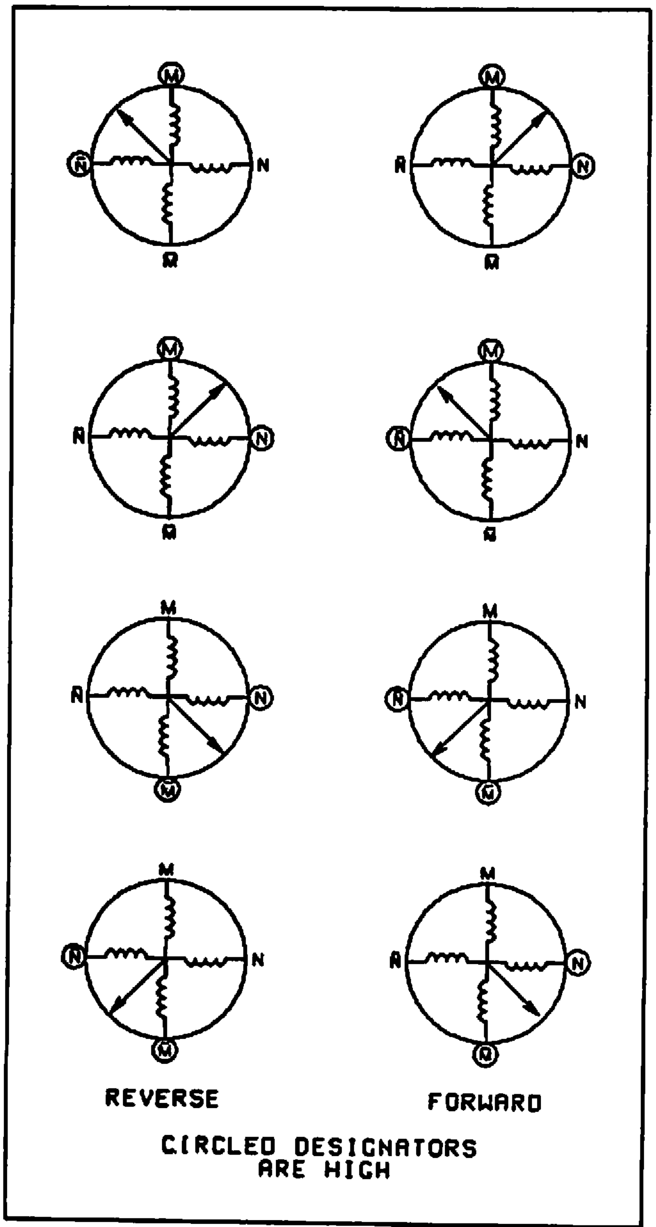

Figure 4-3. Stepper Motor Phase Sequencing

These are the returns for the opaque detector LED's. Failure of the microprocessor to detect a voltage level above ground when the AIL detectors are strobed indicates an open LED circuit and causes a malfunction alarm. EB9 provides a ground integrity check of the embolism detector. If the ground connection at P4, Pins 10 and 11 is broken, EB9 will be pulled high by RA3, 3. This is detected as a malfunction and sets the malfunction alarm. If the collectors of all detector photo- transistors are high with the strobe, opaque fluid is in the line and there are no air bubbles. The opaque detectors are Q1, Q4 and Q5. Should the collectors of any two of these be low during strobe time, it indicates a bolus of air in the line of 3/8 inch or longer. This is detected by the microprocessor which sees the AIR IN LINE alarm and interrupts motor drive pulses (M, $\overline{M}$, N and $\overline{N}$) to stop the pump. An AIR IN LINE alarm sets PB0 alternately high and low.

FOSTER

The state of PB0 is latched into U20, pin #13 when ST2 goes high (see Figure 4-6), thereby, causing the "AIR IN LINE" LCD message to appear.

HIGHTOWER

The state of PB0 is read at port PA0 of the PIO chip (U2) by the display processor (U1). When a high state is detected at port P1.2 (ST2) of the processor coincident with a high at the PIO port, the processor commands the display driver (U5) to display the "AIR IN LINE" message (see Figure 4-6a).

Since PB0 is alternately high and low, the display will flash on and off. If the collectors of all photo-transistors are low at time of the strobe, clear fluid is in the line and there are no air bubbles. If either collector, Q2 or Q3, is high, but the other low at strobe time, a bubble less than 3/8 inch long is in the line but is allowed to pass without stopping the pump. If the collectors of both are high at strobe time, the air bubble is 3/8 inch long, or longer. The microprocessor then interrupts the output of motor drive pulses M, $\overline{M}$, N and $\overline{N}$, stopping the pump. It also sets P70 of Z3 alternately low and high (see Figure 4-5) which, through Z6-6 and Q14, sounds the audible alarm. It also sets the PB0 output of Z2 alternately high, then low. The state of PB0 is sent to the display board coincident with ST2 going high. Since PB0 is alternately high then low, the "AIR IN LINE" message flashes on and off. The pump is restored to the operate mode when the cause of the alarm has been cleared and the START control is pressed.

OCCLUSION Alarm

The OCCLUSION alarm is activated whenever the pump is in the prime or operate mode and the stepper motor stops for any reason. The most common cause of motor stoppage is an occlusion in either the inlet or outlet lines from the cassette. This is the reason for labeling this alarm "OCCLUSION". Refer to the angle plate assembly schematic diagram, Figure 4-7. The motor rotation sensor is ESS A1. It is mounted such that its light path is completed and interrupted by apertures in a segmented disc mounted on the stepper motor shaft. Its LED is energized by SSD which is a strobe that occurs at 20 millisecond intervals. If the state of the collector of A1 is the same during 40 motor pulses, it is assumed that the motor has stalled since it is unlikely that a state change would not occur in that period. The microprocessor then halts the output of motor drive pulses and sets P70 of Z3 (see Figure 4-5) alternately low then high to sound the audible alarm through invertor Z6-6 and Q14. It also sets the B-output of Z2 alternately high and low.

FOSTER

The state of PB1 is latched into U2, pin #11 when ST2 goes high (see Figure 4-6), thereby, causing the "OCCLUSION" LCD message to appear.

HIGHTOWER

The state of PB1 is read at port PA1 of the PIO chip (U2). When a high is detected on port P1.2 of the display processor (U1) concurrently with a high on the PIO port, the processor commands the display driver to display the "OCCLUSION" message (see Figure 4-6a).

Since PB1 is alternately high and low, the "OCCLUSION" message will flash on and off. The alarm is reset when the cause of the motor stall is removed and the START control is pressed.

LOW BATTERY Alarm Logic

The LOW BATTERY alarm is set to actuate whenever the battery voltage drops to <5.8 volts. The LOW BATTERY message appears on the LCD panel and the audible alarm sounds but the pump does not stop. At infusion rates <500 mL/hr, the battery will continue to furnish power to the pump for approximately one hour after the Low Battery alarm is activated. The low battery alarm adjustment is shown in the schematic diagram of the power supply, Figure 4-8. The battery voltage is regulated down to 2.5 volts by Z4 and its output is applied to operational amplifier Z3. Therefore, the voltage across R18 is constant with the battery voltage at 5.4 volts, or above. As the battery voltage drops, the input threshold of Z3-6 will also drop. R12, 15, 16 are set so that when the battery voltage drops to 5.8 volts Z3-7's output transitions low to high creating LB1 at P7, pin 5. Signal LB1 is applied to the data bus of the main logic board through buffer Z9-9 (see Figure 4-5). When this line is high, coincident with strobe ST4, the microprocessor will set the low battery alarm. (Output PA4 of Z2 goes low to create ST4 and, simultaneously, enables buffers Z9-3, Z9-5, Z9-7 and Z9-9). The low battery alarm sets the PB5 output of Z2 alternately high and low.

FOSTER

The state of PB5 is latched into U21, pin #13 when ST2 goes high (see Figure 4-6), thereby, causing the "LOW BATTERY" LCD message to appear.

HIGHTOWER

The state of PB5 is read at port PA5 of the PIO chip (U2). When a high is detected on port P1.2 (ST2) of the display processor concurrently with a high at the PIO chip, the display processor (U1) commands the display driver (U5) to display the "LOW BATTERY" message (see Figure 4-6a).

Since PB5 is alternately high and low, the "LOW BATTERY" message will flash on and off. The P70 output of Z3 (see Figure 4-5) will alternately go low then high turning Q14 on and off through invertor Z6-6 to turn the audible alarm on and off. A second input, Z3-13, is set so that the output of invertor Z3-14 goes high when the battery voltage drops to 5.4 volts, generating LB2 at pin 6 of P7. This condition is detected by the microprocessor as a malfunction which stops the pump, displays the "MALFUNCTION" message on the LCD and sounds the audible alarm; the "LOW BATTERY" message remains on.

INFUSION COMPLETE Alarm Logic

The INFUSION COMPLETE alarm logic sets a message, "INFUSION COMPLETE", in the LCD and sounds the audible alarm when the volume of fluid infused is equal to or greater than the setting of the volume to be infused. It also sets up a 1 mL/ hr (for 960A) or *0.1* mL/hr (for *965A*)

KVO rate to prevent clotting within the venipuncture device. After approximately 194 motor drive pulses (for 960A), or *46.2* motor drive pulses (for *965A*), the logic board processor commands the display processor to increment the VOLUME INFUSED display of the LCD. When the volume displayed by the LCD is equal to the value displayed by the volume to be infused, the microprocessor sets the PB2 output of Z2 (see Figure 4-5) alternately high and low.

FOSTER

The state of PB2 is latched into U20, pin #9 when ST2 goes high (see Figure 4-6), thereby, causing the "INFUSION COMPLETE" LCD message to appear.

HIGHTOWER

The state of PB2 is read at port PA2 of the PIO chip (U2). When a high is detected on port P1.2 (ST2) of the display processor concurrently with a high at the PIO chip, the display processor (U1) commands the display driver (U5) to display the "INFUSION COMPLETE" message (see Figure 4-6a).

The logic board processor (Z1) also sets P70 of Z3 (see Figure 4-5) alternately low then high to turn the audible alarm on and off. The microprocessor then outputs the motor drive pulses, M, $\overline{M}$, N and $\overline{N}$, appropriate to a 1 mL/hr (for 960A) or *0.1* mL/hr (for *965A*) KVO infusion rate.

DOOR OPEN Alarm

The DOOR OPEN alarm is activated whenever instrument power is on and the door is open. A magnet implanted in the door actuates a magnetic sensing (Hall Effect) switch. The signal at pin J6-5 is high whenever the door is open. When the PA4 output of Z2 on the main logic board (see Figure 4-5) goes low to create strobe ST4, it enables Z9-3 and places the state of DOOR OPEN on the data bus. With the door open the PB3 output of Z2 is alternated high then low.

FOSTER

The state of PB2 is latched into U2, pin #11 when ST2 goes high (see Figure 4-6), thereby, causing the "DOOR OPEN" LCD message to appear.

HIGHTOWER

The state of PB2 is read at port PA2 of the PIO chip (U2). When a high is detected on port P1.2 (ST2) of the display processor concurrently with a high at the PIO chip, the display processor (U1) commands the display driver (U5) to display the "DOOR OPEN" message (see Figure 4-6a).

With the door open, the PB2 output of Z2 is alternately high and low, this causes the "DOOR OPEN" message to flash on and off. The prime and operate modes are inhibited when the door is open. When the door is closed, the "DOOR OPEN" message continues to display until a valid start or priming sequence is initiated.

NOT OPERATING Alarm

The "NOT OPERATING" visual and audible alarm activates once a prescribed time interval has elapsed following actuation of the ON/STOP control or completion of a priming sequence which is not followed by actuation of the START control. This function is completely microprocessor controlled. The logic board processor sets PB7, alternately, high and low.

FOSTER

The state of PB7 is latched into U19, pin #13 when ST2 goes high (see Figure 4-6), thereby, causing the "NOT OPERATING" LCD message to appear.

HIGHTOWER

The state of PB7 is read at port PA7 of the PIO chip (U2). When a high is detected on port P1.2 (ST2) of the display processor concurrently with a high at the PIO chip, the display processor (U1) commands the display driver (U5) to display the "NOT OPERATING" message. (see Figure 4-6a).

Since PB7 is, alternately, high and low, the "NOT OPERATING" message flashes on and off. The audible alarm is sounded by continuously setting the P70 output of Z3 on the main logic board (see Figure 4-5) low. Through invertor Z6-6 and Q14, the audible alarm is turned on. The alarm is silenced if the PRIME ON/OFF or START control is pressed. This alarm is not silenced when the "AUDIO OFF" message appears in the LCD.

SET 0000 VOLUME Alarm

The SET VOLUME 0000 alarm causes "SET VOLUME 0000" to appear in the LCD and the audible alarm to sound when the VOL INF RESET control is pressed. This function is completely microprocessor controlled. The VOL INF RESET control resets the volume accumulator in the microprocessor to zero if the volume to be infused is at zero. This function is inhibited if the is set to something other than zero and the alarm is set. The P70 output of Z3 on the main logic board (see Figure 4-5) is set low to sound the audible alarm through invertor Z6-6 and Q14. The PB2 and PB3 outputs of Z2 are, alternately, set high and low.

FOSTER

The state of PB2 is latched into U18, pin #13 and the state of PB3 is latched into U19, pin 15 when ST3 goes high (see Figure 4-6), thereby, causing the "SET 0000 VOLUME" LCD message to appear.

HIGHTOWER

The state of PB2 & PB3 is read at ports PA2 and PA3 of the PIO chip (U2). When a high is detected on port P1.3 (ST3) of the display processor concurrently with a high at the PIO chip, the display processor (U1) commands the display driver (U5) to display the "SET 0000 VOLUME" message (see Figure 4-6a).

Since these signals are, alternately, high and low, the "SET 0000 VOLUME" display flashes on and off. The alarm is not activated when the volume to be infused is set to 0000 and the VOL INF RESET control is pressed.

SET VOLUME Alarm

The SET VOLUME alarm is activated when START is pressed and the volume to be infused is set at 0000. This function is completely microprocessor controlled. Z1 sets the P70 output of Z3 on the main logic board (see Figure 4-5) low while START is being pressed to sound the audible alarm through invertor Z6-6 and Q14. Output PB3 of Z2 is, alternately, set high and low.

FOSTER

The state of PB3 is latched into U19, pin #15 when ST3 goes high (see Figure 4-6), thereby, causing the "SET VOLUME" LCD message to appear.

HIGHTOWER

The state of PB3 is read at port PA3 of the PIO chip (U2). When a high is detected on port P1.3 (ST3) of the display processor concurrently with a high at the PIO chip, the display processor (U1) commands the display driver (U5) to display the "SET VOLUME" message (see Figure 4-6a).

Since PB3 is alternately high and low, the "SET VOLUME" message flashes on and off. The alarm is cleared when START is released. The message flashes for approximately two seconds after the START control is released.

RATE 000 Alarm

The RATE 000 alarm is activated when START is pressed and the rate is set at 000. This function is completely microprocessor controlled. It sets the P70 output of Z3 on the main logic board (see Figure 4-5) low while START is being pressed to sound the audible alarm through invertor Z6-6 and Q14. Output PB1 of Z2 is, alternately, set high and low.

FOSTER

The state of PB1 is latched into U19, pin #11 when ST3 goes high (see Figure 4-6), thereby, causing the "RATE 000" LCD message to appear.

HIGHTOWER

The state of PB1 is read at port PA1 of the PIO chip (U2). When a high is detected on port P1.3 (ST3) of the display processor concurrently with a high at the PIO chip, the display processor (U1) commands the display driver (U5) to display the "RATE 000" message (see Figure 4-6a).

Since PB1 is, alternately, high and low, the "RATE 000" message flashes on and off. The alarm is cleared when the START control is released. The message flashes for approximately two seconds after release of the START control.

RATE NOT 000 Alarm

The RATE NOT 000 alarm is activated when the PRIME ON/OFF control is pressed and the rate is not set at 000. This function is completely microprocessor controlled. It sets the P70 output of Z3 on the main logic board (see Figure 4-5) low while the PRIME ON/OFF control is being pressed to sound the audible alarm through invertor Z6-6 and Q14. Outputs PB0 and PB1 of Z2 are, alternately, set high and low.

FOSTER

The state of PB0 is latched into U19, pin #9 and PB1 is latched into U19, pin #11 when ST3 goes high (see Figure 4-6), thereby, causing the "RATE NOT 000" LCD message to appear.

HIGHTOWER

The state of PB0 is read at port PA0 and PB1 is read at PA1 of the PIO chip (U2). When a high is detected on port P1.3 (ST3) of the display processor concurrently with a high at the PIO chip, the display processor (U1) commands the display driver (U5) to display the "RATE NOT 000" message (see Figure 4-6a).

Since they are, alternately, high and low, the "RATE NOT 000" message flashes on and off. The alarm is cleared when the PRIME ON/OFF control is released. Message flashes for two seconds after release of the PRIME ON/OFF control.

AUDIO OFF Alarm

The AUDIO OFF function is not an alarm condition. When the AUDIO switch is pressed, the audible alarm is inhibited and the "AUDIO OFF" message displays on the LCD panel. The audio alarm will remain inhibited for approximately two minutes. It is then automatically re-enabled and the "AUDIO OFF" message disappears from the LCD. The audible tone can not be silenced for malfunction alarms. The alarm silence function is completely microprocessor controlled. Refer to the interconnection diagram, Figure 4-9. The AUDIO switch is a momentary contact type connected to the main logic board at J5 and is strobed by ST4. The AUDIO switch return is to data line KR3 through CR12. If this line is high at ST4, the microprocessor inhibits the P70 output of Z3 from going low to sound the audible alarm.

FOSTER

The state of PB6 is latched into U18, pin #11 when ST4 goes high (see Figure 4-6) causing the "AUDIO OFF" message to appear.

HIGHTOWER

The state of PB6 is read at port PA6 of the PIO chip (U2). When a high is detected on port P1.4 (ST4) of the display processor concurrently with a high at the PIO chip, the display processor (U1) commands the display driver (U5) to display the "AUDIO OFF" message (see Figure 4-6a).

NOT CHARGING Alarm

The NOT CHARGING alarm, like the AUDIO OFF alarm, does not constitute an alarm since the audible alarm does not sound and the pump is not stopped when the "NOT CHARGING" message appears on the LCD. This function is microprocessor controlled. Refer to the power supply schematic diagram, Figure 4-8. When the power cord is connected to the 120V AC receptacle, the voltage at the junction of CR1 and R8 will be between 5.4 and 7.2 volts, depending on the charge condition of the battery. The other end of R8 is connected to P7, pin 7 and is labeled CHG. Refer now to the main logic board schematic diagram, Figure 4-5. CHG is connected to data bus line KR2 through buffer Z9-5 which the microprocessor will read coincident with ST4.

FOSTER

If CHG is high, battery charger connected, PB4 goes low and is latched into U21, pin #13 when ST2 goes high. This turns off the "NOT CHARGING" LCD message, if displayed.

If CHG is low while operating on battery power, PB4 goes high and is latched into U21, pin #13 when ST2 goes high and causes the "NOT CHARGING" LCD message to display.

HIGHTOWER

If CHG is high, battery charger connected, PB3 is read into PA4 of the PIO chip (U2) by the display processor (U1). When port P1.2 of the processor goes high (ST2), the processor commands the LCD driver (U5) to turn off the "NOT CHARGING" message, if displayed.

If CHG is low while operating on battery power, PB4 goes low signaling the display processor (U1) to display the "NOT CHARGING" LCD message.

The NOT CHARGING alarm is not displayed in the presence of other alarms (except LOW BATTERY) to eliminate confusion.

MALFUNCTION Alarm Logic.

The program stored in the EPROM (Z2 Figure 4-5) directs the microprocessor to continually monitor a number of electrical parameters to verify normal operation. If one of these should malfunction, the malfunction alarm will be activated. A malfunction is indicated by "MALFUNCTION" flashing on and off in the LCD and the VOLUME INFUSED XXXX display alternating with a number code which indicates the cause of the malfunction alarm. The audio alarm also sounds irrespective of the AUDIO OFF display condition. Table 5-2 lists the cause of the malfunction alarm associated with a discrete number. Malfunctions 10 and 11 are detected by the microprocessor without external malfunction detecting circuits. The collector of each photo-transistor in the air-in-line detector is connected through a 33K ohm resistor (R12 through R16) to +5V. If any one of these is low without a strobe, it indicates a shorted photo-transistor. This produces malfunction code 4. The same resistors are in the collector circuits of the valve motor, shuttle and stall sensors on the angle plate assembly (see Figure 4-7). The microprocessor can then detect if one of the signal lines connected to these resistors is high when it should not be. Such a case is both valve motor stop sensor collectors being high simultaneously. These conditions produce malfunction codes 5 and 6. As discussed under Air-in-line alarm, the returns for CR1, CR4 and CR5 in the air-in-line detector are 100 ohm resistors. If there is a voltage drop across any one of these resistors in the absence of the strobe for the three LED's, malfunction code 7 is displayed. If there is no drop across any one of these resistors in the presence of a strobe, there is either a broken connection or one of the LED's is open. This produces malfunction code 9. If the ground connection for the air-in-line detector opens, a voltage drop is produced across R11 at strobe time resulting in display of malfunction code 8. If the battery is allowed to discharge to a level of 5.4 volts, LB2 at P7 goes high. This sets the malfunction alarm with code 14 displayed. Refer to the main logic board schematic, Figure 4-5. A second oscillator comprised of two invertors, Z6-2 and Z6-4, operates at approximately 2.0 KHz and clocks counter Z4 setting the Q7 output high at 36 milliseconds after being reset by the P26 output of Z1. The microprocessor completes the loop in approximately 5 milliseconds. It looks for the Q7 output of Z4 at its T1 output every five milliseconds. If it sees a rising edge before the 6th loop (30 milliseconds), an underrate condition is indicated which sets the malfunction alarm with code 13 displayed. If it sees a rising edge after 6 loops but before the 8th loop (40 milliseconds) is entered, things are normal and continues operation. If it sees a rising edge after 8 loops (40 milliseconds) are completed, an overrate condition is indicated, which sets the malfunction alarm with code 12 displayed. Counter Z4 is reset by the P26 output of Z1 whenever Z1 detects a rising edge from the Q7 output of Z4. If the microprocessor does not reset Z4, Z4 will be clocked until its Q12 output goes high which will turn on Q14 to sound the audible alarm. The Q12 output will alternate between high and low once every two seconds producing an audible alarm every two seconds. When Q12 goes high, it also turns on Q11 which turns off Q12. Q12, in turn, turns off Q2 in the power supply (see Figure 4-8). This prevents the pump from continuing its four-hour powered down operation in the event of a microprocessor malfunction.

FOSTER

The state of PB4 is latched into U21, pin #9 when ST32 goes high (see Figure 4-6), thereby, causing the "MALFUNCTION" LCD message to appear.

HIGHTOWER

The state of PB4 is read at port PA4 of the PIO chip (U2).When a high is detected on port P1.3 (ST3) of the display processor concurrently with a high at the PIO chip, the display processor (U1) commands the display driver (U5) to display the "MALFUNCTION" message (see Figure 4-6a).

Since PB4 is alternately high and low, the "MALFUNCTION" message will flash on and off. The malfunction code number, as stated above, is alternately, displayed with the volume infused digits.

PRESS Prompt

The PRESS Start indicator is illuminated when the display processor strobes the Rate and VTBI keys and detects an actuation that is not followed-up by a press of the START key within a ten second delay period.

FOSTER

The "PRESS" Start indicator is illuminated when the display processor (U7) detects actuation of the Rate and VTBI keys at the keyboard chip (U6) that is not followed by an actuation of the START key within 10 seconds. The processor places a 80H at address 803H. This locks the latch (U10). Bit 7 (80H) ties to invert (U14) to drive the LED bar (DS8).

HIGHTOWER

The PRESS Start indicator is illuminated when the display processor (U1) detects activation of RATE and VTBI keys [generated and read by the PIO chip (U2)] with no follow-up actuation of the START key within 10 seconds. The processor port, pin P2.5 goes high, turning on Q7 which causes DS10 to illuminate.

4.3.2.13 Liquid Crystal Display (LCD).

The functions of the LCD have been explained for the most part in the preceding paragraphs. However, there are some operational features of the LCD that are more appropriately explained in a separate paragraph. The LCD is not, strictly speaking, a DC device. Rather, it requires an AC potential between the energized elements and the back plane.

FOSTER

AC voltage to drive the LCD backplane is generated by an oscillator and a full-wave negative voltage generator. The oscillator (2 gates in hex invertor U22) provides a 0 to +5V square wave. The remaining 4 gates of U22, driven by the oscillator, are split into 2 negative-voltage charge pumps 180° apart. Their outputs are summed to provide a full-wave rippling negative voltage of ≈ -5V DC. The square wave is applied to the LCD's backplane and segment drivers U16 through U26. The negative voltage is also applied to the segment drivers. Internal to the LCD drivers are latches and level shifters. When a logic 0 is latched into these chips, the level shifter provides a net potential between the LCD's backplane and segment of ≈ 0V. The crystals won't align (no voltage field) and hence the message remains invisible. When a logic 1 is latched into these chips, the level shifter drives the LCD's backplane and segment 180° out-of-phase, generating a voltage field of ≈ 20V P-P. This potential aligns the crystals and the message becomes visible, i.e, turns dark. U16 through U21 are quad one-bit latches for driving "message" segments, whereas U23 through U26 have internal BCD to 7-segment decoders to generate VOLUME INFUSED digits.

HIGHTOWER

AC voltage to drive the LCD backplane is generated by two 180° phase-shifted oscillators internal to the 2 LCD controller chips (U5 and U3). The display processor (U1) reads ports P1.0 through P1.7 and the PIO chip (U2) ports PA0 through PA7 to get display information. When logic dictates turning on an LCD segment, the display processor loads U5 (message controller chip) or U3 (7-segment digit controller chip). These 2 chips turn on or off LCD segments with in-phase or out-of-phase voltage fields in the same manner as described above in the FOSTER explanation. The net potential between the segment and backplane is only ≈ 10V P-P.

The LCD is updated every 20 milliseconds by ST0 through ST4.

4.3.2.14 Pressure Adjustments.

<u>960A Angle Plate</u>
There are two pressure adjustment potentiometers on the angle plate assembly which are represented by R16 and R20 in Figure 4-7. These potentiometers are wired in series with the common stepper motor lead. Adjustment of the

lower pot controls the maximum delivery pressure (up stroke) that may be developed before the motor stalls and an occlusion alarm is activated. Adjustment of the upper pot controls the level of torque that may be developed during a down-stroke before an occlusion alarm is activated. During the upstroke, Q8 and Q9 are turned on shorting out R16. Q8 and Q9 are turned off during the first three downstrokes following START control actuation which allows the pump to sense a closed input signal. After the third downstroke, both R16 and R20 are shorted continuously during the downstroke cycle. During the upstroke Q10 and Q11 are turned off, Q8 and Q9 are turned on allowing R20 to regulate the current applied to the motor which establishes the maximum pressure that can be developed. In the operate mode, R20 and R16 are not shorted out during the first three fill stroke cycles following START control actuation. Therefore, torque during the first three fill stroke cycles is low and if a clamp on the IV administration set is left closed, the pump will go into occlusion alarm.

965A Angle Plate
There are two pressure adjustment potentiometers on the angle plate assembly, which are represented by R16 and R20 in Figure 4-7a. These two rheostats are part of the 2-stage current source for the stepper motor. The adjustment of the lower pot controls maximum delivery pressure (up stroke) that may be developed before motor stall and subsequent occlusion alarm. The adjustment of the upper pot controls maximum fill (down stroke) pressure before motor stall and an occlusion alarm. During upstroke Q8 and Q9 are activated, Q10 and Q11 are off, allowing current to flow to the stepper motor through R16. This current is turned off during the first three downstrokes after the START key is pressed to allow sensing of a blocked IV set. R20 becomes the blocked tubing sensor as it is the only stepper motor current source during the first three downstroke cycles (low torque easily stalls motor). After the third downstroke, both current sources are turned on for maximum fill pressure.

4.4 ELECTRICAL/ELECTRONIC OPERATION

The following paragraphs provide a functional and detailed circuit description of the subsystems within the PIP/P4.x configured versions of the *960A/965A* instruments. Refer to the descriptions in the preceding sections for explanations of subsystems that are common to all version of these instruments. The logic block diagram for the PIP version instruments is shown in Figure 4-4.

4.4.1 Functional Descriptions

4.4.1.1 Microprocessor System

The microprocessor system consists of an 8032A 8-bit controller (U8), a 27256 EPROM (U5) and a 82C55 programmable I/O device (U9). A 12MHz crystal (Y1) provides the clock signal for the system. The operating program is stored in the EPROM. The three 8 bit ports on the 82C55 provide the interface to the angle plate and the ultrasonic air-in-line detector. An input latch, output latch and LED driver are utilized for additional I/O support. The LED driver (1CM7218C) provides the logic necessary to store and display the 7 LED digits representing rate and volume. In addition, the missing segment detector automatically detects failed (open) LED segments. Two bits from the output latch along with a 2 line to 4 line data selector provide 4 strobes for scanning the keyboard. The responses from the keyboard are read via the input latch. Three lines from the output latch are dedicated to driving status lights (operate, alarm and press). The three remaining lines are utilized for mechanizing a serial interface to the LCD driver.

4.4.1.2 Prime Mode Logic

The PRIME ON/OFF control is keyboard activated. Contact closure is communicated to the microprocessor through the input latch. The microprocessor will continue sampling peripheral device outputs. If conditions for initiating the prime mode are not satisfactory (e.g., rate not set to 000/*00.0*), the microprocessor generates an alarm, places the alarm data on the serial bus via the output latch to: the serial/parallel driver, the LCD, the audible alarm driver and the alarm LED driver. If conditions are normal, the microprocessor, through the 82C55 expander and circuitry on the angle plate assembly, develops motor drive pulses and valve motor drive signals at rates and times appropriate to the prime mode.

4.4.1.3 Operate Logic

The operate mode is initiated by pressing the START control which is keyboard activated. The microprocessor will continue sampling the outputs of the peripheral devices. If conditions required to initiate 'operate" are not satisfied, the instrument will generate an alarm and place the alarm data on the serial bus via the output latch through the serial/parallel LCD driver to the LCD and through the status driver to the audible alarm and alarm LED. If conditions are satisfied, the microprocessor, through the 82C55 expander and angle plate circuitry will generates motor drive pulses and valve motor drive signals appropriate to the selected rate. The microprocessor system totals the number of motor drive pulses generated during each delivery stroke, and for every 194/*46.2* forward (delivery) pulses, the microprocessor updates the VOLUME INFUSED display by 1/*0.1* mL. Volume Infused display data is sent via the output latch and serial/parallel driver to the LCD. The microprocessor periodically compares the accumulated volume infused data with the volume to be infused setting. When the two are equal, the microprocessor generates an INFUSION COMPLETE alarm, places the alarm data on the LCD, the audible alarm driver and the alarm LED driver. It also outputs motor drive pulses to invoke the KVO delivery rate of 1/*0.1* mL/hr.

4.4.1.4 Photo-sensor System

The photo-interrupters on the angle plate assembly comprise the photo-sensor system. These sensors are strobe enabled. The microprocessor responds to any change in the state of the angle plate photo-interrupters. For example, when the shuttle reaches the top of the delivery stroke, the change of state of the forward limit stop photo-interrupter output will produce a valve motor drive signal to rotate the valve motor shaft and the cassette valve to the fill position.

4.4.1.5 Alarm System

When an alarm is activated, the nature of the alarm appears on the LCD, an audible alarm is sounded and the alarm LED flashes. The alarm messages are a permanent feature of the LCD. The audible alarm driver is activated by one output (P15) of the 8032, if the audio silence switch has not been recently closed. Closing the audio silence switch permits a signal to appear on the T1 line of the microprocessor. This disables the audible alarm and causes the microprocessor to latch the "AUDIO OFF" display in the LCD. After a temporary delay period, the "AUDIO OFF" message is cleared and the audio alarm enabled. The circuit conditions that activate the alarms are covered as part of the detailed circuit descriptions subsection.

4.4.1.6 Volume and Rate Inputs

In addition to the PRIME ON/OFF and START control inputs discussed above, the operator provides volume-to-be-infused and rate inputs through the front panel controls which are also keyboard activated. As previously mentioned, the volume infused data is accumulated by the microprocessor and displayed on the LCD. This data is retained in memory for 4 hours after the pump is turned off and will re-display if the instrument is turned on again within 4 hours. This allows the pump to be turned off for reconfiguration without losing the existing data. The VOLUME INFUSED display can be reset to "0" by setting the volume to be infused to 0000/*000.0* then pressing the VOL INF RESET control. This control is also keyboard activated.

4.4.2 Detailed Circuit Descriptions

4.4.2.1 Microprocessor System

The 8032 microprocessor (U8) communicates with the EPROM (U5) via the bi-directional bus P00-P07 (D0-D7) and port 2. Address information is output on these ports and latched by (U18) by the ALE signal. The data associated with this address is output by the EPROM in response to PSEN going low. The data is received on the bi-directional Data Bus (Port 0) and utilized by the microprocessor. All other peripheral devices also communicate over port 0. The peripheral devices are enabled selectively by exclusive combination of latched address bits A0-A4 and the control signals /RD and /WR.

These three I/O ports to the 82C55 (U9) allow communication with the Angle Plate Electronics, the Air-in-Line detector and the door sensor. Port A and Port C are configured as output lines. Port B is an Input port.

4.4.2.2 Keypad Entry

All controls, except the ON/STOP control, are scanned periodically by four (4) strobe lines output form the data selector (U1/B). The input to the data selector is controlled by two lines from the output latch (U15) in response to the microprocessor via the data bus. If a control is pressed, a response will be detected on one of the 5 keyboard lines via input latch (U4). The microprocessor determines which control was pressed by knowing which strobe was active and which line to the input latch responded. The control detected is stored into an internal register for utilization by other parts of the program.

The ON/STOP control when actuated to turn on the instruments, applies a ground signal via J4, pin 6 which in turn sinks current from the base of Q16 via CR23 and R33. This switches battery power on to the 6VSB line which in turn supplies the 5V regulator and provides system 5V DC. When the microprocessor is activated, it sets the PWR line high and turns Q17 on. This latches a current to Q16 and maintains 6VSB. When the ON/STOP control is again activated the microprocessor senses the switch via input latch (U4). The microprocessor responds by stopping the pump and turning off the displays. Power, however, is not turned off for 4 hours so that the Volume and Rate data may be retained, should the instrument be reactivated during this period. After the 4 hour holding period times out the microprocessor will change the power line to low and shut down the system.

4.4.2.3 Displays

LED DISPLAY

The rate and VTBI values are displayed on 7-segment LED displays. The microprocessor updates the LED displays by sequentially loading each of the digits into the LED display driver (U1). The display driver with its own internal RAM, segment/digit drivers, scan logic and oscillator automatically scans the display digits with the stored data.

LCD DISPLAY

The individual messages and segments of the Volume display are each driven by a dedicated line from one of the LCD drivers (U2 or U3). Data is loaded into the drivers serially via the LCD clock and data lines. When all bits are transmitted into the drivers, the data is transferred to the output lines. The clock and data lines are controlled by the microprocessor via 3 lines on the output latch (U15).

STATUS INDICATORS

The status LEDs: Operate, Alarm and Press are controlled by 3 lines from the output latch (U15). Transistor drivers are provided for higher current drive.

4.4.2.4 Back Up Battery

An audio alarm backup is provided should the internal main battery fail or become disconnected (see Figure 4-10). the audio alarm is normally powered by the main battery through D1. Normal audio is provided when Audio is grounded under microprocessor control. Should the main battery fail, Battery (B1) supplies voltage to the audio alarm via D2. Q2 will be turned on thus driving Q1 which shorts the audio (-) line to ground thus producing a continuous audio alarm. Battery (B1) is normally charged from the main battery through R4. A battery test input is provided to enable the microprocessor to test the state-of-charge of B1. During the test a 51Ω resistor (R18) loads B1. If the voltage falls below the predetermined threshold set by R7, R8 and V_{REF} D3, the output of comparator (U1) will go high indicating to the microprocessor a test failure and initiating a malfunction alarm signal. In addition to the backup battery, a blown fuse detector is incorporated. Should the fuse blow or become dislodged, the bias current to Q5 is interrupted thereby turning on Q8 and driving Audio low.

4.4.2.5 Battery Charger

The battery charger subsystem consists of components mounted on the power/display board (see Figure 4-5a Sht 3). The circuit utilizes a switching regulator concept based on the UC2524A (U1) regulator chip. Unregulated AC voltage is rectified through the diode bridge (CR13-CR11). The unregulated DC output from the rectifier bridge charges capacitor C22. C22 provides filtered DC voltage to the regulator chip and the switching circuit which consists of transistors Q13 - Q15. When Q15 is "On", power flows through inductor (L1). As the current through the inductor builds, the regulator senses the control voltage limit and turns off the switching circuit. The collapsing field in the inductor supplies voltage to charge capacitor C27. C27 output is supplied directly to the battery. Current is sensed across resistor R37 to automatically limit charging current to ≈2 Amps maximum. A separate voltage regulator (Q18) receives power from the rectified DC voltage and supplies regulated power to backlight invertor PS1. This invertor produces ≈100V AC for the electro-luminescent panel mounted behind the LCD. The panel is thereby illuminated whenever the instrument is plugged into an AC power source. Transistor (Q12) switches off the regulator when the rectified power is not available.

4.4.2.6 Ultrasonic AIL Detector

The PIP/P4.x instrument utilizes an ultrasonic air-in-line detection system. The active elements of the system include two piezo-electric (PE) crystals and a signal processing circuit. The PE crystals are bonded in tandem with acoustic lenses and are mounted diametrically opposed on opposite sides of the tubing path in the AIL detector block.

Ultrasonic sensing is used for air-in-line detection since ultrasonic wave transmission is independent of fluid opacity. Ultrasonic signal transmission (acoustic impedance) through all IV compatible solutions falls within a very discrete range which is easily discernable from passage through air.

The air-in-line detector is located on the distal side of the cassette and checks the integrity of the fluid column entering the patient side (distal portion) of the tubing set. The acoustic lenses and installed tubing set provide a coupling path for the continuous wave ultrasonic transmission to travel from the transmitting to the receiving crystal. When the tubing contains an IV solution the acoustic impedance is low and maximum energy is coupled to the receiving element which generates a voltage signal that is proportional in amplitude and frequency to the coupled energy. If an air bolus is interposed between the lenses the acoustic impedance is significantly increased as the acoustic wave is reflected by the liquid-air interface. The energy received is reduced and the voltage output is commensurately reduced. This signal differentiation combined with the instruments programmed delivery rate is used to measure the volume of the air bolus.

The AIL detector circuits (see Figure 4-4a) provide a continuous wave voltage drive. Integrated circuit (U1) implements an adjustable frequency oscillator and a push-pull driver. Received signals cause Q3 to conduct when the voltage is greater than the threshold set by potentiometer (R12). Q1 saturates when a signal is present, viz. no air in the line; and cuts off with a small signal, viz. air in the line. An enable input is provided which turns off the oscillator and allows the microprocessor to self-test the detector circuit periodically.

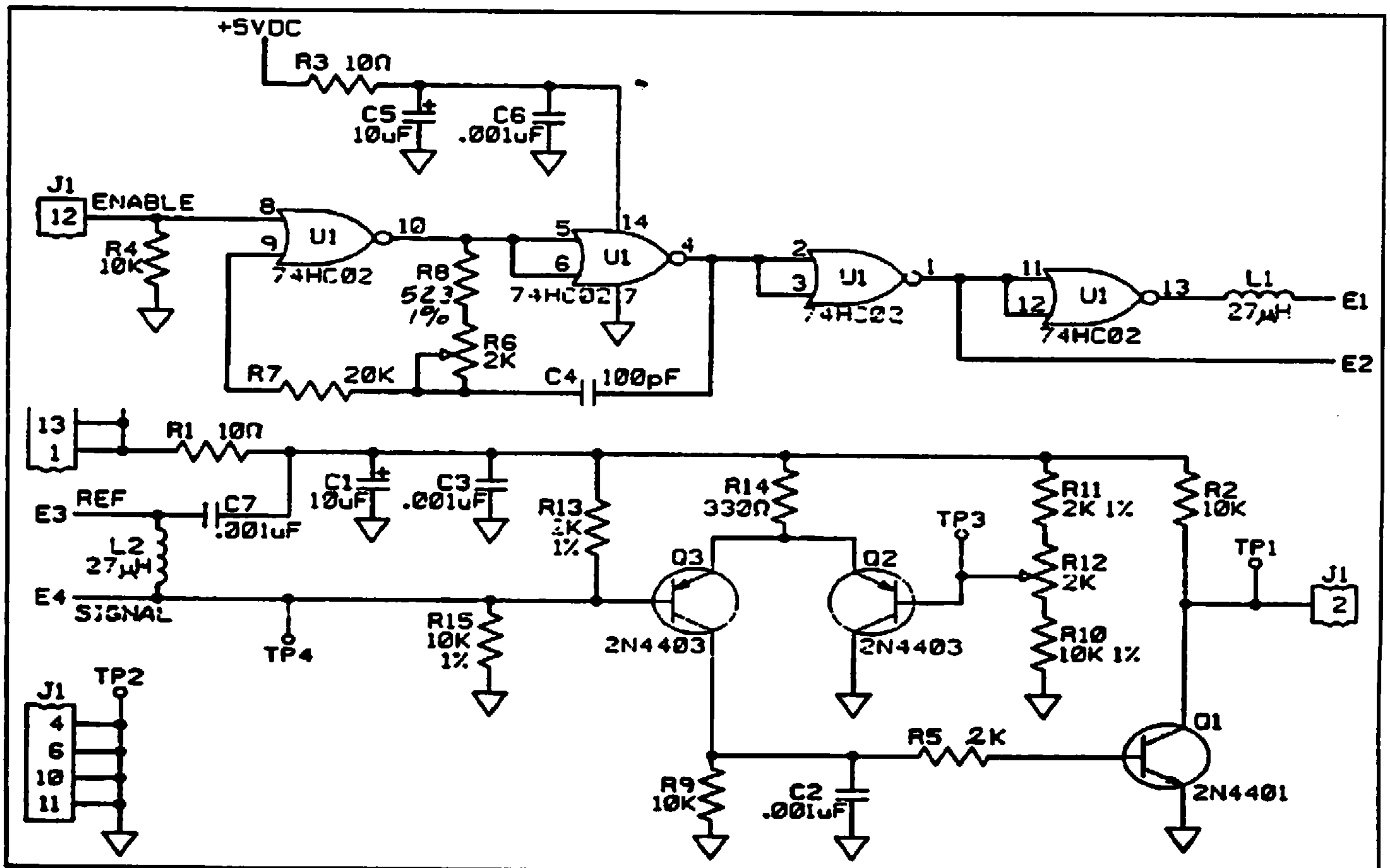

Figure 4-4a. Ultrasonic AIL Detector Schematic

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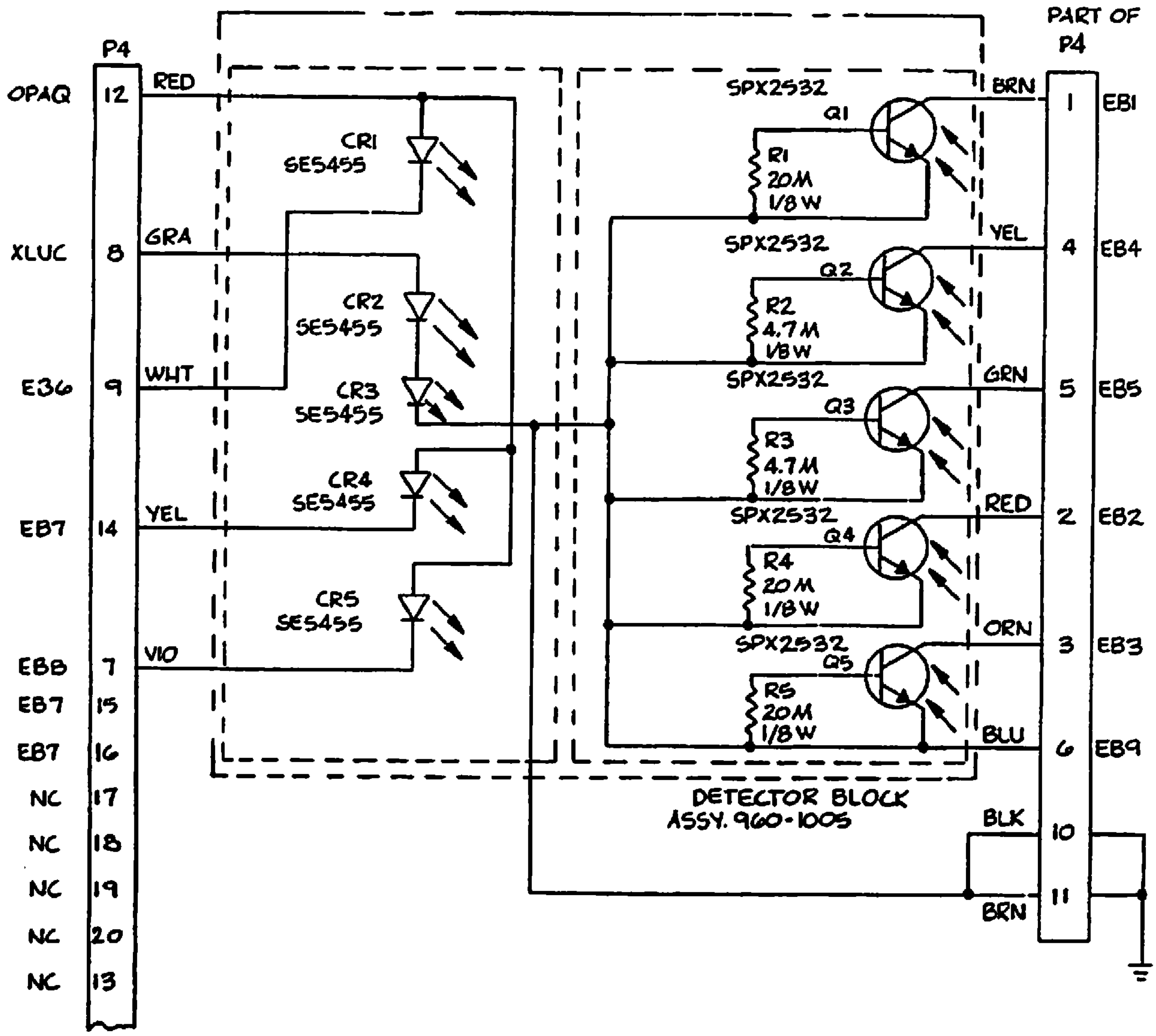

Figure 4-11. 960A AIL Detector (Optical) Schematic

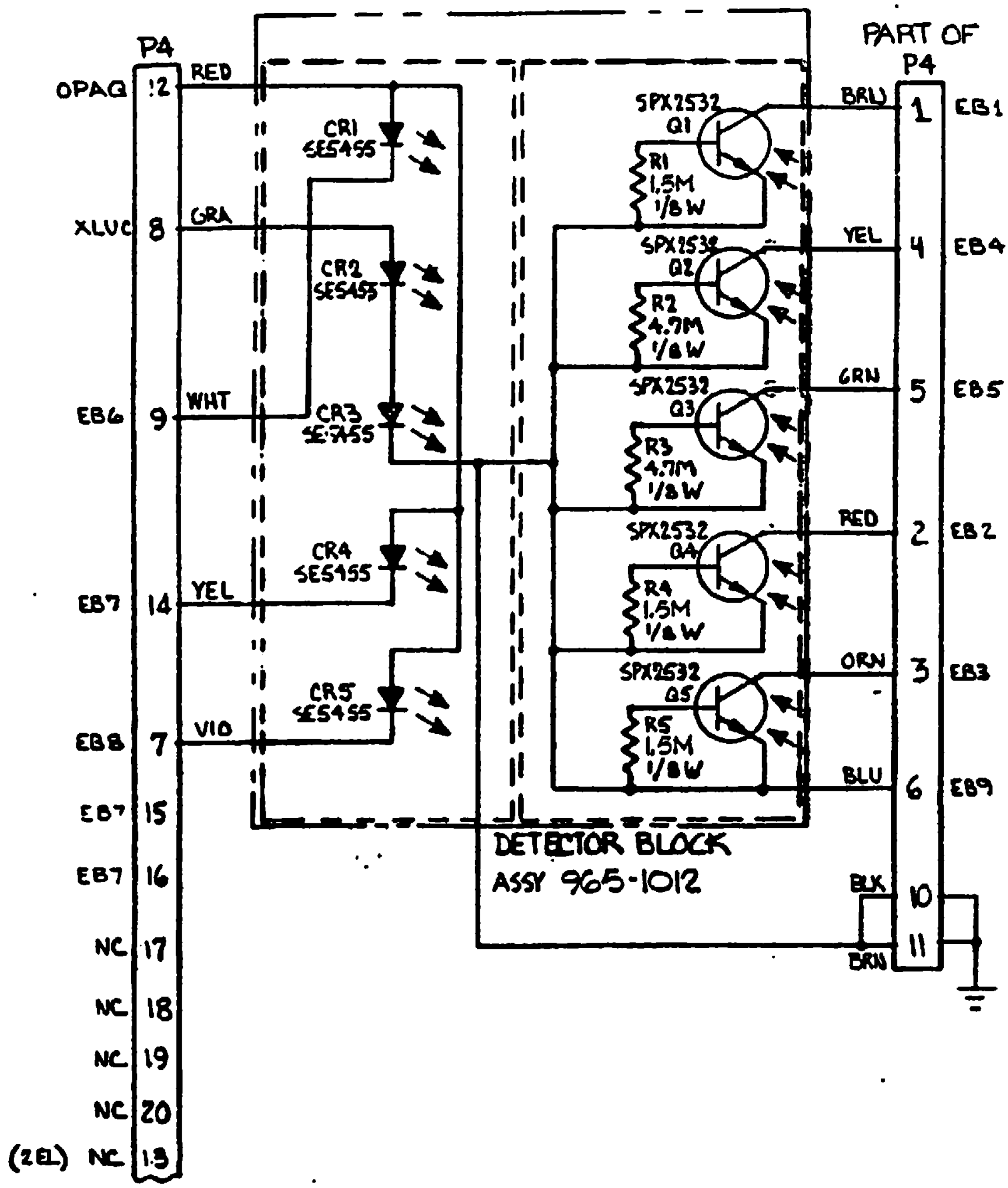

Figure 4-11a. *965A* AIL Detector (Optical) Schematic

SECTION 5 - MAINTENANCE

5.1 INTRODUCTION

This section contains preventive maintenance instructions, maintenance mode operating procedures, troubleshooting routines, disassembly and reassembly procedures and a comprehensive operational performance test for the IMED 960A Volumetric and *965A* Micro Volumetric Infusion Pumps.

WARNING

Potentially lethal voltages are present within the instument case when the instrument is operated using external AC power. When the case is opened for maintenance action, it is recommended the instrument be operated using the internal battery.

CAUTION

Printed circuit boards (PCBs) are easily damaged when integrated circuits are removed and replaced. Excessive heat applied to the circuit board traces and pads can cause delamination of the metal foil and base material. Damage of that type is essentially irreparable; therefore, only low-temperature soldering irons and vacuum solder removal tools should be used when removing and replacing components on PCBs. Leads on integrated circuit components should be cut before attempting unsoldering and removal.

NOTE

CMOS devices are sensitive to static electrical charges and may be damaged during repair if the repair activity is not performed in an ESD protected environment using approved ESD protective procedures.

5.2 PREVENTIVE MAINTENANCE

The 960A/*965A* instruments have been designed and assembled with the goal of minimizing maintenance requirements. The integral microprocessor incorporates a diagnostic routine that monitors several of the instrument's subsystems and operating parameters. Detection of operating system irregularities or failures that affect the instrument's functional operation activates audio and visual Alarms or Malfunction alerts for operator notification. Problems of this nature are recorded in the non-volatile RAM error log for subsequent use by biotechnical personnel in performing troubleshooting and repair actions.

Maintenance-free operation between regularly scheduled preventive maintenance inspections can be enhanced by performing routine cleaning on an as required basis. The recommended interval for preventive maintenance inspections is once every three months. Verification of proper operation is the responsibility of the user. At the user's option, such tests and verification may be performed at the factory at nominal cost. The following paragraphs describe in detail the procedures for performing general maintenance on the 960A/*965A* infusion pumps.

5.2.1 Cleaning Instructions

CAUTION

Always unplug the AC power cord before cleaning. Do not steam-sterilize/autoclave the instrument. Do not immerse the instrument in any solution.

Exterior surfaces of the instrument may be cleaned using any of the following recommended solutions. This list is considered adequate to permit cleanup of all expected contaminates.

Isopropyl alcohol
Warm soapy water
Household Bleach (10% solution, i.e. 1 part household bleach to 9 parts water)

These solutions may be applied using a soft, lint free cloth; a soft bristle brush and/or a cotton swab. Once the contamination has been removed, a cloth soaked with fresh water should be used to rinse the entire instrument removing and diluting all of the residual cleaning solution. Then the entire instrument surface should be completely rinsed using another cloth thoroughly moistened with fresh water. Following the fresh water rinses the instrument must be thoroughly dried with a soft, lint free cloth.

WARNING

Prior to reattaching the AC power cord to the instrument, ensure the male base of the power input module is clean of any electrolyte and thoroughly dry. Check the female contacts on the power cord for contamination; if contaminated, replace the power cord.

5.2.2 Mechanical Inspection

Perform the mechanical inspection described in section 2.2 of this manual.

5.2.3 Electrical Inspection

Perform the standard electrical inspections described in section 2.3.2 of this manual.

5.2.3.1 Battery Voltage Check

Perform the battery voltage check by following the disassembly procedures described in section 5.4 to separate the instrument's front and rear pump assemblies. When the instrument is open connect a multimeter across the battery terminals and measure the voltage. The voltage should read 6 volts +0.6, -0.2 volts. If the AC power cord is connected, the battery charger circuit will be energized and the battery voltage could read as high as 7.2 volts.

5.3 TROUBLESHOOTING

The maintenance concept for the 960A & *965A* instruments is based on isolation of failed or faulty modules, replacement of the defective module and operational testing of the repaired instrument prior to returning it to service. The troubleshooting guide provided is not exhaustive, but covers those problems that have been found to be common to microprocessor controlled devices plus any recurring discrepancies uncovered through failure analysis of in-service instruments. A diagnostic routine is incorporated in the instrument software subsystem that monitors specific parameters and in the event of a failure presents a visual display of the appropriate error code. The corrective actions recommended are listed in a descending order of failure probability. Performing the corrective actions in the sequence described should reduce repair time and expedite returning the instrument to patient care service.

If the test equipment required to troubleshoot and repair a microprocessor based system is not available at your facility, it is recommended the instrument be returned to IMED for repair.

Potential problem areas that are not monitored by the instrument's diagnostic program are listed in Table 5-1. System failures that can be detected by the diagnostic program are listed in Tables 5-2 and 5-3 by Malfunction Alarm Code number.

NOTE

In the event it becomes necessary to return the instrument to IMED Service for repair, complete and forward with the instrument a copy of the Infusion Device Discrepancy Report Form provided in the back of this manual.

Table 5-1. Troubleshooting/Fault Isolation Guide

Test/Fault	Probable Cause	Corrective Action
INITIALIZATION		
LCD Panel not Backlighted	AC Power Cord not connected to an AC power source	Plug AC power cord into a suitable outlet
	Fuse F1 blown	Replace fuse
	Transformer T1 failed	Replace transformer
	Connector P10/J10 or P11/J11 disconnected	Reconnect connector
	Invertor failure	Replace invertor
	Power Supply Board failure	Replace Power Supply Board
ON/STOP Switch No response	ON/STOP switch failure	Replace Front Panel Keypad
	Front Panel Keypad/Display Board interconnect failure	Repair or replace interconnect
	Display Board failure	Replace Display Board
	Main Logic Board failure	Replace Main Logic Board
Audio Failure	Connector P9/J9 disconnected	Reconnect P9/J9
	Battery failure	Replace battery
	Sonalert failure	Replace sonalert
	Display Board failure	Replace Display Board
	Main Logic Board failure	Replace Main Logic Board
	Audio Switch failed closed	Replace Switch

800 513 2254

Table 5-2. Malfunction Alarm Codes (P0.x/1.x)

Code No.	Type of Malfunction	Probable Cause	Recommended Remedy
00	KR bus not low without strobe	Shorted transistor Q5-Q10 on Main Logic Board	Replace Main Logic Board
		Display Board Failure	Replace Display Board
04	Collectors of photo-interrupter detectors low without strobe	Shorted photo-transistor in air-in-line detector	Check condition of J4 and ribbon cable
			Replace angle plate assembly
		Shorted photo-sensor on motor board	Replace air-in-line assembly
05	Forward and Reverse valve stop collectors high without strobe	Open LED in valve motor photo-interrupter	Check condition of J4 and ribbon cable
		Open connection between main logic board and angle plate assembly	Replace angle plate assembly
06	Both shuttle sensors high with strobe	Open LED in shuttle position photo-interrupter.	Replace angle plate assembly
		Open connection between main logic board and angle plate assembly	Test and replace defective photo-interrupter
07	Collector of air-in-line detector low without strobe or high state of P10, P11 or P12 at Z1 (microprocessor)	Shorted photo-interrupter in air-in-line detector.	Check J3 and ribbon cable
		Open LED in air-in-line detector	Test and replace defective photo-interrupter
		Open connection between main logic board and air-in-line detector	Replace angle plate assembly
		Shorted interrupter on motor board	Replace air-in-line detector
08	Open ground connection at air-in-line detector	Broken connection at Main Logic Board	Check condition of J4 and ribbon cable
			Replace air-in-line detector
09	Open LED circuit return or open LED (CR1, CR4 or CR5) in air-in-line detector	Bad connection at main logic board	Check condition of J4 and ribbon cable
		Open LED in air-in-line detector	Replace air-in-line detector

Table 5-2. Malfunction Alarm Codes (P0.x/1.xx)
(continued)

Code No.	Type of Malfunction	Probable Cause	Recommended Remedy
10	PRIME ON/OFF stuck in closed position when power first applied	Front Panel Assembly failure	Replace Front Panel Assembly
11	PRIME ON/OFF stuck in closed position when RATE dial moved from any setting to "0"	Defective Purge switch Dried IV fluid in switch	Remove, clean and/or replace switch
12	Rate in excess of selected rate (overrate)	Defective crystal in master oscillator Monitor oscillator frequency out of limits	Check adjustment of monitor oscillator Replace Main Logic Board
13	Rate substantially less than selected rate (underrate)	Defective crystal in master oscillator Monitor oscillator frequency out of limits	Check adjustment of monitor oscillator Replace Main Logic Board
14	Battery discharged to 5.4 volts or less	Power cord unplugged Power cord defective Battery charger circuit defective Battery defective	Plug power cord in AC receptacle Replace power cord Analyze and repair battery charger circuit Replace battery
15	Main Logic Board receiving bad data from Display Board	Bad Harness Display Board failure	Replace harness Replace Display Board
16	7-segment display failure	Display Board failure	Replace Display Board
17	Logic Board Timing Failure	Main Logic Board failure	Replace Main Logic Board

Table 5-2. Malfunction Alarm Codes *(P4.x)*

Code No.	Type of Malfunction	Probable Cause	Recommended Remedy
00	ROM CRC Error	EPROM Program Corrupted EPROM Defective Power/Display Board failure	Replace EPROM Replace EPROM Replace Power/Display Board
01	Internal RAM Error	Microprocessor Defective Power/Display Board failure	Replace Microprocessor Replace Power/Display Board
02	NOT USED		
03	960/965 Jumper Mismatch	EPROM Program incompatible with jumper configuration Wrong jumper configuration for pump model	Replace EPROM with proper version Change jumper configuration
04	Optical Sensor Circuit Failure	Shorted Phototransistor on Angle Plate Assembly	Replace Angle Plate Assembly
05	Valve Sensor Failure	Forward or Reverse Valve Sensor Phototransistor open on Angle Plate	Replace Angle Plate Assembly
06	Shuttle Sensor or Shuttle Failure	Top or Bottom Shuttle Sensor Phototransistor open on Angle Plate	Replace Angle Plate Assembly
07	Air-in-Line Circuit Failure	Defective Air-in-Line Assembly	Replace Air-in-Line Assembly
08	Air-in-Line Interface Error	Connector from Air-in-Line Detector to J7 on Logic Board not properly seated Defective Air-in-Line cable	Reconnect Air-in-Line cable to Logic Board Replace Air-in-Line assembly
09	LED Fault Detection Circuit Failure	Defective diode or transistor in LED Fault Detection circuit	Replace Power/Display Board
10-11	NOT USED		
12	Watchdog Slow	Watchdog circuit failure Defective System clock crystal	Replace Power/Display Board Replace Power/Display Board
13	Watchdog Fast or Watchdog Failure	Watchdog circuit failure Defective System clock crystal	Replace Power/Display Board Replace Power/Display Board

Table 5-2. Malfunction Alarm Codes (P4.x) (continued)

Code No.	Type of Malfunction	Probable Cause	Recommended Remedy
14	Low Battery 2 Condition	Power cord unplugged	Plug power cord in AC receptacle
		Power cord defective	Replace power cord
		Battery defective	Replace battery
		Battery charger circuit defective	Replace Power/Display Board
15	Internal Error - Invalid Rate, VTBI or Pumpstate	Microprocessor Defective	Replace Power/Display Board
16	LED Fault Detect	Open 7-Segment LED	Replace Power/Display Board
17	NOT USED		
18	Audio Interface Error	Battery Backup Board connector to J5 on Power Board not properly seated	Reconnect Audio Harness connector (J5)
		Audio Harness connector not connected to Battery Backup Board	Reconnect Audio Harness connector
		NiCad battery on Battery Backup Board not charged or defective	Allow NiCad battery to charge for >1 hour
			Replace Battery Backup Board
19	8255 Peripheral Interface Error	Non-programmed Port Status change	Replace Power/Display Board
20	Valve Timeout	Valve Motor Defective	Replace Angle Plate Assembly
		Motor Drive Circuitry failure	Replace Angle Plate Assembly

5.4 DISASSEMBLY

The following procedures are presented in a sequence that provides the most efficient means of accessing and removing the subassemblies that make up the 960A and *965A* Infusion Pumps. ***Procedures printed in Times Roman are applicable to instruments designated (PIP/P4.x) configured with software release 4.x and subsequent.***

CAUTION

Before attempting to disassemble the 960A/*965A*, unplug the AC power cord from the wall outlet, remove the power cord retention bracket and disconnect the cord from the rear pump assembly. Check that the instrument is in the power off condition. See the WARNING under re-assembly paragraph 5.5 Before reattaching the ac power cord to the instrument.

NOTE

It is recommended that all maintenance actions be performed on an anti-static surface, preferably a grounded anti-static mat.

5.4.1 Separating the Case (Figure 6-1)

Before disassembling the instrument, use a #1 Phillips screwdriver to remove the 2 screws that fasten the AC Power Cord connector to the rear case and unplug the power cord from the instrument. Prior to removing the screws which mate the front and rear case assemblies, it is helpful to stabilize the rear case. Insert a 7 inch long piece of 1 to 1 1/4 inch round stock (dowel or PVC pipe) in the pole clamp so the bottom of the stock rests on the working surface. Tighten the pole clamp. This brace will reduce the tendency of the rear case to falling over once the front case is detached.

1. Use a #2 Phillips screwdriver to remove the 6 screws that connect the front and rear pump assemblies. (Do not leave screws on work surface. The front panel could be damaged if laid face down on the screws).
2. Carefully separate the front and rear pump assemblies. Use a #2 Phillips screwdriver to disconnect the 1 clear and 2 green ground harness cables from the rear pump assembly's chassis.
3. Disconnect connectors P5 and P7 from the Main Logic Board.
4. Disconnect the two wire molex connector between the Power Supply Board and the Invertor.
5. Use a 1/4" nut driver to loosen and remove the standoff that anchors the outside corner of the Main Logic Board.
6. Depress the tangs on the 2 nylon standoffs and carefully lift the Main Logic Board sufficiently to allow unplugging P9 from the back of the Display Board.

The front and rear pump assemblies are now separated and further disassembled can be performed independently.

5.4.2 Front Pump Assembly Disassembly (Figure 6-2)

The following disassembly procedures are promulgated based on a requirement to completely disassemble the front pump assembly. Several front pump sub-assemblies are not directly accessible and require sequential disassembly for access. Those assemblies are identified with a note addressing the prerequisite procedure.

5.4.2.1 Main Logic Board Removal (Software Release 0.x/1.x only)

1. Unplug the ribbon cable connectors from J1, J2, J3, J4 and J6.
2. Ensure the tangs on the nylon standoffs are released, then lift the Main Logic Board out of the front case.

5.4.2.2 Front Panel Assembly Removal (Software Release 0.x/1.x only)

1. Requires removal of the Main Logic Board (see 5.5.2.1).
2. Unplug the Hall Effect harness from connector J5 (white) on the back of the front panel PCB.

3. Disconnect the 2 wire Molex connector between the invertor and the front panel PCB.

4. Use a 1/4" nut driver to loosen and remove the 4 KEP nuts that attach the front panel assembly to the front case.

5. Remove the front panel assembly from the front of the front case.

5.4.2.1 Power and Display Board Removal (PIP/P4.x & subsequent)

1. Unplug the door sensor harness from connector J8 on the power supply board.

2. Unplug the LCD backlight harness from connector J11 on the power supply board.

3. Unplug the Audio harness cable from connector J5 on the power supply board.

4. Unplug the AIL detector cable from connector J7 on the power supply board.

5. Unplug the Angle Plate cable from connector J6 on the power supply board.

6. Unplug the Battery/AC power harness from connector J12 on the power supply board.

7. Use a #1 Phillips screwdriver to remove the 4 screws that attach the power supply board to the standoffs between the power and display boards.

8. Use a 3/16" nut driver to remove the standoffs that attach the display board to the front case.

9. Lift the power/display board assembly out of the front case.

5.4.2.2 Keypad Assembly Removal (PIP/4.x & subsequent)

1. Use a #2 Phillips screwdriver to disconnect the ground wire from the chassis.

2. Use a 1/4" nut driver to remove the 4 nuts that attach the keypad assembly to the front case.

3. Remove the keypad assembly from the exterior side of the front case.

5.4.2.3 Angle Plate Assembly Removal

NOTE

If removal of the Main Logic Board is not required, unplug the angle plate ribbon cable from J3 on the Main Logic Board.

1. Open the door and use a 3/16" blade screwdriver to remove the 4 screws that attach the shuttle boot retainer to the front case.

2 Remove the retainer and shuttle boot.

3. Use a 1/4" nut driver to loosen and remove the standoff and lock washer that anchor the upper right corner of the angle plate assembly to the front case.

4. Use a #2 Phillips screwdriver to remove the 3 screws and lock washer that attach the remaining corners of the angle plate assembly to the front case.

5. Lift the angle plate assembly out of the front case.

5.4.2.4 Door Assembly Removal

1. Use a #1 Phillips screwdriver to remove the 4 screws that attach the door hinge to the front case.

2. Remove the door assembly from the front case.

5.4.2.5 Cassette Nest Removal

1. Requires removal of the Angle Plate Assembly (see 5.5.2.2).

2. Use a #2 Phillips screwdriver to remove the 4 thread cutting screws that attach the cassette nest to the front case.

3. Remove the cassette nest from the front case.

5.4.2.6 Air In Line Detector Removal

1. Requires removal of the Angle Plate Assembly (see 5.5.2.2).

2. Use a #2 Phillips screwdriver to remove the 2 screws and lock washers that attach the AIL detector to the front case.

3. Use a knife to separate the RTV that bonds the AIL detector block to the front case.

4. Thread the AIL detector ribbon cable through the U-shaped slot in the front case and remove the AIL detector harness.

5.4.2.7 Inverter Removal

1. The invertor is attached to the front case with double adhesive foam.

2. Use finger pressure to break the adhesion and remove the invertor.

5.4.2.8 Hall Effect Sensor Harness Removal

1. Requires removal of the Angle Plate Assembly (see 5.5.2.2).

2. The Hall Effect sensor and harness is held in place with RTV and masking tape.

3. Remove the tape, pry the sensor and harness loose from the front case and remove.

5.4.3 Disassembly of the Angle Plate Assembly

When the Angel Plate Assembly has been removed from the front case, the valve shaft drive motor and shuttle drive motor can each be replaced without having to disassemble the angle plate assembly.

5.4.3.1 Valve Shaft Drive Motor Removal

1. Unsolder the valve motor wires from the angle plate circuit card assembly (red lead from E9 and white from E10).

2. Use a 1/16" Allen wrench and loosen the 2 set screws that fasten the valve shaft to the valve motor drive shaft.

3. Use a #2 Phillips screwdriver to remove the 2 screws and lock washers that attach the valve motor to the angle plate.

4. Lift the valve motor off of the angle plate circuit card assembly withdrawing the drive shaft from the valve shaft.

5.4.3.2 Shuttle Drive Motor Removal

1. Identify then unsolder the shuttle drive motor wires from the angle plate circuit card assembly (yellow leads from E3 & E4, grey leads from E1 & E2, red leads from E5 & E8 and black leads From E6 & E7).

2. Remove the spring clip that retains the drive pin through the shuttle lead screw and encoder hub.

3. Remove the drive pin.

4. Rotate the encoder disc until the shuttle lead screw is clear of the motor drive shaft.

5. Use a 1/16" Allen wrench to loosen the 3 set screws that secure the encoder hub to the shuttle drive motor shaft.

6. Lift the encoder hub and thrust bearing assembly off the drive shaft.

7. Use a 5/64" Allen wrench to loosen and remove the 4 socket head screws and washers that attach the shuttle drive motor to the angle plate.

8. Separate the motor from the angle plate.

5.4.3.3 Angle Plate Circuit Card Removal

1. Perform the procedure in 5.5.3.1 to remove the valve shaft drive motor.

2. Perform the procedure in 5.5.3.2 step 1 to disconnect the shuttle motor harness from the angle plate circuit card.

3. Use a #2 Phillips screwdriver to remove the 4 screws and lock washers that attach the angle plate circuit card to the angle plate.

4. Separate the angle plate and angle plate circuit card.

5.4.3.4 Shuttle Assembly Removal

1. Perform the procedure described in 5.5.3.3 to separate the angle plate circuit card from the angle plate.
2. Use a #2 Phillips screwdriver to remove the 2 screws and lock washers that attach the shuttle slide to the angle plate.
3. Lift the shuttle assembly clear of the angle plate.

5.4.4 Front Panel Assembly Disassembly

1. Use a #1 Phillips screwdriver to remove the 4 screws and lock washers that attach the front panel to the front panel circuit card.
2. Separate the front panel from the front panel circuit card. Exercise care so as not to damage the P4/J4 connection.
3. Remove the 3 ribbon cable assemblies connected to J1, J2 and J6, as necessary.

5.4.5 Rear Pump Assembly Disassembly

To facilitate working on components within the rear pump assembly the preferred procedure is to detach the chassis assembly from the rear case. Sufficient service-loop is available in the wiring harnesses to permit working on components mounted in the rear case or on the chassis assembly without having to disconnect the harnesses.

5.4.5.1 Chassis Assembly Removal

1. Use a #2 Phillips screwdriver to remove the AC power input module ground wire from the chassis.
2. Use a #2 Phillips screwdriver to remove the 6 screws and lock washers that attach the chassis to the rear case.
3. Unplug the Black lead from the AC power input module.
4. Disconnect the in-line connector on the white lead between the AC power input module and transformer.
5. The rear case and chassis assemblies are now mechanically separate and can be laid out on the work surface.

5.4.5.2 Pole Clamp Assembly Removal

1. Requires removal of the chassis assembly (see 5.4.5.1).

NOTE

The Top Plate, Wedge and Shaft assembly can be removed and replaced without removing the chassis assembly.

2. Use a #3 Phillips screwdriver to remove the 4 screws and lock washers that attach the pole clamp assembly to the rear case.
3. Separate the Top Plate plus Wedge and Shaft assembly from the Frame.
4. From the interior of the rear case press the frame out of the rear case recess.

5.4.5.3 AC Power Entry Module Removal

1. Requires removal of the chassis assembly (see 5.4.5.1).
2. From the interior side of the rear case apply thumb pressure to the inboard edge of the AC power entry module forcing that edge clear of the rear case.
3. Grasp the AC power entry module from the exterior side of the case and pivot it around the remaining point of attachment until it is released.

5.4.5.4 Sonalert Removal

1. Use fingers to unscrew the plastic retaining ring from the exterior side of the sonalert.
2. From the exterior side use thumb pressure to release the adhesive seal on the sonalert and extract the sonalert from the mounting hole.
3. Tag, then use a 1/4" screwdriver to remove the two wires from the sonalert terminals.

5.4.5.5 Audio Silence Switch Removal

1. Tag and unsolder the 2 wires from the common and NO terminals on the back of the switch.
2. Use thumb pressure and a rocking motion to dislodge the plastic seal and push the switch assembly out of the mounting hole.

NOTE

On reassembly a new plastic seal will have to be installed.

5.4.5.6 Nurse Call Receptacle Removal

1. Tag and unsolder the 3 wires from the terminals on the receptacle.
2. Use a 3/8" nut driver to remove the nut that attaches the Nurse Call receptacle to the rear case.
3. Extract the Nurse Call receptacle from the interior side of the rear case.

5.4.5.7 Line Cord Clip Removal

1. Use a #2 Phillips screwdriver to remove the 2 screws that attach the clip to the rear case.

5.4.6 Chassis Assembly Disassembly

5.4.6.1 Battery Removal

1. Requires removal of the chassis assembly (see 5.4.5.1).
2. Use a pair of diagonal pliers to cut the wire tie that holds the battery to the chassis.
3. Tag, then pull the battery harness connectors from the battery terminals.

5.4.6.2 Power Supply Board Removal

1. Disconnect the 4 wire in-line connector P8/J8 between the power supply board and the transformer/battery.
2. Use a 1/4" nut driver to remove the nuts, lock washers and flat washers that attach the components Q2 & Z2 to the chassis.
3. Use a #1 Phillips screwdriver to remove the 2 screws and lock washers that attach the power supply board to the chassis.
4. Lift the power supply board clear of the chassis.

NOTE

When reassembling the power supply board to the chassis, the thermal insulating pad between components Q2 & Z2 and the chassis must be replaced.

5.4.6.2 Battery Backup Board Removal (PIP/ Software Release V4.x & Subsequent)

1. *Unplug the sonalert/AC power cable from connector J2 on the battery backup board.*
2. *Use a #1 Phillips screwdriver to remove the 2 screws that attach the battery backup board to the chassis assembly.*
3. *Lift the battery backup board from the chassis assembly.*

5.4.6.3 Transformer Removal

1. Use a 3/32" pin pusher to remove the red and black transformer wires from the J9 connector.
2. Use a 3/32" drill to drill out and remove the pop rivets that attach the transformer to the chassis.
3. Separate the transformer from the chassis.

CAUTION

The recommended procedure for installing a replacement transformer is to attach the transformer to the chassis using a #8-32 x 7/16" PAN HD screw with a #8 flat washer on the chassis side and a #8 flat washer with a #8 x 32 KEP nut on the transformer side.

5.5 REASSEMBLY

The procedures for reassembly of the 960A/*965A* are the reverse of the preceding disassembly procedures. In those cases where a procedure(s) unique to reassembly is required, a note is provided following the last step in the disassembly procedure.

WARNING

Prior to reattaching the AC power cord to the instrument, ensure the male base of the power input module is clean of any electrolyte and thoroughly dry. Check the female contacts on the power cord connector for presence of any electrolyte; clean as required and thoroughly dry. When removal of washers is specified during disassembly, ensure that all washers are reinstalled during reassembly.

Ensure that all ground wire connections are complete before re-mating the front and rear case.

During reassembly tighten all screws in accordance with the torque values set forth in Table 5-4.

Table 5-4. Table of Torque Values

Functional Application	Item Description	Figure/Item Reference	Torque Value
FINAL ASSEMBLY			
Front Case to Rear Case	#8-32 x 2 5/16	6-1/190	Hand Tight
	#8-32 x 1/2	6-1/200	Hand Tight
Power Cord Retention	#4-40 Standoff	6-1/180	7 in-lbs
	#4-40 x 3/8	6-1/210	Hand Tight
FRONT PUMP ASSEMBLY			
Door Hinge to Front Case	#2-56 x 3/16	6-2/500	5 in-lb
Boot Retainer to Front Case	#4-40 x 3/8(N)	6-2/460	Hand Tight
Strike to Front Case	#6-32 x 5/8(N)	6-2/470	Hand Tight
Cassette Nest to Front Case	8-32 x 3/8	6-2/450	Hand Tight
AIL Detector to Front Case	#6-32 x 3/8	6-2/490	Hand Tight
Front Panel to Front Case	#4 KEP Nut	6-2/550	Hand Tight
Keypad Assy to Front Case	*#4 KEP Nut*	*6-2/550*	*Hand Tight*
Display Board to Front Case	*#4-40 Standoff*		*Hand Tight*
Power Board to Standoff	*#4-40 x 1/4*		*Hand Tight*
Nylon standoff to Front Case Boss	#8-32 Standoff	6-2/300	Hand Tight
Main Logic Board to Front Case	#8-32 Standoff	6-2/290	Hand Tight
Angle Plate Assy to Front Case	#8-32 x 1/2	6-2/440	14 in-lbs
	#8-32 Standoff	6-2/280	14 in-lbs
ANGLE PLATE ASSEMBLY			
Angle Plate PCB to Angle Plate	6-32 x 3/8	6-3/210/360	5 in-lbs
Valve Shaft to Valve Motor	#6-32 x 1/8(S)	6-3/230/400	3.2 in-lbs
Shuttle Slide to Angle Plate	#6-32 x 3/8	6-3/210/360	5 in-lbs
Ground Wire to Angle Plate	#6-32 x 1/4	6-3/260/390	5 in-lbs
Encoder Hub to Shuttle Drive Motor	#6-32 x 1/8	6-3/230/400	3.2 in-lbs
Shuttle Drive Motor to Angle Plate	#6-32 x 1/2	6-3/290/370	9 in-lbs
DOOR ASSEMBLY			
Door Hinge to Hinge Plate	#2-56 x 1/4	6-5/190/130	2 in-lbs
Door Latch to Door	#6-32 x 1/2	6-5/200	Hand Tight
	#6-32 x 1/4	6-5/120	Hand Tight
SHUTTLE ASSEMBLY			
Shuttle Back to Shuttle Body	#4-40 x 1/2	6-6/16/90	5 in-lbs
FRONT PANEL ASSEMBLY (HT)			
Circuit Card to Keyboard & Display	#4-40 x 3/8	6-8/90/90	T.B.D
REAR CASE			
Power Cord Clip to Rear Case	#8-32 x 3/8	6-10/490	Hand Tight
Nurse Call Receptacle Nut	3/8-32	6-10/630	Hand Tight
Sonalert Retention Collar	- - -	6-10/320	Hand Tight
Pole Clamp to Rear Case	1/4-20 x 3/4	6-10/470	14 in-lbs
	1/4-20 x 1 1/4	6-10/480	14 in-lbs
Pole Clamp Knob to Shaft	#10-32 x 5/8(S)	6-10/410	14 in-lbs
Battery Backup Board to Chassis	*#4-40 x*		
Power Supply Board to Chassis	#4-40 x 3/8	6-10/500	5 in-lbs
PSB Q2 & Z2 to Chassis	#4 KEP Nut	6-10/620	3 in-lbs
Chassis to Rear Case	#10-32 x 1	6-10/460	14 in-lbs
	#8-32 x 3/8	6-10/490	14 in-lbs
Ground Wires to Chassis	#6-32 x 1/4	Various	

(N) = Nylon, (S) = Set Screw

5.6 COMPREHENSIVE OPERATIONAL PERFORMANCE TEST

A comprehensive operational performance test should be conducted on any 960A or *965A* that has been removed from service for repair or has been subjected to servicing that required the case to be opened. In the event an instrument should fail to meet specified performance test criteria, it will be necessary to troubleshoot specific areas of deficiency and perform the repairs needed to restore full operational capability prior to returning the instrument to service.

5.6.1 Electrical Inspection

The electrical inspection consists of the Electrical Leakage Test, Electrical Ground Test and a Dielectric Test. Perform these tests in compliance with UL 544 for Patient Care Equipment and/or CSA Standard C22.2 No. 125 for Risk Class 2 Equipment. Test parameters are described in Section 2.3.2.

5.6.2 Qualitative Operational Performance Test

The abbreviated qualitative operational performance test will check the 960A/*965A* keypad, audio silence, displays and indicators; instrument operation plus the audio and visual alarms. Perform the abbreviated qualitative operational performance test in accordance with the procedures described in Section 2.3.3.2.

5.6.3 Quantitative Operational Performance Test

The following operational performance tests are designed to ensure the 960A/*965A* is functioning in accordance with design specifications. Test procedures are provided to evaluate specific areas of instrument performance. The following test procedures are presented in a sequence that will allow the required test protocols to be accomplished accurately and in an expeditious and efficient manner. Record test results of each test on the Test Data Sheet (see Figure 5-4).

5.6.3.1 Equipment Requirements

1. Universal test station, including: (see Figure 5-1)
   - Selector valve manifold
   - 50 mL Volumetric burette
   - Pressure gauge, 0-30 psig (0-1500 mm Hg) accurate within 2.0% or better
   - Vacuum gauge, 0-30 inches (0-760 mm) of Hg.
2. Clear and Opaque fluid simulators
3. Stopwatch with minimum resolution of 1 sec.
4. Vented bottle or bag of Normal Saline
5. ACCUSET administration set
6. Waste fluid catch basin
7. Nurse Call test lamp
8. Test Data Sheet (see Figure 5-4)

5.6.3.2 Test Setup

1. Plug the Nurse Call Test Light into the Nurse Call receptacle.
2. Spike a vented bottle or bag of Normal Saline or tap water with an IMED ACCUSET Non-vented Administration set and hang it on the IV solution test stand. Ensure the roller clamp is closed.
3. Connect the distal end of the tubing set to the input side of the stopcock manifold on the Universal Test Station (see Figure 5-1).
4. Set the stopcocks to allow fluid to pass through the manifold to the fluid catch basin.
5. Install the cassette in the cassette nest, press the plunger onto the shuttle arm and press the tubing into the Air in Line detector block.
6. Open the roller clamp and flood the drip chamber.
7. Adjust the height of the solution container to provide a recommended head height of 24" (61cm) i.e. 24" of vertical displacement between the fluid level in the container and the top of the cassette piston.

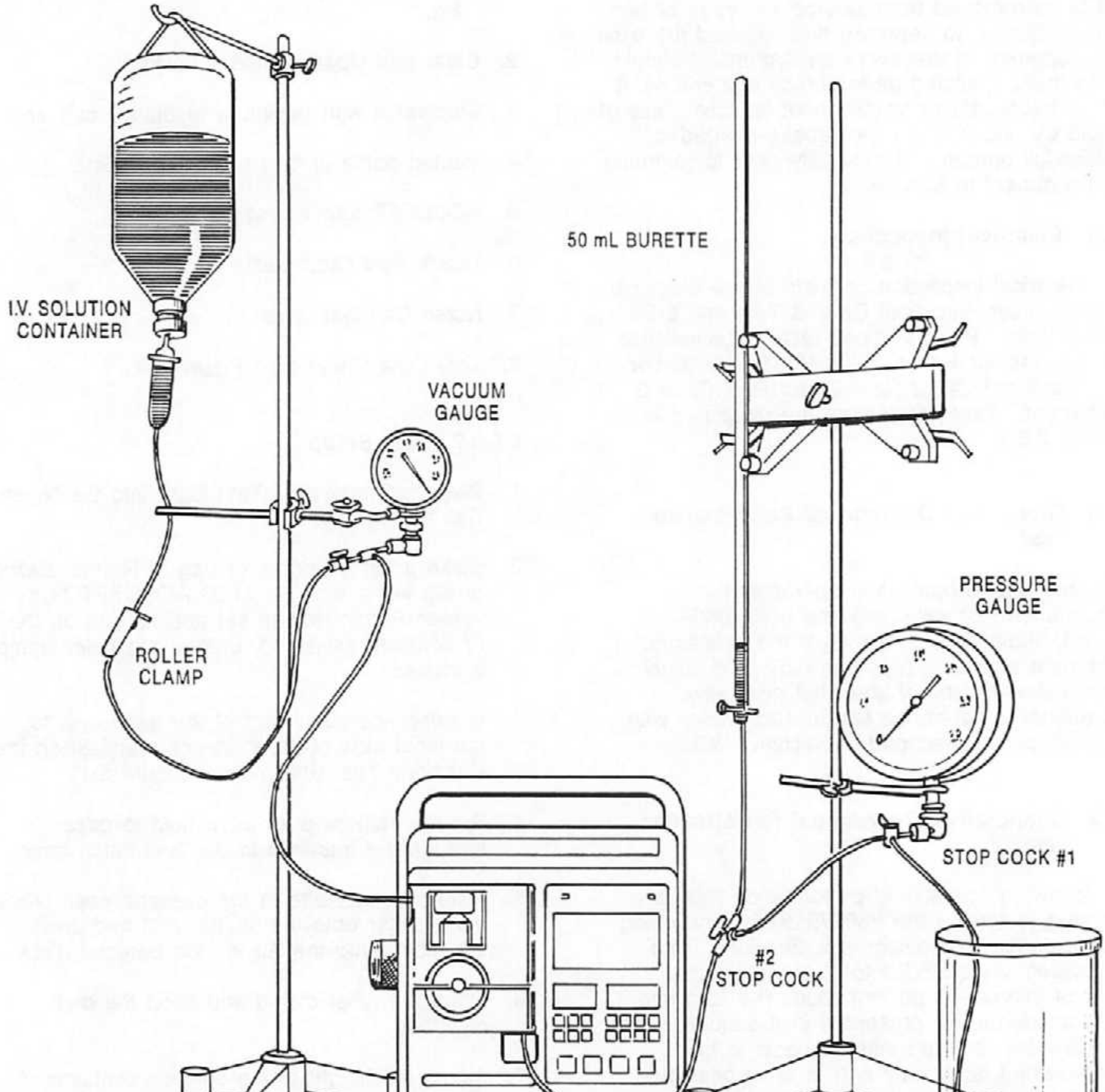

Figure 5-1. Universal Test Station Setup

8. Press ON/STOP, set Rate to 000/*00.0*, then press the PRIME ON/OFF control. When all the air has been expelled from the tubing down to the stopcock manifold, turn valve #2 and fill the burette to the 50 mL line.

9. Close Stopcock #2 and open #1 to prime the tubing to the pressure gauge.

10. Press ON/STOP and shut off the instrument.

11. Set the #1 and #2 stopcocks so that instrument output will be discharged into a waste fluid container.

5.6.3.3 Rate/Volume Inhibit Test Procedure

1. Press ON/STOP, set Rate to 000/*00.0*, set Volume To Be Infused to 0000/*000.0*.

2. Press VOL INF RESET. Verify LCD VOLUME INFUSED reads "0".

3. Press START and check:
   - RATE 000 message in LCD flashes and all other messages in LCD extinguish. After several seconds, LCD returns to previous state.

4. Set Rate to 125/*50* mL/hr, then press START and check:
   - "SET VOLUME" message in LCD flashes and all other messages in LCD extinguish. After several seconds, LCD returns to previous state.

5.6.3.4 Prime Inhibit Test Procedure

1. Press PRIME ON/OFF and check:
   - Auto Prime cycle does not function.

5.6.3.5 Volume Infused Reset Inhibit Test Procedure

1. Set Volume To Be Infused to 25/*10* mL/hr.

2. Press and hold VOL INF RESET control and check:
   - "SET 0000 VOLUME" message in LCD panel flashes for 2 seconds and all other messages extinguish. After several seconds LCD returns to previous state.

5.6.3.6 Normal Operation Test Procedure

1. Press START and check:
   - OPERATING indicator flashes
   - Pumping mechanism operates
   - Operating/Rate graphics sequence
   - "NOT OPERATING" message extinguishes
   - Volume Infused value increments.

5.6.3.7 Walk-Away Alarm Test Procedure

1. Enter a new Rate of 250/*100* mL/hr or change VTBI then wait approximately 10 seconds and check:
   - Audio alarm sounds
   - "PRESS" indicator flashes
   - Rate and/or VTBI display(s) flashes
   - Pumping continues at previously set parameters.

2. Press START and check:
   - Pumping mechanism changes to new Rate and/or VTBI
   - Audio Alarm silences
   - "PRESS" indicator extinguishes
   - Rate and/or VTBI display stops flashing and reverts to a steady presentation of the new parameter(s).

5.6.3.8 Door Alarm Test Procedure

1. Prior to the instrument reaching INFUSION COMPLETE status, open the door and check:
   - ALARM indicator flashes
   - OPERATING indicator extinguishes
   - Audio Alarm sounds
   - "DOOR OPEN" message flashes, and "NOT OPERATING" message displays steadily
   - Operating/Rate graphics extinguish
   - Nurse Call test light illuminates
   - Pumping mechanism stops.

2. Close the door, press START and check:
   - ALARM indicator extinguishes
   - OPERATING indicator flashes
   - Audio Alarm silences
   - "DOOR OPEN" and "NOT OPERATING" messages extinguish.
   - Operating/Rate graphics sequence
   - Nurse Call test light extinguishes
   - Pumping mechanism operates.

5.6.3.9 **Power Off Memory Test Procedure**

1. Make note of the current values for Rate, VTBI and Volume Infused, then press ON/STOP to turn the instrument off.
2. Wait 3 seconds then press ON/STOP to turn the instrument on and check the Rate, VTBI and Volume Infused values.
   - All values should remain the same.

5.6.3.10 **Purge Pressure Test Procedure**

1. Turn the #1 stopcock to direct the administration set output to the pressure gauge.
2. Set the Rate to 000/*00.0*, press PRIME and check:
   - ALARM indicator flashes
   - Audio Alarm sounds
   - "OCCLUSION" message flashes on the LCD panel.
   - Nurse Call test light illuminates
   - Pumping Mechanism stops.
3. Record the pressure reading on the Test Data Sheet (see Figure 5-4).
4. Press ON/STOP to turn off the instrument.
5. Turn stopcock #1 to relieve the pressure on the gauge, then reset to the pressure gauge position.

5.6.3.11 **Operate (up stroke) Pressure Test Procedure**

1. Press ON/STOP, set the Rate to 200/80.0 mL/hr and ensure the VTBI is at least 5 mL greater than the Volume Infused.
2. Press START and check:
   - ALARM indicator flashes
   - OPERATING indicator extinguishes
   - Operating/Rate graphics extinguish
   - "OCCLUSION" message flashes and "NOT OPERATING" displays steadily on the LCD panel
   - Audio Alarm sounds
   - Nurse Call test light illuminates
   - Pumping mechanism stops.
3. Record the pressure reading on the Test Data Sheet. Minimum pressure reading should be 16/*10* psig and the maximum should be 25/*25* psig.
4. Press ON/STOP to turn off the instrument.
5. Turn stopcock #1 to relieve the pressure on the gauge, then reset to the bypass position.

5.6.3.12 **Volume-Rate Test Procedure**

1. Turn stopcock #2 to direct instrument output to the 50 mL burette.
2. Press ON/STOP to turn the instrument on, use the prime feature or stopcock #2 to adjust the fluid level in the burette to the 50 mL line.
3. Set the VTBI to 0000/*000.0*. Press VOL INF RESET to "0" the Volume Infused.
4. Set the Rate to 144/*99.9* mL/hr and the VTBI to 10/*9.0* mL.
5. Press START and start the stopwatch simultaneously.
6. When the "INFUSION COMPLETE" alarms sounds, press ON/STOP and stop the stopwatch immediately.
7. Read the volume delivered on the burette and note the elapsed time on the stopwatch and record both on the Test Data Sheet. Volume delivered should be between 9.8 and 10.2/*8.8* and *9.2* mL and the elapse time should be between 4:05 and 4:15/*5:17.8* and *5:30.8* (min:sec).

5.6.3.13 **Downstroke Occlusion Pressure Test Procedure**

1. Close the roller clamp and disconnect the set from the input side of the cassette.
2. Connect the vacuum gauge to the input side of the cassette.
3. Press ON/STOP to turn on the instrument.
4. Set Rate to 900/*99.0* mL/hr, then press START and check:
   - ALARM indicator flashes
   - OPERATING indicator extinguishes

- OPERATING indicator extinguishes
- Operating/Rate graphics extinguish
- "OCCLUSION" message flashes and "NOT OPERATING" displays steadily on the LCD panel
- Audio Alarm sounds
- Nurse Call test light illuminates
- Pumping mechanism stops.

5. Record vacuum reading on the Test Data Sheet. Minimum reading should be 15" (381 mm) of Hg and maximum reading should be 22.4" (567 mm) of Hg.

NOTES

The following sections provide an alternative method for checking occlusion pressures. IMED instrument manufacturing has implemented the procedure of adjusting and testing upstroke occlusion pressure on 96X type cassette pumps against a constant backpressure. This procedure allows verification of a pressure setting across the full range of shuttle travel versus having the instrument occlude upon sensing the occlusion pressure at a single point within the stroke.

The following pressure test procedures relate to the Pressure Test and Adjustment Setup shown in Figure 5-4.

5.6.3.14 Operate (up stroke) Pressure Test Procedure (Alternate)

1. Press ON/OFF twice to turn instrument Off then On and reset plunger to bottom of stroke.
2. Install test station cassette.
3. Set Rate to 200 and ensure VTBI is 5 mL greater than Volume Infused reading.
4. Open the pressure regulator, set pressure to 16.0 psi (827 mm Hg) and turn stopcock to apply pressure to the cassette.
5. Press START and check:
   - The shuttle completes a delivery stroke without occluding.
6. Press ON/OFF to turn instrument off when the valve motor rotates.

NOTE

Failure to turn the instrument off at valve motor actuation may cause a false occlusion when the down stroke begins with pressure on the cassette.

7. Turn the stopcock to relieve the pressure in the cassette.
8. Reset the test station pressure valve to 25.0 psi (1292 mm Hg).
9. Press ON/OFF to turn instrument on and reset shuttle to the bottom of the stroke.
10. Turn the stopcock to apply pressure to the cassette.
11. Press START and confirm the following occur during the first upstroke:
    - ALARM indicator flashes
    - OPERATING indicator extinguishes
    - Audio Alarm sounds
    - "OCCLUSION" message flashes, and "NOT OPERATING" message displays steadily
    - Operating/Rate graphics extinguish
    - Nurse Call test light illuminates (P0.6 ONLY)
    - Pumping mechanism stops.
12. Record the results on the Test Data Sheet.
13. Press ON/OFF to turn the instrument off.
14. Close the test station pressure regulator.
15. Turn the stopcock to relieve cassette pressure prior to removing the cassette from the instrument.

5.6.3.15 AIL Detector Test Procedure

1. Place small test magnet over cassette nest door interlock to disable "DOOR OPEN" alarm indicator.
2. Turn pump on and press START control.

OPTICAL SENSOR

1. Slide clear fluid simulator down to expose first sensor to air. No alarm should be activated.
2. Expose first and second sensor to air. No alarm should be activated.

3. Expose first, second and third sensor to air. The following should occur:
   - "AIR IN LINE" message in LCD flashes
   - "NOT OPERATING" message appears in LCD
   - "NOT CHARGING" message appears in LCD
   - Red ALARM indicator flashes
   - Pump stops.
   - Intermittent audio alarm sounds.
   - Nurse call test lamp illuminates (Software 0.x/1.x configured instruments only)
4. Position clear fluid simulator so that all sensors are exposed to the fluid.
5. Press START and verify that audio alarm stops and nurse call lamp, if appropriate, extinguishes.
6. Slide simulator upwards to expose bottom three sensors to air. No alarm should be activated.
7. Slide simulator upwards to expose bottom four sensors to air. Step 3 alarm conditions should occur.
8. Replace clear fluid simulator with opaque simulator. Position opaque simulator so that all sensors are exposed to opaque fluid.
9. Press START control.
10. Slide opaque simulator down to expose upper three sensors to air. No alarm should be activated.
11. Slide simulator down to expose top four sensors to air. Step 3 alarm conditions should occur.
12. Reposition opaque simulator so that all sensors are exposed to opaque fluid.
13. Press START control.
14. Slide simulator upwards to expose bottom sensor to air. No alarm should be activated.
15. Slide simulator upwards to expose bottom two sensors to air. Step 3 alarm conditions should occur.
16. Record results on test data sheet

ULTRASONIC DETECTOR

1. Ensure AIL detector block is clear.
2. Set RATE to 25 mL/hr and verify VTBI is >1 mL.
3. Press START control and confirm conditions described in Optical Sensor step 3 occur.
4. Insert open-ended fluid simulator into the AIL detector and set fluid lever above the top of the detector block.
5. Press START control and confirm normal operation.
6. After the shuttle begins an upstroke, lower the fluid level to expose the AIL detector to air.
7. Use a stop watch to verify the following occur within 6 (+2, -1) seconds after the AIL detector is exposed to air:
   - "AIR IN LINE" message in LCD flashes
   - "NOT OPERATING" message appears in LCD
   - "NOT CHARGING" message appears in LCD
   - Red ALARM indicator flashes
   - Pump stops.
   - Intermittent audio alarm sounds.
8. Record results on data sheet, Test No. 12.

5.7 ADJUSTMENT AND CALIBRATION PROCEDURES

The following procedures describe in detail the steps necessary to calibrate or correct discrepancies discovered during instrument operational perform tests.

5.7.1 Equipment Requirements

1. Adjustable, regulated DC power supply, 0-10 volts, 500mA

5.7.2 Battery Alarm Check

1. Verify the instrument power is off.
2. Unplug the power cord from the AC outlet.
3. Separate the front and rear pump assemblies (refer to section 5.4.1 through step #2, but do NOT disconnect the ground wires).
4. Unplug connector P8/J8.
5. Connect the positive (+) lead of an adjustable, regulated DC power supply to pin #1 of P8 and the negative (-) lead to pin #2.

6. Connect a Digital Volt Meter (DVM) to the output of the regulated power supply.

7. Turn on the regulated power supply and adjust the output to 6.0 volts as indicated on the DVM.

8. Press ON/STOP, set the Rate to 000/*00.0* and verify the Low Battery alarm is not activated.

9. Slowly reduce the power supply output until the "LOW BATTERY" alarm is activated, then check:
   - DVM reads between 5.75 and 5.85 volts
   - "LOW BATTERY" message flashes on the LCD panel
   - ALARM indicator flashes
   - Audio alarm sounds.

10. Continue to reduce the power supply output until the Low Battery "MALFUNCTION" alarm is activated, then check:
    - Digital volt meter reads between 5.35 and 5.45 volts
    - "MALFUNCTION" message flashes on the LCD panel
    - Malfunction code 14 appears in the Volume Infused quantity display
    - Pumping mechanism stops.

11. Set the power supply voltage output to 5.95 volts, then press ON/STOP twice to reset the instrument and check:
    - "LOW BATTERY" & "MALFUNCTION message are not displayed
    - ALARM indicator is not activated
    - Audio alarm does not sound.

5.7.3 Occlusion Calibration

1. Separate the front and rear pump assemblies (refer to section 5.4.1 through step #2, but do NOT disconnect the ground wires).

2. If the minimum pressure obtained during the Operate (up stroke) Pressure Test (see Section 5.6.3.11) is less than 16/*10* psig, use a #2 Phillips head screwdriver to turn the lower potentiometer on the angle plate circuit card clockwise to increase pressure.

3. If the maximum pressure obtained during the Operate Pressure Test is greater than 25/*25* psig (1292/*1292* mm Hg), turn the lower potentiometer counterclockwise to decrease pressure.

4. If the minimum vacuum obtained during the Downstroke Occlusion Test (see Section 5.6.3.13) is less than 15"/*15"* (381 mm) of Hg, turn the upper potentiometer on the angle plate circuit card clockwise to increase vacuum.

5. If the maximum vacuum obtained during the Downstroke Occlusion Test is more than 22.4"/*22.4"* (567 mm) of Hg, turn the upper potentiometer counterclockwise to decrease vacuum.

6. Repeat Operate Pressure and Downstroke Occlusion Tests to verify new pressure readings.

WARNING

The following procedure requires 120 VAC to be applied to the instrument while the case is open. Under this condition contact can be made with potentially lethal voltage at several points in the rear case assembly. Use caution when performing this adjustment.

5.7.4 Battery Charger Adjustment

1. Unplug the AC power cord from the wall outlet.

2. Separate the front and rear pump assemblies (refer to section 5.4.1 through step #2, but do NOT disconnect the ground wires).

3. Remove the chassis assembly from the rear case (refer to Section 5.4.5.1).

4. Disconnect the battery leads from the battery terminals.

5. Place a 150Ω, 5%, 1W resistor across the battery leads.

6. Connect a Digital Volt Meter (DVM) across the resistor.

7. Plug the AC power cord into a wall outlet.

8. Adjust potentiometer R1 on the power supply board to give a reading of 7.2 ±0.1 volts on the DVM.

9. Unplug the AC power cord from the wall outlet.

10. Remove the DVM and resistor front the battery leads.

11. Connect the battery leads to the battery terminals (red/white wire to + and black/white wire to -) and reassemble the instrument (refer to Section 5.5).

5.7.5 Plunger Limit Adjustment

The plunger in the cassette should not come closer than 1/16" (1.6 mm) to the top of the cylinder when the shuttle reaches its upper travel limit. Plunger travel is adjusted by moving the flag on the shuttle. This sets the point where the optical sensor light path is interrupted. The flag is attached to the shuttle by 2 screws. The holes in the flag are slotted permitting the flag to be adjusted up or down approximately 1/8" (3.2 mm). These screws are accessible through an opening in the angle plate assembly circuit card.

1. Install a cassette in the instrument's cassette nest.
2. Press ON/STOP to turn the instrument on.
3. Set Rate to 000/*00.0*.
4. Press PRIME ON/OFF to activate the shuttle.
5. Press ON/OFF when the shuttle reaches the top of its stroke (when valve shaft rotates).
6. Measure the distance between the top of the plunger and the top of the cylinder.
7. If the distance is less than 1/16" (1.6 mm)or more than 1/8" (3.2 mm), separate the case (see Section 5.4.1 through step #2, but do NOT disconnect the ground wires).
8. Loosen the 2 screws that are visible through the opening in the angle plate assembly circuit board.
9. If the distance between the plunger and cylinder top was less then 1/16" (1.6 mm) move the flag upward 1/16" (1.6 mm). If the distance was more than 1/8" (3.2 mm) lower the flag 1/16" (1.6 mm).
10. Tighten the screws.
11. Repeat steps 4-6 to recheck the distance; readjust as necessary.
12. When proper adjustment is achieved, re-assemble the instrument (see Section 5.5).

5.7.6 Valve Drive Shaft Check and Adjustment

1. Press ON/STOP to turn the instrument on.
2. Set the Rate to 000/*00.0*.
3. Press PRIME ON/OFF.
4. When the shuttle reaches the top of its travel and the valve motor has rotated, press ON/STOP to turn off the instrument.
5. Open the door, remove the cassette and check the orientation of the slot in the valve shaft.
6. If the slot is vertical, the check is complete; if not, proceed with step 7.
7. Separate the front and rear pump assemblies (refer to section 5.4.1 through step #2, but do NOT disconnect the ground wires).
8. Bend the valve flag slightly in the direction that the valve shaft slot was deflected from vertical.
9. Repeat steps 3-8 as necessary to achieve a true vertical orientation of the valve shaft slot.
10. Press ON/STOP to turn the instrument off, then reassemble the instrument (refer to Section 5.5).

5.7.7 Ultrasonic AIL Detector Calibration Procedure

1. Remove the Cover Assembly (see Section 5.5.1).
2. Set up a dual trace oscilloscope as follows:
   Channel #1 0.2 Volt/division, AC coupling
   1 μsec/division
   Channel #2 0.2 Volt/division, DC coupling
   1 msec/division
   A 10X probe must be used with channel #1
3. Connect oscilloscope probes as follows:
   Probe Channel #1 TP4
   Probe Channel #2 TP1
   Probe Ground TP2
4. Install the open-ended air-in-line simulator (see Figure 5-2) in the AIL detector block and raise the fluid level above the AIL detector block.

5. Wait 45 seconds, then turn R6 (see Figure 5-3) on the AIL PCB board through its full range to obtain the maximum signal on scope channel #1; voltage should be >800 mV (p-p). Record the p-p voltage.

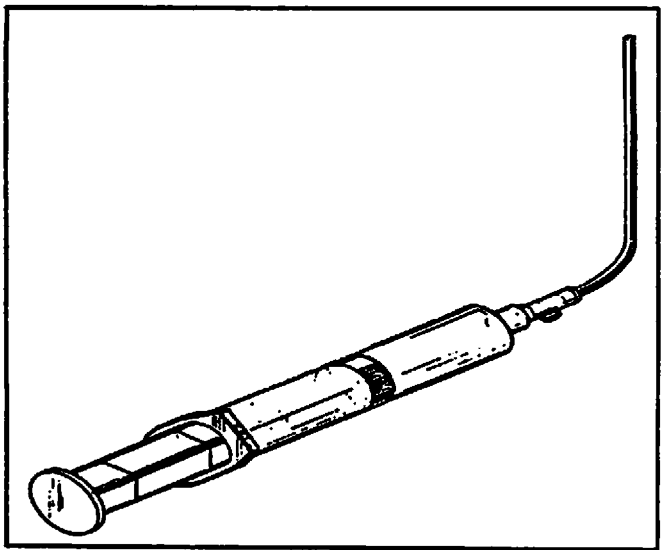

Figure 5-2. Open-ended AIL Simulator

6. Attach the Frequency Counter red (+) lead to the top of L1 and the black (-) lead to TP2. Verify the frequency of the step e. voltage peak is between 1.6 and 2.5 MHz. If not repeat step e. using the next highest voltage peak.

7. Use the syringe plunger to lower the fluid level in the simulator below the AIL detector block.

8. Connect a DVM (DC) between TP4 (+) and TP3 (-), then adjust potentiometer R12 on the AIL PCB board until the DVM voltage reads 1/6 (±10 mV) of the voltage recorded in step e. (e.g. step e = 840 mV + 6 = 140 mV).

NOTE

DVM reading MUST be positive

9. Disconnect the DVM leads.

10. Raise the fluid level above the detector block and check:
    - Channel #1 voltage should read the same as in step e (±100 mV). If not, return to step e. and recalibrate.
    - Channel #2 voltage should read <0.4 VDC

11. Set oscilloscope channel #1 to .2 volts/division on 10X scale and channel #2 to 1 volt/division.

12. Lower the fluid level to below the detector block and check:
    - Channel #1 voltage should read <1/10 the step e. voltage (p-p) (e.g. step e = 840 mV + 10 = 84 mV).
    - Channel #2 voltage should read >4.5 VDC.

13. If step l. produces results within the specified ranges, calibration is complete, If not, return to step e. and recalibrate. In case of repeated failures replace the AIL assembly.

14. Install the Cover Assembly.

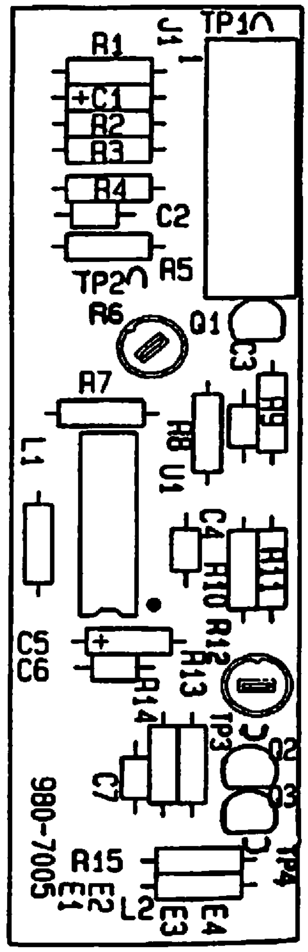

Figure 5-3. AIL PCB Board

5.7.8 Occlusion Calibration (Alternate Method)

1. Separate the front and rear pump assemblies (refer to section 5.4.1 through step #2, but do NOT disconnect the ground wires).

2. Press the ON/OFF control to turn the instrument on and home the shuttle to the bottom position.

3. Install the pressure test station cassette in the instrument's cassette nest.

4. Set the rate to 200 mL/hr and the VTBI to 100 mL.

5. Adjust the pressure regulator to set the pressure gauge to 19.0 psi.

6. Press START.

7. Adjust the lower potentiometer on the angle plate board to allow the shuttle to complete a delivery stroke without occluding.

8. Press ON/OFF to turn the instrument off **when the valve motor begins to rotate.**

9. Turn the stopcock to vent the pressure in the cassette to ambient.

10. Reset the presssure requlator to read 22.0 psi on the pressure gauge.

11. Press ON/OFF to turn the instrument on and reset the shuttle to the bottom of the stroke.

12. Turn the stopcock to apply pressure to the cassette.

13. Press START and verify the following occur during the first upstroke:
    - ALARM indicator flashes
    - OPERATING indicator extinguishes
    - Operating/Rate graphics extinguish
    - "OCCLUSION" message flashes and "NOT OPERATING" displays steadily on the LCD panel
    - Audio Alarm sounds
    - Nurse Call test light illuminates (P0.6 only)
    - Pumping mechanism stops.

14. Turn stopcock to relieve cassette pressure before removal.

15. If the minimum vacuum obtained during a Downstroke Occlusion Test (see Section 5.6.3.13) is less -7.4 psi (15" Hg), turn the upper potentiometer on the angle plate board clockwise to increase vacuum.

16. If the maximum vacuum obtained during the Downstroke Occlusion Test is more than -11.0 psi (22.4" Hg), turn the upper potentiometer counterclockwise to decrease vacuum.

17. Repeat Operate Pressure and Downstroke Occlusion Tests, as necessary, to verify the new pressure settings.

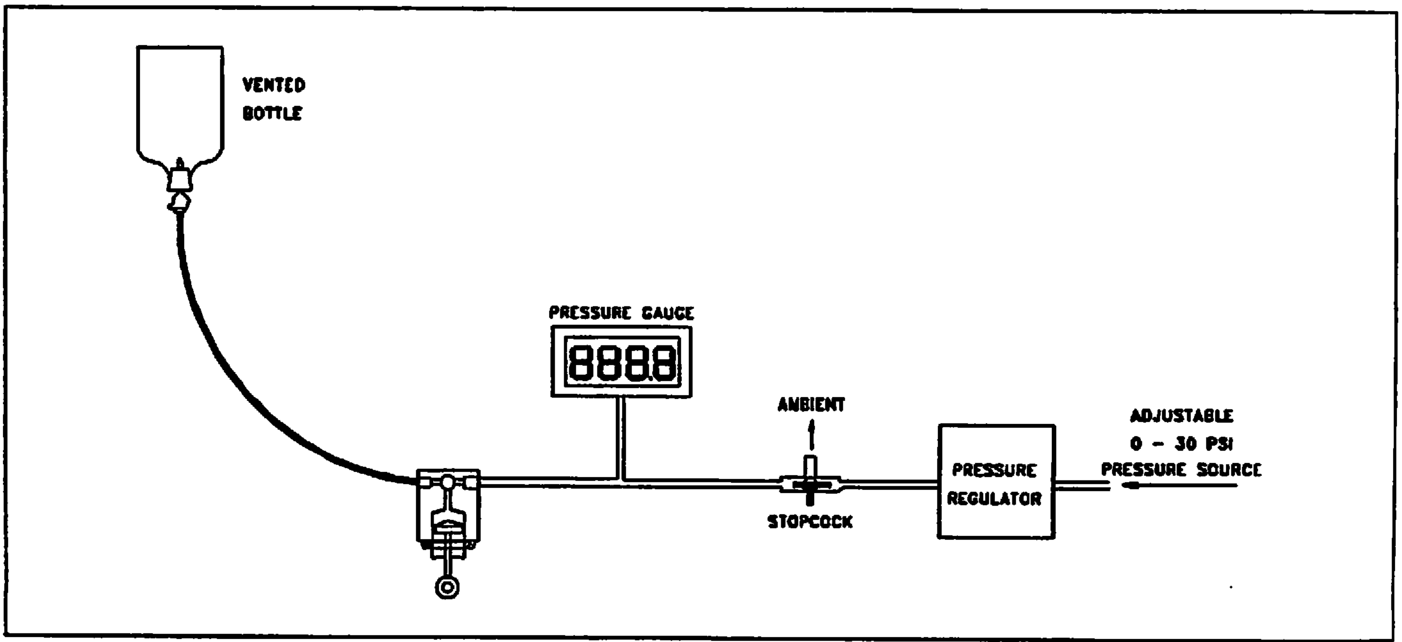

Figure 5-4. Typical Pressure Test Station Setup

960A/*965A* TEST DATA SHEET

Instrument Model/Ser. No.________/_________ Software Revision________ Date__________
Test Technician______________________________

Test No.	Description	Reference	Pass/Fail
1.	Battery Charging Indicator	2.3.3.2 (2)	______/______
2.	Liquid Crystal Display	2.3.3.2 (4)	______/______
3.	LED Functions	2.3.3.2 (4)	______/______
4.	Unattended Pump Function	2.3.3.2 (14)	______/______
5.	INFUSION COMPLETE Alarm	2.3.3.2 (17)	______/______
6.	AUDIO Alarm	2.3.3.2 (18)	______/______
7.	Rate/Volume Inhibit	5.6.3.3	______/______
8.	Prime Inhibit	5.6.3.4	______/______
9.	Volume Infused Reset Inhibit	5.6.3.5	______/______
10.	Operational Test	5.6.3.6	______/______
11.	Walk-Away Alarm Test	5.6.3.7	______/______
12.	Door Alarm Test	5.6.3.8	______/______
13.	Power Off Memory	5.6.3.9	______/______
14.	Prime (Purge) Pressure Test	5.6.3.10	______/______
15.	Operate Pressure Test	5.6.3.11	______/______
16.	Volume-Rate Delivery Test (960A)	5.6.3.12	______/______

	Actual Vol. Infused	Time
Rate @ 144 mL/hr VTBI @ 10 mL	____________	______

Test No.	Description	Reference	Pass/Fail
	Volume-Rate Delivery Test (*965A*)	5.6.3.12	______/______

	Actual Vol. Infused	Time
Rate @ 99.9 mL/hr VTBI @ 9.0 mL	____________	______

Test No.	Description	Reference	Pass/Fail
17.	Downstroke Occlusion Test	5.6.3.13	______/______
18.	AIL Detector Test:		
	Optical Clear Fluid	5.6.3.14	______/______
	Optical Opaque Flui	5.6.3.14	______/______
	Ultrasonic	5.6.3.14	______/______

Figure 5-5. 960A/*965A* Test Data Sheet

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SECTION 6 - ILLUSTRATED PARTS BREAKDOWN

6.1 INTRODUCTION

The tables and figures presented in this section identify the sub-assemblies and list the component parts of each sub-assembly in the 960A Volumetric and *965A* Micro Volumetric Infusion Pumps. Part listings printed in normal font pertain to the 960A or are common to both instruments. Part listings printed in *oblique type* relate to parts unique to the *965A* instrument. Descriptions and numbers printed in **Times Roman/*Times Roman italic*** pertain to common and unique parts for the **960A/*965A*** PIP/P4.x instruments. Parts unique to the Foster Front Panel Assembly are identified with a (F). Parts unique to the Hightower Front Panel Assembly are identified with a (HT). Any part listed without an accompanying part number is not field-replaceable, and is available only as an integral part of the next higher assembly.

NOTE

Use of parts procured from sources other than IMED will void the product warranty (see Section 7).

Each tabular listing of parts is supplemented with either an exploded view illustration of the respective assembly or a component location diagram. These drawings are provided solely for use by biomedical technicians and engineers to service, maintain and/or repair the 960A/*965A*. Customers experiencing repair requirements beyond their local capability are encouraged to return those items or assemblies to IMED for repair or replacement. The IMED Service Department maintains facilities to troubleshoot, repair and test all 960A/*965A* integrated circuit boards.

In the event difficulty is encountered in identifying any part, IMED's Customer Service Department should be contacted by telephone or letter for assistance.

Table 6-1. Parts List - 960A/*965A* Final Assembly

Fig No/Item		Qty	Description	Part No	Reference
		X	Final Pump Assembly 960A (F)	960-1074-1	
		X	*Final Pump Assembly 965A (F)*	*965-1031-1*	
		X	Final Pump Assembly 960A (HT)	960-1076-1	
		X	*Final Pump Assembly 965A (HT)*	*965-1036-1*	
		X	**Final Pump Assembly 960A (PIP/P4.x)**	**960-1102-1**	
		X	***Final Pump Assembly 965A (PIP/P4.x)***	***965-1050-1***	
6-1	10	1	Front Pump Assembly 960A (F)	960-1072-1	Table 6-2
6-1	10	1	*Front Pump Assembly 965A (F)*	*965-1030-1*	Table 6-2
6-1	10	1	Front Pump Assembly 960A (HT)	960-1082-1	Table 6-2
6-1	10	1	*Front Pump Assembly 965A (HT)*	*965-1037-1*	Table 6-2
6-1	10	1	**Front Pump Assembly 960A (PIP/P4.x)**	**960-1103-1**	
6-1	10	1	***Front Pump Assembly 965A (PIP/P4.x)***	***965-1052-1***	
6-1	20/*20*	1	Rear Pump Assembly 960A/*965A* (F)	960-1073-1	Table 6-10
6-1	20/*20*	1	Rear Pump Assembly 960A/*965A* (HT)	960-1085-1	Table 6-10
6-1	20/*20*	1	Rear Pump Assembly 960A/*965A* (PIP/P4.x)	960-1104-1	
6-1	60/*60*	1	Label, Operating Instructions	960-2101-7	
6-1	70	1	Label, 960 Top	960-2103-7	
6-1	70	1	*Label, 965 Top*	*965-2020-7*	
6-1	80	1	Label, Nameplate	960-2102-7	
6-1	80	1	*Label, Nameplate*	*965-2021-7*	
6-1	80	1	**Label, Nameplate (PIP/P4.x)**	**960-2181-7**	
6-1	80	1	**Label, Nameplate (PIP/P4.x)**	**965-2032-7**	
6-1	90	1	Label, Accent 960	960-2105-7	
6-1	90	1	*Label, Accent 965*	*965-2019-7*	
6-1	100/*100*	1	**Label, UL/CSA Phoenix (PIP/P4.x)**	**960-2100-7**	
6-1	110/*110*	1	Label, Nurse Call	960-2104-7	
6-1	120/*120*	1	Label, Factory Seal	922-2027-7	
6-1	130/*130*	1	Label, Serial Number	960-2106-7	
6-1	140/*140*	1	Power Cord, Detachable	960-2129-7	
6-1	180/*180*	2	Standoff, 4-40 M/F Hex	805035	
6-1	190/*190*	4	Screw, 8-32 x 2 5/16 FilHd Ni Plt	801503	
6-1	200/*200*	2	Screw, 8-32 x 1/2 FilHd XREC	801504	
		2	**Screw, 6-32 x 1/2 FilHd XREC (PIP/P4.x)**	**801505**	
6-1	210/*210*	2	Screw, 4-40 x 3/8 PPH	801003	
6-1	220/*220*	2	Washer, #4, Flat	803000	

Table 6-4a. Parts List 960A Angle Plate Circuit Board

Fig No/	Ref Desig	Qty	Description	Part No	Reference
6-3a	40	X	Circuit Card Assy., Angle Plate	960-7028-1	
6-4a	CA3	1	Harness Assy, Angle Plate	960-1016-1	
		1	PCB, Angle Plate	960-6028-7	
			Resistors		
6-4a	R1	1	Resistor, 1mΩ, 1/4W, 5% Carbon	810125-105	
6-4a	R2		NOT USED		
6-4a	R3,R4	2	Resistor, 120Ω, 1/4W, 5% Carbon	810125-121	
6-4a	R5	1	Resistor, 1KΩ, 1/4W, 5% Carbon	810125-102	
6-4a	R6	1	Resistor, 510Ω, 1/4W, 5% Carbon	810125-511	
6-4a	R7	1	Resistor, 20KΩ, 1/4W, 5% Carbon	810125-203	
6-4a	R8	1	Resistor, 1KΩ, 1/4W, 5% Carbon	810125-102	
6-4a	R9	1	Resistor, 510Ω, 1/4W, 5% Carbon	810125-511	
6-4a	R10	1	Resistor, 20KΩ, 1/4W, 5% Carbon	810125-203	
6-4a	R11	1	Resistor, 120Ω, 1/4W, 5% Carbon	810125-121	
6-4a	R12	1	Resistor, 68Ω, 1/2W, 5% Carbon	810135-680	
6-4a	R13	1	Resistor, 3.9KΩ, 1/4W, 5% Carbon	810125-392	
6-4a	R14	1	Resistor, 51Ω, 1W, 5% Carbon	810145-510	
6-4a	R15	1	Resistor, 510Ω, 1/4W, 5% Carbon	810125-511	
6-4a	R16	1	Resistor, 15Ω, 3W, 10% POT	810366-150	
6-4a	R17	1	Resistor, 3.9KΩ, 1/4W, 5% Carbon	810125-392	
6-4a	R18	1	Resistor, 51Ω, 1W, 5% Carbon	810145-510	
6-4a	R19	1	Resistor, 510Ω, 1/4W, 5% Carbon	810125-511	
6-4a	R20	1	Resistor, 15Ω, 3W, 10% POT	810366-150	
6-4a	R21	1	Resistor, 5.6KΩ, 1/4W, 5% Carbon	810125-562	
6-4a	R22	1	Resistor, 100Ω, 1/4W, 5% Carbon	810125-101	
6-4a	R23	1	Resistor, 10Ω, 1/4W, 5% Carbon	810125-100	
6-4a	R24	1	Resistor, 5.6KΩ, 1/4W, 5% Carbon	810125-562	
6-4a	R25	1	Resistor, 100Ω, 1/4W, 5% Carbon	810125-101	
6-4a	R26	1	Resistor, 10Ω, 1/4W, 5% Carbon	810125-100	
6-4a	R27	1	Resistor, 5.6KΩ, 1/4W, 5% Carbon	810125-562	
6-4a	R28	1	Resistor, 100Ω, 1/4W, 5% Carbon	810125-101	
6-4a	R29	1	Resistor, 10Ω, 1/4W, 5% Carbon	810125-100	
6-4a	R30	1	Resistor, 5.6KΩ, 1/4W, 5% Carbon	810125-562	
6-4a	R31	1	Resistor, 100Ω, 1/4W, 5% Carbon	810125-101	
6-4a	R32	1	Resistor, 10Ω, 1/4W, 5% Carbon	810125-100	
6-4a	R33-R38	6	Resistor, 510Ω, 1/4W, 5% Carbon	810125-511	
			Capacitors		
6-4a	C1	1	Capacitor,1.2µF,20V,10%,TANT Axial	811136-125A	
6-4a	C2-C4	3	Capacitor, .22µF,100V,20% CER	811257-224	
6-4a	C5-C9	5	Capacitor,1000pF,1000V,20% CER	811136-102	
			Integrated Circuits		
6-4a	Z1	1	I.C. 4049 HEX Inverting Buffer	812002	
6-4a	Z2	1	I.C. 4081 QUAD 2-Input and Gate	812021	

Table 6-4a. Parts List 960A Angle Plate Circuit Board
(continued)

Fig No/ Ref Desig		Qty	Description	Part No	Reference
			Diodes		
6-4a	CR1	1	Diode IN4148, Gen Purpose	813500	
6-4a	CR2-CR5	4	Diode IN4001, Switching	813200	
6-4a	CR6,CR7	2	Diode IN4148, Gen Purpose	813500	
			Transistors		
6-4a	Q1,Q2	2	Transistor 2N4401 NPN	814103	
6-4a	Q3	1	Transistor 2N4403 PNP	814104	
6-4a	Q4,Q5	2	Transistor 2N4401 NPN	814103	
6-4a	Q6	1	Transistor 2N4403 PNP	814104	
6-4a	Q7,Q8	2	Transistor 2N4401 NPN	814103	
6-4a	Q9	1	Transistor MJE210 PNP	814201	
6-4a	Q10	1	Transistor 2N4401 NPN	814103	
6-4a	Q11	1	Transistor MJE210 PNP	814201	
6-4a	Q12	2	Transistor 2N4401 NPN	814103	
6-4a	Q13	1	Transistor MJE180 NPN	814202	
6-4a	Q14	1	Transistor 2N4401 NPN	814103	
6-4a	Q15	1	Transistor MJE180 NPN	814202	
6-4a	Q16	1	Transistor 2N4401 NPN	814103	
6-4a	Q17	1	Transistor MJE180 NPN	814202	
6-4a	Q18	1	Transistor 2N4401 NPN	814103	
6-4a	Q19	1	Transistor MJE180 NPN	814202	
			Miscellaneous		
6-4a	A1-A5	5	Sensor Photo	815017	
6-4a	L1,L2	2	Choke-RF, 22µh, .96Ω, 500mA	815005	
		1	Block, Spacer	960-2039-7	
		Ref	Schematic, Angle Plate	960-5004	

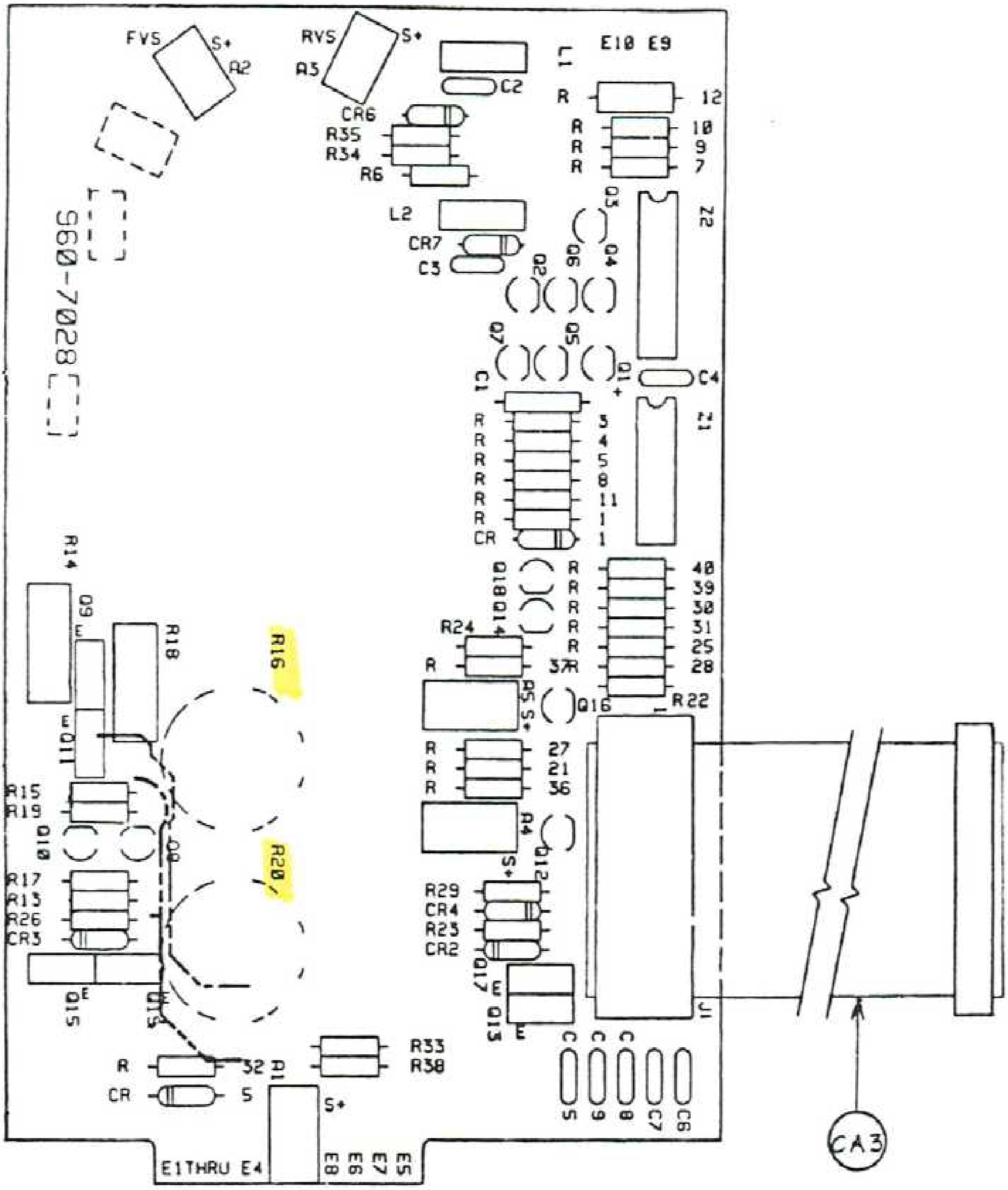

Figure 6-4a. Parts Identification 960A Angle Plat Circuit Card

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Table 6-4b. Parts List *965A* Angle Plate Circuit Card

Fig No/ Ref Desig		Qty	Description	Part No	Reference
6-3b	130	X	Circuit Card Assy., Angle Plate	965-7000-1	
6-4b	W3	1	Harness Assembly, Angle Plate	960-1016-1	
		1	PWB, Angle Plate	965-6000-7	
			Resistors		
6-4b	R1	1	Resistor, 1MΩ, 1/4W, 5%	810125-105	
6-4b			NOT USED		
6-4b	R3,R4	2	Resistor, 120Ω, 1/4W. 5%	810125-121	
6-4b	R5	1	Resistor, 1KΩ, 1/4W, 5%	810125-102	
6-4b	R6	1	Resistor, 510Ω, 1/4W, 5%	810125-511	
6-4b	R7	1	Resistor, 20KΩ, 1/4W, 5%	810125-203	
6-4b	R8	1	Resistor, 1KΩ, 1/4W, 5%	810125-102	
6-4b	R9	1	Resistor, 510Ω, 1/4W, 5%	810125-511	
6-4b	R10	1	Resistor, 20KΩ, 1/4W, 5%	810125-203	
6-4b	R11	1	Resistor, 120Ω, 1/4W. 5%	810125-121	
6-4b	R12	1	Resistor, 68Ω, 1/2W. 5%	810135-680	
6-4b	R13	1	Resistor, 510Ω, 1/4W, 5%	810125-511	
6-4b	R14,R15	2	Resistor, 30Ω, 1/4W, 5%	810125-300	
6-4b	R16	1	Wirewound Variable Resistor, 3Ω, 2W, 20%	810366-030	
6-4b	R17	1	Resistor, 510Ω, 1/4W, 5%	810125-511	
6-4b	R18,R19	2	Resistor, 30Ω, 1/4W, 5%	810125-300	
6-4b	R20	1	Wirewound Variable Resistor, 3Ω, 2W, 20%	810366-030	
6-4b	R21	1	Resistor, 5.6kΩ, 1/4W, 5%	810125-562	
6-4b	R22	1	Resistor, 100Ω, 1/4W. 5%	810125-101	
6-4b	R23	1	Resistor, 10Ω, 1/4W, 5%	810125-100	
6-4b	R24	1	Resistor, 5.6kΩ, 1/4W, 5%	810125-562	
6-4b	R25	1	Resistor, 100Ω, 1/4W. 5%	810125-101	
6-4b	R26	1	Resistor, 10Ω, 1/4W, 5%	810125-100	
6-4b	R27	1	Resistor, 5.6kΩ, 1/4W, 5%	810125-562	
6-4b	R28	1	Resistor, 100Ω, 1/4W. 5%	810125-101	
6-4b	R29	1	Resistor, 10Ω, 1/4W, 5%	810125-100	
6-4b	R30	1	Resistor, 5.6kΩ, 1/4W, 5%	810125-562	
6-4b	R31	1	Resistor, 100Ω, 1/4W. 5%	810125-101	
6-4b	R32	1	Resistor, 10Ω, 1/4W, 5%	810125-100	
6-4b	R33-R38	6	Resistor, 510Ω, 1/4W, 5%	810125-511	
6-4b	R39,R40	2	Resistor, 47KΩ, 1/4W, 5%	810125-473	
			Capacitors		
6-4b	C1	1	Capacitor, 1.2µF, 20V, TANT	811136-125A	
6-4b	C2-C4	3	Capacitor, .22µF, 100V, CER	811257-224	
6-4b	C5-C9	5	Capacitor, .001µF, 1KV, CER	811287-102	
			Integrated Circuits		
6-4b	Z1	1	I.C. 4081B Quad & Gate	812021	
6-4b	Z2	1	I.C. 4049UB HEX Inverter	812002	

Table 6-4b. Parts List *965A* Angle Plate Circuit Card
(continued)

Fig No/ Ref Desig	Qty	Description	Part No	Reference
		Diodes		
6-4b CR1	1	Diode IN4148	813500	
6-4b CR2-CR5	4	Diode IN4001	813200	
6-4b CR6-CR13	8	Diode IN4148	813500	
6-4b CR14	1	Diode IN4001	813200	
6-4bCR15,CR16	2	Diode IN4148	813500	
6-4b CR17	1	Diode IN4001	813200	
		Transistors		
6-4b Q1,Q2	2	Transistor, 2N4401, NPN	814103	
6-4b Q3	1	Transistor, 2N4403, PNP	814104	
6-4b Q4,Q5	2	Transistor, 2N4401, NPN	814103	
6-4b Q6	1	Transistor, 2N4403, PNP	814104	
6-4b Q7,Q8	2	Transistor, 2N4401, NPN	814103	
6-4b Q9	1	Transistor,	814201	
6-4b Q10	1	Transistor, 2N4401, NPN	814103	
6-4b Q11	1	Transistor,	814201	
6-4b Q12	1	Transistor, 2N4401, NPN	814103	
6-4b Q13	1	Transistor, MJE180, NPN	814202	
6-4b Q14	1	Transistor, 2N4401, NPN	814103	
6-4b Q15	1	Transistor, MJE180, NPN	814202	
6-4b Q16	1	Transistor, 2N4401, NPN	814103	
6-4b Q17	1	Transistor, MJE180, NPN	814202	
6-4b Q18	1	Transistor, 2N4401, NPN	814103	
6-4b Q19	1	Transistor, MJE180, NPN	814202	
		Miscellaneous		
6-4b J1	1	Connector	855004	
6-4b A1-A5	5	Sensor	815017	
6-4b L1,L2	2	Choke, RF, 22µh, .96Ω, 500mA	815005	
6-4b	1	Block, Spacer	960-2033-7	
	Ref	Schematic, Angle Plate	965-5000	

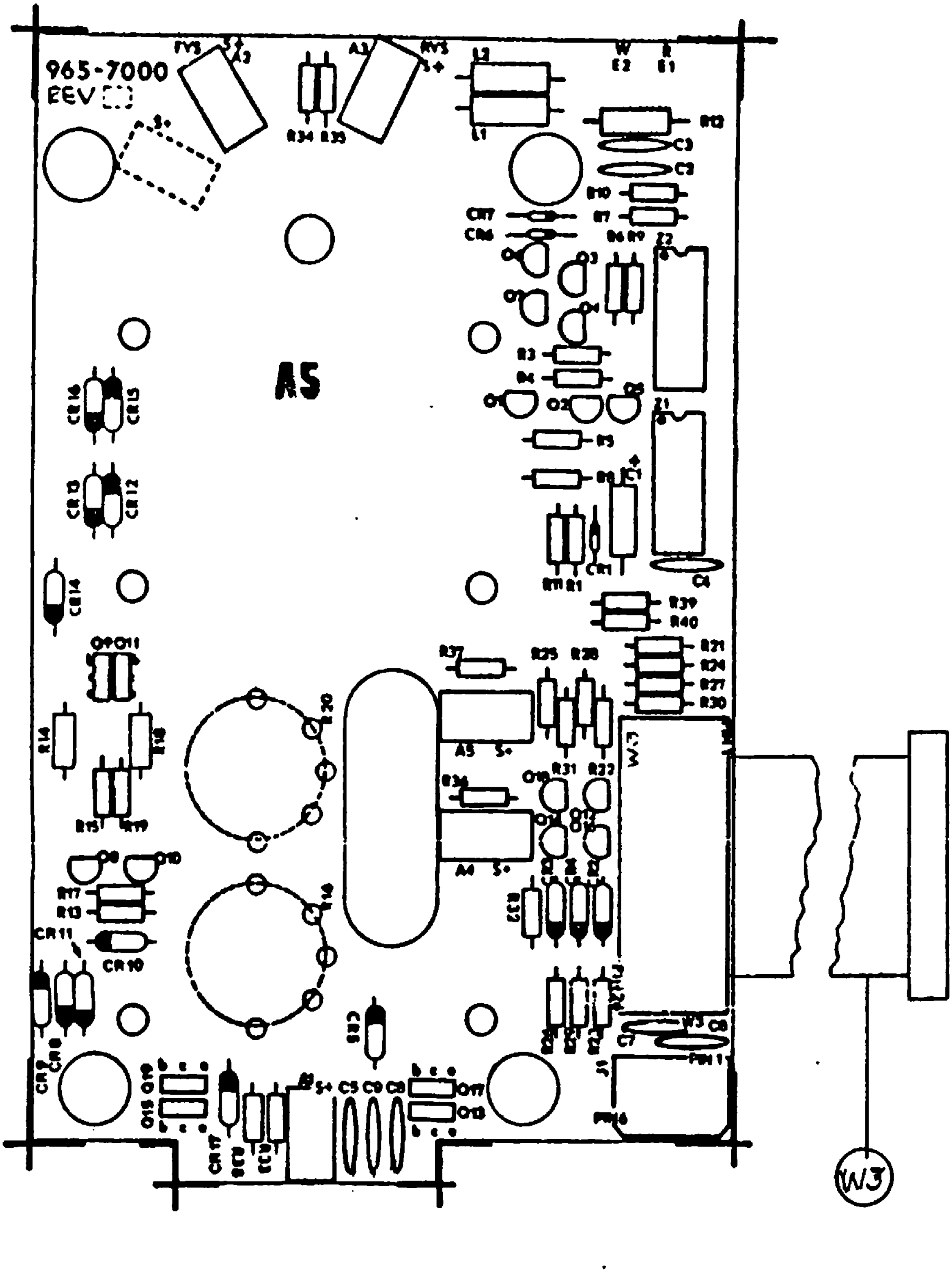

Figure 6-4b. Parts Identification *965A* Angle Plate Circuit Card

Table 6-5. Parts List 960A/*965A* Door Assembly

Fig No/Item		Qty	Description	Part No	Reference
6-2	200	X	Door Assembly w/Hinge	960-1055-2	
6-2	*200*	*X*	*Door Assembly w/Hinge*	*965-1006-1*	
6-5	70	1	Door, GRAVISET, Machined	960-2092-7	
6-5	*100*	*1*	*Door, Machined*	*965-3004-8*	
6-5	10/*10*	1	Hinge Assembly	960-1030-1	
6-5	80/*40*	1	Bumper, Door	960-2023-7	
6-5	90/*50*	1	Button, Door	960-2040-7	
6-5	100/*60*	1	Latch, Door	960-2062-7	
6-5	110	1	Label, GRAVISET	960-2091-7	
6-5	40/*70*	1	Plate, Hinge	960-2035-7	
6-5	*120*	*1*	*Screw, #6-32 x 1/4, PNH, SST*	*801006*	
6-5	190/*130*	4	Screw, #2-56 x 1/4, 110°, Flt HD, PHH, CAD	801109	
6-5	140/*140*	1	Magnet	809015	
6-5	150/*150*	AR	Adhesive, MVP II	832043	
	160	1	Spring	809037	
6-5	170/*160*	1	Insert, Ultra #6 x .250	809037	
6-5	200	1	Screw, #6-32 x 1/2" BTN, SST	801601	

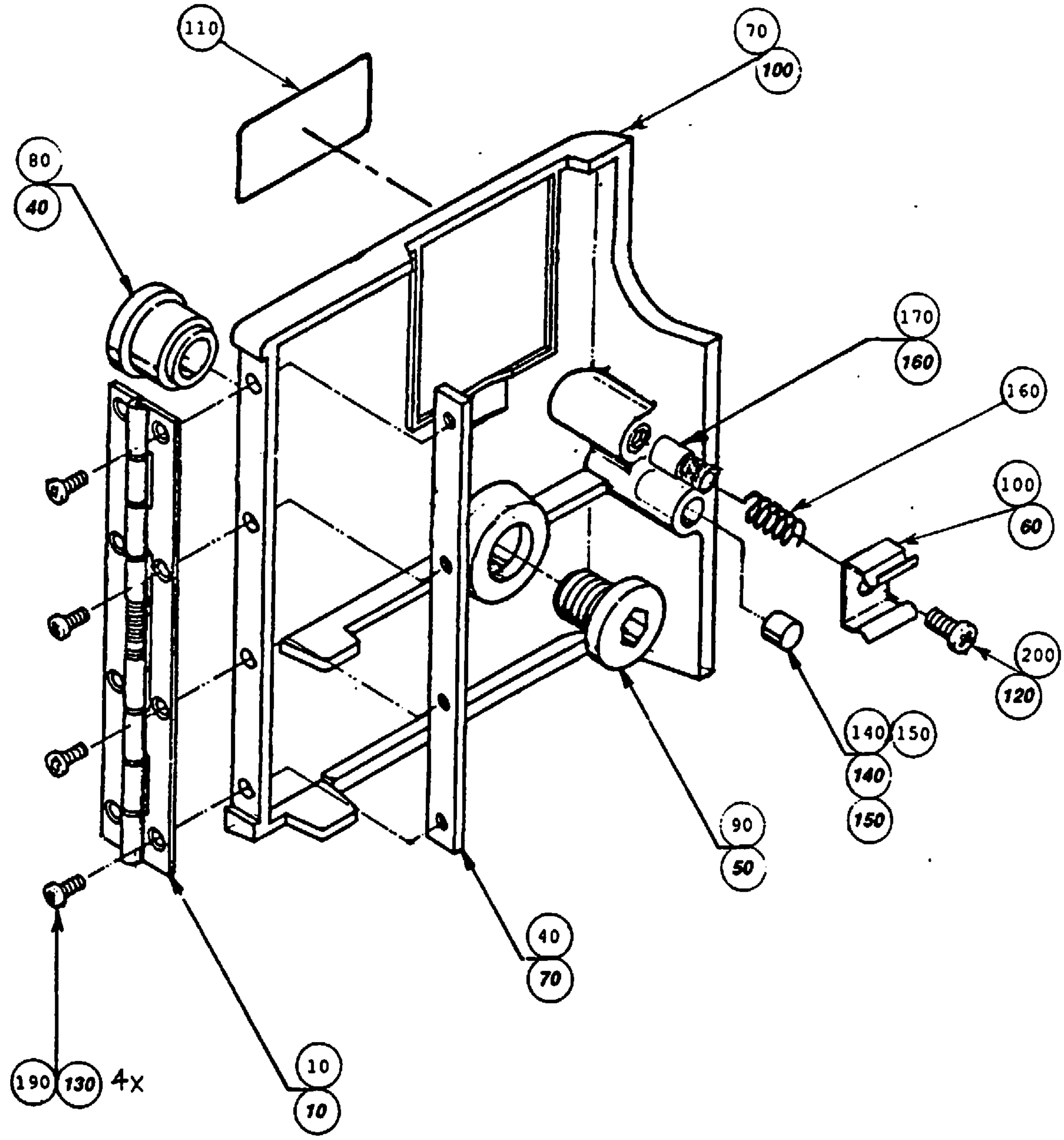

Figure 6-5. Parts Identification 960A/*965A* Door Assembly

Table 6-6. Parts List 960A/*965A* Shuttle Assembly

Fig No/Item		Qty	Description	Part No	Reference
6-3a	20	X	Shuttle Assembly, Molded	960-1036-1	
6-3b	*10*	*X*	*Shuttle Assembly, Molded*	*965-1013-1*	
6-6	7/*10*	1	Shuttle Slide	922-2017-7	
6-6	8/*20*	1	Shuttle Flag	960-2041-7	
6-6	9/*30*	1	Shuttle Back, Molded	922-2067-7	
6-6	10/*40*	1	Shuttle Body, Machined	922-2071-7	
6-6	11/*50*	1	Shuttle Nose, Machined	922-2090-7	
6-6	12	1	Lead Screw	922-2018-7	
6-6	16/*90*	6	Screw, Pan HD, #4-40 x 1/2", XREC, CAD I or II	801004	
6-6	17	1	Roll Pin, CRES, 1/16" D x 5/8" L	804000	
6-6	*100*	1	Roll Pin, CRES, 1/16" D x 5/8" L	804001	
6-6	20	AR	STP Oil Treatment	831007	
6-6	21/*140*	AR	Slip Spray	831005	

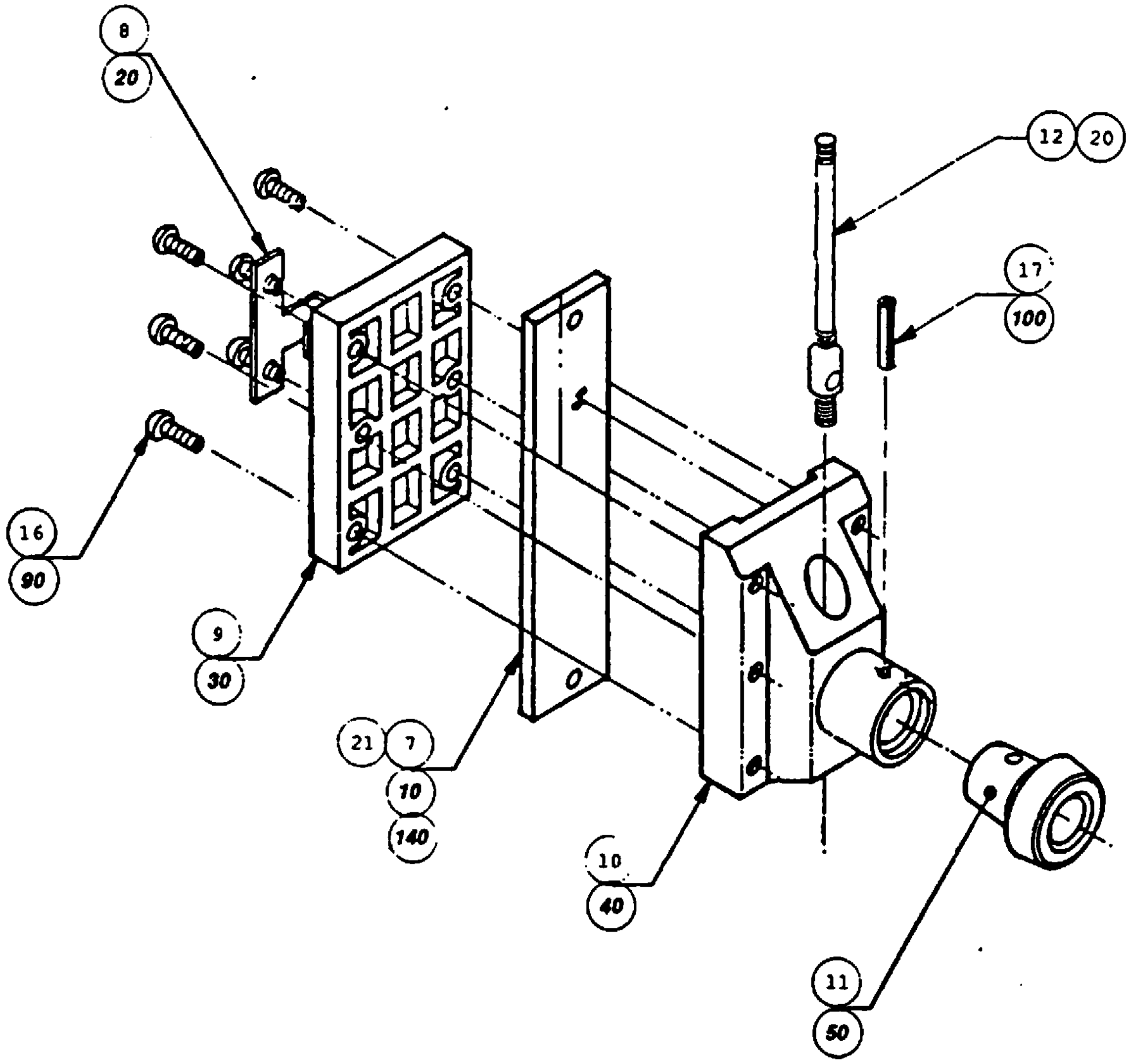

Figure 6-6. Parts Identification 960A/*965A* Shuttle Assembly

Table 6-7. Parts List 960A/*965A* MLB Circuit Card Assembly

Fig No/ Ref Desig	Qty	Description	Part No	Reference
	X	Circuit Card Assembly, MLB	960-7030-1	
5	1	PWB, Main Logic Board Pallet	960-6029-8	
6	Alt	PWB, Main Logic Board	960-6029-7	
		Connectors		
J1,J2	2	Connector, Header 20 Ckt	851004	
J3	1	Connector, Header 26 Ckt	851006	
J4	1	Connector, Header 20 Ckt	851004	
J5	1	Connector, Header 10 Ckt	851001	
J6	1	Connector, Header 20 Ckt	851005	
J7	1	Header, Mod.	960-2054-7	
		Capacitors		
C2	1	Capacitor,20pF,1KV,20% CER	811287-200	
C3	1	Capacitor,2.2µF,10V,10% TANT AXIAL	811116-225A	
C4,C5	2	Capacitor,390pF,1KV,20% CER	811287-391	
C6	1	Capacitor,1.2µF,20V,10% TANT AXIAL	811136-125A	
C7	1	Capacitor,100µF,10V,10% TANT RAD	811116-107	
C8	1	Capacitor,.22µF,100V.20% CER	811257-224	
C9	1	Capacitor,100µF,10V.10% TANT RAD	811116-107	
C10-C14	5	Capacitor,.22µF,100V,20% CER	811257-224	
		Integrated Circuits		
Z1	1	I.C. 8035 Microcomputer	812030	
Z2	1	I.C. Programmed 8755 EPROM (812031)	960-9005	
Z2	1	I.C. Programmed 8755 EPROM (812031)	965-1027	
Z3	1	I.C. 8243 I/O Expander	812032	
Z4	1	I.C. 4040B 12 Bit Counter	812020	
Z6-Z8	3	I.C. 4094UB Hex Inv	812002	
Z9,Z10	2	I.C. 40097 Hex Buffer	812040	
		Diodes		
CR1	1	Diode IN4148	813500	
CR6-CR9	4	Diode IN4148	813500	
CR12	1	Diode IN4148	813500	
CR15	1	Diode IN4148	813500	
CR17	1	Diode IN4148	813500	
CR20	1	Diode IN4148	813500	
		Resistor Arrays		
RA1	1	Resistor Array 47kΩ, 10 pin	810900-473	
RA2	1	Resistor Array 2.2KΩ, 10 pin	810900-222	
RA3	1	Resistor Array 33KΩ, 10 pin	810900-333	
RA4	1	Resistor Array 2.2KΩ, 10 pin	810900-222	

Table 6-7. Parts List 960A/*965A* MLB Circuit Card Assembly (continued)

Fig No/ Ref Desig	Qty	Description	Part No	Reference
		Resistors/Potentiometers		
R1	1	Resistor, 390KΩ, 1/4W, +/- 5%	810125-394	
R2	1	Potentiometer, 200KΩ,3/4W,+/- 10%	810396-204	
R3	1	Resistor, 1MΩ, 1/4W, +/- 5%	810125-105	
R4	1	Resistor, 20KΩ,1/4W, +/- 5%	810125-203	
R5	1	Resistor, 10KΩ,1/4W, +/- 5%	810125-103	
R6		NOT USED		
R7	1	Resistor, 1KΩ,1/4W +/- 5%	810125-102	
R8-R10	3	Resistor, 100Ω,1/4W, +/- 5%	810125-101	
R11-R16		NOT USED		
R17	1	Resistor, 20Ω,1/4W, +/- 5%	819125-200	
R18	1	Resistor, 3.9KΩ,1/4W, +/- 5%	810125-392	
R19	1	Resistor, 120Ω,1/4W, +/- 5%	810125-121	
R20		NOT USED		
R21,R22	2	Resistor, 3.9KΩ,1/4W, +/- 5%	810125-392	
R23		NOT USED		
R24	1	Resistor, 7.5KΩ,1/4W +/- 5%	810125-752	
R25		NOT USED		
R26	1	Resistor, 7.5KΩ,1/4W +/- 5%	810125-752	
R27		NOT USED		
R28	1	Resistor, 7.5KΩ,1/4W +/- 5%	810125-752	
R29		NOT USED		
R30	1	Resistor, 7.5KΩ,1/4W +/- 5%	810125-752	
R31		NOT USED		
R32	1	Resistor, 7.5KΩ,1/4W +/- 5%	810125-752	
R33		NOT USED		
R34	1	Resistor, 7.5KΩ,1/4W +/- 5%	810125-752	
R35		NOT USED		
R36-R39	4	Resistor, 10KΩ,1/4W, +/- 5%	810125-103	
R40	1	Resistor, 5.6KΩ,1/4W, +/- 5%	810125-562	
R41	1	Resistor, 10KΩ,1/4W, +/- 5%	810125-103	
R42		NOT USED		
R43	1	Resistor, 10KΩ,1/4W, +/- 5%	810125-103	
R44		NOT USED		
R45	1	Resistor, 51KΩ,1/4W, +/- 5%	810125-513	
R46	1	Resistor, 10KΩ,1/4W, +/- 5%	810125-103	
R47	1	Resistor, 3.9KΩ,1/4W, +/- 5%	810125-392	
R48	1	Resistor, 10KΩ,1/4W, +/- 5%	810125-103	
R49-R56		NOT USED		
R57	1	Resistor, 20KΩ,1/4XW, +/- 5%	810125-203	
R58		NOT USED		
R59,R60	2	Resistor, 47KΩ,1/4W, +/- 5%	810125-473	
R61		NOT USED		
R62,R63	2	Resistor, 47KΩ,1/4W, +/- 5%	810125-473	
R64-R71		NOT USED		
R72	1	Resistor, 180Ω,1/4W, +/- 5%	810125-181	
R73,R74		NOT USED		
R75	1	Resistor, 5.6KΩ,1/4W, +/- 5%	810125-562	

Table 6-7. Parts List 960A/*965A* MLB Circuit Card Assembly
(continued)

Fig No/ Ref Desig	Qty	Description	Part No	Reference
		Transistors		
Q1	1	Transistor 2N4401 NPN	814103	
Q2	1	Transistor 2N4403 PNP	814104	
Q3	1	Transistor 2N4401 NPN	814103	
Q4-Q10	7	Transistor 2N4403 PNP	814104	
Q11-Q16	6	Transistor 2N4401 NPN	814103	
		Miscellaneous		
Y1	1	Crystal 3.0MHz (Monitor MC-18A-B)	815004	
XZ1/XZ2	2	Socket, I.C. 40 Ckt	815002-1	
XZ3	1	Socket, I.C. 24 Ckt	815002-2	
K1	1	Relay	815000	
JPR1	1	Resistor, 0Ω,1/4W	810125-000	
	Alt	Jumper (J500X125T22)	815015	Alt JPR1
	Ref	Schematic, MLB	960-5505	

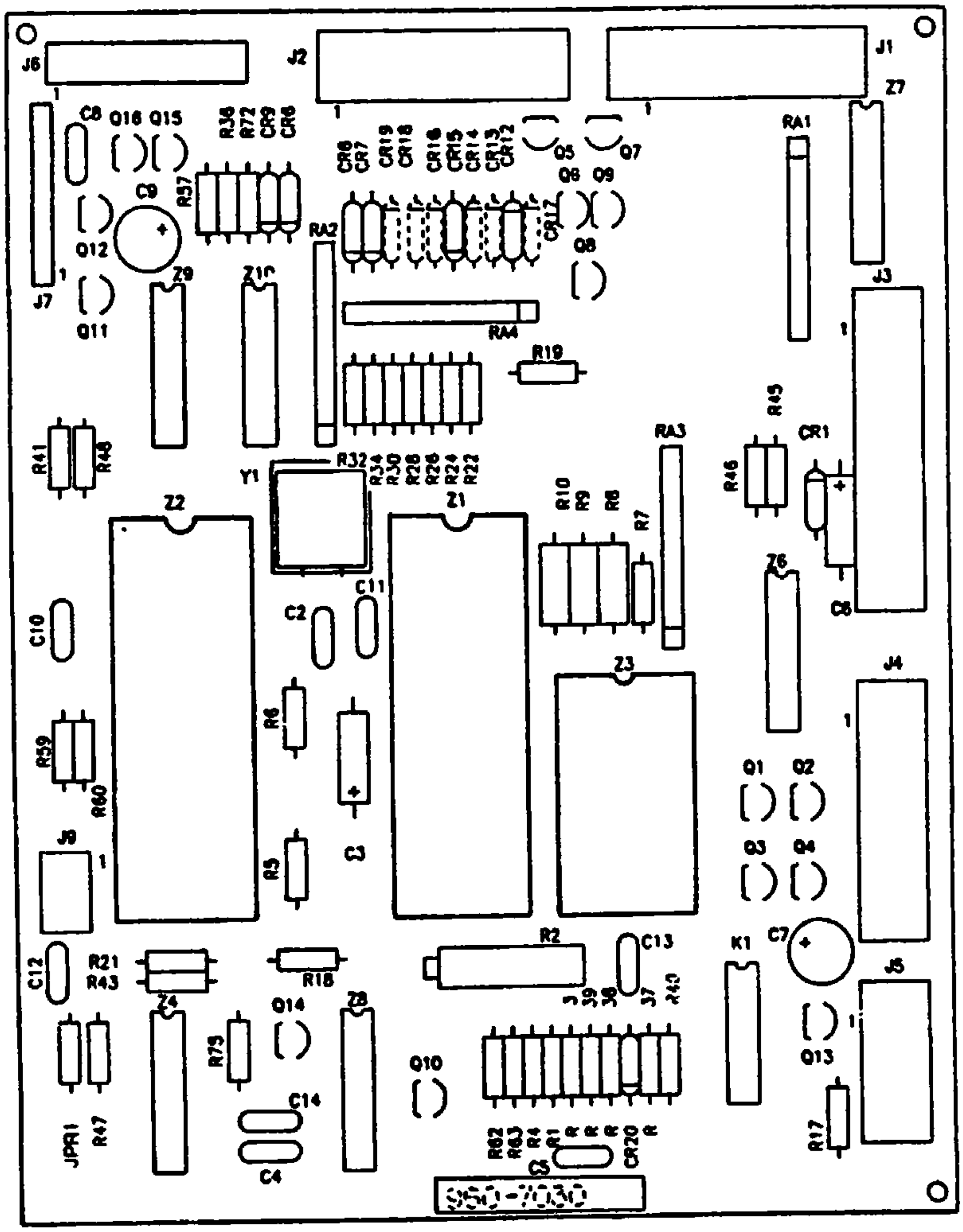

Figure 6-7. Parts Identification 960A/*965A* MLB Circuit Card Assembly

Table 6-7a. Parts List 960A/*965A* Power and Display CCA (PIP/P4.x)

Fig No/ Ref Desig	Qty	Description	Part No.	Reference
6-2	1	CCA, Power and Display, 960A	960-7046-1	
	1	PWB, Power and Display, 960A/965A	960-6046-7	
		Displays		
DS1-DS7	7	Display, 7-Segment, Green (LA310)	815054	
DS8	1	Diode, Green, Rect. LED	813307	
DS9	1	Diode, Red, Rect. LED	813318	
DS10	1	Display, Yellow Quad-LED Pkg (HLMP 2450)	815053	
DS11	1	LCD	960-3002-8	
		Connectors		
J1,J2	2	Connector, Socket, 40 Pin in Line	856022	
J3		NOT USED		
J4	1	Connector, 2 x 6 Header	851069	
J5	1	Connector, 2 x 5 Header	851001	
J6	1	Connector, 2 x 13 Header	851006	
J7	1	Connector, 2 x 7 Header	851025	
J8	1	Connector, 3 in Line Header	851023	
J9	1	Flex Strip, 18 Pins-in-Line	828000	
J10		NOT USED		
J11	1	Connector, 2-Pin	851051	
J12	1	Connector, 4-Pin	851050	
		Capacitors		
C1	1	Capacitor, 68μF, 15V, TANT	811197-686A	
C2	1	Capacitor, 470 pF, CERAMIC, AXIAL	811246-471a	
C3	1	Capacator, .001 μF, 50V, CERAMIC	811246-102	
C4	1	Capacitor, 10μF, 10V, TANT	811116-106	
C5	1	Capacitor, 390pF, 50V, CER COG	811294-391A	
C6	1	Capacator, .001 μF, 50V, CERAMIC	811246-102	
C7	1	Capacitor, 47μF, 10V, TANT	811117-476	
C8,C9	2	Capacitor, 30pF, 50V, CERAMIC	811245-300A	
C10	1	Capacator, .001 μF, 50V, CERAMIC	811246-102	
C11	1	Capacitor, 100 pF, 50V, CERAMIC	811246-101A	
C12-C15	4	Capacitor, .001 μF, 50V, CERAMIC	811246-102	
C16	1	Capacitor, 0.1μF, AXIAL, CERAMIC	811247-104A	
C17	1	Capacitor, 2.2μF, 10V, AXIAL, TANT	811116-225A	
C18		NOT USED		
C19	1	Capacitor, .01μF, 50V, AXIAL, CERAMIC	811246-103A	
C20	1	Capacitor, 100μF, 10V, AXIAL, TANT	811116-107A	
C21	1	Capacitor, 2.2μF, 10V, AXIAL, TANT	811116-225A	
C22	1	Capacitor, 4700μF, 35V-Elect	811399-478	
C23	1	Capacitor, .001μF, 50V, CERAMIC	811246-102	
C24	1	Capacitor, 0.1μF, AXIAL, CERAMIC	811247-104A	
C25	1	Capacitor, 0.01μF, 50V, AXIAL, CERAMIC	811246-103A	
C26	1	Capacitor, 0.1μF, AXIAL, CERAMIC	811247-104A	
C27	1	Capacitor, 330μF, 10V, ELECT	811317-337	
C28-C30	3	Capacitor, 0.1μF, AXIAL, CERAMIC	811247-104A	

Table 6-7a. Parts List 960A/*965A* Power and Display CCA (PIP/P4.x)
(continued)

Fig No/ Ref Desig	Qty	Description	Part No.	Reference
C31	1	Capacitor, 0.1µF, 50V, CERAMIC, RAD	811246-104-1	
		Diodes		
CR1-CR8	8	Diode, IN4148, SIGNAL	813500	
CR9	1	Diode, IN5711, SCHOTTKY	813019	
CR10-CR12	3	Diode, IN4148, SIGNAL	813500	
CR13-CR16	4	Diode, MBR350, SCHOTTKY-POWER	813504	
CR17		NOT USED		
CR18	1	Diode, IN4148, SIGNAL	813500	
CR19		NOT USED		
CR20	1	Diode, MBR350,SCHOTTKY-POWER	813504	
CR2		NOT USED		
CR22	1	Transient Supp, 5V UNIPOL (IN5908)	813024	
CR23-CR25	3	Diode, IN4148, SIGNAL	813500	
		Displays		
DS1-DS7	7	Display, 7-Segment, Green (LA310)	815054	
DS8	1	Diode, Green, Rect. LED	813307	
DS9	1	Diode, Red, Rect. LED	813318	
DS10	1	Display, Yellow QUAD-LED Pkg (HLMP-2450)	815053	
		Integrated Circuits		
U1	1	I.C. M72I8C LED-Controller	812197	
U2,U3	2	I.C. MM5453N LCD-Driver	812198	
U4	1	I.C. 74HCT373 OCTAL LATCH	812056	
U5	1	I.C. EPROM PHOENIX CIP V4.0	960-1126-1	
U6	1	I.C. 74HC4060 Counter CMOS	812095	
U7	1	I.C. 74HCT32 QUAD NAND, CMOS	812090	
U8	1	I.C. 8032A 8-BIT N-MOS CPU	812123	
U9	1	I.C. 82C55A CMOS, Programmable EPROM	812199	
U10	1	I.C. 74HCT373 OCTAL LATCH	812056	
U11	1	I.C. 74HCT139 DUAL DECODER, CMOS	812116	
U12	1	I.C. LM324A QUAD OP-AMP	812195	
U13	1	I.C. MC1403 2.5V, REF	812022	
U14	1	I.C. UC2524A PWM Controller	812168	
U15	1	I.C. 74HCT574	812122	
		Resistors		
RA1	1	Resistor Array, 39Ω, DIP, 16-Pin ISO	812085	
RA2	1	Resistor Array, 3.9KΩ, DIP, 16-Pin ISO	812086	
RA3	1	Resistor Array, 47KΩ, SIP, 10-Pin BUS	810900-473	
RA4	1	Resistor Array, 33KΩ, SIP, 10-Pin BUS	810900-333	
R1	1	Resistor, 10KΩ, 5%, 1/4W, MF	810125-103	
R2	1	Resistor, 1MΩ, 5%, 1/4W, MF	810125-105	
R3	1	Resistor, 2.2KΩ, 5%, 1/4W, MF	810125-222	
R4	1	Resistor, 100Ω, 5%, 1/4W, MF	810125-101	

Table 6-7a. Parts List 960A/*965A* Power and Display CCA (PIP/P4.x) (continued)

Fig No/ Ref Desig	Qty	Description	Part No.	Reference
R5	1	Resistor, 2.2KΩ, 5%, 1/4W, MF	810125-222	
R6	1	Resistor, 100Ω, 5%, 1/4W, MF810125-101		
R7	1	Resistor, 2.2KΩ, 5%, 1/4W, MF	810125-222	
R8,R9	2	Resistor, 51Ω, 5%, 1/4W	810125-510	
R10,R11	2	Resistor, 47KΩ, 5%, 1/4W, MF	810125-473	
R12	1	Resistor, 10KΩ, 5%, 1/4W, MF	810125-103	
R13	1	Resistor, 511KΩ, 1%, 1/4W, MF	810223-5113	
R14	1	Resistor, 100KΩ, 5%, 1/4W, MF	810125-104	
R15	1	Resistor, 2.2KΩ, 5%, 1/4W, MF	810125-222	
R16,R17	2	Resistor, 10KΩ, 5%, 1/4W, MF	810125-103	
R18,R19	2	Resistor, 47KΩ, 5%, 1/4W, MF	810125-473	
R20	1	Resistor, 5.6KΩ, 5%, 1/4W, MF	810125-562	
R21	1	Resistor, 47KΩ, 5%, 1/4W, MF	810125-473	
R22	1	Resistor, 24.9KΩ, .25%, 1/4W, MF	810219-2492	
R23	1	Resistor, 1.47KΩ, .25%, 1/4W,	810219-1471	
R24	1	Resistor, 20.0KΩ, .25%, 1/4W, MF	810219-203	
R25		NOT USED		
R26,R27	2	Resistor, 1KΩ, 5%, 1/4W, MF	810125-102	
R28	1	Resistor, 200Ω, 5%, 1/4W, MF	810125-201	
R29,R30	1	Resistor, 10.0KΩ, 1%, 1/4W, MF	810229-103	
R31	1	Resistor, 47KΩ, 5%, 1/4W, MF	810125-473	
R32	1	Resistor, 2.2KΩ, 5%, 1/4W, MF	810125-222	
R33	1	Resistor, 270Ω, 5%, 1/4W, MF	810125-271	
R34		NOT USED		
R35	1	Resistor, 12.0KΩ, 5%, 1/4W, MF	810125-123	
R36	1	Resistor, 20Ω, 5%, 1/4W, MF	810125-200	
R37	1	Resistor, 0.1Ω, 1%, 400mW, MF	810591-OR1	
R38		NOT USED		
R39	1	Resistor, 4.75KΩ, 1%, 1/4W, MF	810229-4751	
R40	1	Resistor, 47KΩ, 5%, 1/4W, MF	810125-473	
R41	1	Resistor, 4.7KΩ, 5%, 1/4W, MF	810125-472	
R42,R43	2	Resistor, 1KΩ, 5%, 1/4W, MF	810125-102	
R44	1	Resistor, 17.8KΩ, 1%, 1/4W, MF	810221-1782	
R45	1	Resistor, 40.2KΩ, 1%, 1/4W, MF	810221-4022	
R46	1	Resistor, 1KΩ, 5%, 1/4W, MF	810125-102	
R47	1	Resistor, 121Ω, 1%, 1/4W, MF	810223-1210	
R48	1	Resistor, 1KΩ, 1%, 1/4W	810229-102	
R49	1	Resistor, 47KΩ, 5%, 1/4W, MF	810125-473	
R50	1	Resistor, 100KΩ, 5%, 1/4W, MF	810125-104	
R51	1	Resistor, 4.7KΩ, 5%, 1/4W, MF	810125-472	
R52,R53	2	Resistor, 100Ω, 5%, 1/4W, MF	810125-101	
R54,R55		NOT USED		
R56,R57	2	Resistor, 100KΩ, 5%, 1/4W, MF	810125-104	
R58	1	Resistor, 2.2KΩ, 5%, 1/4W, MF	810125-222	
R59	1	Resistor, 10KΩ, 5%, 1/4W, MF	810125-103	
R60-R63	4	Resistor, 3.9KΩ, 5%, 1/4W, MF	810125-392	
		Transistors		
Q1-Q4	4	Transistor, 2N4401, NPN	814103	
Q5-Q8	4	Transistor, MPSA13, NPN	814301	

Table 6-7a. Parts List 960A/*965A* Power and Display CCA (PIP/P4.x) (continued)

Fig No/ Ref Desig	Qty	Description	Part No.	Reference
Q9	1	Transistor, 2N4403, PNP	814104	
Q10	1	Transistor, LM317, ADJ. Regulator	812178	
Q11	1	Transistor, MJE210, Power NPN	814201	
Q12	1	Transistor, 2N4403, PNP	814104	
Q13	1	Transistor, MPSA13, NPN	814301	
Q14	1	Transistor, 2N4403, PNP	814104	
Q15	1	Transistor, MFP12P08, Power FET	814109	
Q16	1	Transistor, MJE210, Power NPN	814201	
Q17-Q19	3	Transistor, MPSA13, NPN	814301	
Q20	1	Transistor, 2N4401, NPN	813103	
		Sockets		
XU5	1	Socket, I.C. 28 CKT	815002-3	
XU8,XU9	2	Socket, I.C. 40 CKT	815002-1	
XDS10	1	Socket, 8-Pin, MACH SIP	856071	
		Miscellaneous		
	1	Backlight Assembly	960-1101-1	
PS1	1	Inverter	960-3526-8	
L1	1	Choke, 320 µH, Toroid	1310-3007-7	
Y1	1	Crystal, 12.00 Mhz	815023	
K1	1	Relay, DIP, SPST 5V Coil	815000	
F1	1	Fuse, 5 Amp, 3AG	842004	
	2	Fuse, Clip, Dual Size	845026	
JPR1,JPR2	2	Test Point	815032	
	14	I.C. Spacer, .060" Thick	805037	
	Ref	Schematic, Power and Display	960-5039	

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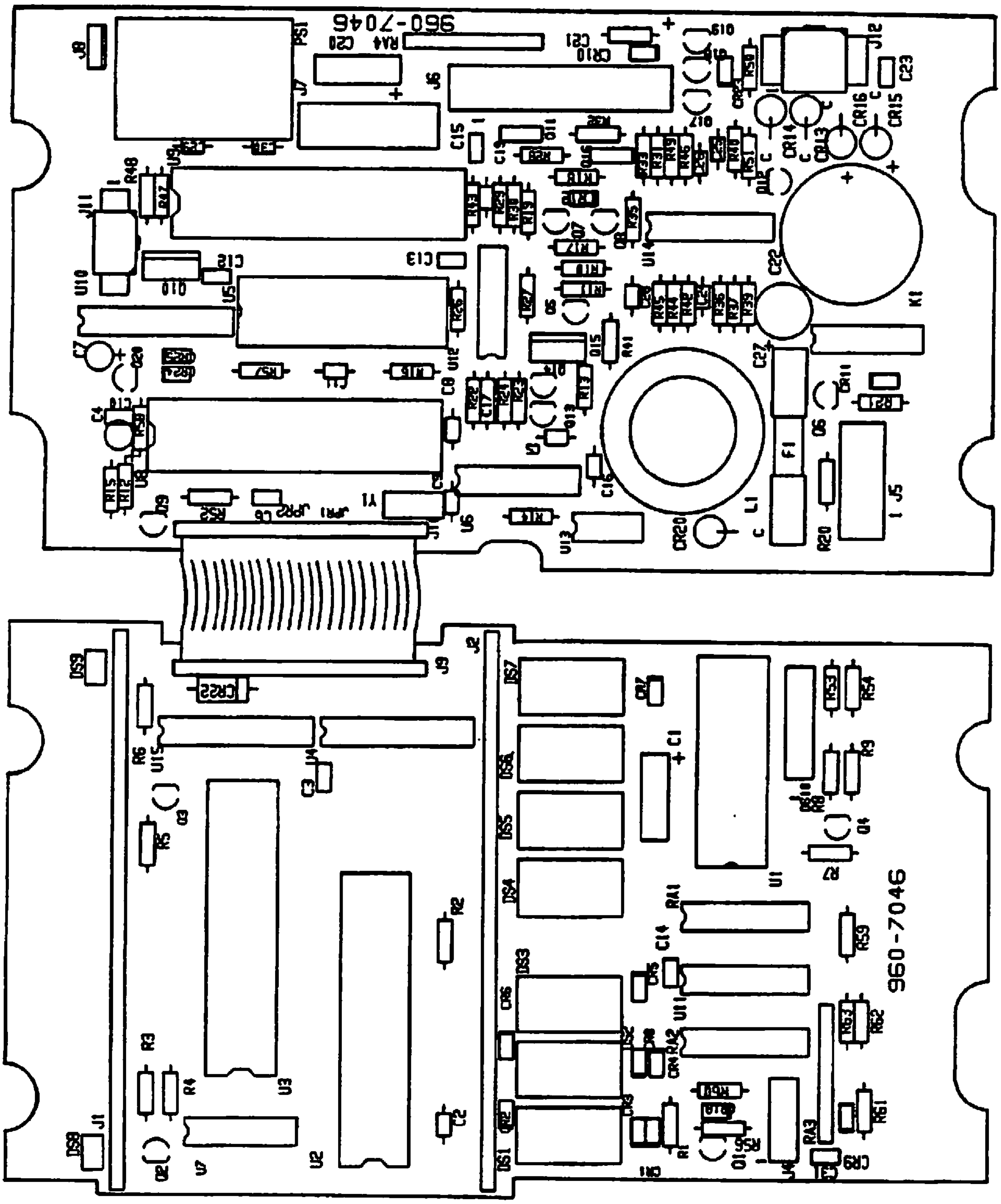

Figure 6-7a. Parts Identification 960A/*965A* (PIP/P4.x) Power & Display CCA

Table 6-8. Parts List 960A/*965A* Front Panel Assembly (HIGHTOWER)

Fig No/Item		Qty	Description	Part No	Reference
6-2	80	X	Front Panel Assembly	960-1081-1	
6-2	*80*	*X*	*Front Panel Assembly*	*965-1035-1*	
6-8	10/*10*	1	Circuit Card Assembly, Keyboard & Display	960-7035-1	Table 6-9
6-8	20/*20*	1	EL Panel Assembly	960-1054-1	
6-8	30	1	Keyboard Overlay Assy 960A	960-2148-7	
6-8	*30*	1	*Keyboard Overlay Assy 965A*	*965-2022-7*	
6-8	40/*40*	3	Harness Assy Rate & Volume Switch	960-1084-1	
6-8	50/*50*	1	Gasket, Front Panel	960-3005-7	
6-8	60/*60*	1	LCD, Transreflective Back	960-3002-8	
6-8	80	1	Connector, Jumper, 2 ckt Shrouded	815003	
6-8	90/*90*	4	Screw, #4-40 x 3/8" PHH	801003	
6-8	100/*100*	4	Washer, #4 Lock	803203	

Table 6-9. Parts List 960A/*965A* Front Panel Circuit Card Assembly Keyboard and Display (HT)

Fig No/	Ref Desig	Qty	Description	Part No	Reference
6-8	10	X	Circuit Card Assembly, Keyboard & Display	960-7035-1	
		1	PWB, Display & Keyboard	960-6031-7	
			Integrated Circuits		
6-9	U1	1	Microcomputer, Programmed	960-1083-1	
6-9	U2	1	I.C. Peripheral Port 82C55A-2	812199	
6-9	U3	1	I.C. LCD Driver 145453	812198	
6-9	U4	1	I.C. LED Driver ICM7218CIJI	812197	
6-9	U5	1	I.C. LCD Driver 145453	812198	
			Transistors		
6-9	Q1,Q2	2	Transistor, Darlington MPSA13	814301	
6-9	Q3	1	Transistor, PNP 2N4403	814104	
6-9	Q4	1	Transistor, NPN MJE210	814201	
6-9	Q5-Q7	3	Transistor, Darlington MPSA13	814301	
6-9	Q8	1	Transistor, PNP 2N4403	814104	
6-9	Q9,Q10	2	Transistor, Darlington MPSA13	814301	
			Diodes		
6-9	CR1-CR9	9	Diode, Switching 1N4148	813500	
6-9	CR10	1	Transorb, 10V SA10	813021	
6-9	CR11-CR20	9	Diode, Switching 1N4148	813500	
			Displays		
6-9	DS1-DS7	7	LED, 7 segment, Green LA3410	815054	
6-9	DS8	1	LED, Rectangular Green	813307	
6-9	DS9	1	LED, Rectangular Red	813318	
6-9	DS10	1	LED, Rectangular Yellow HLMP 2450	815053	
			Capacitor		
6-9	C1	1	Capacitor, 0.1µF, 50V CER	811247-104A	
6-9	C2,C3	2	Capacitor, 10pF, 50V	811245-300A	
6-9	C4	1	Capacitor, 1µF, 10V	811137-105A	
6-9	C5	1	Capacitor, 0.1µF, 50V CER	811247-104A	
6-9	C6	1	Capacitor, 39µF, 50V	811116-396A	
6-9	C7	1	Capacitor, 470pF, 50V	811246-471A	
6-9	C8	1	Capacitor, 39µF, 50V	811116-396A	
6-9	C9-C11	3	Capacitor, 1000pF, 50V	811247-102A	
6-9	C12	1	Capacitor, 1µF, 10V	811137-105A	
			Resistor		
6-9	R1	1	Resistor, 10KΩ, 1/4W, 5%	810125-103	

Table 6-9. Parts List 960A/*965A* Front Panel Circuit Card Assembly
Keyboard and Display (HT) (continued)

Fig No/	Ref Desig	Qty	Description	Part No	Reference
6-9	R2	1	Resistor, 1MΩ, 1/4W, 5%	810125-105	
6-9	R3-R5	3	Resistor, 10KΩ, 1/4W, 5%	810125-103	
6-9	R6,R7	2	Resistor, 100Ω, 1/4W, 5%	810125-101	
6-9	R8	1	Resistor, 39Ω, 1/4W, 5%	810125-390	
6-9	R9-R12	4	Resistor, 47KΩ, 1/4W, 5%	810125-473	
6-9	R13	1	Resistor, 680Ω, 1/4W, 5%	810125-681	
6-9	R14		NOT USED		
6-9	R15,R16	2	Resistor, 82Ω, 1/4W, 5%	810125-820	
6-9	R17	1	Resistor, 680Ω, 1/4W, 5%	810125-681	
6-9	R18	1	Resistor, 10KΩ, 1/4W, 5%	810125-103	
6-9	R19	1	Resistor, 47KΩ, 1/4W, 5%	810125-473	
6-9	R20	1	Resistor, 5.6KΩ, 1/4W, 5%	810125-562	
6-9	R21	1	Resistor, 47KΩ, 1/4W, 5%	810125-473	
6-9	R22	1	Resistor, 39Ω, 1/4W, 5%	810125-390	
6-9	R23	1	Resistor, 47KΩ, 1/4W, 5%	810125-473	
6-9	R24	1	Resistor, 100KΩ, 1/4W, 5%	810125-104	
6-9	R25	1	Resistor, 10KΩ, 1/4W, 5%	810125-103	
			Resistor Array		
6-9	RA1	1	Resistor, 1KΩ, SIP 8 pin	810900-102H	
6-9	RA2	1	Resistor, 10KΩ, 1/4W, 5%	810900-103	
6-9	RA3	1	Resistor, 82Ω, 1/4W, DIP 16 pin	812102	
6-9	RA4	1	Resistor, 10KΩ, 1/4W, 5%	810900-103	
6-9	RA5	1	Resistor, 39Ω, 1/4W, 2%,DIP 16 pin	812085	
			Miscellaneous		
6-9	Y1	1	Crystal, 20pF 12.00 MHz	815023	
6-9	J1,J2	2	Header, unshrouded 2x10	851005	
6-9	J3	1	Connector, 3 Ckt Locking Header	851023	
6-9	J4	1	Connector, header, 2x6 unshrouded	851069	
6-9	J5	1	Header, unshrouded 1x3	851048	
6-9	J6	1	Header, unshrouded 2x10	851005	
6-9	J7,J8	2	Connector, Socket 1x20	856022	
6-9	J9	1	Connector, header, 2x3 unshrouded	851017	
6-9	TP1	1	Header, unshrouded 1x2	851018	
		1	Socket, 40 pin DIP	856068	
		1	Socket, 1x8	856070	
		1	Press Stud	809092	
		REF	Schematic, Front Panel	960-5028	

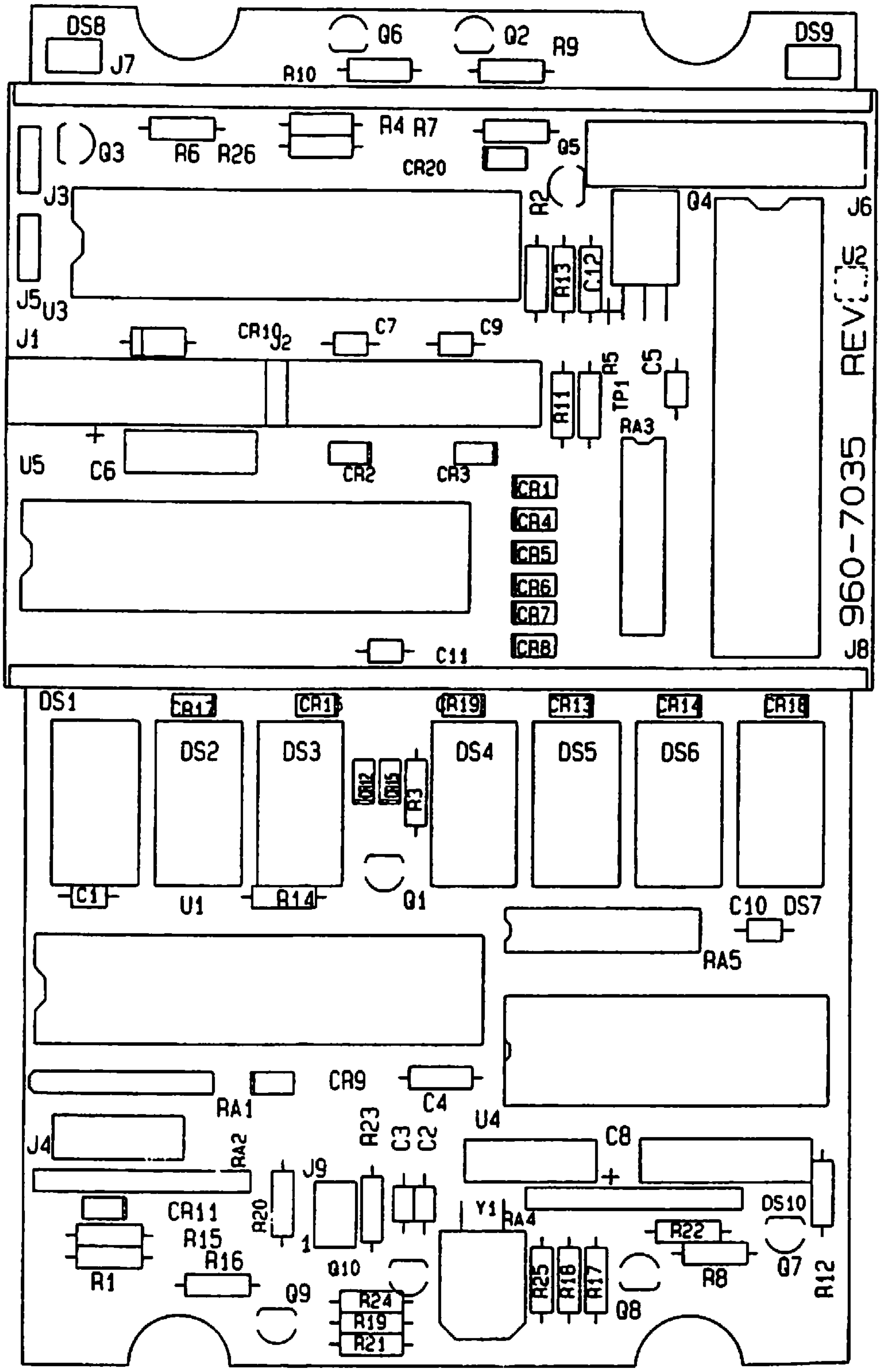

Figure 6-9. Parts Identification 960A/*965A* Front Panel Circuit Card Assembly Keyboard and Display (HT)

Table 6-10. Parts List 960A/*965A* Rear Case Assembly

Fig No/Item		Qty	Description	Part No	Reference
6-1	20	X	Rear Pump Assembly (F)	960-1073-1	
6-1	20	X	Rear Pump Assembly (HT)	960-1085-1	
6-1	20	X	**Rear Pump Assemble (PIP/P4.x)**	**960-1104-1**	
6-10	10	1	Audio Harness Assembly (F) (P-0.x/1.x ONLY)	960-1014-1	
Not Shown		1	**Audio Cable Assembly (PIP/P4.x)**	**960-1074-1**	
6-10	20	1	Nurse Call Harness Assembly (P-0.x/1.x ONLY)	960-1068-1	
6-10	30	1	Power Supply PCB Assembly	960-7034-1	Table 6-11
6-10	35	1	**Battery Back-Up PCB Assembly (PIP/P4.x)**	**960-7043-1**	Table 6-12
6-10	40	1	Battery Harness Assy. Quick Discon (F)	960-1020-2	
		1	Harness Assembly, Battery/Audio (HT)	960-1071-1	
6-10	45	1	**AC/DC Power Harness Assembly (PIP/P4.x)**	**960-1100-1**	
		1	**Transformer 220V**	**960-2145-7**	**with item 45**
6-10	70	1	Power Receptacle, AC / **(PIP/P4.x)**	960-2127-7/8	
6-10	80	1	Heatsink, Pole clamp	960-2107-7	
6-10	90	1	Case, Rear / **(PIP/P4.x)**	960-2099-7/8	
6-10	100	1	Clip, Line Cord	960-2005-7	
6-10	110	2	Insert, Pole Clamp	960-2032-7	
6-10	120	2	Pad, Heatsink	960-2139-7	
Not Shown		1	Seal, Case 42" (in recess item 90)	960-2142-8	
Not Shown		1	Seal, Case 13" (in recess item 90)	960-2142-7	
On chassis		1	Label, Fuse Warning (back of item 180)	960-2070-7	
Not Shown		1	**Label, Battery (PIP/P4.x)**	**1320-2245-7**	
6-10	140	1	**Label, Rear Pump (PIP/P4.x) (Ver P-4.x & Sub)**	**960-2151-7**	
6-10	150	1	Seal, Conductive, 42 inches	960-2185-8	
6-10	160	1	Seal, Conductive, 13 inches	960-2185-7	
6-10	180	1	Chassis	960-2096-7	
6-10	190	1	**Transformer, 110V (PIP/P4.x)**	**960-2184-7**	
		1	Transformer, 110V	960-2143-7	alt item 190
6-10	220	1	Top Plate, Machined	960-2015-9	
6-10	230	1	Frame, Machined	960-2014-9	
6-10	240	1	Knob	960-2008-7	
6-10	250	1	Shaft	960-2007-7	
6-10	260	1	Wedge	960-2006-7	
6-10	270	1	Seal, Audio Switch	960-2089-7	
6-10	280	1	Insulator, Heatsink	960-2144-7	With item 30
6-10	285	Alt	Insulator, Heatsink	847034	Alt item 280
6-10	290	2	Feet, Rubber	809002	
6-10	300	1	Switch, Momentary	840011	
6-10	310	1	Button, Engraved AUDIO	840003	
6-10	320	1	Sonalert	847000	
6-10	330	1	Battery, 6V, 10 Amp-Hr	841012	
6-10	340	1	Fuse, 0.4A Slo-blo 1/4 x 1 1/4	842018	
6-10	390	1	Ring Retaining	806201	
6-10	400	2	Thrust Race	806003	
6-10	410	1	Screw, Set	801408	
6-10	420	AR	Lubricant, #111	831011	
Not Shown		2	Screw, #6-32 x 1/4" PPH CAD (connects GND wire to item 180)	801000	

Table 6-10. Parts List 960A/*965A* Rear Case Assembly
(continued)

Fig No/Item		Qty	Description	Part No	Reference
6-10	460	2	Screw, #10-32 x 1" PPH	801046	
6-10	470	2	Screw, 1/4-20 x 3/4" PPH	801010	
6-10	480	2	Screw, 1/4-20 x 1 1/4" PPH	801011	
6-10	490	8	Screw, #8-32 x 3/8" PPH	801007	
6-10	500	2	Screw, #4-40 x 3/8" PPH	801003	
Not Shown		2	Washer, Lock #6 Int tooth (connects GND wire to item 180)	803201	
6-10	540	6	Washer, Lock #8 Int tooth	803200	
6-10	550	2	Washer, Lock #10 Int tooth CAD	803204	
6-10	560	4	Washer, Lock 1/4 Int tooth	803205	
6-10	570	1	Washer, Flat #4 .016 Thk	803000	
6-10	575	2	Screw, 4-40 x 1/4 PPH	801003	
6-10	580	2	Washer, Lock #4 Int tooth	803202	
6-10	590	1	Washer, Shoulder	803612	
6-10	600	10	**Washer, #8, FLW ANSI B27.2 Type B SS (PIP/P4.x)**	**803031**	
6-10	610	2	**Nut, #8 KEP (PIP/P4.x) (Ver P-4.x & Sub)**	**802002**	
6-10	620	2	Nut, KEP #4	802201	
6-10	625	1	**Cotter Pin (PIP/P4.x) (Ver P-4.x & Sub)**	**804201**	
6-10	630	1	Nut, Panel 3/8-32 (Ver P-0.x ONLY)	802007	with item 20
Not Shown		1	Tie Wrap (holds transformer to chassis)	834001	
Not Shown		1	**Clip, Cable 1/4 inch Dia. (PIP/P4.x)**	**845024**	

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Table 6-11. Parts List 960A/*965A* Power Supply PCB Assembly

Fig No/	Ref Desig	Qty	Description	Part No	Reference
6-10	30	X	Power Supply PCB Assembly	960-7034-1	
6-11	J10	1	Backlight, PWR Supply Harness	960-1052-1	
6-11	P8	1	PWR Supply Input Harness	960-1018-1	
6-11	P7	1	PWR supply Output Harness	960-1019-1	
6-11		1	PWB, Power Supply	960-6024-7	
			Capacitors		
6-11	C1	1	Capacitor, 1000µF,25V,20%,Elec	811397-108A	
6-11	C2	1	Capacitor, 0.1µF,12V,CERDISC,20%	811227-104	
6-11	C3	1	Capacitor, 0.01µF,400V,10%	811896-103	
6-11	C4	1	Capacitor, 100µF,10V,TANT RADIAL	811116-107	
6-11	C5	1	Capacitor, 2.2µF,10V,TANT AXIAL	811116-225A	
6-11	C6	1	Capacitor, 22µF,35V,TANT RADIAL	811196-226	
6-11	C7,C8	2	Capacitor, 0.1µF,500V,CER DISC,+80/-20	811299-104	
			Diodes		
6-11	CR1	1	Diode IN5400	813201	
6-11	CR2,CR3	2	Diode IN4148	813500	
			Integrated Circuits		
6-11	Z1	1	I.C., Bridge Rect.,2W005	815014	
6-11	Z2	1	I.C., Voltage Regulator, LM317	812178	
6-11	Z3	1	I.C., Op Amp, LM324	812026	
6-11	Z4	1	I.C., Prec. Lo Volt, 1403	812022	
			Resistors		
6-11	R1	1	Potentiometer,5K,3/4W, +/- 10%	810396-502	
6-11	R2	1	Resistor, 4.3KΩ, +/- 5%, 1/4W	810125-432	
6-11	R5	1	Resistor, 200Ω, +/- 5%, 1/4W	810125-201	
6-11	R6,R7	2	Resistor, 10KΩ, +/- 1%, 1/4W	810223-103	
6-11	R8	1	Resistor, 20KΩ, +/- 5%, 1/4W	810125-203	
6-11	R9	1	Resistor, 10KΩ, +/- 5%, 1/4W	810125-103	
6-11	R10	1	Resistor, 680Ω, +/- 5%, 1/4W	810125-681	
6-11	R12	1	Resistor, 24.9KΩ, .25%, 1/4W	810219-2492	
6-11	R13	1	Resistor, 1KΩ, +/- 5%, 1/4W	810125-102	
6-11	R15	1	Resistor, 1.47KΩ, .25%, 1/8W	810219-1471	
6-11	R16	1	Resistor, 20.0KΩ, .25%, 1/8W	810219-2002	
6-11	R17	1	Resistor, 1KΩ, +/- 5%, 1/4W	810125-102	
6-11	R18	1	Resistor, 10KΩ, +/- 5%, 1/4W	810125-103	
			Miscellaneous		
6-11	Q1,Q2	2	Transistor, PNP MJE210	814201	
6-11	F1	1	Fuse, 5 Amp, Pico Fuse	842001	
		Ref	Power Supply Schematic	960-5024	

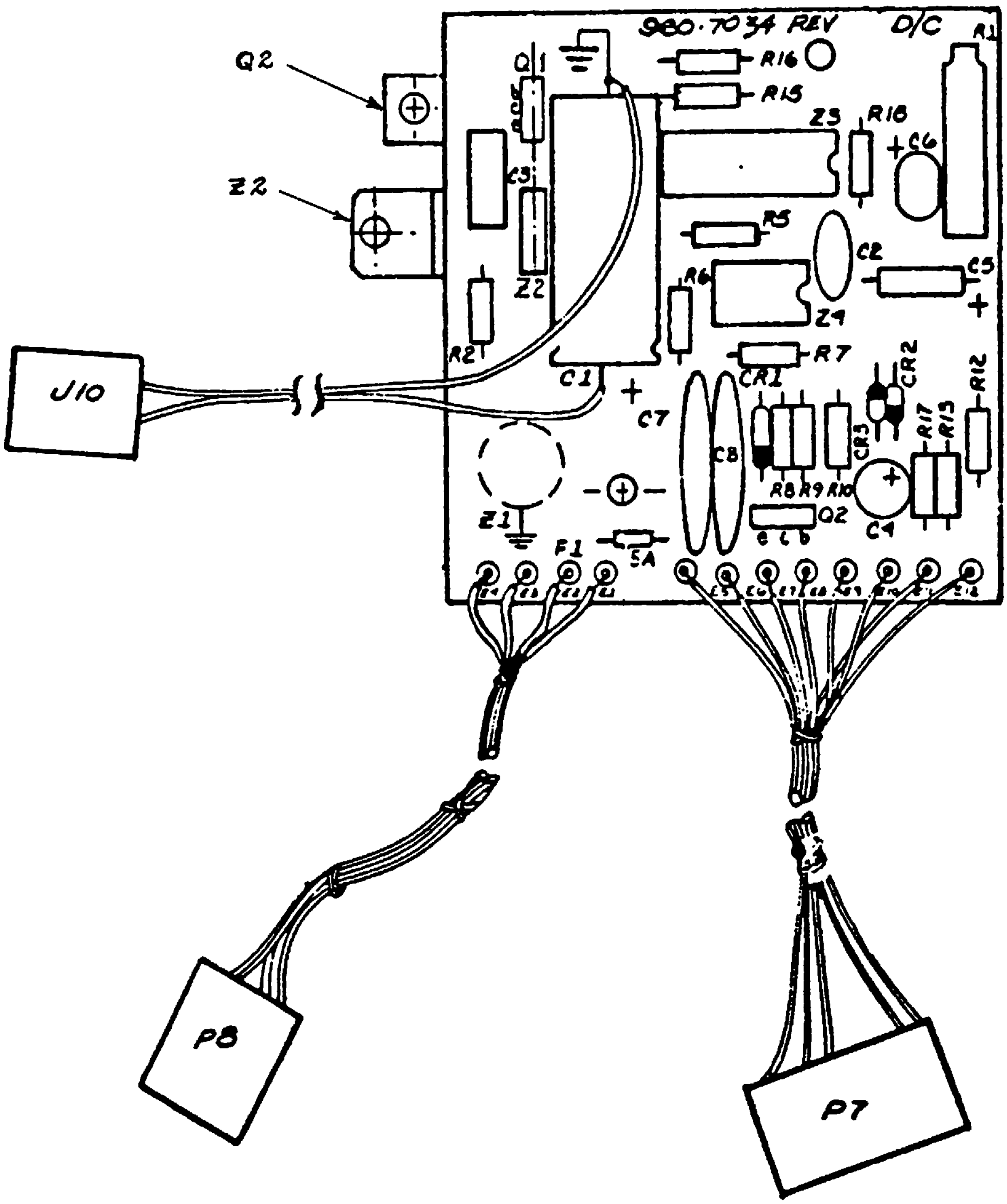

Figure 6-11. Parts Identification 960A/965A Power Supply PCB

Table 6-12. 960A/965A Battery Back-Up PCB Assembly (PIP/P4.x)

Fig No/ Ref Desig		Qty	Description	Part No	Reference
6-10	35	X	Battery Back-Up PCB Assembly (PIP/P4.x)	960-7043-1	
6-12	10	1	PWB Battery, Back-Up	960-6043-7	
B1		1	Battery, NICAD 4.8V	841018	
U1		1	I.C. LM393N Dual Comparator	812167	
C1		1	Capacitor, 1μF, 20V, 10% TANT	811136-105A	
J1		1	Connector, IDC, 10 Ckt, RIB/PC	854005	
J2		1	Connector, HDR, 4-wall 2 x 5	851001	
P5		1	Connector, IDC, 2 x 5 Female Plug	850001	
D1,D2		1	Diode, Schottky, MBR 120P	813503	
D3		1	I.C. Ref 2.5V Lo Pwr	812151	
Q1		1	Transistor, 2N4103	814103	
Q2		1	Transistor, 2N4403	814104	
Q3		1	Transistor, 2N4103	814103	
R1		1	Resistor, 47KΩ, 5%, 1/4W, CF	810125-473	
R2,R3		2	Resistor, 10KΩ, 5%, 1/4W, CF	810125-103	
R4		1	Resistor, 680Ω, 5%, 1/4W, CF	810125-681	
R5		1	Resistor, 10KΩ, 5%, 1/4W, CF	810125-103	
R6		1	Resistor, 47KΩ, 5%, 1/4W, CF	810125-473	
R7		1	Resistor, 75KΩ, 1%, 1/4W, MF	810229-753	
R8		1	Resistor, 100KΩ, 5%, 1/4W, MF	810229-104	
R9		1	Resistor, 47KΩ, 5%, 1/4W, CF	810125-473	
R10		1	Resistor, 51Ω, 5%, 1/4W, CF	810125-510	
		AR	Cable Ribbon 10 x 26 AWG	829011	
		Ref	Schematic, Battery Back-Up	960-5043	

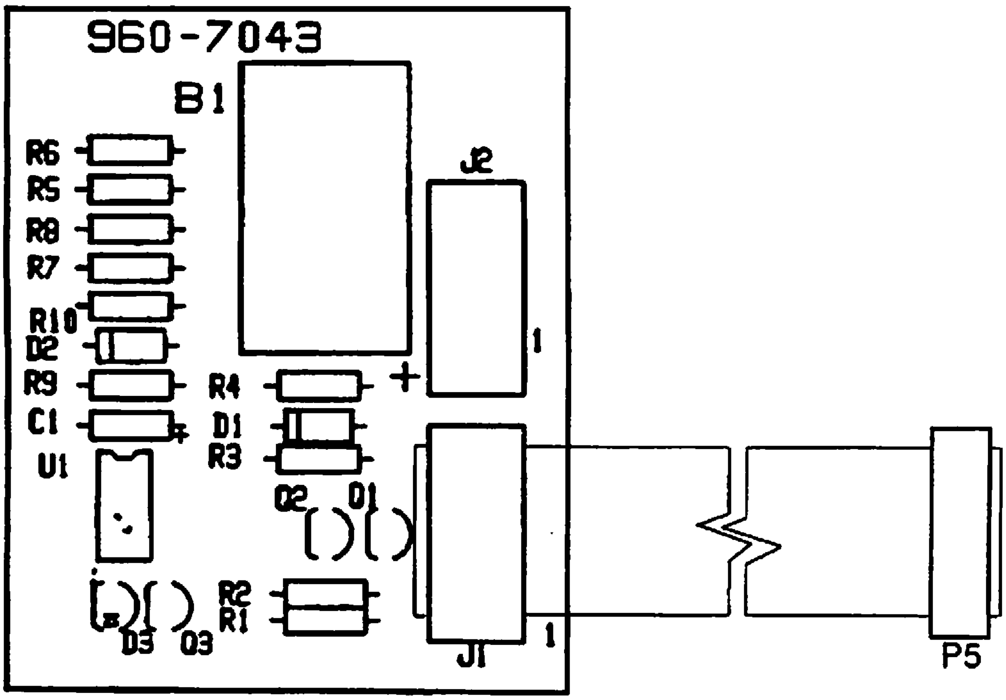

Figure 6-12. Parts Identification 960A/*965A* Battery Back-Up PCB Assembly (PIP/P4.x)

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INFUSION DEVICE DISCREPANCY REPORT

FACILITY DATA:

Hospital Name:______________________________ Technician's Name:______________

Telephone No. (____)________________________ Date of Report________________

DEVICE DATA:

Model: ☐PC-1 ☐PC-2 ☐980 ☐980C ☐960A ☐965A ☐______ Serial No.____________

OPERATING CONDITION:

Electrical Power: ☐AC LED On: ☐Yes ☐No; ☐Battery LED On: ☐Yes ☐No

Reorder No. for Installed set:____________ Fluid Infusing:____________________

Delivery Mode Selected: (PC-1, -2 ONLY) ☐Pump ☐Controller ☐VersaTaper ☐AutoTaper

☐Universal ☐Micro ☐Macro P/C Mode Locked: ☐Yes ☐No; ECD Connected: ☐Yes ☐No

Access Mode (980/980C): ☐1 ☐2; Occlusion Pressure Switch: ☐High ☐Low

Operational Control: ☐Independent ☐Host Computer; If computer, ☐Monitor or ☐Computer Control

Primary Parameters: RATE ______ VTBI ______ Infusion in progress: ☐Primary ☐Secondary

Secondary Parameters:RATE ______ VTBI ______ Bottle Height:_____ Needle/Cath. size:____

Please forward the set, installed when the problem occurred, along with the Instrument

ALARM/MALFUNCTION DATA:

Audio tone sound: ☐Yes ☐No; Pumping stop: ☐Yes ☐No; Device Shutdown: ☐Yes ☐No

Message Display:______________; Error Code Displayed: _____ Error Log Checked: ☐Yes ☐No

Error Log Entries: (PC-1, -2) ____, ____, ____, ____, ____, ____, ____, ____, ____, ____.

Was Problem repeatable: ☐Yes ☐No Other Equipment Operating in Vicinity: ☐Yes ☐No

If Yes, type Equipment: ______________, ______________, ______________

Troubleshooting Actions Performed: ______________________________________

Remarks/Comments:____

____

____

IMED Form 9000-x (1/90)

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