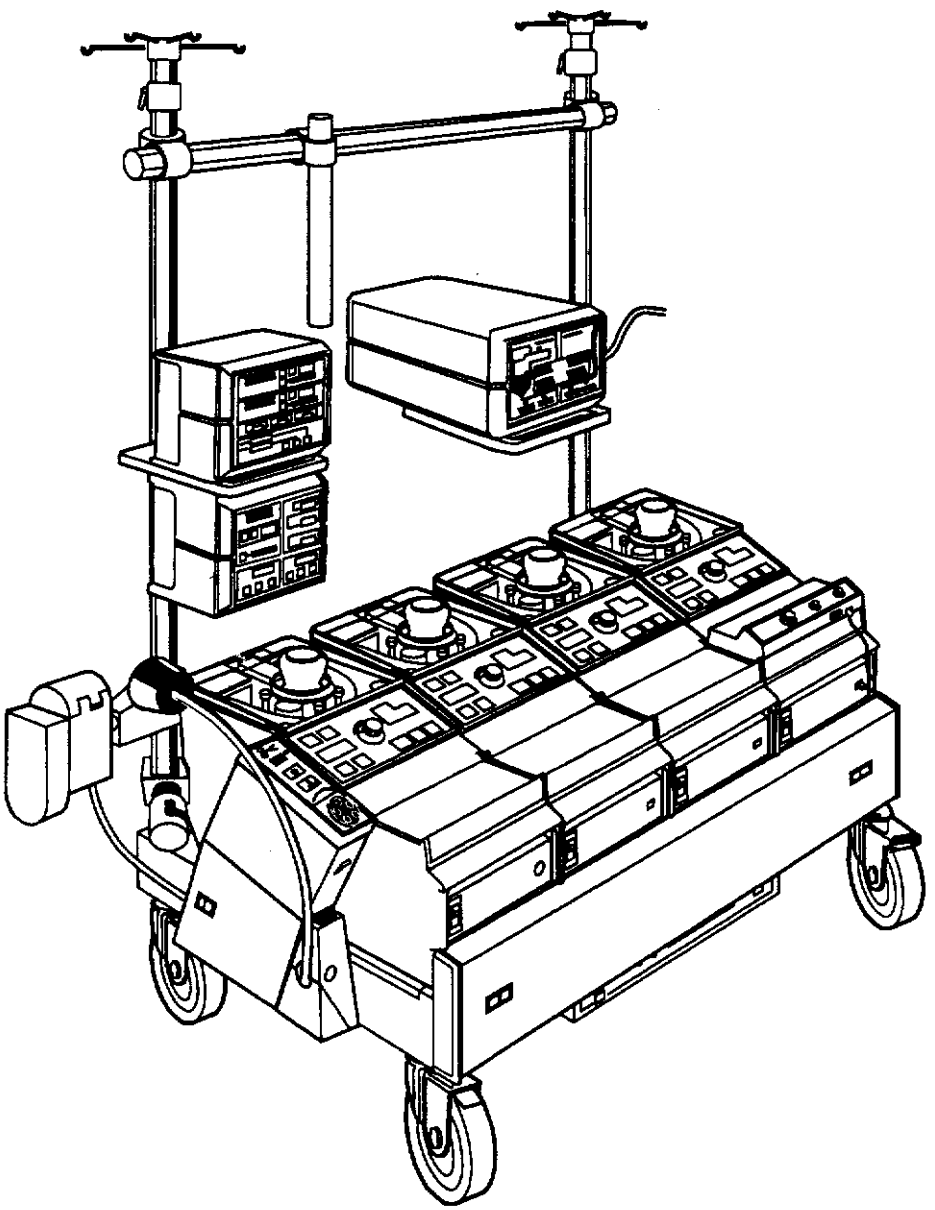
Field Service Handbook

Sarns™ 8000 Modular Perfusion System



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Sarns
3M Health Care
6200 Jackson Road
Ann Arbor, Michigan 48103

3M

How To Use This Manual

This manual provides technical information about the Sarns™ 8000 Perfusion System. It is intended only for those trained to service Sarns equipment. The information in this manual is specific to this system and should not be used for any other equipment.

Repairs may be made only by persons specifically trained and certified by Sarns to work on the 8000 Perfusion System.

Fully test the 8000 Perfusion System after each servicing.

8000 Perfusion System

3M ID	Description
98-0702-0643-2	5 pump base, 100V
98-0702-0644-0	5 pump base, 115V
98-0702-0645-7	5 pump base, 220-240V
98-0702-0640-8	4 pump base, 100V
98-0702-0641-6	4 pump base, 115V
98-0702-0642-4	4 pump base, 220-240V
98-0702-0646-5	Pump module, 100V
98-0702-0647-3	Pump module, 115V
98-0702-0648-1	Pump module, 220-240V
98-0702-0660-6	Safety Monitor
98-0702-0655-6	Arterial Monitor
98-0702-0654-9	Cardioplegia Monitor
98-0702-0659-8	Occluder Module
98-0702-0722-4	Battery Module

Additional Information Communications Module

This insert contains technical information and instructions for inspecting the Communications Module of the Safety Monitor on a 3M™ Sarns™ 8000 Modular Perfusion System.

Insert these pages into the appropriate section of the Sarns™ 8000 Perfusion System Field Service Handbook as directed.

Table of Contents	Replace pages	i, ii
Table of Contents, Section 1	Replace pages	1-3,1-4
Communications Module Performance Specification	Insert pages	1-84 — 1-97
Table of Contents, Section 5	Replace pages	5-1, 5-2
Troubleshooting, Communications Module	Insert pages	5-22
Table of Contents, Section 6	Replace page	6-1
System Diagrams, Communications Interface	Insert page	6-22
Illustrated Parts Breakdown, Section 7	Replace pages	7-19, 7-20

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34-9998-3373-3 R/A

Section 1. System Description

Section 2. Maintenance

Section 3. Adjustment Procedures

Section 4. Replacement Procedures

Section 5. Troubleshooting

Section 6. System Diagrams

Section 7. Illustrated Parts Breakdown

Additional Information Ultrasonic Air Sensor Pulse Module

This insert contains technical information and instructions for inspecting the Ultrasonic Air Detection System and the Pulse Module on a 3M™ Sarns™ 8000 Modular Perfusion System.

The air detection information in this insert applies to the following ultrasonic air sensors:

Color	Description	Catalog No.	3M ID No.
Red	3/8 in x 3/32 in (9,5 mm x 2,4 mm)	5773	78-8067-6923-4
Gold	1/4 in x 3/32 in (6,4 mm x 2,4 mm)	5791	78-8067-6922-6
Black	1/4 in x 1/16 in (6,4 mm x 1,6 mm)	5785	78-8067-6921-8

The pulse module information in this insert applies to Pulse Module, 3M ID 98-0702-0657-2, Catalog No. 16416.

It is recommended that the following parts be ordered for technician parts inventory:

For Ultrasonic Air Sensor:

3M ID	Description	Qty
78-8067-7375-6	Cable Asby, UAS to Control	1

For Pulse Module:

3M ID	Description	Qty
78-8067-4666-1	Cable Asby, Pulse to Pump	1
78-8067-4379-1	Cable Asby, Potentiometer	1
78-8067-7068-7	Cable Asby, LED	1
78-8067-4385-8	PC Asby, Main Board	1

Insert these pages into the appropriate section of the Sarns™ 8000 Perfusion System Field Service Handbook as directed below.

Table of Contents	Replace pages i, ii
Table of Contents, Section 1	Replace pages 1-3, 1-4
Pulse Module Performance Specification	Insert pages 1-82, 1-83
Section 2, Maintenance	Replace pages 2-5 through 2-15
Table of Contents, Section 5	Replace pages 5-1, 5-2
Troubleshooting, Pulse Module	Insert pages 5-19 through 5-21
Table of Contents, Section 6	Replace page 6-1
System Diagrams, Pulse Board	Insert page 6-20
System Diagrams, Pulse Schematic	Insert page 6-21
Table of Contents, Section 7	Replace page 7-1
Illustrated Parts Breakdown	Insert pages 7-35 through 7-37

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34-9998-3073-9 R/A

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Section 1. System Description

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Table of Contents

Performance information was selected from the performance specifications for the 8000 Perfusion System, including monitors and modules.

1.1 System Revision History

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1.2 Accessories

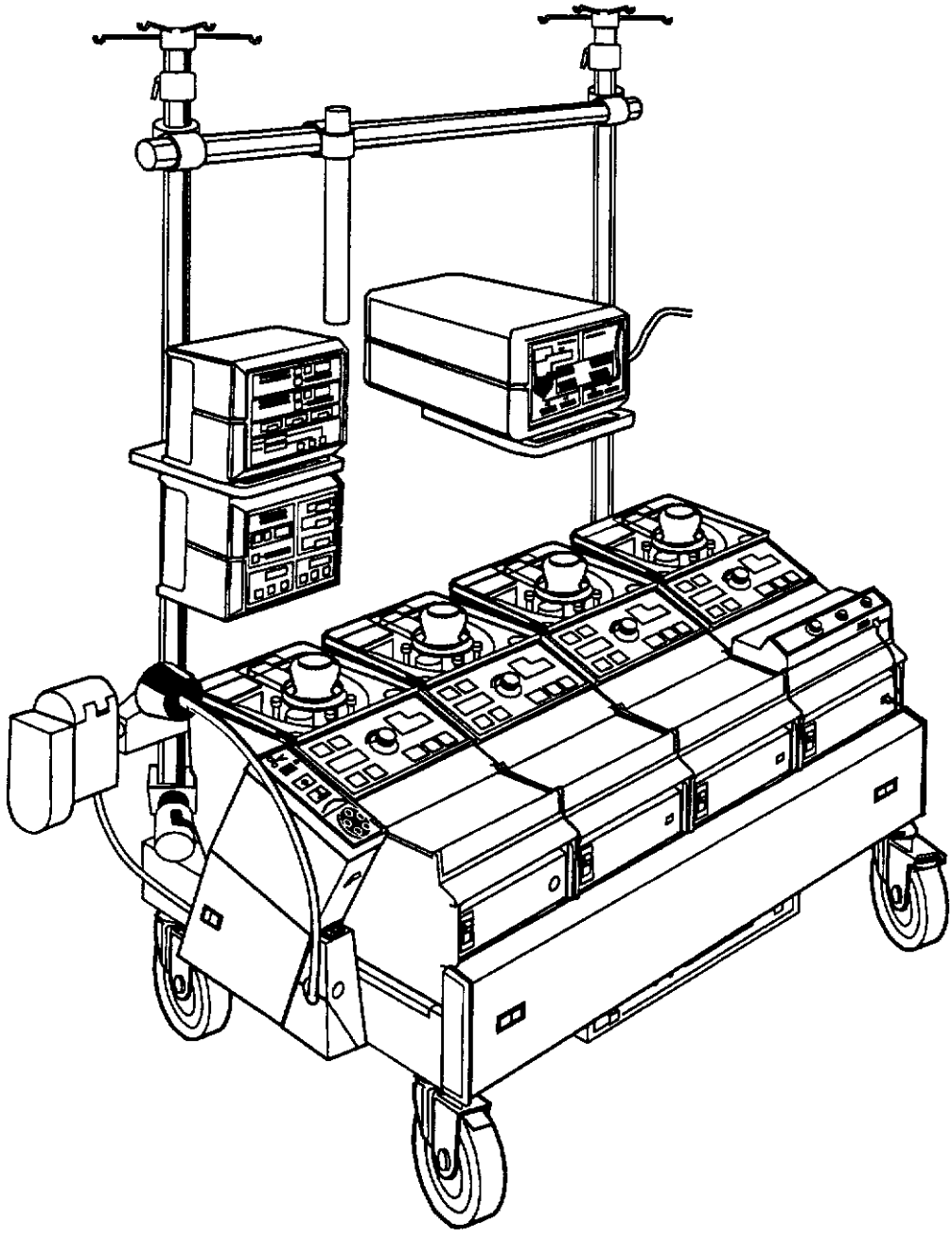
Part Number	Description
78-8067-4166-2	Accessory Kit
78-8067-4930-1	Cable Retainer, 1/2 inch
78-8067-5068-9	Cable Retainer, 1 inch
98-0702-0275-3	Instrument Tray with Long Mounting Arm
78-8066-6728-9	Level Sensor Transducers
98-0702-0272-0	Level Sensor Pads, 20 sets per box
98-0702-0305-8	Long Mounting Arm with 5/8 inch (1,6 cm) pole
98-0702-0692-9	Mounting Arm for Monitors
78-8066-9381-4	Pole Mounted Writing Surface
98-0702-0664-8	Positionable Lamp
78-8066-6721-4	Pressure Transducer
98-0702-0353-8	Pressure Transducer Holder
98-0702-0211-8	Pressure Transducer Monitoring Kit
98-0702-0304-1	Short Mounting Arm with 5/8 inch (1,6 cm) pole
78-8066-7511-8	Solution Rack
78-8066-7520-9	Tube Clamp Assemblies

1.3 Abbreviation Key

ART	Arterial
CB	Circuit Breaker
CPG	Cardioplegia
DVM	Digital Volt Meter
DSP	Digital Signal Processing

1.4 System Description

1.4.1 System Components



1.4.2 Functional Description

The Sarns™ 8000 Modular Perfusion System is a four-unit or five-unit modular heart/lung machine that will accommodate Sarns modular blood pumps. Besides the base and pumps, the basic system includes the safety monitor for level and air bubble detection. The safety monitor receives power and transmits stop-line signals from the base.

Options that can be added include the arterial and cardioplegia monitors, occluder module, lamp, and battery module.

Each pump receives power from one of the pigtail power cords coming from the front of the base, behind the front access door. Alarms are available for air detection, level detection and excessive pressure. When appropriately configured, these alarms stop the arterial and/or cardioplegia pumps.

A pump can be assigned for arterial use by connecting the base pigtail marked ART to the pump connector marked ART/CPG. The cardioplegia pump is so assigned by connecting the pigtail marked CPG to the ART/CPG connector of that pump. These pigtails contain the stop lines for the pump and the RS-485 computer communications lines.

The arterial pump will stop when an activated air detector senses the presence of air, when an activated level detector senses low volume conditions in the reservoir, or when the arterial monitor detects over pressure alarm conditions. The cardioplegia pump will stop during an arterial alarm condition or if the cardioplegia monitor detects an over pressure alarm condition. An arterial pump stop due to over pressure is enabled by connecting an 8000 monitor to the ART port on the safety monitor. Similarly, a cardioplegia pump stop due to over pressure is enabled by connecting an 8000 monitor to the CPG port on the safety monitor.

Two auxiliary outlets are located on the front of the base. One outlet will lose its power if the safety system alarms while the other will not. In this way, the perfusionist has the choice of whether or not to stop attached equipment in the event of an alarm condition.

A 24 VDC receptacle for the lamp is located beneath the base at either end of the base power supply pan so that a lamp can be connected at either end of the base. If the optional battery module is installed, the power to the lamp will be uninterrupted.

The occluder connector is located at the left end of the base power supply pan. The occluder cable is long enough to accommodate locating the occluder at either end of the base. If the optional battery module is installed, power to the occluder will be uninterrupted.

The arterial and cardioplegia monitors interconnect with the 8000 system through the rear of the safety monitor. If the battery module is installed, all three monitors (safety, arterial and cardioplegia) will receive uninterrupted power.

The optional battery module is mounted underneath the base. Electrical connection is made by removing the stainless steel top from the base and connecting the two cables as defined in the battery module performance specification. Uninterruptable power is available for the 8000 pumps to which the ART and CPG battery cables are connected, as well as to the system components indicated above.

> **Warning**: If a battery module is not included on an 8000 system, the safety system will not be operational if main power is lost. When handcranking due to loss of power, the safety systems are not operational; monitor closely for air and reservoir level.

1.4.3 Theory of Operation

The Sarns™ 8000 Modular Perfusion System is a robust, state-of-the-art, modular heart/lung machine for extracorporeal oxygenation and perfusion of a patient during cardiovascular surgery. The system can be configured to meet a surgical center's unique needs by selecting from the number of 8000 options provided.

Accessory equipment such as gas blenders, flowmeters, blood gas monitors, or other patient monitors can be mounted to the standard 1.3 in. (3,3 cm) poles. The 8000 system is intended to meet all worldwide standards for perfusion equipment. Accessory equipment requiring significant power (e.g., cooler/heaters) needs separate power outlets and should not be connected to a base power receptacle.

1.5 Modular Perfusion System Performance Specification

1.5.1 Introduction

The Sarns™ 8000 Modular Perfusion System is indicated for use in extracorporeal circulation of blood for arterial perfusion, regional perfusion and cardiopulmonary bypass procedures only, when used by a qualified perfusionist who is experienced in the operation of Sarns or similar equipment.

It consists of various modules and monitors which receive power from the base module.

This specification provides an overview of the system and its performance. For details, refer to the appropriate specification listed below (See Section 1, System Characteristics).

Base Electronics Performance Specification
Safety Monitor Performance Specification
Arterial Monitor System Performance Specification
Cardioplegia Monitor System Performance Specification
Roller Pump Performance Specification
Occluder Module Performance Specification
Battery Module Performance Specification

1.5.2 Operating Parameters

Electrical Power Requirements

	115 V Bases	220-240 V Bases	100 V Bases
Voltage:	103.5-126.5 V~ (115 V, nominal)	198-264 V~ (220-240 V, nominal)	90-110 V~ (100 V, nominal)
Frequency:	50/60 Hz	50/60 Hz	50/60 Hz
Circuit Breaker Protection:	16 amps	8 amps	16 amps
Fully loaded system current rating*:			
4 pump base	13 amps	6 amps	14 amps
5 pump base	15 amps	7 amps	16 amps
Base for 4 Pumps**	16400 (98-0702-0641-6)	16405 (98-0702-0642-4)	16409 (98-0702-0640-8)
Base for 5 Pumps**	16401 (98-0702-0644-0)	16406 (98-0702-0645-7)	16410 (98-0702-0643-2)

Notes: *A fully loaded system is defined as follows:

4 or 5 pumps properly occluded with 1/2 in. diameter tubing. Water circuit is at ambient temperature. Pump in continuous mode and running at 250 RPM. Both lamps on. Both auxiliary outlets loaded at specified rating. Occluder activated (stalled). Safety, Arterial and Cardioplegia Monitors on. Battery Module installed.
**5 digit numbers are catalog numbers; 11 digit numbers are 3M I.D. numbers.

Electrical Power Performance

Leakage Current: <100 microamperes for 115 V and 100 V bases (fully loaded); <200 microamperes for 220-240 V bases (fully loaded).

The maximum leakage current for the base without pumps is 45 microamperes for all input voltages.

Ground Resistance: 0.1 Ohm maximum for all bases.

Emergency Power: 8000 system battery (two 12 volt, sealed gel cell batteries) will power the arterial pump (operating in continuous mode), the monitors, occluder and lamp for 40 minutes; when the arterial pump is operated in pulsatile mode or the cardioplegia pump is also operating on battery power, the battery time available will diminish to 25 minutes.

The base is tested for high potential.

- 1200V~ for 100-115 VAC units.
- 1500V~ for 220-240 VAC units.

Environmental Conditions

Operation	10° to 40°C, less than 95% relative humidity, noncondensing.
Storage	Ventilated area, -30°C to 54°C (-22 to 130°F),less than 95% relative humidity, noncondensing.
Transporting	Units may be transported up or down an incline of up to 15 degrees without tipping.

1.5.3 Functional Description

The Sarns™ 8000 Modular Perfusion System is a four-unit or five-unit modular heart/lung machine that will accommodate Sarns modular blood pumps. Besides the base and pumps, the basic 8000 system includes the 8000 Safety Monitor for level and air bubble detection. The Safety Monitor receives power and transmits stop-line signals via the multiconductor cable from the base.

Options that can be added include the 8000 Arterial and Cardioplegia Monitors, 8000 Occluder Module, 8000 Lamp and 8000 Battery Module.

Each pump receives power from one of the pigtail power cords coming from the front of the base, behind the front access door. Alarms are available for air detection, level detection and excessive pressure. When appropriately configured, these alarms stop the arterial and/or cardioplegia pumps.

A pump can be assigned for arterial use by connecting the base pigtail marked "ART" to the pump connector marked ART/CPG. The cardioplegia pump is so assigned by connecting the pigtail marked "CPG" to the ART/CPG connector of that pump. These pigtails contain the stop lines for the pump and the RS-485 computer communications lines.

The arterial pump will stop when an activated air detector senses the presence of air, when an activated level detector senses low volume conditions in the reservoir, or when the arterial monitor detects over-pressure alarm conditions. The cardioplegia pump will stop during an arterial alarm condition or if the cardioplegia monitor detects an overpressure alarm condition. An arterial pump stop due to overpressure is enabled by connecting an 8000 monitor to the ART port on the safety monitor. Similarly, cardioplegia pump stop due to overpressure is enabled by connecting an 8000 monitor to the CPG port on the safety monitor.

Two auxiliary outlets are located on the front of the base. One outlet is switched, the other is not. That is to say, one outlet will lose its power if the safety system alarms while the other will not. In this way, the perfusionist has the choice of whether or not to stop attached equipment in the event of an alarm condition.

A 24 VDC receptacle for the lamp is located beneath the base at either end of the base power supply pans so that a lamp can be connected at either end of the base. If the optional Battery Module is installed, power to the lamp will be uninterrupted.

The occluder connector is located at the left end of the base power supply pan. The occluder cable is long enough to accommodate locating the occluder at either end of the base. If the optional Battery Module is installed, power to the occluder will be uninterrupted.

The Arterial and Cardioplegia Monitors interconnect with the 8000 system through the rear of the Safety Monitor. If the Battery Module is installed, all three monitors (Safety, Arterial and Cardioplegia) will receive uninterrupted power.

1.5.3 Functional Description (Continued)

The optional Battery Module is mounted underneath the base. Electrical connection is made by removing the base's stainless steel top and connecting the two cables as defined in the Battery Module performance specification (See Section 1, System Characteristics). Uninterruptable power is available for the 8000 pumps to which the ART and CPG battery cables are connected, as well as to the system components indicated above.

> **Warning**: If a battery module is not included on an 8000 system, the safety system will not be operational if main power is lost. When handcranking due to loss of power, the safety systems are not operational; monitor closely for air and reservoir level.

1.5.4 Physical Description

The base is of stainless steel construction mounted on four polyurethane casters. The casters on the left end of the machine will lock so that the base does not roll if positioned on an incline. The casters on the right end of the machine will lock in position so that they will not swivel. With just the right-end casters locked and in the trailing position, the base is easily maneuvered by pulling it.

A polyethylene cover protects the base from fluid spills. The pump feet rest in depressions in this base cover; the weight of the pump keeps the pump in place and allows easy removal from the base.

The poles for mounting accessory equipment on the 8000 system are standard 1.30 in. (3,3 cm) stainless steel. Special fittings connect the horizontal cross bars to the two vertical poles of the system.

The monitor brackets mount around a pole, just above a split-ring collar; the monitors slide onto a track located on the bracket assemblies.

System Dimensions

Base:	with 4 pumps	with 5 pumps
Height	25.8 in. (65,5 cm)	same
Width	33.3 in. (84,5 cm)	41.6 in. (105,6 cm)
Depth	26.5 in. (67,3 cm)	same
Weight	330 lbs. (149,5 kg)	380 lbs (172,1 kg)

Pump	Roller
Height	14.0 in. (35,6 cm)
Width	8.2 in. (20,8 cm)
Depth	19.7 in. (50,0 cm)
Weight	50 lbs (22,6 kg)

Telescoping Pole: 1.30 in. (3,3 cm) diameter, 6-7 ft. (1,8 -1,9 m) height.

1.5.5 Electrical Description

> **Note:** Always refer to appropriate module specifications for details.

The 8000 base electronics distributes main voltage to the pumps and converts it to 24 VDC unregulated power for the various modules of the system. The main circuit breaker controls power to the entire system. Most modules and pumps have their own on/off circuit breaker, but the communications and pulse modules receive power directly from their electrical connectors.

There are two fuses in the base which protect the transformers of the internal power supply and the Battery Module power supply.

The circuit breaker switch on the rear of the Safety Monitor controls 24 VDC power to the monitors. Each monitor has one internal fuse to protect against internal electrical faults. The stop-line signals from the Safety Monitor to the arterial and cardioplegia pumps are separate current loops.

The Battery Module is intended to be used for uninterruptable backup power to the arterial and cardioplegia pumps, lamp, pole monitors and occluder. In order to conserve maximum backup power, the 8000 system should only be powered using an AC voltage source.

The Sarns™ 8000 Modular Perfusion System has been designed to be approvable by all global regulatory agencies including FDA, UL, CSA and TUV.

1.5.6 Interface

Refer to the individual performance specifications of the various modules for details on the user interfaces.

1.5.7 Theory of Operation

The Sarns™ 8000 Modular Perfusion System is a robust, state-of-the-art, modular heart/lung machine for extracorporeal oxygenation and perfusion of a patient during cardiovascular surgery. The system can be configured to meet a surgical center's unique needs by selecting from the number of 8000 options provided.

Accessory equipment such as gas blenders, flowmeters, blood gas monitors, or other patient monitors can be mounted to the standard 1.3 in. (3,3 cm) poles. The 8000 system is intended to meet all worldwide standards for perfusion equipment. Accessory equipment requiring significant power (e.g., cooler/heaters) needs separate power outlets and should not be connected to a base power receptacle.

1.5.8 Calibration and Configuration Specification

Any base, pump module or Battery Module can be configured to accommodate various global power sources. It is essential that all modules and the base are configured to the same local power voltage. Refer to the wiring diagram of each module for setup.

1.5.9 Service

All parts are accessible for servicing.

1.5.9.1 Field Service Diagnostics

Not Applicable

1.5.9.2 Preventive Maintenance Guide

The Sarns™ 8000 Modular Perfusion System should receive preventive maintenance inspections every six months. The Battery Module batteries should be replaced every two years.

1.5.9.3 Precautions

See the various module specifications regarding aspects which may affect the safety of service personnel or functionality of the unit.

1.6 Base Electronics Performance Specification

1.6.1 Operating Parameters

Electrical Power Requirements

	115 V Bases	220-240 V Bases	100 V Bases
Voltage:	103.5-126.5 V~ (115 V, nominal)	198-264 V~ (220-240 V, nominal)	90-110 V~ (100 V, nominal)
Frequency:	50/60 Hz	50/60 Hz	50/60 Hz
Circuit Breaker Protection:	16 amps	8 amps	16 amps
Fully loaded system current rating*:			
4 pump base	13 amps	6 amps	14 amps
5 pump base	15 amps	7 amps	16 amps
Base for 4 Pumps**	16400 (98-0702-0641-6)	16405 (98-0702-0642-4)	16409 (98-0702-0640-8)
Base for 5 Pumps**	16401 (98-0702-0644-0)	16406 (98-0702-0645-7)	16410 (98-0702-0643-2)

Notes: *A fully loaded system is defined as follows:
4 or 5 pumps properly occluded with 1/2 in. diameter tubing. Water circuit is at ambient temperature. Pump in continuous mode and running at 250 RPM. Both lamps on. Both auxiliary outlets loaded at specified rating. Occluder activated (stalled). Safety, Arterial and Cardioplegia Monitors on. Battery Module installed.

**5 digit numbers are catalog numbers; 11 digit numbers are 3M I.D. numbers.

1.6.1 Operating Parameters (Continued)

Electrical Performance

Leakage Current: <100 microamperes for 115V and 100V bases (fully loaded); <200 microamperes for 220-240V bases (fully loaded).

The maximum leakage current for the base non-loaded is 45 microamperes for all input voltages.

Ground Resistance:
- 0.1 Ohm maximum for all bases.

High potential testing:
- 1200V~ for 100-115 VAC units.
- 1500V~ for 220-240 VAC units.

Emergency Power: 8000 system battery (two 12 volt, sealed gel cell batteries) will power the arterial pump (properly occluded, and operating in continuous mode), the monitors, occluder and lamp for 40 minutes; when the arterial pump is operated in pulsatile mode or the cardioplegia pump is also operating (properly occluded) on battery power, the battery time available will diminish to 25 minutes.

Environmental Conditions

Operation	10° to 40°C, less than 95% relative humidity, noncondensing.
Storage	Ventilated area, -30° to 54°C (-22 to 130°F), less than 95% relative humidity, noncondensing.
Stability	Units, loaded with any combination of 8000 system components, may be transported up or down an incline of up to 15° without tipping.

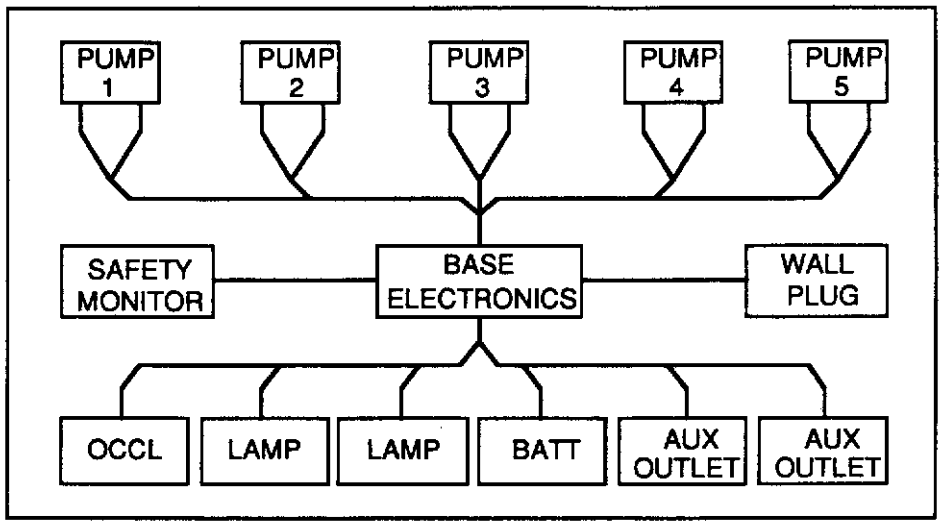
Watts x 0.341 = 655 BTU
20A dedicated outlet

1.6.2 Functional Description

The 8000 base is a multidistribution center which distributes AC and DC voltages throughout the base and also handles communication and safety lines.

The base (see figure below) provides connection points for the following:

- Power cord with wall plug
- 4-5 8000 pumps
- Safety Monitor
- Occluder Module
- Two lamp assemblies
- Battery Module
- Two auxiliary outlets



1.6.2.1 DC Power Supply

The DC power supply has a minimum output of 21 VDC or greater, with a maximum load of 8 amps at the minimum specified voltage. The power supply also has a maximum output of 36 VDC or less, with a minimum load of 0.5 amp at the maximum specified voltage.

1.6.2.2 AC Power Supply

The AC power supplies are designed to deliver output voltages equal to that of the input line voltage.

The AC power to the 8000 Pumps is not isolated from the wall input AC supply. The same is tapped off terminal block TB2, which is connected directly to the input AC line voltage through terminal block TB1 and circuit breaker CB1.

The AC power to the external outlets is isolated from the the wall input AC supply. The same is tapped off terminal block TB3 and TB4, which are connected directly to the isolation transformers (secondary winding) T2 and T3.

The AC supply to the Battery Module is not isolated from the wall input AC supply. The same is tapped off terminal block TB1, which is connected directly to the input AC line voltage through circuit breaker CB1.

1.6.3 Physical Description

System Dimensions

Base:	with 4 pumps	with 5 pumps
Height	25.8 in. (65,5 cm)	same
Width	33.3 in. (84,5 cm)	41.6 in. (105,6 cm)
Depth	26.5 in. (67,3 cm)	same
Weight	330 lbs. (149,5 kg)	380 lbs (172,1 kg)

Telescoping Pole: Diameter 1.30 in. (3,3 cm)
Height 6-7 ft. (1,8 -1,9 m)

Two casters steer & wheel lock 6 in. diameter.
Two casters steer lock 6 in. diameter.

1.6.4 Electrical Description

The 8000 base electronics consist of one DC power supply and three AC power supplies. The supplies are designed to drive limited amounts of loads protected by circuit breakers and fuses.

The main circuit breaker controls both DC and all AC power supplies.

The following subsections provide detailed information concerning the above mentioned DC and AC power supplies.

1.6.4.1 DC Power Supply:

The DC power supply section of the base electronics is composed of an input line filter (LF1), a terminal block (TB5), an isolated step down transformer (T1), a diode rectifier bridge (DB1), a current limiting resistor (R1), a filter capacitor (C1), two Schottky rectifier fast diodes (D1 and D2) and three linear regulators mounted on a printed circuit board.

- The DC power supply has the ability to deliver uninterruptible DC power to the safety monitor and all the DC powered accessories connected to it. This is achieved only when the battery option is installed.

1.6.4.2 AC Power Supply

The AC section of the base electronics is composed of three types of power supplies as follows:

- Direct line supply: This supply is composed of a main system circuit breaker (CB1), a distribution terminal block (TB1), a section of the configuration terminal block (TB2), and a section of the configuration/distribution terminal blocks (TB3 and TB4).

  This supply is used to drive all the pumps (each protected with its own circuit breaker), and the Battery Module which is protected by a slo-blow fuse.

  See base distribution board performance specifications for details.

- Isolated supply No. 1: This supply is composed of a 1:1 isolation transformer (T2), a section of the configuration terminal block (TB2) and a section of the configuration/distribution terminal

1.6.4.2 AC Power Supply (Continued)

This supply is used to drive the auxiliary outlet. The outlet is rated at 3 amps and protected by a 4 amp circuit breaker for voltages of 100 and 115 VAC. For a 220-240 VAC, it is rated at 1.5 amps and protected by a 2 amp circuit breaker. Power to this supply is controlled by the main system circuit breaker.

- Isolated supply No. 2: This supply is composed of a 1:1 isolation transformer (T3), a section of the configuration terminal block (TB2) and a section of the configuration/distribution terminal blocks (TB3 and TB4).

  This supply is used to drive the auxiliary outlet controlled by the safety stop signal. This outlet is rated at 3 amps and protected by a 4 amp circuit breaker for voltages of 100 and 115 VAC. For 220-240 VAC, it is rated at 1.5 amps and protected by a 2 amp circuit breaker. Power to this supply is also controlled by the main system circuit breaker.

1.6.5 Interface

1.6.5.1 DC Power Supply

There are two different types of DC power supplies in the base electronics; these are called regulated and unregulated DC power supplies.

The regulated supply interfaces with both lamp assemblies, the safety circuit on the PC board and the fan.

See the base distribution board performance specifications for details.

The unregulated power supply interfaces with the occluder assembly and the safety, arterial and cardioplegia monitors.

1.6.5.2 AC Power Supply

The AC power supplies interface with the 8000 Pumps via terminal blocks TB3 and TB4, both auxiliary outlets via terminal blocks TB3 and TB4, the DC power supply via terminal block TB5 and the Battery Module via terminal block TB1.

1.6.6 Power Distribution

The table below describes the type of receptacle on the base from which each module receives its power and the type of power supplied.

8000 Base Power Distribution Table

Monitor/Module	Receptacle Type	Voltage
Pump	International power cord with molded plug.	100, 115, 220-240 ±10%.
Safety Monitor	12-pin socket panel mount receptacle.	Unregulated VDC. 18 - 36 VDC.
Occluder	IEC panel mount receptacle, 4-pin.	Unregulated VDC. 18 - 36 VDC.
Lamp	IEC panel mount receptacle, 5-pin .	Regulated VDC. 18 - 24.5 VDC. 24 VDC typical.
Battery	Mate and lock.	100, 115, 220-240 ±10%.
Auxiliary outlet, switched	IEC 320 power inlet receptacle panel mount.	100, 115, 220-240 ±10%.
Auxiliary outlet, unswitched	IEC 320 power inlet receptacle panel mount.	100, 115, 220-240 ±10%.
Fan	None.	Regulated VDC. 18 - 24.5 VDC. 24 VDC typical.

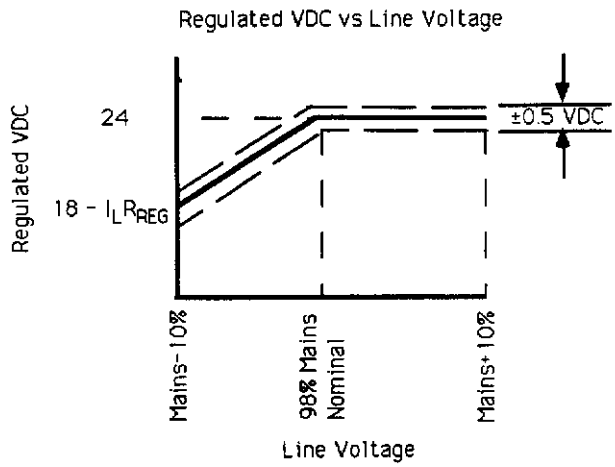
1.6.7 Theory of Operation

1.6.7.1 Regulated DC Power Supply

The theory of operation for this section is located in the performance specifications for the base distribution board. The following chart depicts how the regulated voltage varies as a function of the line voltage supplied to the base. As long as mains voltage is present and greater than or equal to 98% of the nominal line voltage, regulation remains within ±0.5 VDC of 24 volts. If the line voltage falls below 98% of the nominal line voltage, DC voltage will fall correspondingly.

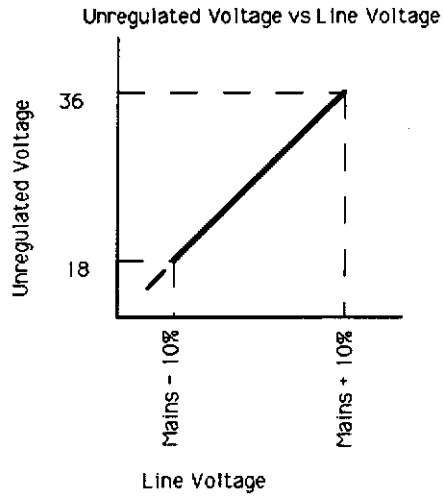
1.6.7.1 Regulated DC Power Supply (Continued)

At the minimum specified line voltage (-10%), VDC will be 18 VDC less the resistive drop across the regulator. All modules have been designed to maintain proper operation at this voltage.



1.6.7.2 Unregulated DC Power Supply

The unregulated power varies directly as a function of mains voltage. The following graph depicts this variation. All modules receiving unregulated DC voltage have their own converters and regulators to assure proper operation within the specified line voltage.



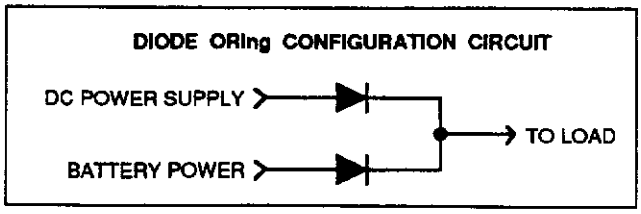
The unregulated supply receives its main power from terminal block TB2. This power is filtered through line filter LF1 and then connected directly to terminal block TB5. This terminal block configures the primary windings of the unregulated power supply transformer to the appropriate line voltage.

Voltage on the secondary of the transformer is rectified by the bridge rectifier diode DB1. The rectified voltage, which is current limited by the power resistor R1, is filtered by capacitor filter C1.

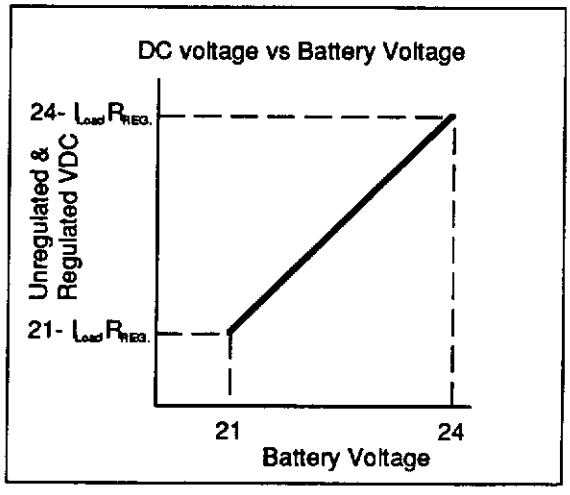
The filtered voltage is connected to J4 on the power distribution printed circuit board, along with the power diodes.

1.6.7.3 Uninterruptible Power

The uninterruptible power is available only when the battery option is installed. The 24 VDC regulated and unregulated power is diode OR'd with the battery voltage (see figure below).



The battery circuitry senses line voltage. The battery is disabled as long as the main power switch is on and line voltage is present. Battery power is enabled by closing a relay when line voltage is lost, as evidenced by loss of zero crossings on the line voltage input. The diodes thus prevent backward current flow into the DC power supply. Under these conditions, all DC voltages are that of the battery voltage until the battery voltage drops below 21 volts. At this point, protective circuitry switches off the batteries to prevent deep discharging.



1.6.7.4 Power Supply AC

The main power from the wall circuit is connected to terminal block TB1. This terminal block distributes power to the Battery Module, the unregulated power supply, auxiliary outlets and the 8000 pumps.

Power to the Battery Module is protected by fuse F2 on the base distribution printed circuit board; power to the unregulated power supply is protected by fuse F1, also on the base distribution printed circuit board. This is accomplished through connector P1.

Power to the 8000 pumps is routed from TB1, through TB2 and J/P1 to terminal blocks TB3 and TB4. These blocks serve as distribution points for all 8000 pump positions on the base.

Power to the auxiliary outlet controlled by the stop signal is routed from TB1 through J/P1, into TB2 where the isolation transformer T3 is configured. The secondary of this transformer is brought up to TB4 through connector T2/T3, where it is configured to match the input line voltage. The output to the outlet is taken from TB4-1 and TB4-5 through the solid state relay K1; K1 is controlled by the safety system stop line.

1.6.7.4 Power Supply (Continued)

Power to the auxiliary outlet is routed from TB1 through J/P1, into TB2 where the isolation transformer T2 is configured. The secondary of this transformer is brought up to TB3 through connector T2/T3, where it is configured to match the input line voltage. The output to the outlet is taken from TB3-1 and TB3-5.

For more details and clarification, see the 8000 base wiring diagram.

1.6.8 Calibration and Configuration Specification

No calibration required.

1.6.9 Service

All parts are accessible for servicing by removing the base assembly cover.

Assigned circuit breakers and fuses:

Output	Designation	Rating
8000 pumps (4 pump base, voltages of 100 - 115 VAC)	CB4 - CB7	3 amps
8000 pumps (4 pump base, voltages of 220 - 240 VAC)	CB4 - CB7	1.5 amps
8000 pumps (5 pump base, voltages of 100 - 115 VAC)	CB4 - CB8	3 amps
8000 pumps (5 pump base, voltages of 220 - 240 VAC)	CB4 - CB8	1.5 amps
Safety Monitor	CB9	3 amps
Occluder Module	CB11	3 amps
Lamps assemblies	CB10, CB12	1 amp
Battery Module (voltages of 100 - 115 V)	F2	0.4 amps
Battery Module (voltages of 220- 240 V)	F2	0.2 amps
Auxiliary outlets (voltages of 100 - 115V)	CB2, CB3	4 amps
Auxiliary outlets (voltages of 220-240 V)	CB2, CB3	2 amps
DC power supply (voltages of 100 - 115V)	F1	2.5 amps
DC power supply (voltages of 220 - 240V)	F1	1.2 amps

Note: See wiring diagram for clarification.

1.6.10 Field Service Diagnostics

Normal behavior for the base electronics can be diagnosed only when the unit is properly connected to the appropriately rated wall outlet.

With the main circuit breaker in the on position, the following can be verified:

- Nominal 24 VDC should be present on the pole cable assembly (between pin #M and pin #J, K or L).
- Nominal 24 VDC should be present at the lamp receptacles (between pin #5 and pin #1).
- Nominal 24 VDC should be present at the occluder receptacle (between pin #4 and pin #2).
- Voltage to the pumps (with circuit breakers on) should be equal to the input line voltage applied to the base.
- Voltage to the auxiliary outlets (with circuit breakers on) should be equal to the input line voltage applied to the base.
- Under an arterial alarm condition, there should be no output power to the auxiliary outlet controlled by the stop line (switched outlet).
- With the battery option installed, line voltage present and the system circuit breaker on, no output voltage should be present on the arterial and cardioplegia battery cables to the pumps (check TB1 and TB2 on PC board).
- With the battery option installed, line voltage absent and the system circuit breaker on, battery output voltage should be present on the arterial and cardioplegia battery cables to the pumps (check TB1 and TB2 on PC board); also, nominal 24 VDC should be present at the receptacles for the lamps, occluder and pole cable assembly. This is true only if the batteries are charged.

1.6.10.1 Preventive Maintenance Guide

The air filter should be checked periodically and replaced if necessary.

1.6.10.2 Precautions

The following may affect the safety of service personnel or functionality of the unit:

- Electrical shock precautions should be taken when working on the base electronics.
- Static precautions should be taken when working on boards.

1.7 Roller Pump Performance Specification

1.7.1 Operating Parameters

Electrical Power Requirements

	115 V Pumps	220-240 V Pumps	100 V Pumps
Voltage:	103.5-126.5 V~ (115 V, nominal)	198-264 V~ (220-240 V, nominal)	90-110 V~ (100 V, nominal)
Frequency:	50/60 Hz	50/60 Hz	50/60 Hz
Circuit Breaker Protection:	2.5 amps	1.25 amps	2.5 amps
Fully loaded current rating*:			
Continuous	1.4 amps	0.7 amps	1.6 amps
Pulsing	0.9 amps (1.4 A Peak)	0.5 amps (0.7 A Peak)	1 amp (1.6 A Peak)
Roller Pump**	16402 (98-0702-0647-3)	16407 (98-0702-0648-1)	16411 (98-0702-0646-5)

Notes: *A fully loaded pump is defined as one properly occluded with 1/2 in. diameter tubing, pumping water at ambient temperature and 250 RPM.
**5 digit numbers are catalog numbers; 1 digit numbers are 3M I.D. numbers.

Pump Performance
Leakage current: <12 microamperes for 115V and 100V pumps; <30 microamperes for 220-240V pumps.

Ground resistance: 0.1 Ohm maximum for all pumps.

The base module is tested for high potential.
- 1200V~ for 100-115 VAC units.
- 1500V~ for 220-240 VAC units.

Environmental Conditions

Operation	10° to 40°C, less than 95% relative humidity, noncondensing.
Storage	Ventilated area, -30° to 54°C (-22 to 130°F), less than 95% relative humidity, noncondensing.

1.7.2 Functional Description

The 8000 Roller Pump consists of a universal pump, which is a microprocessor controlled 2-roller peristaltic pump with adjustable occlusion, and a power supply. The pump is capable of flows up to 9.99 L/min (depending on pump head tubing used) at pump speeds up to 250 RPM.

In the case of a microprocessor failure, the pump is capable of basic operation (control of direction, stop and speed) and basic safety system function (cover interlock, overcurrent and hardware overspeed), without display.

The pump's built-in DC power supply is capable of driving a universal roller pump. The power supply includes a terminal block, which configures the transformer's primary windings for proper input voltages, and a board which handles the communication and safety lines and regulates DC power for the fan.

The power supply assembly provides connection points for the following:
- Power cord receptacle
- Universal Roller Pump
- Safety/Communication signals
- Battery power input

1.7.2.1 Speed Regulation Under Load

Pump-head torque: 30 to 40 in-lbs (3.4 to 4.5 N-m) at maximum RPM.

Speed variation: With a 10 in-lb (1.1 N-m) change in load, final speed = initial speed ± 1 RPM.

Response time to change in load
- ≤ 60 msec to make 63% recovery speed.
- ≤ 180 msec to make 100% recovery in speed.

Speed range: 0 to a maximum of 245 to 255 in forward and reverse after the 24 hour break-in.

Speed resolution: The displayed resolution is equal to 1 RPM.

Speed accuracy: The speed accuracy is equal to ± 2 RPM or 1% of actual, whichever is greater.

Zero speed setting: Zero speed is set at ≥ 10° clockwise rotation of speed pot from full counterclockwise before pump turns.

Pump acceleration: Pump acceleration with properly installed tubing, is ≥ 198 RPM/sec with soft start (pump demand set > 0 before pump Forward or Reverse mode engaged).

Pump deceleration: The pump will reach 0 RPM in response to Stop command within 1 pump-head revolution at any specified speed.

1.7.2.2 Pump Flow

Flow rate calculation

- Flow = RPM x Flow Constant
- Display range: 0.00 to 9.99 L/min.
- Display resolution: 0.01 L/min.

> **Note:** Display accuracy is based on using Tygon S50HL tubing, with proper occlusion, outlet pressure < 500 mmHg.

Effect of fluid temperature on display accuracy

- 20-40°C ± 8% of actual with defined flow constants;
- < 20°C must use Variable Flow Constant, accuracy not defined.

Flow Constants

Measured on Tygon S50HL tubing, 20-40°C.

Tube ID	Flow Constant (ml/rev)	F Value
0.25 in.	12.7	127
0.37 in.	25.9	259
0.50 in.	41.9	419
0.62 in.	60.8	608
6 mm	11.9	119
8 mm	20.0	200
10 mm	28.8	288
12 mm	41.6	416
S4:1	15.5	155
S2:1	18.0	180
S1:1	25.4	254

Tube Clamps and Inserts

A tubing retention force applies sufficient friction to the tubing to prevent migration during use. This is accomplished when the proper tube insert is installed (according to tube size), and the tube clamp assembly is properly installed and locked in position on the pump head.

Removal of tube clamp assembly (P/N 78-8066-7520-9) does not require excessive force.

Tube Insert Sizes

Part No.	Tube OD	Color
6070	1/4	aluminum
6071	5/16	light green
6072	3/8	black
6073	7/16	gold
6074	1/2	dark green
6075	9/16	red
6076	5/8	aluminum
6080	11/16	aluminum
6079	3/4	aluminum
6077	3/8, 3/8 (1:1)	white
164195	3/8, 0.302 (2:1)	tan
164190	3/8, 1/4 (4:1)	blue

1.7.2.3 Pump-Head Concentricity

Roller to roller: 0.0015 in. (0.04 mm) Total Indicator Reading (TIR) maximum.

Drive shaft to race: 0.0015 in. (0.04 mm) TIR maximum.

Occlusion can be set by rotation of an adjustment knob on the top of the pump.

Belt tension: With 0.06 in. (1,52 mm) deflection of belt (at mid span of free belt between pulleys), indicated force shall be 1.5-2.0 lbs (6,7 - 8,9 N).

Reference: Spring adjust/Spring length set to 0.625 ± 0.005 in., equivalent to 30 lbs. (134 N) per spring manufacturer's specification.

Motor mount slide static friction ≤ 10 lbs. (44,5 N).

Accuracy: The pump run time display must represent the time in forward or reverse with an additive accuracy of ± 0.1 hour for each time the pump is placed in forward or reverse mode.

1.7.2.4 Switches

Manual switch: Activating the Manual switch while in Computer Control mode will result in the pump being placed in the Stop mode.

Tube size selection: Tube size selection may not be changed unless the pump is in Stop mode. RPM may be momentarily displayed by depressing the select switch.

Stop switch: Activating the Stop switch while in Computer Control mode will result in the pump being placed in the Manual mode.

Computer Control: Computer Control of the pump can only subtract speed from the demand pot setting.

Prevention of accidental switch actuation: The Stop mode can be easily entered by depressing any of 3 switches located underneath the Stop button, whereas Forward, Reverse, and Computer Control modes can only be entered by depressing both appropriate switches. All switches, except Reverse, must be actuated for 100 ms before resulting action is taken, whereas the reverse switch requires a longer actuation of approximately 4 ± 1 sec. before resulting action is taken.

1.7.2.5 Electrical Performance for Communications

Meets communications requirements of EIA-485 Standard.

The A terminal of the generator shall be negative with respect to the B terminal for a binary 1 (MARK or OFF) state.

The A terminal of the generator shall be positive with respect to the B terminal for a binary 0 (SPACE or ON) state.

1.7.2.5 Electrical Performance for Communications (Continued)

Send:

Voltage output (A or B) 0 to 5 .0 V (typically 0 to 3.75 V)
Differential voltage: 1.5 to 5.0 V

Receive:

Differential input high threshold 0.2 V minimum
Differential input low threshold -0.2 V minimum
Hysteresis 50 mV peak to peak

EEPROM (Electrically Erasable/Programmable Read Only Memory) stores the following information:

Run time: The pump run time which is defined as the time that the pump is powered in Forward or Reverse mode. The run time is incremented at the end of each 0.1 hour up to a maximum of 9999.9 hours.

Tube size: The last tube size set when the pump was used in forward or reverse mode.

Variable flow constant : The variable flow constant corresponds to the last VFC entered.

1.7.2.6 Communication Commands

All commands and data communicated back and forth from the pump are sent in packets of characters as follows:

Character format

1 start bit, 7 data bits, 1 odd parity bit, 2 stop bits.
Baud rate = 2400

Packet format

- Header: 1 character namely "<".
- Device address: 1 character in range of "A"-"Z". Calculated by adding the ASCII value of A to the local processor ID number. The device address for the 8000 roller pump is hard wired to "B".
- Record length: 2 character count representing number of characters in packet. Calculated as 8 + length in characters (hexadecimal).
- Command code: 1 character representing a command in range "A"-"Z" or "a"-"z" or "?".
- Parameters: 0 to 56 characters. In a response packet, the first character will be a digit representing the status condition.
- Checksum: 2 characters representing a hexadecimal number in the range 0-7F.
- Terminator: 1 character namely ">".

1.7.3 Physical Description

8000 Roller Pump:

Width 8.2 in. (20,8 cm)
Depth 19.7 in. (50,0 cm)
Height 14 in. (35,6 cm)
Weight 50 lbs. (22,6 kg)

1.7.3.1 Universal Pump

Width 8.12 in. (20,6 cm)
Depth 14.0 in. (35,5 cm)
Height 8.0 in. (20,3 cm)
Weight 31 lbs. (14 kg)

1.7.3.2 Power Supply

Width 7.4 in. (18,8 cm)
Length 5.5 in. (14,0 cm)
Height 7.1 in. (18,0 cm)
Weight 22 lbs. (10 kg)
1.7.4 Electrical Description
1.7.4.1 Universal Pump

On-board power supply:
Positive 12 VDC ± 5%
Negative 12 VDC ± 5%
Positive 5 VDC ± 5 %

1.7.4.2 Power Supply

- The DC power supply has a minimum output equal to 21 VDC with a maximum load of 8 amperes at the minimum specified voltage.
- The DC power supply has a maximum output equal to 40 VDC with a minimum load of 0.5 amperes at the maximum specified voltage.

1.7.5 Circuit Protection:

- Output power for the fan is limited to 1 amp regardless of the input line voltage and is protected with a fuse (F1) on the PC board.
- Output power to the roller pump is protected by the power supply main circuit breaker.

1.7.6 Interface

1.7.6.1 Roller Pump

The roller pump interfaces with the user via displays and buttons located on the front panel of the pump. The displays provide information such as fluid flow rates, pump speed and pump status. The buttons allow the user to govern the pump's rotation and direction (forward and reverse).

The 8000 Roller Pump interfaces with the base electronics through the ART/CPG cable assembly, the AC universal power cable and the battery (UPS) cable assembly.

- The ART/CPG cable assembly handles the safety signals and the RS-485 communication signals from the base electronics. This cable connects to a 6-pin panel mount receptacle located on the dress panel of the 8000 roller pump.
- The AC universal power cable handles mains power to the pump, ranging from 100 to 240 VAC. This cable connects to an AC panel mount receptacle located on the dress panel of the 8000 roller pump.
- The UPS cable assembly handles battery power to the pump at a nominal voltage of 24 VDC. This cable connects to a 3-pin panel mount receptacle located on the dress panel of the 8000 roller pump.

1.7.6.2 Universal Pump

The universal roller pump interfaces with the power supply via a 12 pin panel mount Cannon connector located on the rear bracket of the power supply. The same will handle power, pump "ID" number, safety stop lines, RS-485 communication lines and safety ground (chassis).

1.7.7 Theory of Operation

1.7.7.1 Universal Pump

A potentiometer sets the pump speed/flow rate.

The pump display can be set to show calculated flow for the pump header tube section used or RPM. The display also shows messages representing status of the pump.

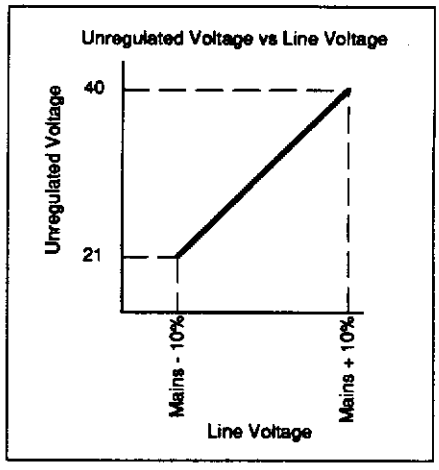
1.7.7.2 Power Supply

The primary windings of the transformer are configured to match the input line voltage.

AC power is applied to the receptacle located on the front panel of the power supply. Power is stepped down to a nominal voltage via a step-down isolated low leakage transformer, then rectified and filtered by a rectifier bridge and a 27000 µf capacitor.

The DC rectified voltage (unregulated power supply) is used to power the pump, and is also regulated down to 24 VDC to power the fan.

The unregulated power varies directly as a function of mains voltage. The following graph depicts this variation.

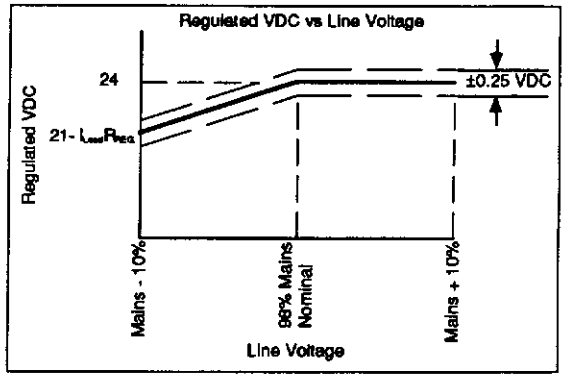


1.7.7.3 Regulated DC Power Supply

The theory of operation for this section is located in the performance specifications for the pump distribution board.

The following chart depicts how the regulated voltage varies as a function of the line voltage supplied to the base. As long as mains voltage is present, and greater than or equal to 98% of the nominal line voltage, regulation remains within ±0.25 VDC of 24 volts. If the line voltage falls below 98% of the nominal line voltage, DC voltage will fall correspondingly.

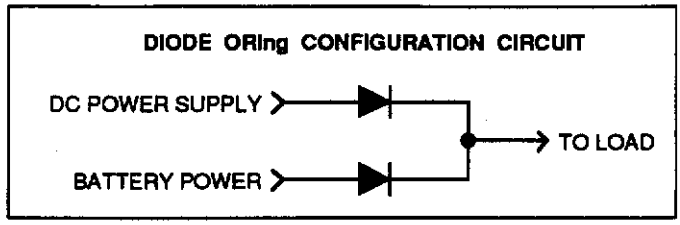
At the minimum specified line voltage (-10%), VDC will be 21 VDC less the resistive drop across the regulator. All modules have been designed to maintain proper operation at this variation.



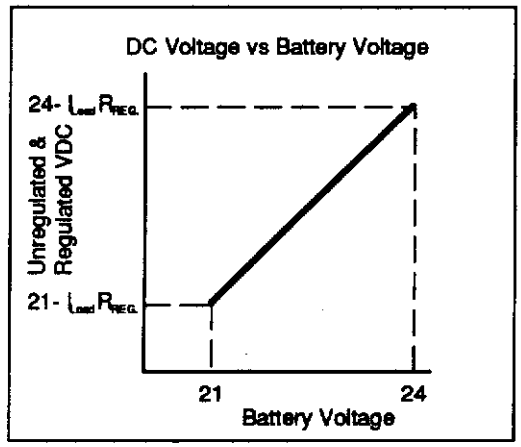
1.7.7.4 Uninterruptible Power

The uninterruptible power is available only when the battery option is installed.

When the battery option is installed, the battery is diode OR'd with the unregulated power supply within the pump (see figure below). If AC mains is lost, the battery will be automatically brought on-line to power the pump (see base electronics performance specification). Under this condition, the main circuit breaker on the pump is by-passed.



The battery circuitry senses line voltage. The battery is disabled as long as the main power switch is on and line voltage is present. Battery power is enabled by closing a relay when line voltage is lost, as evidenced by loss of zero crossings on the line voltage input. The diodes thus prevent backward current flow into the DC power supply. Under these conditions, all DC voltages are that of the battery voltage until the battery voltage drops below 21 volts. At this point, protective circuitry switches off the batteries to prevent deep discharging.



1.7.8 Calibration and Configuration Specifications

1.7.8.1 Universal Pump

For calibration on the Universal Pump, see Section 3, Roller Pump Adjustments

1.7.8.2 Power Supply

No calibration required.

1.7.9 Service

1.7.9.1 Field Service Diagnostics

Normal behavior for the roller pump can be diagnosed only when the unit is properly connected to the appropriately rated outlet.

With the main circuit breaker in the on position, the battery cable connected (only if the battery option is installed), the communication safety cable and the AC power cable connected to their respective input receptacle, the following can be verified:

- Regulated 24 VDC should be present at the pulse connector on the front of the pump.
- The flow and RPM display on the pump should be blank.
- The alphanumeric display should read "RESET" for a few seconds, then go through the self diagnostic tests.
- The pump should be in the stop mode with the LED over the stop and the manual buttons lit.
- The fan should be running.
- With AC power loss, the pump should remain operational if Battery Module is installed.
- An alarm condition will activate the stop relay in the pump.
- The circuit breaker will not shut down the unit when the 8000 system is operating on battery.

1.7.9.2 Preventive Maintenance Guide

The air filter should be checked periodically and replaced if necessary.

1.7.9.3 Precautions

The following may affect the safety of service personnel or functionality of the unit:

- Electrical shock precaution should be taken when working on the pump.
- Static precautions should be taken when working on boards.
- The ground strap must remain connected to the two sheet metal panels (hosting components of the power supply) at all times.

1.7.9.4 Safety Features

Stop mode: Two independent relays are employed to put the pump into Stop mode.

- The pump will enter the Stop mode when the stop line is activated at the pump by the base electronics. This consists of a 5 mA current loop signal from the base electronics to the pump power supply. The condition is obtained using one of the two stop relays on the pump drive board of the universal roller pump.

- Actuation of the Stop switch will independently place the pump in the Stop mode using the second redundant stop relay.

  Loss of pump-head tachometer: Pump must enter Stop mode if pump-head tachometer indicates 0 RPM (loss of pump-head tach) and motor speed voltage is greater than zero (indicating motor is turning).

Belt slip detection: Pump display must indicate "Belt Slip" message if motor tachometer (adjusted for pump drive ratio of 6:1) indicates desired pump speed is greater or equal to 120% of pump-head tachometer indicated speed.

1.7.9.4 Safety Features (Continued)

Cover interlock:

- Pump must not be capable of operating if cover is open greater than 1.5 in. (3,8 cm).
- Pump must be capable of operating if cover is open less than 0.2 in. (0,5 cm).
- No message will be displayed if pump cover is open.

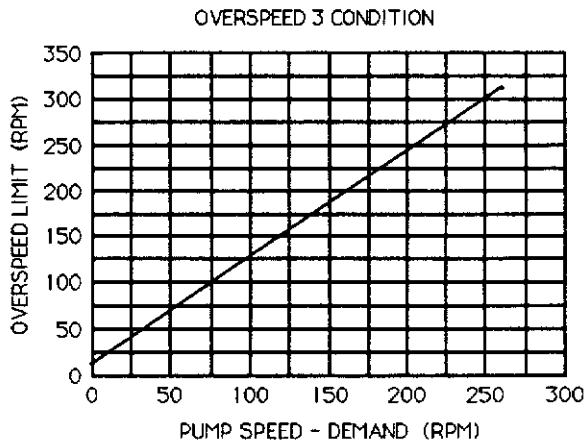
Overcurrent (Pump Jam): Within 1 sec. of motor current exceeding 8.0 ± .05 amp, the pump will enter the Stop mode and display the "Pump Jam" message.

Overspeed: There are three overspeed detection conditions designed into the pump. These conditions will redundantly be checked, ensuring a pump stop whenever a run-away condition is detected at any stage.

- Overspeed 1: Pump must enter Stop mode if pump-head tachometer indicates pump speed ≥ 275 ± 10 RPM and display the "OVRSPD 1" message. This condition is controlled by pump electronic hardware.

- Overspeed 2: Pump must enter Stop mode if pump-head tachometer indicates pump speed > 290 RPM and display the "OVRSPD 2" message. This condition is controlled by pump micro processor software.

- Overspeed 3: Pump must enter stop mode if pump-head tachometer indicates desired pump speed equals or exceeds the overspeed limit of its pump speed demand. Graphic representation of this relationship for the entire operating range of the pump is shown in Figure 1 below.



- Note regarding microprocessor watchdog: A hardware circuit will detect loss of normal microprocessor function by performing a timing test on the processor.

1.8 Safety Monitor Performance Specification

1.8.1. Operating Parameters

Air Detection Tubing Requirements

Type	Clear, flexible PVC tubing.
Size	1/4 Air Sensor (P/N 15020) requires tubing of 1/4 in. (6,4 mm) I.D. x 1/16 in. (1,6 mm) wall.
	3/8 Air Sensor (P/N 13540) requires tubing of 3/8 in. (9,5 mm) I.D. x 3/32 in. (2,4 mm) wall.

Air Sensor Performance

1/4 Sensor	Detects bubbles of 0.5 ml or larger at flow rates up to 3 L/min in blood with a hematocrit of 15-40%.
3/8 Sensor	Detects bubbles of 1 ml or larger at flow rates up to 6 L/min in blood with a hematocrit of 15-40%.

Level Detection Requirements

Fluid Level	Level detection occurs when the fluid level in the reservoir is within ± 0.2 in. (0,5 cm) from the horizontal center line of the level sensor pad.
Reservoir	Functions only with clear hard-shell reservoirs of acrylic, PVC, butadiene styrene or polycarbonate which have a wall thickness of 0.03-0.10 in. (0,8-2,5 mm).
	Internal structures must be more than 1.0 cm from the sensor.
Gel	Use the gel which comes packaged with the level sensor pads.

Level Detection Performance

Alert and alarm signals function properly with clear priming solutions or blood of any hematocrit.

Environmental Conditions

Operation	10° to 40°C, less than 95% relative humidity, noncondensing.
Storage	Ventilated area, -30° to 54°C (-22 to 130°F), less than 95% relative humidity, noncondensing.

1.8.2. Functional Description

The safety monitor performs the following main functions for the 8000 system:

- Air detection and level detection monitoring,
- Power distribution from the base to the arterial and cardioplegia monitors,
- Interface for stop signal from the arterial and cardioplegia monitors.

The primary function of the safety monitor is to provide air detection and blood reservoir level detection. The air detector activates an alarm if air is detected in the blood line being monitored. The level detection can activate an alert and/or an alarm if the blood level in the reservoir drops below the location of the respective sensor attached to the reservoir.

Alerts result in both audible and visual indications. Alarms result in audible and visual indications, and additionally activate the pump stop signal which is routed to the arterial and cardioplegia pumps.

The safety monitor serves as the power distribution point for all pole mounted modules and provides circuit breaker protection for those devices.

The air detection and level detection functions of the safety system are always active and monitor the outputs of the air and level transducers but they must be in the ON mode in order to have alarm capability (with safety features) to stop the pump.

The air detection and level detection features will automatically be in the OFF mode a few seconds after the safety monitor circuit breaker is switched from OFF to ON. Any console panel switch must be pressed and held for approximately 1 second in order to prevent accidental activation of control panel functions.

1.8.2.1 Air Detection Controls

The RESET switch can be pressed to clear any prior alarms. If the air detection transducer is not connected to the safety monitor, the air detection feature can not be reset. After the RESET switch has been pressed and the air alarm indicator no longer illuminates, the air detection system is cleared of prior alarms.

While in the OFF mode, detected air will cause the right most portion of the air alarm indicator (1/8 of indicator bar) to illuminate. In ON mode, detected air will cause the entire air alarm indicator to flash, the audio alarm to sound, and the arterial and cardioplegia pumps to stop.

The green indicator above the ON switch and the red indicator above the OFF switch displays the ON or OFF mode and shows which switch was last pressed.

When an alarm is detected, an audio warning will sound for two seconds and repeat every 60 seconds until the condition ceases and the air detection RESET switch is pressed.

1.8.2.2 Level Detection Controls

A mode switch on the level detection module rear panel selects the level detection mode.

Switch Position	Mode Selected
1	use of both the alert and alarm.
2	use of only the alarm.
3	not applicable for this product but functions nominally as an alarm only.
4	use of only the alert.

The RESET switch clears any prior alarms. If the rear panel mode switch is set to the alert/alarm or alarm and the level detection alarm transducer is not connected to the safety monitor, the level detection feature can not be reset. If the level detection alert transducer is not connected, the level detection feature can be reset but the yellow disconnected level transducer indicator will illuminate to indicate operation with only the level alarm transducer. After the RESET switch has been pressed and the level alarm indicator no longer illuminates, the level detection system is cleared of prior alarms.

While in the OFF mode, the level detection alarm will cause the left most portion of the level alarm indicator (1/8 of indicator) to illuminate if the level drops below the set reservoir alarm level. In the OFF mode, the level detection alert will cause the left most portion of the alert indicator (1/8 of indicator bar) to illuminate if the level drops below the set reservoir alert level. In ON mode, level detection will cause the entire level alarm and alert indicator bars to flash, an audio warning to sound, and the arterial and cardioplegia pumps to stop.

The green indicator above the ON switch and the red indicator above the OFF switch displays the ON or OFF mode and shows which switch was last pressed.

A single-tone audio alert will sound for two seconds and repeat every 60 seconds until an alert condition ceases. When a level alarm is detected, a dual-tone audio warning will sound for two seconds and repeat every 60 seconds until the condition ceases. After the reservoir level has been restored the alert indicator will stop flashing automatically, but a level alarm will require pressing the RESET switch in order to clear the alarm.

1.8.3. Physical Description

Height: 6 in. (15,2 cm)
Width: 8 in. (20,3 cm)
Depth: 10 in. (25,4 cm)

The safety monitor is a pole mounted structural foam enclosure. Cables are plugged into the rear of the module under a cable cover. Setup adjustments are made at the rear of the module. Normal operation is via the front panel which includes LED indicators and membrane switches.

The safety monitor contains a motherboard and board cage. Boards are installed in the board cage from the rear of the module. A level detection board, air detection board, and a safety power module plug into the motherboard. Cable connections are made at the cover panels of the plug-in boards at the rear of the module. A membrane switch panel and display board are located at the front of the module.

The membrane switch and display boards are 5.4 in. (13,7cm) high by 7.1 in. (18,1 cm) wide. The boards which plug into the motherboard are 4.5 in. (11,4 cm) high by 7.9 in. (19,9 cm) long with a nominal spacing of 1.3 in. (3,2 cm) between boards. The safety power module occupies 2 board slots.

1.8.4 Electrical Description

The safety monitor receives power from the base via an interface cable. The module is powered by unregulated 24 VDC which is converted to +5 and ±12 VDC in the safety monitor and distributed to all boards in the safety monitor. The unregulated 24 VDC is also provided to the arterial and cardioplegia monitors. The safety monitor requires 24 volts at 0.4 amps without arterial and cardioplegia monitors, and 24 volts at 1.4 amps with both arterial and cardioplegia monitors attached.

A circuit breaker switch is located at the rear of the module. The 24 VDC supply to the safety monitor and any attached arterial and cardioplegia monitors are switched by this breaker.

The arterial and cardioplegia pump stop signals are generated within the safety monitor and connected to the base via an interface cable.

An RS-485 compatible communications network connects the arterial monitor to the arterial pump via the safety monitor. A second such network connects the cardioplegia monitor to the cardioplegia pump. Due to the software configuration, there is no communication between the monitors and the pumps.

1.8.5 Interface

A single cable connects the safety monitor to the base. This 12-conductor cable includes 24 VDC power source and return, arterial pump stop signal, cardioplegia pump stop signal, arterial communications network, cardioplegia communications network and chassis ground.

A single cable connects the arterial monitor to the safety monitor. This 6-conductor cable includes 24 VDC power source and return, arterial pump stop signal, arterial communications network and chassis ground.

A single cable connects the cardioplegia monitor to the safety monitor. This 6-conductor cable includes 24 VDC power source and return, cardioplegia pump stop signal, cardioplegia communications network and chassis ground.

The safety power module, air detection board, and level detection board interface to the safety monitor via 56-pin board edge connectors. The motherboard provides all interconnections. The membrane switch and display board each attach to the motherboard via ribbon cables.

1.8.6 Theory of Operation

Level detection is accomplished by one or two ultrasonic transducers which are attached to the side of a clear plastic, hard shell blood reservoir. The transducers emit a high frequency sound wave, then monitor the echo. The transducers detect a difference in the echo when fluid is present versus when the reservoir is empty. One transducer may be used for the alert only or alarm only mode. Two transducers are used for the alert/alarm mode. The upper transducer will be the alert level, and the lower will be the alarm level. When the fluid level falls to the midpoint of the transducer, an alert or alarm is initiated.

Air detection is accomplished by transmitting an infrared light beam through the blood line and detecting it at the other side. Blood will block more light than air. When light above a certain threshold is detected through the blood line, an alarm is initiated.

Alerts will cause visual and audible indications only. An alarm will cause a visual and audible indication and stop the arterial and cardioplegia pumps. The pump stop signal is activated on the safety monitor motherboard by either detector board. The safety power module transmits the stop signal using a current loop to the pump via the base. An arterial alarm will stop both the arterial and cardioplegia pumps.

1.8.6 Theory of Operation (Continued)

The arterial stop signal is the result of OR'ing stop signals from air and level detection and any arterial monitor. The cardioplegia stop signal is the result of OR'ing stop signals from air and level detection and any arterial and cardioplegia monitors.

The safety power module contains circuitry to generate the intermittent alert and warble alarm tones. That board also includes circuitry to repeat the audible indication once per minute if the condition is not resolved.

The safety power module includes a DC/DC converter which converts the 24 VDC power supplied by the base to the internal voltages used by the detector boards.

1.8.7 Calibration and Configuration

There are no calibrations for the safety monitor as a system; however, calibration and/or configuration for individual boards plugged into the safety monitor may be required.

1.8.8 Service

1.8.8.1 Field Service Diagnostics

The diagnostic procedure shall consist of connecting the safety monitor as for normal operation, including connection to base and pump, and operating the safety monitor to verify correct operation. The arterial and cardioplegia pumps should be allowed to run during these tests.

Check startup.

- Apply power to the system.
- Verify that all LED indicators on the front of the safety monitor light for approximately 3 seconds and the audible alarm sounds for approximately 2 seconds.
- Start the arterial and cardioplegia pumps.

Check air detection.

- Place an opaque object in the air sensor in a position normally occupied by the blood line.
- Press RESET to clear any prior conditions.
- Turn on the air detector switch. Verify that the ON indicator lights.
- Remove the test object from the air sensor. Verify that the alarm indicator lights, the audible alarm sounds for 2 seconds, the pumps are stopped and the alarm sounds again after 1 minute.
- Press the RESET switch and verify that the pumps remain stopped.
- Replace the test object in the air sensor. Press the RESET switch and verify that the visual indicator turns off and the pumps can be restarted.
- Press the OFF switch to turn the detector off. Remove the test object from the air sensor. Verify that the pump continues to run.

1.8.8.1 Field Service Diagnostic (Continued)

Check level detection.

- Attach the level sensors to a hard shell plastic reservoir filled with liquid.
- Check that the selection switch on the rear of the level sensor is in the alert/alarm mode prior to applying power.
- Turn on the level detection by pressing the ON switch on the front panel. Verify that only the ON indicator lights.
- Start the arterial and cardioplegia pumps.
- Allow the alert sensor to sense air. Verify that the alert indicator bar flashes, the alert tone sounds for 2 seconds, the alert tone repeats after 1 minute and the pumps continue to run.
- Return liquid to the sensor and verify that the visual indicator turns off.
- Allow the alarm sensor to sense air. Verify that the alarm indicator bar flashes, the alarm tone sounds for 2 seconds, the pumps are stopped and the alarm tone repeats after 1 minute. Return liquid to the sensor. Press the RESET switch and verify that the indicator turns off and the pump can be restarted.
- Press the OFF switch and verify that the OFF indicator lights. Cause the alarm to sense air again and verify that the pump continues to run.

1.8.8.2 Preventive Maintenance Guide

The safety monitor requires no regular preventive maintenance.

1.8.8.3 Precautions

All circuitry in the safety monitor will operate with a maximum of 24 VDC and will not present shock hazards.

Power should be removed prior to removing or installing any circuit boards in the safety monitor.

Circuit boards should be handled using static protective equipment and procedures.

1.9 Arterial Monitor Product Performance Specification

1.9.1 Operating Parameters

Temperature Requirements

YSI (Yellow Springs Instruments) 400 series temperature probes or an equivalent probe so indicated by the manufacturer.

Temperature Performance

Monitors	Between 0 - 49.9 °C, with ± 0.3 °C display accuracy and 0.1°C resolution.
Displays	"—" when <0°C or no probe. "999" when >49.9°C or a partially connected probe. Blank if a channel or temperature system malfunctions.

1.9.1 Operating Parameters (Continued)

Pressure Requirement

Any probe that meets AAMI standards for physiologic pressure probes. Probes other than that supplied by Sarns may require an adapter cable from Fogg Systems Co, Aurora CO.

Pressure Performance

Monitors: Pressures of -45 to 990 mmHg

Display

	Range (mmHg)	Accuracy
Static Conditions	-45 to 500	± 10 mmHg
	500 to 990	± 20 mmHg

Dynamic Conditions: Display accuracy is ± 40 mmHg, with a dynamic variation of 150 mmHg maximum.

Displays: "- - -" at < -45 mmHg, no probe or uncalibrated.
"999" at > 990 mmHg.
(Blank) if a channel or pressure system malfunctions.

Alert and Alarm Limit Set-points (mmHg)

Alert Range	0 - 980 in 10 mmHg increments.	
Alarm Range	10 - 990 in 10 mmHg increments. Displays 999 when disabled.	
Default	Alarm = 360	Alert = 300

Alert: Yellow alert bar flashes with single audio tone.

Alarm: Arterial and Cardioplegia pumps stop, red alarm bar flashes with dual audio tone.

Data Storage: Alert and alarm set-points are saved when power is off.
A disabled alarm is not saved.

Timer Performance

Two independent timers, each with Start, Stop and 0:00 (zero) switches.
Displays in hours, minutes and seconds.

Environmental Conditions

Operation: 10 to 40 °C, less than 95% relative humidity, noncondensing.

Storage: Ventilated area, -30 to 54 °C (-22 to 130 °F), less than 95% relative humidity, noncondensing.

1.9.2 Functional Description

The 8000 Arterial Monitor will display one average pressure and three average temperatures and also provides two digital timers. The pressure channel can have alert and alarm levels set by the user to indicate overpressure conditions. The alert and alarm level settings are retained by the system and can be recalled after the next power up. Alert and alarm conditions are indicated by flashing LED bar with single or dual audio tones; an alarm will also stop the arterial and cardioplegia pumps. The volume of the tone is adjustable by the user.

The front panel is divided into four functional areas:

- One pressure display area which includes digital and alphanumeric displays, membrane switches, and alarm and alert indicators;
- One temperature display area showing three temperatures;
- Two timer areas, with membrane switches to operate the timers.

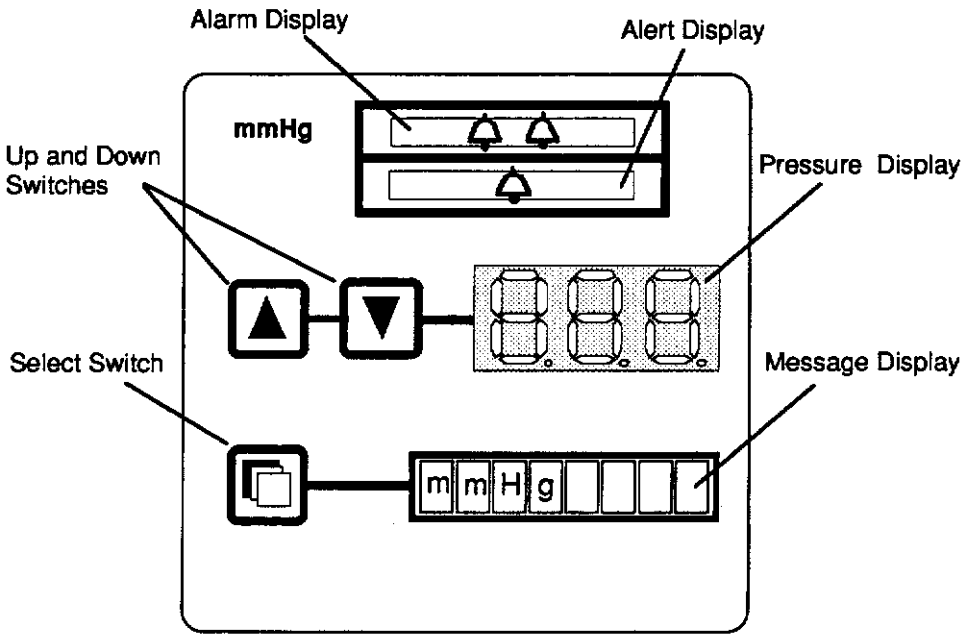
All functions are available to the user at all times. The loss of one or more functions will not halt the overall system.

The rear panel of the monitor has the rotary volume control switch and the arterial monitor cable. The arterial monitor cable is permanently attached to the monitor and the other end plugs into the 8000 safety monitor. The main power cable also carries the pump stop signals and communications.

1.9.2.1 Membrane Switch Panel

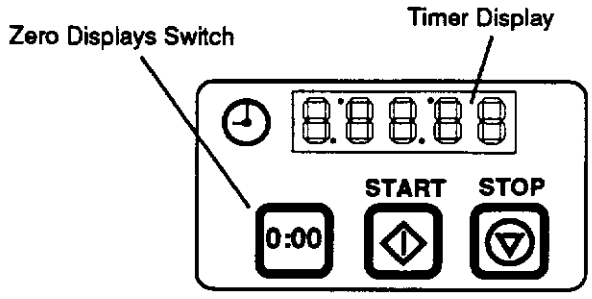
The membrane switch panel covers the total front surface of the monitor and is used for operator input. Switches are provided for each pressure section and for operation of the timers. The temperature section of the panel has write-on surfaces for the labeling of the temperature displays.

1.9.2.1.1 Pressure Displays and Key Pad



1.9.2.1.2 Timers Displays and Key Pad

The 8000 Arterial Monitoring System includes two timers. Each of the timers has a 5-digit, LED display. Time values are displayed continuously. The timers are controlled by START, STOP and 0:00 (zero) switches.



START switch is used to start the timer.

STOP switch is used to stop or pause the timer.

0:00 switch is used to stop the timer and to zero the timer displays.

1.9.2.1.3 Temperature Displays

Each temperature display can be labeled by the user right on the membrane switch panel surface. There are no switches needed for the temperature system.

1.9.2.2. Display Board

The display board presents up-to-date pressure, temperature and timer information in a digital character format. The displays can be read under normal lighting found in the operating room. The board supports seven-segment LEDs, bar format LEDs and eight character, dot-matrix alphanumeric displays. All LEDs are green except for the yellow alert and red alarm displays.

The pressure channel displays pressure values or an alert/alarm set-point on three-digit seven-segment LEDs without a decimal point. The yellow and red LED bars provide flashing visual warnings for alert and alarm conditions. Temperatures are displayed on three-digit seven-segment LEDs with a decimal point. The timer section uses five seven-segment LEDs for each timer; the colons are lighted at all times and do not flash.

1.9.2.3 Temperature and Pressure Monitoring Board

This monitor sub-assembly supports the measurement of one pressure and three temperatures. The hardware on this board is set up to use the Viggo-Spectramed Model P23XL pressure transducer (or an equivalent disposable with an adaptor cable) and YSI 400 series thermistor temperature probes.

The board can be divided into three electrically isolated functional sections: one digital section, one analog pressure measurement section and one analog temperature measurement section. Information from each of the analog sections and the control line signals from the digital to the analog sections are passed over an isolation barrier with optical isolators.

1.9.2.3 Temperature and Pressure Monitoring Board (Continued)

The digital section has a counter, latch for control lines, a buffer for control and address lines and a bus transceiver chip for two way data transfer. A single board microcomputer (located on the power interface board) is used to run software that selects the proper temperature and pressure probe channel, loads and restarts the counter, receives an interrupt to read the count information after each integration period, then calculates the temperature and pressure for later display.

The pressure and temperature measurement sections translate voltage levels, read from a selected probe or reference channel, into frequency based information. This frequency data is passed over an optical isolator and is translated into counts. The count information is used by the system computer to calculate the pressure and temperature. The software then translates the raw data into decimal data suitable for the display board.

The board has the following functional circuitry blocks:

- Power supply and probe excitation
- Reference circuitry
- Demultiplexer for probes
- Gain and impedance matching amplifier(s)
- Voltage to frequency conversion
- Edge to level translation with frequency divided by four
- Optical isolator circuitry
- Computer interface circuitry

More detailed information can be found in the performance specification for this board.

1.9.2.4 Power Interface Board

The power interface board provides power conversion, system cable interconnection and address decoding when used in a monitoring system. This board also provides a mounting location and connector interface for the Ampro Core Module™/XT computer board.

The power interface board converts the unregulated and fused +24 VDC from the 8000 base power supply to +5 VDC power using an isolating DC/DC converter. This board provides +5 VDC power to the computer board, the display board, and the pressure and temperature measurement board.

This board has I/O mapped parallel input and output ports which allow the computer to do the following:

- Read the switches of the membrane key pad.
- Read a four position D.I.P. switch.
- Activate and deactivate the pump stop line.
- Control a single and dual audio tone.
- Pull in temperature and pressure data from the monitor's decoded parallel address and data bus.
- Post information to the display board using the monitor's parallel bus.

1.9.2.5 Processor Board

The monitor uses a PC DOS based single board computer with 512K byte of RAM. The system runs at 9.8 MHz. The computer and software controls all the monitor functions.

The Ampro Core Module™/XT, with the monitor system software, controls the following functions of this monitor system:

- Reading membrane switch panel input.
- Input, storage and retrieval of alert and alarm set points.
- Sampling raw temperature and pressure data counts from the pressure and temperature measurement board for all channels including references.
- Verifying the analog channel set-up.
- Calculating the temperature and pressure for all channels.
- Looking for alert and alarm conditions.
- Reporting audio and visual alert and alarm indications.
- Activating the current loop source for the pump stop line.
- Counting elapsed time.
- Displaying temperature, pressure and timer information.

The Ampro Core Module™/XT is a single board microcomputer with the following standard PC features that are important to the function of the monitor:

- 9.8 MHz V20 CPU
- PC compatible ROM-BIOS 1.13 or later
- 3-channel DMA controller
- 6-channel interrupt controller
- 512K byte of RAM
- System clocks
- Programmable timers
- PC expansion BUS
- Keyboard interface (for development use)

The following are features unique to the Ampro board that is used with the system.

- DOS Solid state disk sockets: Socket S1 contains an EPROM chip configured as a floppy disk drive A. This drive is the start-up drive for the monitor. Socket S0 contains a battery backed SRAM module configured as a floppy disk drive B. This drive is the storage location for the pressure alert and alarm set-points.
- Configuration EEPROM: This contains computer board configuration information so that is can be used as a target system.

1.9.3 Physical Description

Height 9.9 in. (25,1 cm)
Width 8.5 in. (21,6 cm)
Depth 5.1 in. (13,0 cm)
Weight 6.4 lbs. (2,9 kg)

The 8000 Arterial Monitor is composed of a two piece, structural foam, clam shell housing. The structural foam has an EMI shielding coating on the inside and grey paint on the outside. The front and the back edges of the foam each have a slot built into them. The front slot will trap the four edges of the membrane switch panel. The rear slot will trap the brushed stainless steel back plate. The membrane switch panel provides the support structure for the display board. The metal back plate provides the mounting structure for a power cable, the audio volume control switch, two of the electronic subassemblies, the temperature and pressure measurement board and the power interface board. The cable is permanently attached to the back of the membrane switch panel on one end with a black strain relief and has a high performance connector on the other end. Temperature and pressure transducer cable connections are made to the right hand side of the monitor.

A sliding rail-type bracket mounts on the top of the monitor, with #6-32 screws into threaded inserts in the foam housing. This mounting bracket attaches the monitor to the bottom of the 8000 system mounting arm, allowing the monitor to be pole mounted, left, center, or right on the 8000 base.

Inside the unit, the electronics of the system can be divided into three major sub-assemblies interconnected by a 50-pin ribbon cable.

The first subassembly is a membrane switch panel and a display board fastened together with standoffs. Electrical signals from the membrane switch panel are passed through a 10-pin, dual row, connector to the display board for routing to the computer bus. The display board has LED displays, drivers, buffers and decoding circuitry. Power and computer bus signals are brought to the display board through the 50-pin ribbon connector header.

The second subassembly is the power interface board with the Ampro Core Module™/XT processor board piggy-backed to it using a 64-pin connector. This assembly has the system DC/DC power converter. The power cord and the volume control switch cable plug into this assembly. Computer bus signals and the +5 VDC and ± 12 VDC power are delivered to the system from this subassembly through its 50-pin ribbon connector header.

The third subassembly is the temperature and pressure measurement board. First it is mounted to the sheet metal back plate. Then the power interface board is stack-mounted to it using aluminum standoffs. The pressure and temperature probe header connectors pass through holes in the sheet metal back plate. The pressure connector earthing crown is connected to chassis (sheet metal) ground via an EMI reducing grounding ring. The temperature probe connector headers are insulated from the chassis ground.

1.9.3.1 Membrane Switch Panel

The membrane switch panel is a printed circuit board with a polyester graphics overlay. Switch station pads are embossed into the plastic. The membrane switch panel is 7.3 in. wide x 6.35 in. high by 0.119 ± 0.012 in. (18,5 cm x 16,1 cm x 0,3 ± 0,03 cm).

Metal domes inside the switch panel give the switches tactile feed-back when they are pressed. Activation force is approximately 10 ounces. The switch panel is designed to mount into a four-sided slot in the front of the two piece structural foam housing. Four PEM stud fasteners built into the switch panel board are used to attach the display board. Standoffs are used to space out the display board from the switch panel. The switch panel circuitry is passed to the display board using a male, 10-pin, dual row board connector. The switch panel has an ESD layer which is grounded through the four mounting studs.

1.9.3.2 Processor Board

This board assembly is 3.6 in. x 3.8 in. x 0.60 in. (16,0 cm x 9,7 cm x 1,5 cm). It has four 0.125 in. (0,32 cm) diameter mounting holes. It mounts to the power interface board on one 64-pin, dual row, male header. Two plastic #4 male-female standoffs and hex nuts complete the mounting. Two 10-pin, male, ribbon headers connect the processor serial port and reset line to the power interface board.

1.9.4 Electrical Description

The arterial monitor receives power from the safety system via the arterial monitor cable. The monitor is powered by unregulated 24 VDC which is converted to +5 and ±12 VDC in the monitor and distributed to all boards in the monitor. The arterial monitor requires 24 volts at 0.46 amps.

There is not circuit breaker directly on this monitor; instead, the 24 VDC supply for the arterial monitor is switched by a circuit breaker located at the rear of the safety monitor.

1.9.4.1 Membrane Switch Panel

The board switch array is an X-Y matrix.

Switch contact plus trace series resistance is less than 10Ω.

Nominal current carried through any switch is 2 mA during contact.

Maximum current carrying capability is 20 mA.

1.9.4.2 Processor Board

The Ampro Core Module™/XT board requires +5 VDC ± 5% at 280 mA typical. All bus signals are TTL compatible with a 6 mA drive capability.

1.9.5 Interface Description

A single cable connects the arterial monitor to the 8000 safety monitor. This 6-conductor cable includes a 7-pin Fisher connector. The cable supplies power to the monitor, routes a pump stop signal to the safety monitor, and routes communications between the monitors. The cable is shielded, and the shield provides the chassis safety ground connection.

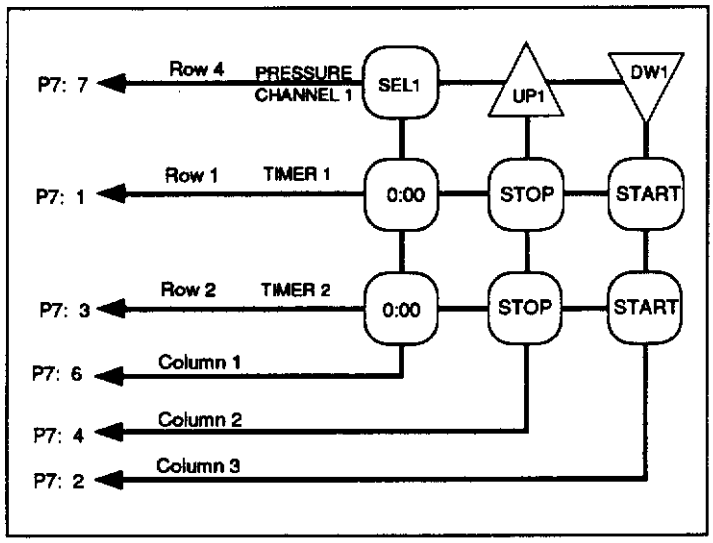
Pin one is the center pin and is used as part of a keying system that prevents the bubble detector cable and the monitor cables from being interchanged.

The pin-out is as follows:

Pin	Signal Description
1	Used as part of keying system
2	+24 VDC power
3	24 VDC power return
4	RS-485
5	RS-485
6	Pump stop output to safety monitor
7	Pump stop return
Shield	Chassis ground

1.9.5.1 Membrane Switch Panel

Two rows of male pins plug into a 10-pin, dual row, female ribbon style header on the display board. The switches are active low (making contact between the signal pin and return) when pressed. The following is the membrane switch panel matrix diagram:



Arterial Membrane Switch Schematic

1.9.5.2 Display Board

The membrane switch panel connector on the display board is a 10-pin, dual row, female board to board interconnect with standard ribbon header pin labeling scheme.

The pin-out for connector P7 is as follows:

Pin	Signal Description	Pin	Signal Description
1	Key Row 1	2	Key Column 3
3	Key Row 2	4	Key Column 2
5	Key Row 3 (Not Used)	6	Key Column 1
7	Key Row 4	8	Not Used
9	Not Used	10	Not Used

The display board gets its computer bus connection through 50-pin connector P6. See the Power Interface Board section below for the 50-pin bus pin-out description.

1.9.5.3 Temperature and Pressure Monitoring Board

One 50-pin ribbon cable forms the system bus and connects the temperature/pressure monitoring board to the display board and the power/safety/processor mother board.

See the Power Interface Board section below for the 50-pin bus pin-out description.

The board includes three board mounted phone jack receptacles for the temperature probes.

It also has one board mounted, 5-pin LEMO™ connector* for the pressure probe.

*Trademark of Lemo USA Inc., Santa Rosa, CA.

1.9.5.4 Power Interface Board

One 50-pin ribbon cable forms the system bus and connects the power interface board to the display board and to the temperature and pressure monitoring board.

The pin-out for the 50-pin ribbon bus connector P6 is as follows:

Pin	Signal Description	Pin	Signal Description
1	A0	2	GND
3	A1	4	GND
5	A2	6	GND
7	A3	8	GND
9	A4	10	GND
11	IOR **	12	GND
13	IOW**	14	GND
15	D0	16	GND
17	D1	18	GND
19	D2	20	GND
21	D3	22	GND
23	D4	24	GND
25	D5	26	GND
27	D6	28	GND
29	D7	30	GND
31	IRQ 2 (or 5)	32	INT Enable from Counter
33	Display Blank	34	+5V DC
35	+5V DC	36	+5V DC
37	+5V DC	38	+5V DC
39	Key Row 4	40	+5V DC
41	Key Row 3	42	Key Column 3
43	Key Row 2	44	Key Column 2
45	Key Row 1	46	Key Column 1
47	Probe Select	48	Counter Chip Select
49	ALPHAS	50	MAXIMS

Note: ** after a signal description defines the signal as active low.

1.9.5.4 Power Interface Board

Two 10-pin ribbon cables connect the processor serial port and reset line to this board.

Serial Port Connector P4:

HDRPin	SignalName	TypicalFunction	Signal DirectionAnd Function
1	DCD	Data Carrier Detect	in, not used
2	DSR	Data Set Ready	in, not used
3	RXD	Receive Data	in
4	RTS	Request to Send	out, direction select
5	TXD	Transmit Data	out
6	CTS	Clear to Send	in, not used
7	DTR	Data Terminal Ready	out, not used
8	RI	Ring Indicator	in, not used
9, 10	GND	Signal Ground	—, not used

Utility Connector P3:

Pin	Signal Name	Function
1	Speaker +	Not Used
2	Speaker -	Not Used
3	Reset SW	Reset control
4	n/c	No Connection
5	Keyboard data	Not Used
6	Keyboard clk	Not Used
7	Ground	Not Used
8	+5V	Not Used
9	Battery V	Not Used
10	Power good	Not Used

One 64-pin, dual row, female header allows the piggy backed connection for the processor board expansion bus. See Processor Board section for the pin-out.

1.9.5.5 Processor Board

One 64-pin, dual row, male header allows the piggy backed connection of the Ampro Core Module™/XT processor board to the power interface board. The pin-out is as follows:

Pin	SignalName	SignalFunction	Pin	Name	Function
A1	-I/O CHCK	Mem parity error	B1	GND	Ground
A2	D7	Data bit 7	B2	RESET	System reset
A3	D6	Data bit 6	B3	+5V	+5 volts power
A4	D5	Data bit 5	B4	IRQ2	Int Request 2
A5	D4	Data bit 4	B5	-5V	o J4 pin 9
A6	D3	Data bit 3	B6	DRQ2	DMA Request 2
A7	D2	Data bit 2	B7	-12V	o J4 pin 10
A8	D1	Data bit 1	B8	-OWS	0 wait state
A9	D0	Data bit 0	B9	+12V	o J4 pin 8
A10	I/O CHRDY	Proc Ready	'B10	GND	Ground
A11	AEN	Address Enable	B11	-SMEMW	Mem Wr lwr 1MB
A12	A19	Address bit 19	B12	-SMEMR	Mem Rd lwr 1MB
A13	A18	Address bit 18	B13	-IOW	I/O Write
A14	A17	Address bit 17	B14	-IOR	I/O Read
A15	A16	Address bit 16	B15	-DACK3	DMA Ack 3
A16	A15	Address bit 15	B16	DRQ3	DMA Request 3
A17	A14	Address bit 14	B17	-DACK1	DMA Ack 1
A18	A13	Address bit 13	B18	DRQ1	DMA Request 1
A19	A12	Address bit 12	B19	-REFRESH	Memory Refresh
A20	A11	Address bit 11	B20	CLK	CPU clock
A21	A10	Address bit 10	B21	IRQ7	Int Request 7
A22	A9	Address bit 9	B22	IRQ6	Int Request 6
A23	A8	Address bit 8	B23	IRQ5	Int Request 5
A24	A7	Address bit 7	B24	IRQ4	Int Request 4
A25	A6	Address bit 6	B25	IRQ3	Int Request 3
A26	A5	Address bit 5	B26	-DACK2	DMA Ack 2
A27	A4	Address bit 4	B27	/C	DMA Term Count
A28	A3	Address bit 3	B28	BALE	Addrs latch en
A29	A2	Address bit 2	B29	+5V	+5 volts power
A30	A1	Address bit 1	B30	OSC	14.3 MHz clock
A31	A0	Address bit 0	B31	GND	Ground
A32	GND (*)	Ground	B32	GND (*)	Ground

1.9.5.5 Processor Board (Continued)

Two 10-pin, male, ribbon headers connect the processor serial port and reset line to the power interface board. The pin-outs are as follows:

Serial Port Connector J2:

HDR Pin	Signal Name	Typical Function
1	DCD	Data Carrier Detect in
2	DSR	Data Set Ready in
3	RXD	Receive Data in
4	RTS	Request to Send out
5	TXD	Transmit Data out
6	CTS	Clear to Send in
7	DTR	Data Terminal Ready out
8	RI	Ring Indicator in
9, 10	GND	Signal Ground —

Utility Connector J4:

Pin	Signal Name	Function
1	Speaker +	Audio signal through 33 ohms
2	Speaker -	Ground
3	Reset SW	Reset control
4	n/c	No Connection
5	Keyboard data	Keyboard data
6	Keyboard clock	Keyboard clock
7	Ground	Ground
8	+5V	+5 for keyboard
9	Battery V	Backup battery connection
10	Power good	Power good signal

1.9.6 Theory of Operation

The arterial monitor digitally displays pressures and temperatures from external probes and provides digital timer functions. The pressure channel can have alert and alarm levels set by the user to warn of impending overpressure and to stop a pump. Warnings include flashing light indicators and audio tones.

1.9.6.1 Membrane Switch Panel

The membrane key pad is X-Y type switch matrix. Pressing a switch closes the metal dome against a switch contact area on the printed circuit board creating a short circuit. The software scans across the matrix periodically by activating one of three column lines and looking for a logic zero for the switches on each row line. The software decodes the switch press into the correct function.

1.9.6.2 Temperature and Pressure Monitoring Board

This board is used by the computer to capture pressure and temperature data in frequency count form. The software then translates the raw data into decimal data suitable for the display board.

The board can be divided into three electrically isolated functional sections: digital section, one analog pressure measurement section and one analog temperature measurement section. Information from each of the analog sections and the control line signals from the digital to the analog sections are passed over an isolation barrier with optical isolators.

The digital section has a counter, latch for control lines, a buffer for control and address lines and a bus transceiver chip for two way data transfer. A single-board microcomputer, located on the Power Interface Board, is used to run software that selects the proper temperature and pressure probe channel, loads and restarts the counter, receives an interrupt to read the count information after each integration period, and calculates the temperature and pressure for later display.

The pressure and temperature measurement sections translate voltage levels, read from a selected probe or reference channel, into frequency-based information. This frequency data is passed over an optical isolator and is translated into counts. The count information is used by the system computer to calculate the pressure and temperature.

1.9.6.3 Processor Board

The Ampro Core Module™/XT is functionally equivalent, from both a hardware and software perspective, with the IBM PC computer mother board with a serial port expansion board and a battery backed RAM feature card.

More information can be found in the "Core Module™/XT Technical Manual", p/n A74080, Revision A, Ampro Computers, Incorporated, Sunnyvale, CA., 1991.

1.9.7 Calibration and Configuration Specifications

1.9.7.1 Pressure Monitoring

The user must zero the pressure transducer to local atmospheric pressure after it is installed into the perfusion circuit. This calibration can be done at any time. Calibration is done from the front panel membrane keypad. The user presses the select switch until "CAL" shows up in the text display. Pressing either of the arrow switches will zero or calibrate the transducer and the monitor to the local atmospheric pressure.

See the performance specification for the pressure and temperature monitoring board for board level calibration information.

1.9.7.2 Temperature Monitoring

The monitor does not need temperature calibration by the user. The temperature system is calibrated only at the board level.

1.9.7.3 Timers

The timers are software driven and do not require calibration.

1.9.7.4 Membrane Switch Panel

None

1.9.8 Service

1.9.8.1 Field Service Diagnostics

1.9.8.1.1 Power On Self-Test

Plug the 8000 Arterial Monitor into the rear of the 8000 Safety Monitor and turn On the power switch on the rear of the Safety Monitor. The arterial monitor will perform a power on self-test (POST). It will sound the two-tone audible alarm and light all the alert and alarm LED bars, all the seven-segment LED displays ("888") and all the dots on both of the alphanumeric message display for approximately three seconds. The software revision level will then appear on each alphanumeric message display in English.

After the POST, the user will see the following:

- The alert and alarm LED bars are off.
- "- - -" will be displayed on the pressure display signifying that the channel is OK but needs to be zeroed (calibrated) to atmospheric pressure.
- "CAL" will be displayed, in the first three character positions of the pressure channel message display, to indicate that the monitor has preselected the calibrate mode for the user at start up or "DEFAULTS" will be displayed indicating that the monitor is using the default alert and alarm pressure set-points. Default alert and alarm values are in use (from EPROM) as battery backed values are not available because they have been lost, corrupted or the BBRAM is new.
- If there is no temperature probe plugged into a channel then "- - -" will be displayed on the temperature display signifying that the channel is OK but needs to have a probe plugged in.
- If the temperature probe is plugged into a channel only part of the way, "999" will be displayed on the temperature display signifying that the system cannot measure the temperature.
- If there is a probe plugged into a channel, then the current temperature will be displayed.
- If any of the pressure or temperature channels or probes are malfunctioning, the 7-segment displays will be blanked.
- Both of the timer displays will show "0:00:00" and will not be running.

1.9.8.1.2 Mode Check

Press the Select switch to display "CAL", "ALARM" and "ALERT".

1.9.8.1.3 Calibrate and Test the Pressure System

Use the SELECT switch to show "CAL" in the message display. Pressing either the UP or DOWN arrow will calibrate a transducer to the monitor pressure system. The pressure display should show zero, "0", until the pressure data become available. The message display will show "mmHg" (or "* * * mmHg" if the alarm is disabled). If there is no transducer plugged in, then the pressure display should remain "- - -" and the text display should remain "CAL". The next selection will show "ALARM" in the message display.

Unplugging a calibrated pressure transducer will cause that channel to lose calibration. The pressure display will show "- - -" and the message display will show "CAL".

Use a pressure transducer simulator to test the pressure accuracy.

1.9.8.1.4 Test Alarm Set-Point

Start the arterial and cardioplegia pumps. Use the Select switch to show "ALARM" in the message display. The red alarm bar should light; the yellow alert bar will go off. The current alarm value will be in the pressure display. Pressing the UP or DOWN arrow switch will increment or decrement the set-point. The alert and alarm set-points cannot be set the same and are kept 10 mmHg apart by the software. If the alarm set-point is decremented to at least 10 mmHg from the alert set-point, the display will blink each time the switch is pressed. The new value is entered and retained by the system by pressing the Select switch. "ALERT" will show up in the message display as this is the next selection. If the monitor receives no further input, it times out in ten seconds and the message display will show "mmHg".

Enter a valid alarm set-point using the instructions above. With the arterial and cardioplegia pumps running, use a pressure transducer simulator to exceed the set-point. The monitor will stop both the arterial and cardioplegia pumps and sound a two-tone alarm while flashing the red LED bar displays. The audio alarm will stop momentarily and then repeat every minute until the alarm condition is removed. The alarm indicators will cease when the pressure is lowered below the set-point. The pump will not restart until the forward buttons are pressed.

1.9.8.1.5 Test Alert Set-Point

Use the Select switch to show "ALERT" in the text display. The yellow alert bar should light; the alarm bar will be off. The current alert value will be in the pressure display. Pressing the UP or DOWN arrow switch will increment or decrement the set-point. The alert and alarm set-points cannot be set the same and are kept at least 10 mmHg apart by the software. If the alert set-point is incremented up to 10 mmHg from the alarm set-point, the display will blink each time the switch is pressed. The new value is entered and retained by the system by pressing the Select switch. "mmHg" or "... mmHg" will show up in the text display as this is the next mode choice. (If uncalibrated, "CAL" will show in the text display.)

Note: Confirmation must be made within 10 seconds or the system will default to "CAL" or "mmHg".

Enter a valid alert set-point using the instructions above. With the arterial and cardioplegia pumps running, use a pressure transducer simulator to exceed the set-point. The monitor should not stop the pumps. The monitor will sound the single tone alert while flashing the yellow LED bar. The audio alert will stop momentarily and then repeat every minute until the alert condition is answered. The alert indicators will cease when the pressure is lowered below the set-point.

1.9.8.1.6 Test a Disabled Alarm

The alarm can be disabled by the user. Use the Select switch to show "ALARM" in the text display. The red alarm bar should light, the yellow alert bar will go off. The current alarm value will be in the pressure display. Press the UP arrow switch to increment the set-point to 999 mmHg. "* * * ALARM" will appear in the text display. The set-point will blink one time for each switch press after the 999 has been reached. The new value is entered and retained by the system by pressing the Select switch. "ALERT" will show up in the text display as this is the next selection. If the monitor receives no further input, it times out in ten seconds and the text display will show "* * * mmHg".

Note: Confirmation must be made within 10 seconds or the system will default to "CAL" or "mmHg".

With the arterial and cardioplegia pumps running, use a pressure transducer simulator to input pressure up to 1000 mmHg. There will be no alarm visual or audio indications. The monitor will not stop the pumps.

1.9.8.1.7 Test Set-Point Storage

Enter valid alert and alarm set-points (not disabled). Turn the monitor off for 10 seconds. Turn the monitor back on again. After the POST, use the Select switch to view the previously entered set-points.

1.9.8.1.8 Operate the Timer System

For either timer, the function of the START, STOP and 0:00 switches are listed below.

	Switch Pressed	Timer Effect
After start-up with 0:00:00 displayed:	START	starts running
	STOP	no change
	0:00	no change
With a timer running:	START	no change
	STOP	freezes, pauses
	0:00	stops at 0:00:00
With a timer paused:	START	starts running from previous value
	STOP	stays frozen
	0:00	stops at 0:00:00

1.10 Cardioplegia Monitor Performance Specification

1.10.1 Operating Parameters

Temperature Requirements

YSI (Yellow Springs Instruments) 400 series temperature probes or an equivalent probe so indicated by the manufacturer.

Temperature Performance

Monitors	Between 0-49.9 °C, with ± 0.3 °C display accuracy and 0.1 °C resolution.
Displays	"—" when <0 °C or no probe. "999" when >49.9 °C or a partially connected probe. Blank if a channel or temperature system malfunctions.

Pressure Requirement

Any probe that meets AAMI standards for physiologic pressure probes. Probes other than that supplied by Sarns may require an adapter cable from Fogg Systems Co, Aurora CO.

1.10.1 Operating Parameters (Continued)

Pressure Performance

Monitors — Pressures of -45 to 990 mmHg

Display — Static Conditions:

Range (mmHg)	Accuracy
-45 to 500	± 10 mmHg
500 to 990	± 20 mmHg

Dynamic Conditions: Display accuracy is ± 40 mmHg, with a dynamic variation of 150 mmHg maximum.

Displays — "- - -" at < -45 mmHg, no probe or uncalibrated.
999" at > 990 mmHg.
(Blank) if a channel or pressure system malfunctions.

Alert and Alarm Limit Set-points (mmHg)

Alert Range	0 - 980 in 10 mmHg increments.	
Alarm Range	10 - 990 in 10 mmHg increments. Displays 999 when disabled.	
Default	Alarm = 360	Alert = 300

Alert — Yellow alert bar flashes with single audio tone beep.

Alarm — Cardioplegia pump stops, red alarm bar flashes with dual audio tone

Data Storage — Alert and alarm set-points are saved when power is off.
A disabled alarm is not saved.

Timer Performance

Delivery timer (CPG) can run when Between Delivery timer (No CPG) is stopped.

Between Delivery timer (No CPG) can run when Delivery timer (CPG) is stopped.

Displays in hours, minutes and seconds.

Environmental Conditions

Operation — 10 to 40 °C, less than 95% relative humidity, noncondensing.

Storage — Ventilated area, -30 to 54 °C (-22 to 130 °F),
less than 95% relative humidity, noncondensing.

1.10.2 Functional Description

The 8000 Cardioplegia Monitor will display two average pressures and three average temperatures and also provides a specialized digital timer function. The pressures can have alert and alarm levels set by the user to warn of overpressure conditions. The alert and alarm level settings are active at the next power up. Alert and alarm conditions are indicated by flashing LED bar displays with single or dual audio tones; an alarm will also stop the cardioplegia pump. The volume of the tone is adjustable by the user.

The front panel is divided into four functional areas:

- Two pressure display areas which include digital and alphanumeric displays, membrane switches, and alarm and alert indicators;
- One temperature display area showing three temperatures;
- One timer area showing cardioplegia delivery time and time since last delivery, with membrane switches to operate the timers.

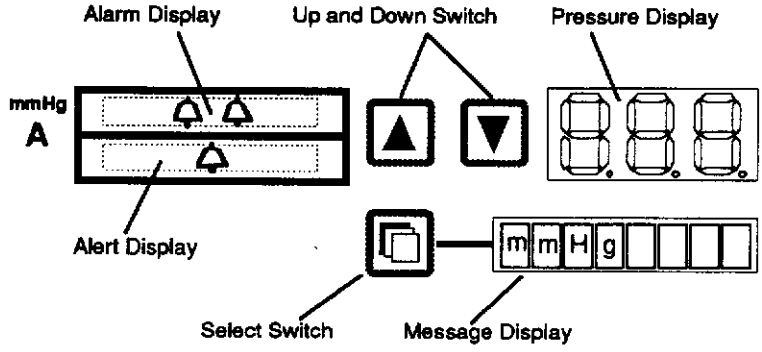
All functions are available to the user at all times. The loss of one or more function will not halt the overall system.

The rear panel of the monitor has the rotary volume control switch and the cardioplegia monitor cable. The cardioplegia monitor cable is permanently attached to the monitor and the other end plugs into the 8000 safety monitor. The main cable power also carries the pump stop signals and communications.

1.10.2.1 Membrane Switch Panel

The membrane switch panel covers the total front surface of the monitor and is used for operator input. Switches are provided for each pressure section and for operation of the timers. The temperature section of the panel has write-on surfaces for the labeling of the temperature displays.

1.10.2.1.1 Pressure Displays and Key Pad



User input for either of the pressure channels:

SELECT switches are used to page through a rotating list of modes. Once calibrated, the display cycles as follows, left justified and sequencing:

"mmHg" or	Units of measurement during use.
"* * * mmHg"	Mode indicating alarm is disabled.
"ALARM" or	Mode for setting alarm.
"* * *ALARM"	Mode indicating alarm is disabled (set beyond limit).
"ALERT "	Mode for setting alert.
"CAL"	Calibrate or recalibrate mode

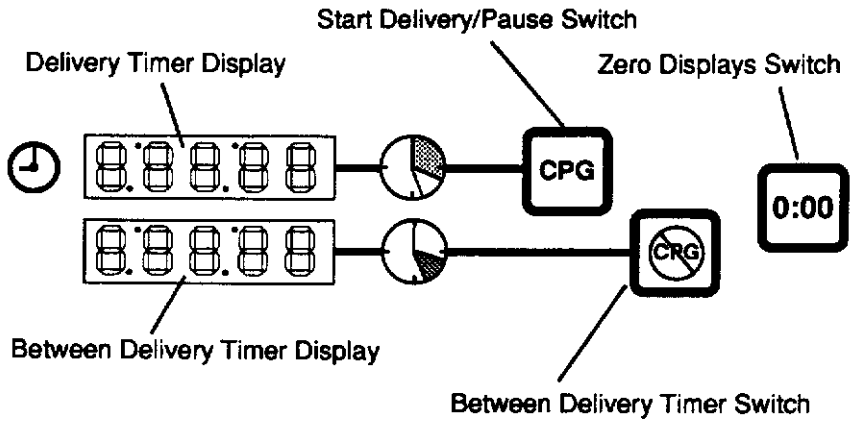
1.10.2.1.1 Pressure Displays and Key Pad (Continued)

Display pressures mode is unavailable when the channel is uncalibrated or malfunctioning.

UP switch is used to increment a pressure alert and alarm set-point. It will also be used during the pressure transducer calibration process (zero the transducer).

DOWN switch is used to decrement a pressure alert and alarm set-point. It will also be used during the pressure transducer calibration process (zero the transducer).

1.10.2.1.2 Timers Displays and Key Pad



User input for the timer section has three switches:

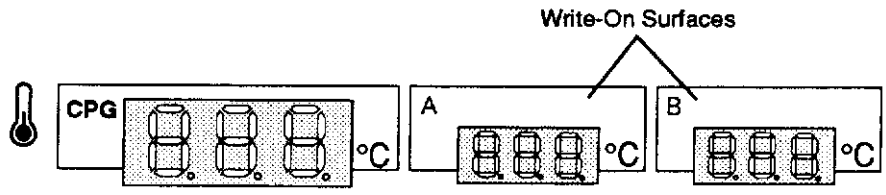
CPG switch is used to start and pause the delivery timer. Pressing this switch while the lower display is running will freeze the lower display and restart the upper display.

NO CPG switch is used to start timing the interval between deliveries.

0:00 switch is used to stop the timer and to zero both of the timer displays.

1.10.2.1.3 Temperature Displays

Each temperature display can be labeled by the user right on the membrane switch panel surface. There are no switches needed for the temperature system.



1.10.2.2. Display Board

The display board presents up-to-date pressure, temperature and timer information in a digital character format. The displays can be read under normal lighting found in the operating room. The board supports seven-segment LEDs, bar format LEDs and eight character, dot-matrix alphanumeric displays. All LEDs are green except for the yellow alert and red alarm displays.

Each pressure channel displays pressure values or an alert/alarm set-point on three-digit seven-segment LEDs without a decimal point. The yellow and red LED bars provide the flashing visual warnings of alert and alarm conditions. Temperatures are displayed on three-digit seven-segment LEDs with a decimal point. The timer section uses five seven-segment LEDs for each timer; the colons are lighted at all times and do not flash.

1.10.2.3 Temperature and Pressure Monitoring Board

This monitor sub-assembly supports the measurement of up to two pressures and three temperatures. The hardware on this board is set up to use the Viggo-Spectramed Model P23XL pressure transducer (or an equivalent disposable with an adaptor cable) and YSI 400 series thermistor temperature probes.

The board can be divided into three electrically isolated functional sections: one digital section, one analog pressure measurement section, and one analog temperature measurement section. Information from each of the analog sections and the control line signals from the digital to the analog sections are passed over an isolation barrier with optical isolators.

The digital section has a counter, latch for control lines, a buffer for control and address lines and a bus transceiver chip for two way data transfer. A single board microcomputer (located on the power interface board) is used to run software that selects the proper temperature and pressure probe channel, loads and restarts the counter, receives an interrupt to read the count information after each integration period, then calculates the temperature and pressure for later display.

The pressure and temperature measurement sections translate voltage levels, read from a selected probe or reference channel, into frequency based information. This frequency data is passed over an optical isolator and is translated into counts. The count information is used by the system computer to calculate the pressure and temperature. The software then translates the raw data into decimal data suitable for the display board.

The board has the following functional circuitry blocks:

- Power supply and probe excitation
- Reference circuitry
- Demultiplexer for probes
- Gain and impedance matching amplifier(s)
- Voltage to frequency conversion
- Edge to level translation with frequency divided by four
- Optical isolator circuitry
- Computer interface circuitry

1.10.2.4 Power Interface Board

The power interface board provides power conversion, system cable interconnection and address decoding when used in a monitoring system. This board also provides a mounting location and connector interface for the Ampro Core Module™/XT computer board.*

The power interface board converts the unregulated and fused +24 VDC from the 8000 base power supply to +5 VDC power using an isolating DC/DC converter. This board provides +5 VDC power to the computer board, the display board, and the pressure and temperature measurement board.

This board has I/O mapped parallel input and output ports which allow the computer to do the following:

- Be reset by a watch dog chip.
- Read the switches of the membrane key pad.
- Read a four position D.I.P switch.
- Activate and deactivate the pump stop line.
- Control a single and dual tone audio tone.
- Pull in temperature and pressure data from the monitor's decoded parallel address and data bus.
- Post information to the display board using the monitor's parallel bus.

*Trademark of Ampro Computers, Inc., Sunnyvale, CA

1.10.2.5 Processor Board

The monitor uses a PC DOS based single board computer with 512K byte of RAM. The system runs at 9.8 MHz. The computer and software control all the monitor functions.

The Ampro Core Module™/XT, with the monitor system software, controls the following functions of this monitor system:

- Reading membrane switch panel input.
- Input, storage and retrieval of alert and alarm set points.
- Sampling raw temperature and pressure data counts from the pressure and temperature measurement board for all channels including references.
- Verification of analog channel set-up.
- Calculating the temperature and pressure for all channels.
- Looking for alert and alarm conditions.
- Reporting audio and visual alert and alarm indications.
- Activation of the current loop source for the pump stop line.
- Counting elapsed time.

1.10.2.5 Processor Board (Continued)

- Displaying temperature, pressure and timer information.

The Ampro Core Module™/XT is a single board microcomputer with the following standard PC features that are important to the function of the monitor:

- 9.8 MHz V20 CPU
- PC compatible ROM-BIOS 1.13 or later
- 3-channel DMA controller
- 6-channel interrupt controller
- 512K byte of RAM
- System clocks
- Programmable timers
- PC expansion BUS
- Keyboard interface (for development use)

The following are features unique to the Ampro board that is used with the system.

- DOS Solid state disk sockets: Socket S1 contains an EPROM chip configured as floppy disk drive A. This drive is the start-up drive for the monitor. Socket S0 contains a battery backed SRAM module configured as floppy disk drive B. This drive is the storage location for the pressure alert and alarm set-points.

- Configuration EEPROM: This contains computer board configuration information so that is can be used as a target system.

1.10.3 Physical Description

Height 8.9 in. (22,6 cm)
Width 8.5 in. (21,6 cm)
Depth 5.1 in. (13,0 cm)
Weight 6.6 lbs. (3,0 kg)

The 8000 Cardioplegia Monitor is composed of a two piece, structural foam clam shell housing. The structural foam has an EMI shielding coating on the inside and grey paint on the outside. The front and the back edges of the foam each have a slot built into them. The front slot will trap the four edges of the membrane switch panel. The rear slot will trap the brushed stainless steel back plate. The membrane switch panel provides the support structure for the display board. The metal back plate provides the mounting structure for a power cable, the audio volume control switch, two of the electronic subassemblies, the temperature and pressure measurement board and the power interface board. The cable is permanently attached to the back of the membrane switch panel on one end with a black strain relief and has a high performance connector on the other end. Temperature and pressure transducer cable connections are made to the right hand side of the monitor.

A sliding rail-type bracket mounts on the monitor with #6-32 screws into threaded inserts in the foam housing. This mounting bracket attaches the monitor to the top of the 8000 system mounting arm, allowing the monitor to be pole mounted, left, center, or right on the 8000 base.

Inside the unit, the electronics of the system can be divided into three major sub-assemblies interconnected by a 50-pin ribbon cable.

1.10.3 Physical Description (Continued)

The first subassembly is a membrane switch panel and a display board fastened together with standoffs. Electrical signals from the membrane switch panel are passed through a 10-pin, dual row, connector to the display board for routing to the computer bus. The display board has LED displays, drivers, buffers and decoding circuitry. Power and computer bus signals are brought to the display board through the 50-pin ribbon connector header.

The second subassembly is the power interface board with the Ampro Core Module™/XT processor board piggy-backed to it using a 64-pin connector. This assembly has the system DC/DC power converter. The power cord and the volume control switch cable plug into this assembly. Computer bus signals and the +5 VDC and ± 12 VDC power are delivered to the system from this subassembly through its 50-pin ribbon connector header.

The third subassembly is the temperature and pressure measurement board. First it is mounted to the sheet metal back plate. Then the power interface board is stack-mounted to it using aluminum standoffs. The pressure and temperature probe header connectors pass through holes in the sheet metal back plate. The pressure connector earthing crown is connected to chassis (sheet metal) ground via an EMI reducing grounding ring. The temperature probe connector headers are insulated from the chassis ground.

1.10.3.1 Membrane Switch Panel

The membrane switch panel is a printed circuit board with a polyester graphics overlay. Switch station pads are embossed into the plastic. The membrane switch panel is 7.3 in. wide x 7.5 in. high by 0.119 ± 0.012 in. (18,5 cm x 19,0 cm x 0,3 ± 0,03 cm).

Metal domes inside the switch panel give the switches tactile feedback when they are pressed. Activation force is approximately 10 ounces. The switch panel is designed to mount into a four-sided slot in the front of the two piece structural foam housing. Four PEM stud fasteners built into the switch panel board are used to attach the display board. Standoffs are used to space out the display board from the switch panel. The switch panel circuitry is passed to the display board using a male, 10-pin, dual row board connector. The switch panel has an ESD layer which is grounded through the four mounting studs.

1.10.3.2 Processor Board

This board assembly is 3.6 in. x 3.8 in. x 0.60 in. (16,0 cm x 9,7 cm x 1,5 cm). It has four 0.125 in. (0,32 cm) diameter mounting holes. It mounts to the power interface board on one 64-pin, dual row, male header. Two plastic #4 male-female standoffs and hex nuts complete the mounting. Two 10-pin, male, ribbon headers connect the processor serial port and reset line to the power interface board.

1.10.4 Electrical Description

The cardioplegia monitor receives power from the safety system via the cardioplegia monitor cable. The monitor is powered by unregulated 24 VDC which is converted to +5 and ±12 VDC in the monitor and distributed to all boards in the monitor. The cardioplegia monitor requires 24 volts at 0.5 amps.

There is not a circuit breaker directly on this monitor; instead, the 24 VDC supply for the cardioplegia monitor is switched by a circuit breaker located at the rear of the safety monitor.

1.10.4.1 Membrane Switch Panel

The board switch array is an X-Y matrix.

Switch contact plus trace series resistance is less than 10Ω.

Nominal current carried through any switch is 2 mA during contact.

Maximum current carrying capability is 20 mA.

1.10.4.2 Processor Board

The Ampro Core Module™/XT board requires +5 VDC ± 5% at 280 mA typical. All bus signals are TTL compatible with a 6 mA drive capability.

1.10.5 Interface Description

A single cable connects the cardioplegia monitor to the 8000 safety monitor. This 6-conductor cable includes a 7-pin Fisher connector. The cable supplies power to the monitor, routes a pump stop signal to the safety monitor, and routes communications. The cable is shielded, and the shield provides the chassis safety ground connection.

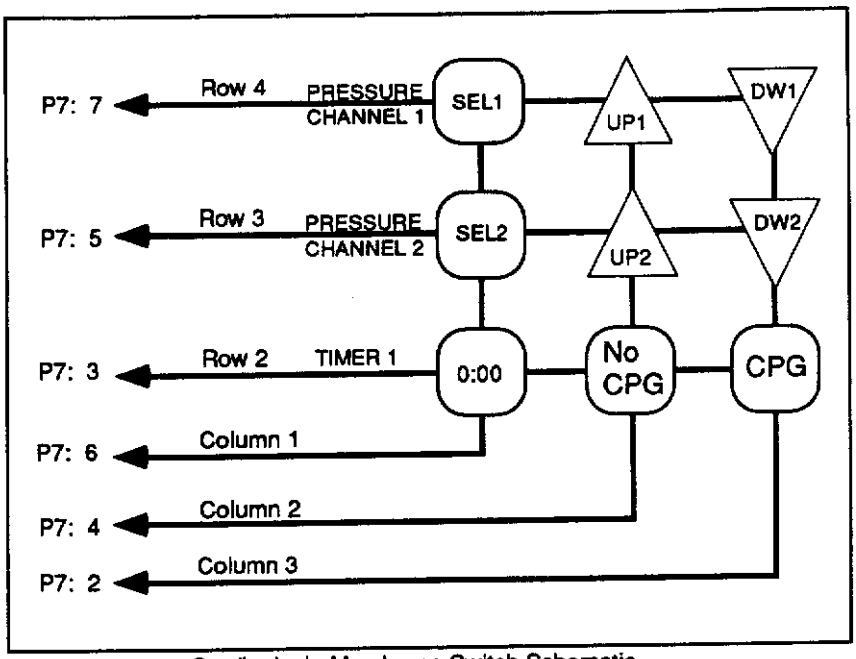
Pin one is the center pin and is used as part of a keying system that prevents the bubble detector cable and the monitor cables from being interchanged.

The pin-out is as follows:

Pin	Signal Description
1	Used as part of keying system
2	+24 VDC power
3	24 VDC power return
4	RS-485
5	RS-485
6	Pump stop output to safety monitor
7	Pump stop return
Shield	Chassis ground

1.10.5.1 Membrane Switch Panel

Two rows of male pins plug into a 10-pin, dual row, female ribbon style header on the display board. The switches are active low (making contact between the signal pin and return) when pressed. The following is the membrane switch panel matrix diagram:



Cardioplegia Membrane Switch Schematic

1.10.5.2 Display Board

The membrane switch panel connector on the display board is a 10-pin, dual row, female board to board interconnect with standard ribbon header pin labeling scheme.

The pin-out for connector P7 is as follows:

Pin	Signal Description	Pin	Signal Description
1	Key Row 1 (Not Used)	2	Key Column 3
3	Key Row 2	4	Key Column 2
5	Key Row 3	6	Key Column 1
7	Key Row 4	8	Not Used
9	Not Used	10	Not Used

The display board gets its computer bus connection through 50-pin connector P6. See the Power Interface Board section below for the 50-pin bus pin-out description.

1.10.5.3 Temperature and Pressure Monitoring Board

One 50-pin ribbon cable forms the system bus and connects the temperature/pressure monitoring board to the display board and the power/safety/processor mother board.

See the Power Interface Board section below for the 50-pin bus pin-out description.

The board includes three board mounted phone jack receptacles for the temperature probes.

It also has two board mounted, 5-pin LEMO™ connectors* for the pressure probes.

*Trademark of Lemo USA Inc., Santa Rosa, CA.

1.10.5.4 Power Interface Board

One 50-pin ribbon cable forms the system bus and connects the power interface board to the display board and to the temperature and pressure monitoring board.

The pin-out for the 50-pin ribbon bus connector P6 is as follows:

Pin	Signal Description	Pin	Signal Description
1	A0	2	GND
3	A1	4	GND
5	A2	6	GND
7	A3	8	GND
9	A4	10	GND
11	IOR *	12	GND
13	IOW *	14	GND
15	D0	16	GND
17	D1	18	GND
19	D2	20	GND
21	D3	22	GND
23	D4	24	GND
25	D5	26	GND
27	D6	28	GND
29	D7	30	GND
31	IRQ 2 (or 5)	32	INT Enable from Counter
33	Display Blank	34	+5V DC
35	+5V DC	36	+5V DC
37	+5V DC	38	+5V DC
39	Key Row 4	40	+5V DC
41	Key Row 3	42	Key Column 3
43	Key Row 2	44	Key Column 2
45	Key Row 1	46	Key Column 1
47	Probe Select	48	Counter Chip Select
49	ALPHAS	50	MAXIMS

Note: * after a signal description defines the signal as active low.

1.10.5.4 Power Interface Board (Continued)

Two 10-pin ribbon cables connect the processor serial port and reset line to this board.

Serial Port Connector P4:

HDRPin	SignalName	TypicalFunction	Signal DirectionAnd Function
1	DCD	Data Carrier Detect	in, not used
2	DSR	Data Set Ready	in, not used
3	RXD	Receive Data	in
4	RTS	Request to Send	out, direction select
5	TXD	Transmit Data	out
6	CTS	Clear to Send	in, not used
7	DTR	Data Terminal Ready	out, not used
8	RI	Ring Indicator	in, not used
9, 10	GND	Signal Ground	—, not used

Utility Connector P3:

Pin	Signal Name	Function
1	Speaker +	Not Used
2	Speaker -	Not Used
3	Reset SW	Reset control
4	n/c	No Connection
5	Keyboard data	Not Used
6	Keyboard clk	Not Used
7	Ground	Not Used
8	+5V	Not Used
9	Battery V	Not Used
10	Power good	Not Used

One 64-pin, dual row, female header allows the piggy backed connection for the processor board expansion bus. See Processor Board section for the pin-out.

1.10.5.5 Processor Board

One 64-pin, dual row, male header allows the piggy backed connection of the Ampro Core Module™/XT processor board to the power interface board. The pin-out is as follows:

Pin	Signal Name	Signal Function	Pin	Name	Function
A1	-I/O CHCK	Mem parity error	B1	GND	Ground
A2	D7	Data bit 7	B2	RESET	System reset
A3	D6	Data bit 6	B3	+5V	+5 volts power
A4	D5	Data bit 5	B4	IRQ2	Int Request 2
A5	D4	Data bit 4	B5	-5V	To J4 pin 9
A6	D3	Data bit 3	B6	DRQ2	DMA Request 2
A7	D2	Data bit 2	B7	-12V	To J4 pin 10
A8	D1	Data bit 1	B8	-OWS	0 wait state
A9	D0	Data bit 0	B9	+12V	To J4 pin 8
A10	I/O CHRDY	Proc Ready	B10	GND	Ground
A11	AEN	Address Enable	B11	-SMEMW	Mem Wr lwr 1MB
A12	A19	Address bit 19	B12	-SMEMR	Mem Rd lwr 1MB
A13	A18	Address bit 18	B13	-IOW	I/O Write
A14	A17	Address bit 17	B14	-IOR	I/O Read
A15	A16	Address bit 16	B15	-DACK3	DMA Ack 3
A16	A15	Address bit 15	B16	DRQ3	DMA Request 3
A17	A14	Address bit 14	B17	-DACK1	DMA Ack 1
A18	A13	Address bit 13	B18	DRQ1	DMA Request 1
A19	A12	Address bit 12	B19	-REFRESH	Memory Refresh
A20	A11	Address bit 11	B20	CLK	CPU clock
A21	A10	Address bit 10	B21	IRQ7	Int Request 7
A22	A9	Address bit 9	B22	IRQ6	Int Request 6
A23	A8	Address bit 8	B23	IRQ5	Int Request 5
A24	A7	Address bit 7	B24	IRQ4	Int Request 4
A25	A6	Address bit 6	B25	IRQ3	Int Request 3
A26	A5	Address bit 5	B26	-DACK2	DMA Ack 2
A27	A4	Address bit 4	B27	T/C	DMA Term Count
A28	A3	Address bit 3	B28	BALE	Addrs latch en
A29	A2	Address bit 2	B29	+5V	+5 volts power
A30	A1	Address bit 1	B30	OSC	14.3 MHz clock
A31	A0	Address bit 0	B31	GND	Ground
A32	GND (*)	Ground	B32	GND (*)	Ground

1.10.5.5 Processor Board (Continued)

Two 10-pin, male, ribbon headers connect the processor serial port and reset line to the power interface board. The pin-outs are as follows:

Serial Port Connector J2:

HDR Pin	Signal Name	Typical Function	
1	DCD	Data Carrier Detect	in
2	DSR	Data Set Ready	in
3	RXD	Receive Data	in
4	RTS	Request to Send	out
5	TXD	Transmit Data	out
6	CTS	Clear to Send	in
7	DTR	Data Terminal Ready	out
8	RI	Ring Indicator	in
9, 10	GND	Signal Ground	—

Utility Connector J4:

Pin	Signal Name	Function
1	Speaker +	Audio signal through 33 Ω
2	Speaker -	Ground
3	Reset SW	Reset control
4	n/c	No Connection
5	Keyboard data	Keyboard data
6	Keyboard clock	Keyboard clock
7	Ground	Ground
8	+5V	+5 for keyboard
9	Battery V	Backup battery connection
10	Power good	Power good signal

1.10.6 Theory of Operation

The Cardioplegia Monitor digitally displays average pressures and temperatures from external probes and provides digital timer functions. The pressures can have alert and alarm levels set by the perfusionist to warn of impending overpressure and to stop a pump. Warnings include flashing light indicators and audio tones.

1.10.6.1 Membrane switch panel

The membrane key pad is X-Y type switch matrix. Pressing a switch closes the metal dome against a switch contact area on the printed circuit board creating a short circuit. The software scans across the matrix periodically by activating one of three column lines and looking for a logic zero for the switches on each row line. The software decodes the switch press into the correct function.

1.10.6.2 Temperature and Pressure Monitoring Board

This board is used by the computer to capture pressure and temperature data in frequency count form. The software then translates the raw data into decimal data suitable for the display board.

The board can be divided into three electrically isolated functional sections: digital section, one analog pressure measurement section and one analog temperature measurement section. Information from each of the analog sections and the control line signals from the digital to the analog sections are passed over an isolation barrier with optical isolators.

The digital section has a counter, latch for control lines, a buffer for control and address lines and a bus transceiver chip for two way data transfer. A single-board microcomputer, located on the Power Interface Board, is used to run software that selects the proper temperature and pressure probe channel, loads and restarts the counter, receives an interrupt to read the count information after each integration period, and calculates the temperature and pressure for later display.

The pressure and temperature measurement sections translate voltage levels, read from a selected probe or reference channel, into frequency-based information. This frequency data is passed over an optical isolator and is translated into counts. The count information is used by the system computer to calculate the pressure and temperature.

1.10.6.3 Processor Board

The Ampro Core Module™/XT is functionally equivalent, from both a hardware and software perspective, with the IBM PC computer mother board with a serial port expansion board and a battery backed RAM feature card.

More information can be found in the "Core Module™/XT Technical Manual", p/n A74080, Revision A, Ampro Computers, Incorporated, Sunnyvale, California, 1991.

1.10.7 Calibration and Configuration Specifications

1.10.7.1 Pressure Monitoring

The user must zero the pressure transducers to local atmospheric pressure after they are installed into the perfusion circuit. This calibration can be done at any time. Calibration is done from the front panel membrane keypad. The user presses the select switch until "CAL" shows up in the text display. Pressing either of the arrow switches will zero or calibrate the transducer and the monitor to the local atmospheric pressure.

1.10.7.2 Temperature Monitoring

The monitor does not need temperature calibration by the user. The temperature system is calibrated only at the board level.

1.10.7.3 Timers

The timers are software driven and do not require calibration.

1.10.7.4 Membrane Switch Panel

None

1.10.8 Service

1.10.8.1 Field Service Diagnostics

1.10.8.1.1 Power On Self-Test

Plug the 8000 Cardioplegia Monitor into the rear of the 8000 Safety Monitor and turn On the power switch on the rear of the Safety Monitor. The cardioplegia monitor will perform a power on self-test (POST). It will sound the two-tone audible alarm and light all the alert and alarm LED bars, all the seven-segment LED displays ("888") and all the dots on both of the alphanumeric message display for approximately three seconds. The software revision level will then appear on each alphanumeric message display in English.

After the POST, the user will see the following:

- The alert and alarm LED bars are off.
- "- - -" will be displayed on each pressure display signifying that the channel is OK but needs to be zeroed (calibrated) to atmospheric pressure.
- "CAL" will be displayed, in the first three character positions on each pressure channels message display, to indicate that the monitor has preselected the calibrate mode for the user at start up or "DEFAULTS" will be displayed indicating that the monitor is using the default alert and alarm pressure set-points. Default alert and alarm values are in use (from EPROM) as battery backed values are not available because they have been lost, corrupted or the BBRAM is new.
- If there is no temperature probe plugged into a channel then "- - -" will be displayed on the temperature display signifying that the channel is OK but needs to have a probe plugged in.
- If the temperature probe is plugged into a channel only part of the way, "999" will be displayed on the temperature display signifying that the system cannot measure the temperature.
- If there is a probe plugged into a channel, then the current temperature will be displayed.
- If any of the pressure or temperature channels or probes are malfunctioning, the 7-segment displays will be blanked.
- Both of the timer displays will show "0:00:00" and will not be running.

1.10.8.1.2 Mode Check

Press the Select switch to display "CAL", "ALARM" and "ALERT".

1.10.8.1.3 Calibrate and Test the Pressure System

Use the Select switch to show "CAL" in the message display. Pressing either the UP or DOWN arrow will calibrate a transducer to the monitor pressure system and zero the display at atmospheric pressure. The pressure display should show zero, "0", until the pressure data become available. The message display will show "mmHg" (or "* * * mmHg" if the alarm is disabled). If there is no transducer plugged in, then the pressure display should remain "- - -" and the text display should remain "CAL". The next selection will show "ALARM" in the message display.

Unplugging a calibrated pressure transducer will cause that channel to lose calibration. The pressure displays will show "- - -" and the message display will show "CAL".

Use a pressure transducer simulator to test the pressure accuracy of each channel.

1.10.8.1.4 Test Alarm Set-Point

Use the Select switch to show "ALARM" in the message display. The red alarm bar should light; the yellow alert bar will be off. The current alarm value will be in the pressure display. Pressing the UP or DOWN arrow switch will increment or decrement the set-point. The alert and alarm set-points cannot be set the same and are kept at least 10 mmHg apart by the software. If the alarm set-point is decremented to 10 mmHg from the alert set-point, the display will blink each time the switch is pressed. The new value is entered and retained by the system by pressing the Select switch. "ALERT" will show up in the message display as this is the next selection. If the monitor receives no further input, it times out in ten seconds and the message display will show "mmHg".

Enter a valid alarm set-point using the instructions above. With the cardioplegia pump running, use a pressure transducer simulator to exceed the set-point. The monitor will stop the pump and sound a two-tone alarm while flashing the red LED bar displays. The audio alarm will stop momentarily and then repeat every one minute until the alarm condition is removed. The alarm indicators will cease when the pressure is lowered below the set-point. The pump will not restart until the forward buttons are pressed.

1.10.8.1.5 Test Alert Set-Point

Use the Select switch to show "ALERT" in the text display. The yellow alert bar should light; the alarm bar will be off. The current alert value will be in the pressure display. Pressing the UP or DOWN arrow switch will increment or decrement the set-point. The alert and alarm set-points cannot be set the same and are kept at least 10 mmHg apart by the software. If the alert set-point is incremented up to 10 mmHg from the alarm set-point, the display will blink each time the switch is pressed. The new value is entered and retained by the system by pressing the Select switch. "mmHg" or "... mmHg" will show up in the text display as this is the next mode choice. (If uncalibrated, "CAL" will show in the text display.)

Note: Confirmation must be made within 10 seconds or the system will default to "CAL" or "mmHg".

Enter a valid alert set-point using the instructions above. With the cardioplegia pump running, use a pressure transducer simulator to exceed the set-point. The monitor should not stop the pump. The monitor will sound the single tone alert while flashing the yellow LED bar. The audio alert will stop momentarily and then repeat every minute until the alert condition is answered. The alert indicators will cease when the pressure is lowered below the set-point.

1.10.8.1.6 Test a Disabled Alarm

The alarm can be disabled by the user. Use the Select switch to show "ALARM" in the text display. The red alarm bar should light, the yellow alert bar will go off. The current alarm value will be in the pressure display. Press the UP arrow switch to increment the set-point to 999 mmHg. "* * * ALARM" will appear in the display. The set-point will blink one time for each switch press after the 999 has been reached. The new value is entered and retained by the system by pressing the Select switch. "ALERT" will show up in the text display as this is the next selection.

Note: Confirmation must be made within 10 seconds or the system will default to "CAL" or "mmHg".

With the cardioplegia pump running, use a pressure transducer simulator to input pressure up to 1000 mmHg. There will be no alarm visual or audio indications. The monitor will not stop the pump.

1.10.8.1.7 Test Set-Point Storage

Enter valid alert and alarm set-points (not disabled alarm). Turn the monitor off for 10 seconds. Turn the monitor back on again. After the POST, use the Select switch to view the previously entered set-points.

1.10.8.1.8 Operate the Timer System

The function of the CPG, NO-CPG and 0:00 switches are listed below:

	SwitchPressed	Timer Display	Timer Effect
After start-up, with 0:00:00 displayed:			
	CPG	Delivery	starts running
		Between Delivery	no change
	NO CPG	Delivery	no change
		Between Delivery	no change
	0:00	Delivery	no change
		Between Delivery	no change
With Delivery timer running:			
	CPG	Delivery	freezes (paused)
		Between Delivery	no change
	NO CPG	Delivery	freezes
		Between Delivery	zeros and starts running
	0:00	Delivery	stops at 0:00:00
		Between Delivery	stops at 0:00:00
With Delivery Timer paused:			
	CPG	Delivery	starts running from previous value
		Between Delivery	no change
	NO CPG	Delivery	stays frozen
		Between Delivery	starts running
	0:00	Delivery	stops at 0:00:00
		Between Delivery	stops at 0:00:00
With Between Delivery timer running	CPG	Delivery	starts running
		Between Delivery	freezes
	NO CPG	Delivery	no change
		Between Delivery	no change
	0:00	Delivery	stops at 0:00:00
		Between Delivery	stops at 0:00:00

1.10.8.2 Preventive Maintenance Guide

Inspect cable and connectors for damage. Monitor main cable shield must not be damaged.

Inspect unit for entry of fluids during each preventive maintenance cycle.

The battery backed SRAM device will require replacement every 10 years according to the vendor, Dallas Semiconductor.

1.10.8.3 Precautions

All circuitry in this unit will operate with a maximum of +36 VDC and will not present shock hazards.

Power should be removed for greater than 30 seconds prior to removing or installing any circuit boards.

Circuit boards should be handled using static protective equipment and procedures.
User input for the pressure channel:

SELECT switch is used to page through a rotating list of modes. Once calibrated, the display cycles as follows, left justified and sequencing:

"mmHg" or	Units of measurement during use.
"* * * mmHg"	Mode indicating alarm is disabled.
"ALARM" or	Mode for setting alarm.
"* * *ALARM"	Mode indicating alarm is disabled (set beyond limit).
"ALERT "	Mode for setting alert.
"CAL"	Calibrate or recalibrate mode

Display pressures mode is unavailable when the channel is uncalibrated or malfunctioning.

UP switch is used to increment a pressure alert and alarm set-point. It will also be used during the pressure transducer calibration process (zero the transducer).

DOWN switch is used to decrement a pressure alert and alarm set-point. It will also be used during the pressure transducer calibration process (zero the transducer).

1.11 Occluder Module Performance Specification

1.11.1 Operating Parameters

Requirements

Tubing Sizes — Minimum: 1/4 in. (6,4 mm) I.D. x 1/16 in. (1,6 mm) wall.
Maximum: 1/2 in. (12,7 mm) I.D. x 3/32 in. (2,4 mm) wall.

Performance

Display — Range: 0-99%.

A blank display indicates that the display is not yet calibrated, or that the occluder is malfunctioning or not connected.

Display shows the approximate percent of flow for 3/8 -1/2 in. (10,0 - 12,0 mm) I.D. tubing only; it shows a reference number only for other tubing sizes.

Accuracy — The occluder will display accurately (±12%) only when using 1/2 in. or 3/8 in. I.D. tubing with the blood at 20 -40°C and with a vertical height of 20 - 36 in. (50,8 - 91,4 cm) from the fluid level in the venous reservoir to the level of the patient.

Accuracy requires proper zeroing and no back pressure.

1.11.2 Functional Description

Occluder fully stops flow under all operating conditions. From the moment the switch is pressed:

- Open switch fully opens the occluder from 0% to 99% of the displayed flow in 2 seconds or less.
- Close switch occludes the tubing from fully open to 0% of the displayed flow in three seconds or less.

Repeatability: With a 10 - 99% flow selected, the position of the occluder anvil can be repeated to within ± 5% of total maximum flow, as measured by the flow through the tubing.

Closure Force: With the anvil in any position, the anvil force is 50 to 60 pounds both when the occluder is first used and after 30 seconds of use. The current, limited to the motor by occluder drive board, is nominally adjusted to 0.86 amps in order to meet this specification.

Latch Release: The occluder latch releases easily, even when the 1/2 in. ID tubing (12,7 mm) is fully occluded.

Occlusion Distance: When fully closed, the occlusion distance is set at 0.08 in. (2,03 mm) nominal with an acceptable range of 0 - 0.1 in. (0 - 2,54 mm); when fully opened, the occlusion distance is a minimum of 0.7 in. (18,0 mm).

Messages: % flow display blank indicates that the internal plunger calibration is lost or the occluder motor assembly is disconnected.

1.11.3 Physical Description

Physical Dimensions

Occluder Module	Depth	8.5 in. (21,6 cm)
	Width	3.0 in. (7,6 cm)
	Height	7.7 in. (19,6 cm)
	Weight	3.6 lbs. (1,6 kg)
Occluder Bracket	Depth	8.0 in. (20,3 cm)
	Width	6.0 in. (15,2 cm)
	Height	9.0 in. (22,9 cm)
	Weight	2.8 lbs. (1,3 kg)
Occluder Head	Depth	8.0 in. (20,3 cm)
	Width	6.5 in. (16,5 cm)
	Height	3.0 in. (7,6 cm)
	Weight	6.2 lbs. (2,8 kg)
Total System Weight	12.6 lbs. (5,7 kg)	

A cable with a 4-pin Cannon connector connects the system to the base.

Environmental Conditions

Operation	10° to 40°C, less than 95% relative humidity, noncondensing.
Storage	Ventilated area, -30° to 54°C (-22 to 130°F), less than 95% relative humidity, noncondensing.

1.11.4 Electrical Description

1.11.4.1 System Inputs

The occluder system consists of a control module and an occluder head. The control module display consists of a membrane keypad with two membrane switches, a rotary encoder and two 7-segment LED displays. The control module provides the means to power the occluder head and to govern the plunger position. The control module receives its unregulated, fused power from the 8000 base and distributes the power to the occluder head. The user inputs information via a membrane keypad and rotary encoder wheel located on the face of the occluder control module.

1.11.4.2 System Outputs

The system provides the means to mechanically occlude the venous return line. When fully closed, the occlusion distance is set at 0.08 in. (2,03 mm) nominal with an acceptable range of 0 - 0.1 in. (0 - 2,54 mm). When fully opened, the occlusion distance is a minimum of 0.70 in. (18,0 mm). A two digit LED display provides the user with the flow expressed in terms of percent of full flow.

1.11.4.3 Electrical Characteristics

Voltage:	18-24 volts (input)
Breaker Protection:	2.5 amps
Current Rating:	1.6 amps (full load, during closure)

1.11.5 Interface

The user interfaces with the system via two membrane switches and a rotary encoder and is supplied feedback by a 2-digit LED. The extracorporeal circuit interfaces with the occluder head (plunger and cover). The occluder interfaces with the occluder module via a 15-pin subminiature "D" connector. The occluder module interfaces with the base via a 4-pin Cannon connector.

1.11.6 Theory of Operation

The user determines the occluder module position (left or right) on the base and connects the proper cabling from the occluder head to module and module to base.

After the initial set-up, the user may push one of two buttons to open/close or rotate a knob for incremental control of the venous line occlusion.

1.11.7 Calibration and Configuration Specifications

The user calibrates the system by placing the tubing in the occluder head and pressing the "Close" switch once.

1.11.8 Service

1.11.8.1 Field Service Diagnostics

When 18 - 36 volts is supplied to the occluder module and the breaker switch is in the "On" position, the system is ready for diagnosis. See the set-up and calibration section for the occluder in the operators manual for set-up procedure.

1.11.8.2 Preventive Maintenance Guide

Clean the occluder head plunger with a stainless steel cleaner after exposure to blood to avoid seal damage.

Turn system On and Off using the breaker switch located on the front of the occluder module once a month to exercise switch components (may be performed with base power off).

1.11.8.3 Precaution

Turn off the breaker switch during connection/disconnection of base and module or occluder head and module to prevent damage to the system.

1.12 Battery Module Performance Specification

1.12.1 Operating Parameters

Electrical Power Requirements

Battery Module Voltage:	115 V 103.5-126.5 V~ (115 V, nominal)	220-240 V 198-264 V~ (220-240 V, nominal)	100 V 90-110 V~ (100 V, nominal)
Frequency:	50/60 Hz	50/60 Hz	50/60 Hz
Fuse Protection:	0.4 amps	0.2 amps	0.4 amps

Electrical Power Performance Leakage Current:	<100 microamperes for 115V and 100V bases (fully loaded); <200 microamperes for 220-240V bases (fully loaded)
Ground Resistance:	0.1 Ohm maximum for all bases.
Emergency Power:	8000 system batteries (two 12 volt, sealed gel cell batteries) will power the arterial pump (operating in continuous mode, at 5 L/min with 1/2 in. tubing), the monitors, occluder and lamp for 40 minutes; when the arterial pump is operated in pulsatile mode or the cardioplegia pump is also operating on battery power, the battery time available will diminish to 25 minutes.
Environmental Conditions Operation	10° to 40°C, less than 95% relative humidity, noncondensing.
Storage	Ventilated area, -30° to 54°C (-22° to 130°F), less than 95% relative humidity, noncondensing.

1.12.2 Functional Description

The 8000 Battery Module is an uninterruptable power supply (UPS). Its purpose is to automatically switch to 24 VDC battery power when mains power is lost as a means to maintain pumping for the period of time necessary to restore mains power. Pumping time is dependent on the state of battery charge, the condition of the batteries and how much of the equipment the perfusionist elects to power while on battery (See Emergency Power in section above). Of the options on the 8000 system, the perfusionist can elect to power the arterial and cardioplegia pumps, the safety monitor, the occluder, the lamp, and the cardioplegia and arterial monitors.

When the 8000 system is powered by mains voltage the battery charging indicator will illuminate. All the equipment will run via power supplies in the base or the pumps. Also, the battery charger will replenish the batteries automatically should they be in a state of discharge. Fully discharged batteries will require 24 hours to reach their full-charge state. Otherwise, a trickle charge is constantly provided to the batteries to maintain their charge.

During loss of mains voltage the UPS will automatically switch to battery power. The battery charging indicator will go out; the two DC power indicators and the battery supply indicators will illuminate. A short audible tone will be emitted every two minutes to remind the operator that they are indeed "on battery". Battery power to the 8000 is protected by the two circuit breakers on the front of the UPS. Once the batteries are depleted the UPS shuts down and the battery supply indicator flashes and the audible tone will continue to sound every two minutes.

When mains power is available again, the battery module will stay "on battery" for approximately 10 seconds to insure that all mains power transients are filtered out. After this delay, the UPS will switch back to mains. The battery charging indicator will relight, the DC power indicators will go out, and the audible tone (every two minutes) will cease.

Once the battery module has been used the 8000 base must be powered by mains voltage with its main circuit breaker turned "on" for a minimum of 24 hours.

1.12.3 Physical Description

Length: 17.0 in. (43,2 cm)
Height: 4.25 in. (10,8 cm)
Depth : 7.5 in. (19,1 cm)
Weight: approx. 27.0 lbs (12,3 kg)

Indicators:
- 1 green square (battery charging)
- 2 yellow square (DC power in use)
- 1 green rectangular (battery charged)
- 1 yellow rectangular (battery power decreasing)
- 1 red rectangular (battery discharged)

Connections
- 1 3-pin mate and lock for VAC input
- 1 9-pin mate and lock for VDC output

1.12.4 Electrical Description

The mains power to the UPS is configured for appropriate voltage by installing the primary transformer wires into their appropriate positions on the printed circuit board. Mains voltage selection can accommodate either 100 V,115 V, or 220-240 V operation. Mains power is needed to charge the batteries inside the UPS. A 24 hour time period is needed to recharge depleted batteries.

The UPS has two 12V batteries that are connected in series to supply 24 VDC to the 8000 base should loss of mains voltage occur. This is done by means of solid state devices in conjunction with electromechanical relays. Incandescent lamps are used to indicate mode and battery condition.

Two circuit breakers on the front of the UPS are for load protection. Each is rated at 10 amps. One breaker is for both pumps while the second breaker protects the pole modules, lamp and occluder.

When the battery is loaded (8000 system operating on battery), the battery condition is displayed on the front panel by red, yellow and green indicator lights. Under normal operating conditions it is possible for two indicators to be illuminated at once. Indicators could illuminate in a solid state or flicker. This is due to changing current draw out of the UPS, relating to the pump roller tube compression.

Light	Battery Voltage	Condition
green	> 23.25	charged
green/yellow	23.25 - 22.75	partial charge
yellow	22.75 - 22.0	partial charge
yellow/red	22.0 - 21.25	partial charge
red	< 21.25	discharged

1.12.5 Interface

There are two cables connecting the Battery Module to the 8000 base: the smaller cable supplies the AC mains while the larger one connects the DC voltages. 27.6 VDC is the maximum output supplied to the base.

The Battery Module may be mounted on the bottom of the 8000 base at any time.

1.12.6 Theory of Operation

The battery module is a unit meant to supply emergency power to the 8000 for a short period of time. It has two 10 amp-hour batteries connected in series. A fully charged set of batteries can supply 10 amps of 24 VDC power for approximately one hour. This module contains one printed circuit board with all the circuitry needed to detect presence of mains power and circuitry to charge the batteries.

Under normal operating conditions the 8000 base has mains power supplied via its power cord. Mains power to this module is brought in through the 3-pin connector in the base. This power is supplied after the main base circuit breaker. The main base circuit breaker is used to tell the UPS that indeed the base is "On" and there is no mains power. When mains power is present and the main base circuit breaker is "On", power is supplied to the transformer in the UPS. The secondary of this transformer does two things: supplies power to the battery charger and indicates state of "Mains power" for detection circuit.

1.12.6.1 Battery Charging Theory

A discharged Battery Module will be recharged once the VAC is available and the main circuit breaker is turned On. Recharge time depends on the condition of the batteries; fully discharged batteries take up to 24 hours to recharge. During initial charging the batteries draw up to 500 milliamps (setting of current limit) but current draw reduces to a trickle (approx. 10 milliamps) once the batteries are fully charged.

A fully charged Battery Module that has been disconnected from VAC for an extended period of time (during storage) may draw more than a trickle charge for a short period of time, quickly reducing the current back down to a trickle charge.

A fully discharged Battery Module left disconnected from VAC for an extended period of time (several hours) may appear to be in good condition, as the batteries rejuvenate themselves from sitting; however, capacity is still diminished immensely and the batteries will require recharging for sustained power backup.

1.12.6.2 Loss of Mains Power Detection Theory

Mains power detection begins at the secondary of the transformer in the UPS. This transformer is powered any time the main base circuit breaker is on and mains power is available. The voltage out of the secondary is rectified, isolated, squared up and then fed to a delay circuit. This delay is implemented to insure that all transients are filtered out. Once loss of mains is detected the circuitry turns on two field effect transistors (FET) that are connected to the batteries. The output of the FETs are connected to the two circuit breakers, then back to the base. Now that battery power is in the base it is brought to the pumps through the pump battery cables. Once in the pump this power is diode OR'd with the pump power supply to insure glitch free operation. The remaining equipment (safety, occluder, lamp) is diode OR'd in the base.

1.12.7 Calibration and Configuration Specifications

1.12.7.1 Calibration Specifications

None required

1.12.7.2 Configuration Specifications

The Battery Module is configured for the proper VAC by installing the primary transformer wires in their appropriate positions in P4 on the PCB (see Section 6, Diagrams and Schematics).

1.12.8 Service

1.12.8.1 Field Service Diagnostics

Check the rechargeable Battery Pack every 3 months. Set up the system with empty, properly occluded tubing in the arterial roller pump and cardioplegia pump; connect the safety monitor to the base, connect the battery cables to both pumps, turn on the lamp and occluder, turn on the system power and start both pumps in Forward mode at 250 RPM. The battery charging indicator should light.

Disconnect the wall power supply; both DC power indicators and battery supply indicator(s) should illuminate.

Run the system for 25 minutes on battery power. If the system is still operational after 25 minutes of use, the battery does not need replacing. Recharge the batteries by operating the system from the wall power supply for at least 24 hours.

Replace the batteries if the system will not operate on battery supply for 25 minutes. Contact Sarns Service or your authorized Sarns distributor for two sealed gel cell batteries.

1.12.8.2 Preventive Maintenance Guide

Replace the system battery pack every two years OR whenever the battery pack can not be fully re-charged within 24 hours OR whenever a fully charged battery pack will not power the arterial pump (operating in continuous mode), monitors, occluder and lamp for 40 minutes.

1.12.8.3 Precautions

Do not store batteries in a discharged state as this will damage them.

1.13 Pulse Module Performance Specification

1.13.1 Operating Parameters

Base setting: 0-100% of pulse height,
Rate: 30-150 beats per minute,
Width time: 0-100% of pulse time.

1.13.2 Functional Description

The Pulse Module attaches to the Sarns™ 8000 Roller Pump and is used to set the operating parameters during the roller pump pulsatile mode of operation. The perfusionist uses three knobs on the Pulse Module to set the Baseline, Pulse Width and Pulse Rate parameters, which are transmitted via serial communications to the arterial pump.

Start and stop of pulsatile mode is controlled by keypad entry on the pump

1.13.3 Electrical Description

Input Power Requirement
18-25 VDC, 80 mA (fuse protection 0.25 A)

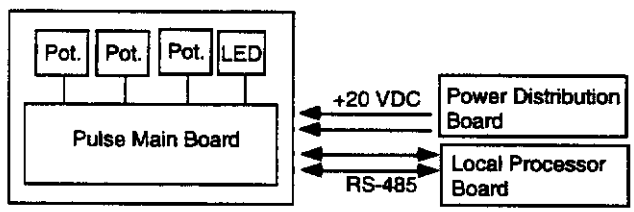
System inputs:
Baseline knob (0-5 volts)
Rate knob (0-5 volts)
Width knob (0-5 volts)
8000 Roller Pump supply (see roller pump performance specification)
RS-485 communications receiving differentially
high input threshhold 0.2V MAX.
low input threshold -0.2V MIN.

System outputs:
RS-485 communications sending differentially (A-B), 0 to 5 volts.

1.13.4 Interface

The cable connector, located on the main board, connects the Pulse Module to the arterial pump.

The cable receives power from the pump and carries communications between the module and the pump (see figure and table below).



Pulse Module Connections with Roller Pump

Pin #	Function
1	RS-485 A
2	RS-485 B
3	regulated +20 volt common
4	regulated +20 volts

The Pulse Module attaches to the RS-485 lines on the arterial pump, thus connecting the module to the arterial branch of the network.

1.13.5 Calibration and Configuration Specification

There are no system level calibration requirements for the Pulse Module. Calibration is performed on the main board at time of manufacture.

1.13.6 Service

When regulated 20 volts is supplied to the Pulse Module, the microcontroller begins a startup routine to check proper function of the external RAM, EPROM, and A/D conversion circuitry. After these self tests are successfully completed,and the pump has responded to the arterial command, the microcontroller turns on the external LED. The Pulse Module sends pulse parameters to the pump; the pulse mode is enabled if the pump's computer control buttons are pressed.

1.13.7 Safety Features

Writing to the watch dog timer ensures that the processor is executing code sequentially and is not caught in a locked state.

An additional watchdog timer ensures board reset if the 5 V logic supply drops below 4.5 volts, e.g., if pump loses and regains power or pump resets.

The software will reset if any of the initialization (EPROM, RAM and A/D) tests fail. If tests do not pass, pulse parameters will not be sent to the pump and pressing computer control mode on the pump will not change pump speed. If the tests pass, normal function begins.

The Pulse Module does not have the capability to stop the pump by sending a stop command.

The Pulse Module has only the following capabilities:
- to set and change the pulsatile parameters
- to request flow information from the pump
- to request pump status to determine if RESET occurred
- to request monitor information.

The user can override pulse mode by pressing the manual mode on the pump.

1.14 Communications Module

1.14.1 Operating Parameters

Environmental Conditions

Operation 10° to 40°C, less than 95% relative humidity, non condensing.

Storage Ventilated area, -30° to 54°C (-22 to 130°F), less than 95% relative humidity, non condensing.

1.14.2 Physical Description

The Communications Module consists of a single board computer and the communications interface board assemblies fastened to a sheet metal bracket. The processor board is attached to the power interface board using a 64 pin connector and two small nylon standoffs. The bracket is used to support the interface board and the module when it is located in the 8K Safety Monitor. The connector for the external computer is also mounted to this bracket; the other end of the cable plugs into the interface board. One LED can be seen near the external computer connector. A sheet metal cover, fastened with four Torx type screws, protects the electronics assemblies from mishandling and electrostatic discharge.

External Dimensions and Weight:

Height	1.8 in. (4,6 cm)
Width	4.5 in. (11,4 cm)
Depth	8.5 in. (21,6 cm)
Weight	1.25 lb. (0,57 kg)

1.14.3 Functional Description

The Communications Module collects perfusion data over two serial communications networks built into the 8K perfusion system. One network is dedicated to arterial devices and the other is dedicated to cardioplegia devices. The data includes arterial and cardioplegia pump flow and temperature and pressure values from the arterial and cardioplegia monitors. The data are repackaged by the Communications Module software into the Sarns ™ Touch And Record (S.T.A.R.) system format and periodically output to a user computer through an isolated RS-232 port.

User Instructions

- Turn off the circuit breaker to the 8K Safety System or to the 8K Base.
- Connect the serial communications cable between the module and the external computer.
- Turn the circuit breaker back on. The LED on the Communications module should light within 35 seconds. This means the module is ready to output data.
- Run S.T.A.R. or other data collection program on the external computer.
- Watch for data every 65 seconds.
- If any of the data are not coming across, check to make sure that the device is powered on and connected to the system.

The 8K Communications Interface Board (8K CIB) provides the interconnection to the arterial and cardioplegia communications networks through the 8K Safety Monitor. It is also the mounting location and connector interface for the single board computer. The 8K CIB has the communications driver chips to run RS-232 or RS-422 interface. It also provides the isolation for the user's external serial communications port.

1.14.3 Functional Description

The power interface board has I/O mapped parallel input and output ports which allow the computer to do the following:

- Indicate that the system is ready by providing the signal to turn on the system O.K. LED.
- Address two, dual channel, serial communications chips used as the interface with the perfusion networks to collect data from the pumps and monitors.
- Post information to an external computer via the external serial communications port.

The 8K Communications Interface Board has a jumper block area and two connectors used to select RS-232 or RS-422 hardware interface and customize the RS-232 interface to the external computer as necessary.

The Communications Module uses a PC DOS based single board computer with 512K or 2 Mbyte of RAM. The computer and software control the following module functions:

- The external system ready LED.
- Requesting and receiving data over the arterial and cardioplegia serial communications networks.
- Sending out the pressure, temperature and pump flows data over the user's external serial port.

The Ampro Core Module™/XT (or /XTPlus) is a single board microcomputer with the following standard PC features that are important to the function of the Communications Module system:

- 9.8 MHz V20 (16 MHz V51) CPU
- PC compatible ROM-BIOS 1.13 (1.08) or later and as qualified
- 3-channel DMA controller
- 6-channel interrupt controller
- 512K byte (2M byte) of RAM
- System clocks
- Programmable timers
- PC expansion BUS
- Keyboard interface (for development use)

The software in the 8K Communications Module will perform the following functions:

- Initialize the microprocessor as a real-time system.
- Initialize the software driven external interface devices.
- Power On Self Test.
- Turn ON/OFF the *System Working* LED.
- Manage the master mode, transition mode and slave mode with the other 8K devices that can be configured (added to and subtracted) from the arterial and cardioplegia LANs.
- Communicate as required with the following 8K devices:
  - Roller Pump
  - ARTMS (Arterial Monitoring System)
  - CPGMS (Cardioplegia Monitoring System)
  - Pulse Module
- Respond properly to changes to the communications network due to the addition or loss of devices due to removal or failure during use.
- Communicate with the user's external computer; by exporting data.
- Respond properly to communications errors.
- Processes the computer watchdog.
- Processes the communications line watchdog.

1.14.4 Electrical Description

The communications module receives power from the 8K Safety Monitor mother board. It requires 470 mA ± 50 mA @ +5 VDC ± 5%.

The external computer's RS-232 and RS-422 communications interface is isolated from the 8000 system's DC and AC power grounds. The DC/DC converter and opto-isolators have isolation ratings of 4000 volts.

The user RS-232 port utilizes RS-232 signals (±9 volt swing).

The user RS-422 port uses ±5 volt differential signals generated by the communications interface chips.

1.14.5 Interface Description

The user's computer connects to the front panel of the communications module via a 9-pin D-type (DB-9) connector. This connector is mounted on the sheet metal bracket.

The other end of this connector assembly is plugged into one of two ribbon header connectors on the communications interface board to configure either an RS-232 or RS-422 interface. This connection and the jumper set-up described in the Calibration and Configuration section complete the interface selection.

The next two sections describe the two different interfaces.

RS-232 Interface Pin out

The table below shows the RS-232 pin out description for 9-pin D-type connector used for the external serial port.

DB9 Pin #	Description (Signal Direction)	DB9 Pin #	Description (Signal Direction)
1	DCD (in) not used	6	DSR (in) not used
2	TX (out)	7	CTS (in)
3	RX (in)	8	RTS (out)
4	DTR (out) not used	9	No connection
5	Isolated ground (—)	-	No connection

The default pin assignment is a RS-232 DTE. Only signals TX, RX, CTS and RTS are implemented. A jumper block is provided on the board assembly to exchange signal assignments to make the 8K Communications Module a DCE device if necessary. The jumper block will also allow alternate jumper configurations for handshaking signals. CTS and RTS may be jumpered together. The default is DCD jumpered to DTR and DSR. Pulling jumpers causes DCD, DTR, DSR not to be connected to each other. See the Calibration and Configuration section for more information.

See Theory of Operation section for more information.

1.14.5 Interface Description (Continued)

RS-422 Interface Pin out

The table below shows the RS-422 pinout description for 9-pin D-type connector used for the external serial port.

DB9 Pin #	Description (Signal Direction)	DB9 Pin #	Description (Signal Direction)
1	TX- (out)	6	CTS- (in)
2	TX+ (out)	7	CTS+ (in)
3	RX- (in)	8	RTS+ (out)
4	RX+ (in)	9	RTS- (out)
5	Iso_GND (—)	-	No connection

The RS-422 signal lines are connected with respect to polarity and signal type. For example the TX+ of the communications module must be connected to RX+ of the external computer. Detailed knowledge of the external computer's configuration and a custom cable will aid in establishing the interface connection.

External Computer Cable Requirements

To help ensure the correct operation of the communications module with the users external computer, the interconnecting cable must be shielded, and be connected to the chassis ground via the connector shell on each end. This will prevent electrostatic discharge from possibly causing a reset of the 8000 System or the user's computer; it also helps to preserve the integrity of the transmitted data.

The shielded cable assembly provided with the 8K Communications Module is a 9-pin D-type connector with pins on one end and a receptacle on the other. The wire connections are straight through.

Compatible Software Versions
The software in the communications module is compatible with the following product software:

- 8K RP (local processor) version 2.3
- 8K PM version 1.1P
- 8K ARTMS version 1.1A
- 8K CPGMS version 1.1K
- S.T.A.R. version 2.24

S.T.A.R. Can Hold Only Three Pressures

If an 8K CPGMS is on the arterial branch then the 2nd pressure, Cardioplegia B, cannot be logged into the S.T.A.R packet as there is not provision for a second arterial pressure. This data value is lost.

1.14.6 Theory of Operation

The 8K Communications Module is mounted within the Sarns™ 8000 Safety Module where it receives its power supply and connects to 8K system devices residing on two independent, multi-dropped RS-485 networks, called the 8K arterial and the 8K cardioplegia local area networks (LAN). The collection of data and maintenance of each of the 8K LAN branches are software functions. Requests for data are sent out by the communications module, and devices respond by sending data back. The perfusion data is repackaged for export in S.T.A.R. format to the external computer. See the S.T.A.R. Network Protocol sections for more information.

Communications Interface Board
The Communications Interface Board is essentially a communications I/O board for the module's single board computer. It interfaces to the computer utilizing a 64-pin, TTL compatible, PC expansion bus of Ampro design. The board has two, dual channel, serial communications controllers (SCC). One is used by the computer to provide two independent networks which operate within the 8000 system; channel A is used for arterial LAN and channel B is used for cardioplegia LAN. Channel A of the second SCC is used to send data out to the external serial port; channel B is not used.

The communications interface board provides ground isolation from the external computer. The signals TX, RX, CTS and RTS pass at TTL levels through optical isolators. Power to the isolated side is provided by a high isolation DC/DC converter. This device powers the configured communications line drivers and receivers along with the receiver side of the optical isolators.

The external serial port can be configured as an RS-232 or RS-422 serial port using the appropriate jumper configurations. These jumpers route the communications signals to a Maxim RS-232 interface chip or National Semiconductor RS-422 driver and receiver pair. See the Calibration and Configuration section.

Single Board Computer
The Ampro Core Module™/XT (or XT Plus) is functionally equivalent, from both a hardware and software perspective, with the IBM PC computer mother board with a serial port expansion board and a battery backed RAM feature card. Software operates under the MS DOS™ environment, version 3.30, while performing communications functions. The communication module system software boots up from an EPROM emulating a floppy disk for program storage, and includes a battery backed RAM emulating a floppy disk for data storage. Peripheral circuitry interfaces with the DOS system utilizing an expansion bus which is signal compatible with the standard XT mother board.

Character Format and Rate for Serial Transmission
The 8K LAN character format will be 1 start bit, 7 data bits, 1 stop bit and 1 odd parity bit. Characters will be sent at 2400 baud ± 5%.

S.T.A.R. Network Protocol
The packet format for all S.T.A.R. communications to the external computer port is shown below containing some sample temperature data. It is comprised of the Packet Header (<), the Packet Length, the Command Letter, the Parameter Values, the Checksum, and the Packet Terminator (>). The length of the packet is determined by the minimum packet length of 8 characters added to the number of parameters out to a maximum of 128 characters. The number of bytes is listed under each segment.

Example of S.T.A.R. Packet Format

	Packet Length	Command Code	Parameters	Checksum	
<	3C	F	ATP 17.3 VTP 20.1 CTP 9.6 TPA 25.2 TPB - - - - TPC 42.9	cc	>
1	2	1	0-121 (53)	2	1

1.14.6 Theory of Operation (Continued)

The characters sent as part of a packet consist of printable ASCII characters only. The range of valid characters is from 020 to 05F hex and 061 to 07A hex. Any character not in the above mentioned range must be converted to a "*" before being sent to S.T.A.R.. The specific fields of the packet are defined below.

Record Header
The first character of any record will be an ASCII '<' character. This character will be recognized as the start of a new record upon any occurrence; therefore, the use of this character should be avoided in the data field. Should this character be encountered in the middle of a record being received, all characters in that record up to the '<' should be discarded, and a new record should be begun.

Packet Length
The second and third characters are to be made up of the ASCII digits 0-9 and letters A-F. The two digit string, with the most significant digit first, represents the total character count of the record being transmitted in hexadecimal. The two digit string is given in hexadecimal notation. For example, if the total length of the packet, including header, length field, command code, parameter field, checksum, and terminator is 64 decimal, the first three characters of the packet will be "<40" (64 decimal is 40H).

Command Code
The fourth character in any record shall be the command code, which identifies the type of record being transmitted. Initially, legal command codes fall in the range of ASCII letters A-Z.

Command Parameters and Fields
The next characters in any record shall be the command parameters. The command parameters can be up to 121 characters, however once a packet is defined, it has a fixed format and length.

The parameter fields consist of one or more occurrences of a descriptive ID field followed by the formatted data for that ID. Each field is separated by a single blank.

- The ID field is unique and consists of 2-4 alphanumeric characters that describe the data being sent.
- The data field is either a value, a flag, or text:
  - Values are indicated by a sequence of X's. The presence of a decimal point indicates whether the value is a floating point value or an integer. Each X represents a digit 0-9, except in the following cases:

    1) The first X of a number can be a '-' to denote a negative number.

    2) Leading spaces (not zeros) will be added to a number if it does not take up the full field width.

    3) In the event that a value that is usually a floating point or integer number is not available (I.E. probe not plugged in) it will be represented by dashes; the number of dashes must equal the field width of the number; the decimal point becomes a dash.

    4) If the number is out of range it will be represented by '9's, the number of '9's must equal the field width of the number.

    5) Floating point or integer fields which have at least 3 characters in the field may also have the value "CAL" (in the left-most 3 positions of the field). "CAL" indicates that a value is not available because the source of the data is uncalibrated. If a "CAL" value is placed into a field which is longer than 3 characters, the positions in the field following the "L" of "CAL" must be padded with blanks.

1.14.6 Theory of Operation (Continued)

6) If the value is a recognized error condition, the number will be represented by a field of blanks (not zeros); the number of blanks equals the field width of the number.

-Flag data is indicated by an "A". The "A" is replaced by a "Y" (event occurred or is occurring) or "N" (event has not occurred or is not currently occurring). Flag data is not used.

-Text data is indicated by a sequence of "B"s. Each B represents an alphanumeric character. Text data is not used.

Checksum
Immediately following the command parameter area is the two character checksum. This value is technically a longitudinal redundancy check (LRC). The LRC is calculated as a 7-bit value. Each bit position in the LRC will be a one if the number of ones in the same bit position of all preceding characters in the record is odd. In programming terms, starting with a zero value, all characters up to the checksum are exclusive-ORed into the accumulated LRC. The LRC is converted to a two digit hexadecimal number in ASCII

Packet Terminator
The ">" character will be recognized as the end of a record upon any occurrence; therefore, the use of this character should be avoided in the parameter field.

Extraneous characters
Additional characters such as carriage return or linefeed may be transmitted after the packet terminator. Because they fall between records, they do not violate the rules outlined above. Such characters are not to be considered as part of any record. The S.T.A.R. DMS will ignore them.

Packet Ordering
All the packets sent to the S.T.A.R. system are always sent in the same order. The following table lists the packets in the order in which they are sent, the content of the packets, and when each packet is sent. To help the reader sort out the requirements, the data values that are collected from the devices on the 8K LAN are inserted into the parameter field locations shown in **bold** type.

Command Code	Packet Content	When Sent
H	Events	Always
I	Events	Always *
J	Alerts	Aways
K	Alarms	Always
A	Actual Temperature Blood Gas	Always
B	Actual Temperature Blood Gas	Always
Q	Normalized Blood Gas	Always
R	Normalized Blood Gas	Always
S	kPa Blood Gas	Always
C	Gas Flow and **Cardioplegia Data**	Always
D	Level Detector, Occluder and **Pressure Data**	Always
E	**Pump Data**	Always
F	**Temp Data**	Always
G	Unused A/D	Always
L	Pump 1 Status	Always *
M	Pump 2 Status	Always *
N	Pump 3 Status	Always *
O	Pump 4 Status	Always *
P	Pump 5 Status	Always *
Z	Expansion (Unused)	Always
X	**8K Arterial and Cardioplegia Timers**	Always
Y	9K Centrifugal pump signed flow data	Always

* 9K Perfusion System sends these events as needed.

1.14.6 Theory of Operation (Continued)

Description of S.T.A.R. Packets Used by 8K Communications Module

The S.T.A.R. format packets which must be sent to the external port are listed with in the following subsections. Note that the packets actually containing 8K system data are a subset of all the packets that have been defined for S.T.A.R. for its use with the 9K Perfusion System. Data to be expected from the 8K Communications Module is shown in **bold type**. Even though only some are filled in with data, the packets used in this application retain their original description form including the listing of all the parameters. S.T.A.R. must have all fields for all the packets complete to accept any of the packets. The H packet must always be sent with the "log now" attribute set to Y (yes). This will cause all the data from the 8K to be logged automatically from the raw data file into the procedure (patient case) data file.

Actual Temperature Blood Gas Data

Command Code	Parameter Field Format	Content Description
A	APO2 XXX VPO2 XXX APCO VPPH X.XX ASAT XX.X VSAT XX.X HCR XX	Art. pO2 (mmHg), Ven. pO2 (mmHg), Art. pCO2 (mmHg), VenpCO2 (mmHg), Art. pH, Ven. pH, Art. Sat, Ven. Sat, Hematocrit.
B	AHCO XX.X VHCO XX.X ATCO XX.X VTCO XX.X AB/E XXX.X VB/E XXX.X K+ XX.X CAT +X.X	Art. HCO3, Ven. HCO3, Art. TCO2, Ven. TCO2, Art. B/E, Ven. B/E, K+, Ca+

All the parameter fields and the decimal places will always have dashes as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

Gas Flow and Cardioplegia Data

Command Code	Parameter Field Format	Content Description
C	GFW - - - - FO2 - - - - FCO - - - - **CXV XXXX**	Total Gas Flow, Fio2, FiCO2, Cumulative Volume

The parameter fields GFW, FO2, FCO will always have dashes as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

Level Detector, Occluder and Pressure Data

Command Code	Parameter Field Format	Content Description
D	OCF - - - VVL - - - - **ARP XXX** **CAP XXX** **AXP XXX** KARP - - - - - KCAP - - - - - KAXP - - - - -	Occluder, Venous Volume, Level, Pressure(mmHg) Pressure (KiloPascals)

The parameter fields OCF, VVL, KARP, KCAP and KAXP will always have dashes as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

1.14.6 Theory of Operation (Continued)

Pump Data

Command Code	Parameter Field Format	Content Description
E	**AFL X.XX CFL X.XX APN - - CPN - - RP1 - - - RP2 - - - RP3 - - - RP4 - - - RP5 - - -**	**Arterial flow, Cardioplegia flow, Arterial pump #, Cardioplegia pump #, RPM for all pumps.** **If arterial or cardioplegia pump is sending RPM value then flow field will be dashes.**

Packet E will be the absolute values for the pump arterial flow rate as S.T.A.R. software version 2.24 is incompatible with negative flows.

The parameter fields pump number and pump RPM will always have dashes as these are 9K Perfusion System parameters not available or required on the 8K Modular Perfusion System.

Temperature Data

Command Code	Parameter Field Format	Content Description
F	**ATP XX.X VTP XX.X CTP XX.X TPA XX.X TPB XX.X TPC XX.X**	Arterial, Venous, Cardioplegia, AuxA, AuxB, AuxC

User Expandable A/D Channel Data

Command Code	Parameter Field Format	Content Description
G	AD1 XXXXX AD2 XXXXX AD3 XXXXX	Readings from the currently unused A/D Channels

All the parameter fields XXXXX will always have dashes as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

Events

Command Code	Parameter Field Format	Content Description
	LOFF N	Level Detector Off, Air Detector Off,
	AOFF N	Off,
H	**LOG Y**	Log S.T.A.R. button pressed,
	VLO N	Venous Line Occluded, no
	APR N	response from Art. pump, Pump
	PTO N	Timer On, Clamp Timer On,
	CTO N	Cardioplegia Complete (Note:
	CMP N	not implemented), Service Pump
	SPS N	Select, Change Pump Selection
	CPS N	(Card = Art), Service Bubble
	SBD N	Detector, Service Temperature
	STM N	Monitor Hardware, Invalid Art
	IPS N	Pump Selection, Arterial Pump
	PBS N	Belt Slip, Service Level Detector,
	SLD N	Invalid Card. Pump Selection,
	ICP N	Extra Status 1, Extra Status 2,
	XS1 N	Stop CPG pump with Arterial pump.
	XS2 N	
	SCA Y	

1.14.6 Theory of Operation (Continued)

Command Code	Parameter Field Format	Content Description
I	PWT XXX PTA X.XX O2B N CFH N ALA BBBBB ALB BBBBB ALC BBBBB PHT XXX	Patient Weight, Patient Area, O2 Air Blend (No = 95/5, Yes = Air), CO2 Flush, Aux. Temp. A-C labels (first 5 chars of label string will be sent), Patient Height

All the parameter fields XXX and decimal points will always have dashes as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System. The auxiliary temperature labels BBBBB will be set to blanks as the 8K Modular Perfusion System has no provision for user entry of a temperature label.

Alerts

Command Code	Parameter Field Format	Content Description
J	PDL N LLL N APL N CPL N HTL N BON N LFI N ABF N AUF N AUS N XT1 N XT2 N XT3 N XT4 N	Gas Pressure Differential Alert, Low Level Alert, Art. Press. Alert, Card. Press. Alert, High Temperature Alert, On battery alert, Low FiO2 Alert, Art. Pump Backflow, Art. Pump Underflow, Art. Pump Underspeed, Extra Alert 1-4.

The attribute parameter fields will always be set to N (no) as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

Alarms

Command Code	Parameter Field Format	Content Description
K	LLM N ADM N APM N CPM N POS N PCL N PJM N AMF N XM0 N XM1 N XM2 N XM3 N XM4 N	Low Level Alarm, Air Detected Alarm, Art. Press. Alarm, Card. Press. Alarm, Arterial Pump Overspeed, Arterial Pump Overcurrent, Arterial Pump Jam, Art. Pump Motorfail, Extra Alarm 0-4.

The attribute parameter fields will always be set to N (no) as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

1.14.6 Theory of Operation (Continued)

Pump 1 Status

Command Code	Parameter Field Format	Content Description
L	MS1 N ST1 N RA1 N RO1 N BS1 N OC1 N MP1 N MD1 N CC1 N OS1 N PM1 N FM1 N UF1 N US1 N PF1 N BF1 N MF1 N NR1 N P01 N P11 N	Motor Safety Test Fail, Stop Test Fail, RAM Test Fail, ROM Test Fail, Belt Slip Detected, Over Current, Motor Speed, Motor Direction Forward, Computer Control On, Motor Over Speed, Pulsatile Mode, Familiarity, Underflow, Underspeed, PAL Fail, Backflow, Motorfail, NoRecall, Centrifugal Pump Family, Unused Pump Family.

The attribute parameter fields will always be set to N (no) as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

Pump 2 Status

Command Code	Parameter Field Format	Content Description
M	MS2 N ST2 N RA2 N RO2 N BS2 N OC2 N MP2 N MD2 N CC2 N OS2 N PM2 N FM2 N UF2 N US2 N PF2 N BF2 N MF2 N NR2 N P02 N P12 N	Motor Safety Test Fail, Stop Test Fail, RAM Test Fail, ROM Test Fail, Belt Slip Detected, Over Current, Motor Speed, Motor Direction Forward, Computer Control On, Motor Over Speed, Pulsatile Mode, Familiarity, Underflow, Underspeed, PAL Fail, Backflow, Motorfail, NoRecall, Centrifugal Pump Family, Unused Pump Family.

The attribute parameter fields will always be set to N (no) as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

Pump 3 Status

Command Code	Parameter Field Format	Content Description
N	MS3 N ST3 N RA3 N RO3 N BS3 N OC3 N MP3 N MD3 N CC3 N OS3 N PM3 N FM3 N UF3 N US3 N PF3 N BF3 N MF3 N NR3 N P03 N P13 N	Motor Safety Test Fail, Stop Test Fail, RAM Test Fail, ROM Test Fail, Belt Slip Detected, Over Current, Motor Speed, Motor Direction Forward, Computer Control On, Motor Over Speed, Pulsatile Mode, Familiarity, Underflow, Underspeed, PAL Fail, Backflow, Motorfail, NoRecall, Centrifugal Pump Family, Unused Pump Family.

The attribute parameter fields will always be set to N (no) as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

1.14.6 Theory of Operation (Continued)

Pump 4 Status

Command Code	Parameter Field Format	Content Description
O	MS4 N ST4 N RA4 N RO4 N BS4 N OC4 N MP4 N MD4 N CC4 N OS4 N PM4 N FM4 N UF4 N US4 N PF4 N BF4 N MF4 N NR4 N P04 N P14 N	Motor Safety Test Fail, Stop Test Fail, RAM Test Fail, ROM Test Fail, Belt Slip Detected, Over Current, Motor Speed, Motor Direction Forward, Computer Control On, Motor Over Speed, Pulsatile Mode, Familiarity, Underflow, Underspeed, PAL Fail, Backflow, Motorfail, NoRecall, Centrifugal Pump Family, Unused Pump Family.

The attribute parameter fields will always be set to N (no) as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

Pump 5 Status

Command Code	Parameter Field Format	Content Description
P	MS5 N ST5 N RA5 N RO5 N BS5 N OC5 N MP5 N MD5 N CC5 N OS5 N PM5 N FM5 N UF5 N US5 N PF5 N BF5 N MF5 N NR5 N P05 N P15 N	Motor Safety Test Fail, Stop Test Fail, RAM Test Fail, ROM Test Fail, Belt Slip Detected, Over Current, Motor Speed, Motor Direction Forward, Computer Control On, Motor Over Speed, Pulsatile Mode, Familiarity, Underflow, Underspeed, PAL Fail, Backflow, Motorfail, NoRecall, Centrifugal Pump Family, Unused Pump Family.

The attribute parameter fields will always be set to N (no) as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

Normalized Blood Gas Data

Command Code	Parameter Field Format	Content Description
Q	AO2N XXX VO2N XXX ACON XX.X VCON XX.X APHN X.XX VPHN X.XX ASTN XX.X VSTN XX.X HCRN XX	Art. pO2, Ven. pO2, Art. pCO2, Ven. pCO2, Art. pH, Ven. pH, Art. Sat, Ven. Sat, Hematocrit. (All are normalized to a 37°C temperature reference).
R	AHCN XX.X VHCN XX.X ATCN XX.X VTCN XX.X ABEN XXX.X VBEN XXX.X K+N XX.X CA+N X.X	Art. HCO3, Ven. HCO3, Art. TCO2, Ven. TCO2, Art. B/E, Ven. B/E, K+, Ca+ (All are normalized to a 37°C temperature reference).

All the parameter fields XXX and decimal points will always have dashes as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

1.14.6 Theory of Operation (Continued)

Kilopascal Blood Gas Data

Command Code	Parameter Field Format	Content Description
S	KAOA XX.X KVOA XX.X KACA XX.X KVCA XX.X KAON XX.X KVON XX.X KACN XX.X KVCN XX.X	Arterial pO2 (kPa, actual) Venous pO2 (kPa, actual) Arterial pCO2 (kPa, actual) Venous pCO2 (kPa, actual) Arterial pO2 (kPa, normalized), Venous pO2 (kPa, normalized), Arterial pCO2 (kPa, normalized), Venous pCO2 (kPa, normalized).

All the parameter fields XXX and decimal points will always have dashes as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

Expansion Area

Command Code	Parameter Field Format	Content Description
Z	V01 X V02 X V03 XX V04 XX V05 XXX V06 XXX V07 XXXX V08 XXXX V09 XXXXX V10 XXXXX V11 N V12 N V13 N V14 N	Extra Field 1-14 (for future expansion).

All the parameter fields XXX and decimal points will always have dashes as these are 9K Perfusion System parameters not available on the 8K Modular Perfusion System.

Arterial and Cardioplegia Timers

Command Code	Parameter Field Format	Content Description
X	**ART1 hmmss** **ART2 hmmss** **CDT hmmss** **BCDT hmmss**	Arterial Monitor Timer 1, Arterial Monitor Timer 2, Cardioplegia Delivery Timer, Between Cardioplegia Delivery Timer

Packet X is incompatible with S.T.A.R. software version 2.24 and S.T.A.R. software will ignore it when it is sent after all the other packets A-Z. This packet has been created with the 8K communications module to allow access to arterial and cardioplegia timer information when using an external computer running a DMS software other than this current version of S.T.A.R. The 9K Perfusion System does not send actual timer information but only timer start/stop events.

Baud Rate, Character Format and Handshaking for Serial Transmission

The external computer port character format will be 1 start bit, 7 data bits, 2 stop bits and1odd parity bit. Characters will be sent at 9600 baud ± 3%.

The hardware handshaking will be used for data flow control in the following manner. Hardware hand-shaking will be initiated by the S.T.A.R. program. When S.T.A.R. is running on the external computer and is ready to receive data, it will make the RTS line active. The communications module will sense this. If the RTS line is made inactive during any part of the data transmission, the communications module will stop sending data and restart with the first packet after the RTS line becomes active again.

1.14.6 Theory of Operation (Continued)

Communicate with External Computer Port
At start-up the communications module establishes that the external computer is present and the S.T.A.R. communications interface begins the process of sending packets to the external port.

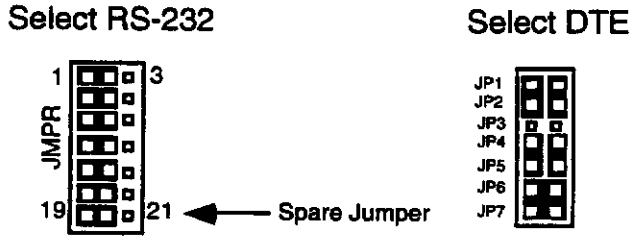
Send S.T.A.R. packets to the external port every 65 seconds (data logging interval).

1.14.7 Calibration and Configuration

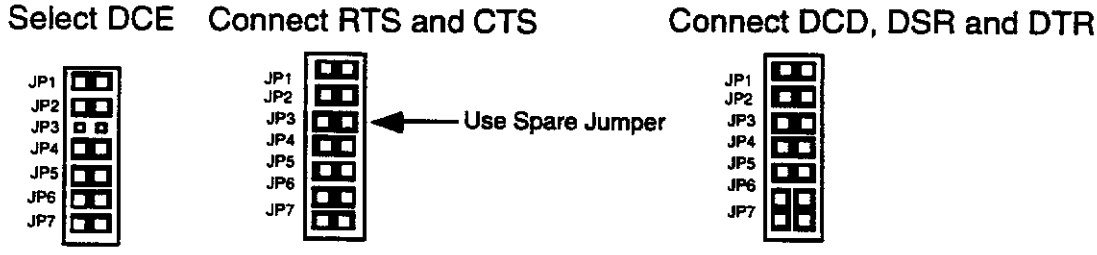
Calibration: None required

Jumpering Communications Interface for External Port
The external serial port of the 8K Communications Module can be configured to RS-232 or RS-422 serial communications interface. The RS-232 interface is shipped as a DTE device. The port can be re-configured from DTE to DCE depending on the user computer's serial port configuration and the available cable. Also provided is jumpering method for connecting DSR, DTR, DCD signal lines together. Select one interface type and configuration using jumper blocks on the 8K CIB. The following sections illustrate the jumpering configurations necessary for each of the serial communications interfaces available.

RS-232
RS-232 and DTE is the default configuration. This setting will allow the use of a male to female, straight through pin-out cable assembly from the module to the user's computer. To select the RS-232 interface, plug the ribbon cable connector end of the serial port cable assembly into connector header J3. Configure the jumpers for RS232 and DTE on the 8K CIB using the following illustration.



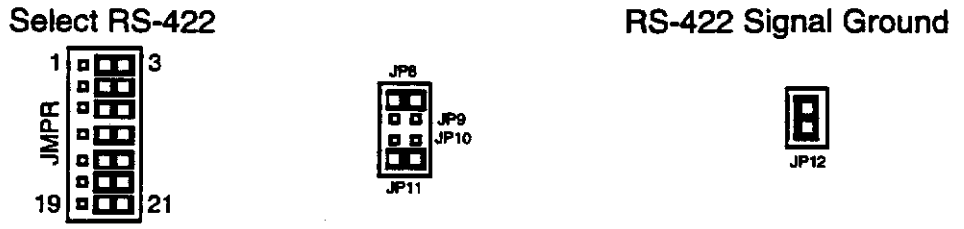
If required specifically by a customer use the following illustrations to implement the following options. Jumpering RTS and CTS together may be implemented for DTE and DCE configurations.



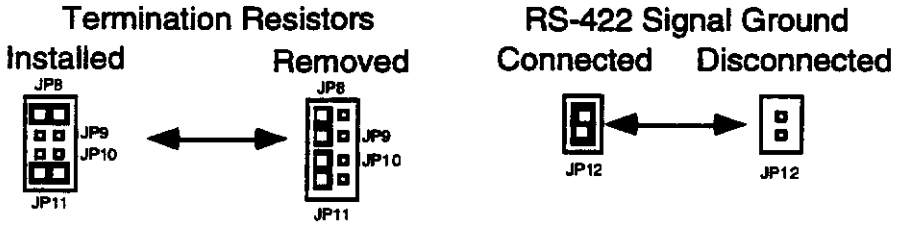
1.14.7 Calibration and Configuration (Continued)

RS-422

RS-422 is the optional differential communications interface configuration. This is designed to be set in the field if required specifically by a customer. To select the RS-422 interface, plug the ribbon cable connector end of the serial port cable assembly into connector header J4. Configure the jumpers on the 8K CIB using the following illustration.



The following illustration shows the other options available when using the RS-422 interface.



DIP Switch SW1

The DIP switch SW1 on the 8K CIB is undedicated, but should be set such that all the switches are open or off.

1.14.8 Service

Field Service Diagnostics

When the 8K Communications Module is installed and powered ON, the external LED will light within 35 seconds. The module will then be collecting data from the internal LAN branches. The software's 3M part number and revision level will be output through the external serial port. Then the first S.T.A.R. data may then be observed within 65 seconds. A terminal program or other diagnostic software will be the only way to verify communications with each device on the networks within the 8K system.

Troubleshooting

If the communications module indicates that data is not being received from some source, communication should be attempted directly with that source. If the direct connection is not successful, proceed with trouble shooting of that particular module. If communication by the test program can be established with all other modules, but the communications module does not indicate such communication, replace the communications module.

If the test system is able to receive all expected data from the communications module, but the user computer does not, check to see that the CTS line is on (-9V, active low) and that TX and RX lines are not reversed. Otherwise, verify user computer functionality.

1.14.8 Service

Preventive Maintenance Guide
Inspect cable and connectors for damage. Main cable shield must not be damaged.

Inspect unit for entry of fluids during each preventive maintenance cycle.

The battery backed SRAM device will require replacement every 10 years according to the supplier.

Table of Contents

Section 2. Maintenance

2.1 Required Tools, Test Equipment, Supplies

The following items are required to service the Sarns™ 8000 Perfusion System:

Item No.	3M I.D.	Description
1	26-1009-7031-3	Lens Remover
2	26-1009-7057-8	Lamp Remover
3	26-1009-3901-1	Terminal Block Tool
4	78-8066-7139-8	Belt Tension Gauge
5	78-8066-7954-0	Pressure Simulator
6	78-8067-7137-2	Occlusion Knob Bearing Insertion Tool
7	78-8067-1686-2	Pump Calibration Fixture
8	78-8066-7138-0	Extender Board
9	78-8066-7140-6	Torx Driver Kit
10	98-0702-0272-0	Level Sensor Pads (20 per package)
11	26-1008-0430-6	AC Current Adapter, Fluke Meter, Y8101
12	78-8066-6969-9	Tubing Insert Screwdriver
13	78-8066-8659-4	Ground Leakage Box
14	78-8066-7253-7	Insulated Screwdriver, Small
15	26-1008-6116-5	Nut Driver, 3/8"
16	26-1008-4445-0	Screwdriver, Medium Blade
17	26-1006-6759-6	Offset Screwdriver
18	26-1008-5018-4	Fluke™ 8060A DMM*
19	26-1008-5074-7	Digital Tachometer, DT107
20	26-1008-5019-2	Soft Face Hammer
21	26-1008-4061-5	Snap Ring Pliers, Small External
22	78-8066-7632-2	Snap Ring Pliers, Modified External
23	26-1007-6794-1	Snap Ring Pliers, Internal
24	26-1008-5017-6	Allen Hex Key Set
25	26-1006-6760-4	Ball Driver 3/16"
26	26-1008-2910-5	Viking Pin Extraction/Insertion Tool
27	78-8066-7119-0	Deluxe Bushing Driver
28	——	Oscilloscope
29	78-8066-7122-4	Adjustment Nut Puller
30	78-8066-7123-2	Spanner Wrench
31	78-8066-7128-1	DX Roller Post Punch
32	78-8066-7129-9	DX Roller Adjustment Tool

*Fluke is a trademark of Fluke International Corp. Everett, Washington, U.S.A.

2.1 Required Tools, Test Equipment, Supplies (Continued)

Item No.	3M I.D.	Description
33	78-8066-8655-2	Roller Bearing Insertion Tool
34	78-8066-7130-7	Torque Wrench Fixture
35	78-8066-7131-5	Tachometer Fixture
36	78-8066-7132-3	Custom to Deluxe Adapter
37	78-8066-7133-1	Roller to Roller Mounting Bar
38	78-8066-7134-9	DX Casting Runout Fixture
39	78-8066-7577-9	Dial Indicator Kit
40	26-1008-4332-0	Torque Wrench, 0-100 in/lbs *
41	26-0001-7472-7	Reamer *
42	26-1008-5072-1	Torque Screwdriver, 6-26 in/lbs ?
43	78-8067-1661-5	Air Sensor Fixture
44	78-8067-1662-3	3/8 Air Sensor Attenuator 2 INFRARED
45	78-8067-1663-1	1/4 Air Sensor Attenuator 2
46	78-8066-9340-0	47° Temperature Probe 2 YSI TEMP PROBES
47	78-8066-9341-8	25° Temperature Probe 1 *
48	78-8067-5159-6	Gapped Screwdriver Bit PUMP MEMBRANE PANEL
49	78-8067-5696-7	Inspection Form
50	78-8066-8426-8	Inspection Label

2.2 EM/PM Procedures

2.2.1 Preliminary Inspection

> **Caution:** Start the system using AC power. Starting the system with battery power and then initiating AC power may cause the system to malfunction.

1. Note any customer comments on the Inspection Report.
2. Record the machine part numbers, serial numbers, run hours, and software version.
3. Note the general appearance of the units. Record any findings, such as broken covers, modifications, missing parts, etc.
4. Measure and record the line voltage. Check the condition of the power cord and strain relief.

2.2.1 Preliminary Inspection (Continued)

5. Measure the system leakage current in normal polarity. Switch off the system. Reverse the polarity, and recheck the leakage current. If it is greater than 100 microamps, refer to Section 5, Troubleshooting.

6. Observe that the following occurs when the system is powered up.

   Start-Up Tests.

   When the system power is first turned on, a self-test is conducted. Always verify that the correct indicators illuminate and pump messages cycle without any fail messages remaining on the message display. If the indicators do not illuminate, check the circuit breakers.

Monitors	On the monitors, all indicators will illuminate for 3 seconds; "888" and the software revision level will appear on the message display; the audio alarm will sound.
Options	The occluder startup lights will illuminate. AC power indicator will illuminate on the battery. Communications light will illuminate on the back of the safety module.
Pumps	The following messages will appear briefly on the pump displays. RESET Ver X.Xd (software version) XXXX.X H (run hours) FAIL 1 (EPROM) FAIL 2 (RAM) FAIL 3 (not applicable) FAIL 4 (EEROM) FAIL 5 (motor fail) FAIL 6 (stop fail) Tube Size, Flow Constant or RPM

If a start-up test fails, the service message will remain on the display until the select switch is pushed. The operator should note the message and then push select so that the testing will continue. Then turn the pump power switch off for 10 seconds and back on to repeat the entire test; if the message appears again and remains on the display, contact Sarns Service before using the pump.

7. Check the rechargeable battery, if installed.

   a. Install tubing in the ART and CPG pumps.

   b. Connect the safety monitor to the base.

   c. Connect the battery cables to both pumps.

   d. Turn on the lamp and occluder.

2.2.1 Preliminary Inspection (Continued)

e. Turn on the system power and start both pumps in forward mode at 250 rpm.

f. The battery charging indicator should illuminate.

g. Disconnect the wall power supply; both DC power indicators and battery supply indicator(s) should illuminate. (Refer to Section 5, Troubleshooting if only the red indicator illuminates.)

h. Plug the power cord into the AC source. Check for and note any abnormal operation.

> **Note:** Power interruption may cause the pumps to go through the startup routine.

i. Stop all the pumps and turn each flowrate knob fully counter-clockwise.

8. Record the existing operator settings:

Pumps:
a. Record which pumps have been designated arterial and cardioplegia, and whether they are battery backed.
b. Record the tube size or flow constant shown in the message display of each roller pump.

Monitors:
a. Record the arterial and cardioplegia pressure alert and alarm limits.
b. Check to see that all the transducer cables installed in the monitor modules are marked. If not, mark them or draw a chart or diagram showing where each transducer is connected.

2.2.2 System Inspection

1. Replace the air filters (base fan, and each pump). Refer to Section 4, Air Filter Replacement.

2. Start both arterial monitor timers.

3. Check the cardioplegia monitor delivery timer.

   a. Press CPG button; timer should start.

   b. Press CPG button, second time; timer should stop.

   c. Press CPG button, third time; timer starts again.

   d. Press NO CPG button; CPG timer should stop and NO CPG timer should start.

   e. Press CLEAR button (0:00); both timers should should stop and clear simultaneously.

4. Check the Safety Monitor:

   a. Record the part numbers and serial numbers of the air sensor and monitor.

   b. Block the air sensor with an opaque object.

2.2.2 System Inspection (Continued)

c. Press the air detection RESET switch on the safety monitor until the red light is no longer illuminated.

d. Press the air detection ON switch.

e. Press the FORWARD switches on the ART and CPG pumps. Turn the speed knobs on both pumps to mid range.

f. Remove the opaque object from the air sensor. The ART pump stops, the red indicator bar flashes, the alarm sounds and repeats once per minute. The pump designated as CPG should also stop.

g. Block the air sensor with an opaque object. Press the air detection RESET switch on the safety monitor until the red indicator is no longer illuminated. The red indicator bar light goes out, the alarm stops, and the pump(s) can be restarted.

h. Check and record the pulse width, period, DC supply, reference voltage, sensor signal voltage, and signal threshold:

- Install the Air Sensor Fixture.
- Connect the common lead of the scope to pin 6. Turn on the air detector. It will alarm during the following four steps.
- Connect the scope to pin 5. The pulse width should be 45 to 65 microseconds. The period should be 1250 to 1600 microseconds.
- Connect the scope to pin 2. The DC supply should be 7.8 to 8.25 VDC.
- Connect the scope to pin 4. The 2.50 VDC reference voltage should be 2.48 to 3.00 VDC.
- Connect the scope to pin 1. Adjust the pot to obtain a reading of 0.6 VAC. Insert the optical calibrator into the sensor. The sensor signal should be 0.125 to 0.200 VAC.
- Block the air sensor with an opaque object. Press the air detection RESET switch.
- Adjust the pot until the air detector alarms. The threshold should be 1.2 to 1.5 VDC.
- Remove the test fixture.

5. Check the Ultrasonic Air Sensor

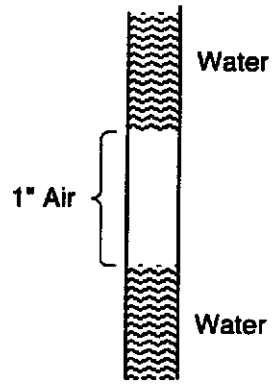
Required tools: 50 MHz Oscilloscope and 10x probe
Air Sensor Test Box , 3M ID 78-8067-1661-5
Adapter Cables: 3M ID 78-8067-6710-5
3M ID 78-8066-6734-7
Tubing, 1-2 feet (0.3 m - 0.6 m): 3/8 in x 3/32 in (9,5 mm x 2,4 mm) for RED air sensor
1/4 in x 3/32 in (6,4 mm x 2,4 mm) for GOLD air sensor
1/4 in x 1/16 in (6,4 mm x 1,6 mm) for BLACK air sensor

Note: Do not use gel with the ultrasonic air sensor.

2.2.2 System Inspection (Continued)

a. Prepare a 1-2 ft. length of water filled tubing. Make sure to entrap a tube-filling bubble of at least 1 inch (2,54 cm) in length. Clamp the ultrasonic air sensor onto the tubing. Do not position the sensor upside down, cover toward floor, as bubbles may go undetected. The tubing must be the appropriate diameter for the sensor.

3/8 in x 3/32 in (9.5 mm x 2.4 mm) for RED air sensor
1/4 in x 3/32 in (6.4 mm x 2.4 mm) for GOLD air sensor
1/4 in x 1/16 in (6.4 mm x 1.6 mm) for BLACK air sensor



Note: This represents a bubble significantly larger than 0.5 ml.

b. Tilt the tubing and air sensor to force any bubbles from the sensor area. Insure that the tubing is fluid filled at the air sensor and that no air bubbles are present in this area.

c. Press and hold the air detection "RESET" switch on the right fixed panel, until the red LED is no longer lit.

d. Press the air detection ON switch.

e. Press the forward switched on the ART and CPG pumps and turn the speed knobs to mid-range. The ART and CPG pumps are designated by the stop/communication lines.

f. Tilt the ultrasonic air sensor to force a 0.5 ml or larger air bubble to pass through the sensor.

g. The ART pump should stop; the CPG pump should stop if designated by the stop communication line; the red indicator bar flashes; the alarm sounds and repeats once per minute.

h. Tilt the air sensor to force the air bubble out of the sensor area. Press and hold the air detection "RESET" switch on the safety monitor. The red indicator bar light goes out and the alarm stops. Restart the pumps. Press the air detector "OFF" switch.

i. Connect the Air Sensor Test Box to the ultrasonic air sensor and to the air detection module in the safety monitor.

j. Tilt the air sensor to force air bubbles out of the sensor area. Turn the potentiometer on the test box fully counterclockwise. Press and hold the air detection "RESET" switch until the red LED is no longer lit, press the air detector "ON" switch.

2.2.2 System Inspection (Continued)

k. Connect the scope probe to ground TP6 on the test box. Connect the scope probe to TP2 on the test box. The voltage reading should be 8.0 ± 0.2 VDC. If not, proceed to Step q.

l. Connect the scope probe ground to TP6 on the test box. Connect the scope probe to TP4 on the test box. The voltage reading should be 2.5 ± 0.1 VDC. If not, proceed to Step q.

m. Measure the pulse width and pulse period. Connect the scope probe ground to TP6 on the test box. Connect the scope probe to TP5 on the test box. The displayed pulse amplitude must be between 2.5 VDC and 8 VDC with a width of 45-65 microseconds. The displayed pulse period should be 1250-1600 microseconds. If not, proceed to Step q.

n. Connect the scope probe ground to TP6 on the test box. Connect the scope probe to TP1 on the test box. Verify that the potentiometer on the test box is turned fully counterclockwise. Tilt the air sensor to force a 0.5 ml or larger air bubble to pass through the sensor. The air detector should alarm. The displayed voltage level should have a minimum amplitude of 4.4 VDC. If not, proceed to Step q. Tilt the air sensor to force the air bubble out of the sensor area. Press the RESET switch.

o. Tilt the air sensor to force all the air bubbles out of the sensor area. With the scope probe ground connected to TP6 and the scope probe connected to TP1, turn the potentiometer on the test box clockwise until the alarm sounds. The voltage reading should be 0.8 VDC - 1.5 VDC. If not, proceed to Step q. Turn the potentiometer fully counterclockwise before proceeding to the next step.

p. Disconnect the test box. Connect the ultrasonic air sensor and the air sensor cord to the air detection module.

q. If the specified voltages or wave forms are not obtained, check all connections at the air sensor and the air detection module in the safety monitor. Verify that all pins are intact. Systematically replace the air sensor cable, the air sensor, then the air detection module. Check for the appropriate voltage or wave form after each replacement. Continue the inspection.

6. Check level detection:

> **Caution:** Do not drop the level sensors as physical shock may damage the sensor.

a. Attach the alarm and alert sensors to a clear plastic container.

b. Rotate the switch on the safety monitor to position 1 for Alert/Alarm.

c. Disconnect the alert sensor from the level detector module. Verify that the yellow LEVEL ALERT SENSOR DISCONNECTED light illuminates to indicate that the alert sensor is disconnected.

d. Fill the container with water until the water level is above both sensors.

e. Press the level detection ON switch.

f. Press the FORWARD or REVERSE switches on the ART and CPG pumps. Turn the speed knobs on both pumps to mid range.

2.2.2 System Inspection (Continued)

g. Tilt the container until the water level is below the alert sensor only. The alert sounds (and repeats once per minute), and the alert indicator bar flashes yellow. The pumps continue to run.

h. Tilt the container until the water level is above both sensors. The alert stops sounding, and the yellow alert indicator bar stops flashing.

i. Tilt the container until the water level is below the alarm sensor. The alarm sounds (and repeats once per minute), the alarm indicator bar flashes red and the pump(s) stop.

j. Tilt the container until the water level is above both sensors. Press the level detection RESET switch. The red indicator bar stops flashing and the alarm stops sounding.

k. Restart the pumps.

l. Rotate the switch on the level detector module to position 2 for alarm only.

m. Repeat steps i, j, and k.

n. Rotate the switch on the level detector module to position 4 for alert only.

> **Note:** Position 3 is not functional on any machine.

o. Repeat steps g and h.

p. Stop the pump(s) and press the level detection OFF switch.

7. Check the occluder, if installed:

a. Record the part number and serial number of the occluder module.

b. Install tubing in the occluder.

c. Press the OPEN switch on the control panel, then press the CLOSE switch. When fully closed, the occluder display reads "0".

d. Press the OPEN switch. The number in the occluder display increases rapidly to 99.

e. Press the CLOSE switch. Fill the tube with water. With a one meter head of water above the occluder, no water should pass through the tube. If it does, perform Section 3, Calibrating the Occluder Drive Board.

f. Verify that the manual control knob opens and closes the occluder.

2.2.2 System Inspection (Continued)

8. Check the pressure displays:

> **Warning:** Pressure transducer cables without transducers attached must be disconnected from the console; cables without transducers act as antennae for electromagnetic interference and may stop the pump.

Arterial Monitor

a. Record the part number and serial number of the monitor.

b. Select CAL on the message display.

c. Install the pressure board test fixture into the jack marked "mmHg" on the monitor. Set the fixture to "0" and "+".

d. Press either arrow switch and then press select switch again.The message display should indicate "0 mmHg".

e. Set the alarm limit to 220 mmHg, and the alert limit to 180 mmHg.

f. Turn the test fixture knob to each setting. The pressure displayed on the message display must be ± 10 mmHg of the test fixture setting.

g. Press the FORWARD or REVERSE switches on the ART and CPG pumps. Turn the speed knobs on both pumps to mid range.

h. Set the test fixture to 200 mmHg. The alert sounds and the yellow indicator bar flashes. The pumps continue to run.

i. Set the test fixture to 300 mmHg. The alarm sounds, the red indicator bar flashes, and the ART and/or CPG pump stops.

j. Set the test fixture to 200 mmHg. The alarm stops and the alert repeats. Restart the pump(s).

k. Remove the test fixture from the "mmHg" jack. The arterial pressure display changes to "- - -".

Cardioplegia Monitor

a. Record the part number and serial number of the monitor.

b. Select CAL on the message display.

c. Install the pressure board test fixture into the Channel A jack marked "mmHg" on the monitor. Set the fixture to "0" and "+".

d. Press either arrow switch and then press select switch again. The message display should indicate "0 mmHg".

e. Set alarm limit to 220 mmHg, and alert limit to 180 mmHg.

2.2.2 System Inspection (Continued)

f. Turn the test fixture knob to each setting. The pressure displayed on the message display must be ±10 mmHg of the test fixture setting.

g. Press the FORWARD or REVERSE switches on the ART and CPG pumps. Turn the speed knobs on both pumps to mid range.

h. Set the test fixture to 200 mmHg. The alert sounds and the yellow indicator bar flashes. The pumps continue to run.

i. Set the test fixture to 300 mmHg. The alarm sounds, the red indicator bar flashes, and the CPG pump only stops.

j. Set the test fixture to 200 mmHg. The alarm stops and the alert repeats. Restart the pump.

k. Repeat steps b through j for channel B of the cardioplegia monitor.

9. Check the temperature displays:

> **Warning:** Use only the specified probes to ensure that the temperature and pressure monitoring function properly

a. Install a calibrated temperature probe into each temperature jack located on the Arterial and Cardioplegia monitors. The displayed temperature must be ± 0.3 °C of the calibrated probe, and each temperature must be within ± 0.1 °C of each other.

10. Check pulse module.

No special tools required.
Record the part number and serial number of the pulse module.
Note customer settings for BASELINE, RATE, and WIDTH.

a. Turn the arterial pump circuit breaker OFF. Connect the pulse module to the arterial pump at the RS-485 port. Turn the arterial pump circuit breaker ON.

b. The green LED on the pulse module should light.

c. Rotate the three control knobs on the pulse module to verify that they turn freely from the minimum parameter to the maximum parameter setting.

d. Set RATE to 60 bpm; WIDTH to 50%; BASELINE to 50%.

e. Press the forward switches on the arterial pump and turn the flowrate knob fully clockwise. The pump should run at maximum speed.

f. Press and hold the two computer control switches on the arterial pump. The message display should indicate that the pump is ramping down from 100 to the BASELINE setting of 50%. The pump will run at full speed for 1/2 second and then half speed for 1/2 second.

g. Set BASELINE to 0%. The pump will run at maximum speed for 1/2 second and then stop for 1/2 second.

2.2.2 System Inspection (Continued)

h. Set BASELINE to 50%; RATE to 30 bpm; and WIDTH to 50%. Verify that the pump pulses 30 times per minute.

i. Test for proper operation of the pulse module on remaining pumps.

j. Reset BASELINE, WIDTH, and RATE to customer settings.

2.2.3 Roller Pump Inspection

1. Record the part number and serial number for each pump.

2. Place each pump in the stop mode and press the select switch. Verify that the message display shows the following in sequence: 1/4, 3/8, 1/2, 5/8, 6mm, 8mm, 10mm, 12mm, S4:1, S2:1, S1:1, Fxxx, and RPM.

3. Turn the machine power switch to OFF, wait ten seconds, and turn it ON. Verify that the message display on each pump shows the following in sequence:

RESET (each pump relay clicks once)
Ver. X.Xd (software version)
XXXX.X H (run hours)
FAIL 1 (EPROM)
FAIL 2 (RAM)
FAIL 3 (not applicable)
FAIL 4 (EEROM)
FAIL 5 (motor fail)
FAIL 6 (stop fail)
Tubing Size, Flow Constant or RPM

If any fail messages remain on the pumps, note them, and refer to Section 5, Troubleshooting.

4. Perform the following for each pump:

a. Install an emergency hand crank into the pump head.

b. Turn the flowrate knob fully counter-clockwise.

c. Place the pump in reverse by pressing both REVERSE switches for four seconds.

d. Hold the hand crank and increase the pump speed until a pump jam occurs. The pump stops and PUMP JAM appears in the message display.

e. Remove the hand crank and press the FORWARD or REVERSE switches to clear the pump jam condition.

f. Install the appropriate size tubing in the pump.

g. Set the proper occlusion for the pump as described in the Roller Pump section of the 8000 Modular Perfusion System Operators Manual.

h. Run the pump in forward and reverse. If there are any unusual noises, note them, and refer to Section 5, Troubleshooting

2.2.3 Roller Pump Inspection (Continued)

i. When removing the tubing, be careful not to touch or move the occlusion knob.

5. Check the pump designations:

   a. Select each pump as arterial by connecting the pigtail cable marked ART from the base to the ART/CPG connector on the pump. Verify that when each pump is selected, it can be stopped by a simulated air bubble alarm.

   b. Select each pump as cardioplegia by connecting the pigtail cable marked CPG from the base to the ART/CPG connector on each pump. Verify that when each pump is selected, it can be stopped by a simulated air bubble alarm.

   c. Return the ART and CPG pumps to their original selections.

6. Check the shoulder screws (Refer to Section 7, Roller Pump Guts for location):

   a. Set the machine power switch to OFF.

   b. Set the torque screwdriver to 17 in-lbs.

   c. Verify that all four shoulder screws on each pump are torqued to 17 in-lbs.

7. Check the roller-to-roller. Refer to Section 3, Adjusting Roller-To-Roller. PAGES 3-2 + 3-3

8. Check the casting:

   a. Check the casting runout. Refer to Section 3, Checking/Adjusting Casting Runout. PAGES 3-6 + 3-7

   b. Inspect the casting for any nicks or scratches in the tubing path. As a guide, the casting should be replaced if a nick or scratch is deep enough to catch a fingernail.

9. Check the rollers and roller bearings:

   a. Spin each roller with your fingers. Each should spin freely; if not, refer to Section 4, Replacing Roller Bearings.

   b. Inspect each roller for any nicks or scratches. As a guide, the roller should be replaced if a nick or scratch is deep enough to catch a fingernail.

10. Check the casting bearing:

    a. Use a hand crank to spin the roller assembly. It should spin freely and smoothly. If any unusual noises are heard, refer to Section 5, Troubleshooting.

11. Check the tube guide rollers:

    a. Remove all the tube guide rollers.

    b. Apply a thin coat of grease to each screw.

    c. Re-install the greased screws and rollers. Torque the roller screws to 7 in-lbs. Clean off any excess grease.

2.2.3 Roller Pump Inspection (Continued)

d. Spin each tube guide roller with your fingers. Each roller should spin smoothly. If not, remove the roller and check for a groove worn into the roller post where the tube guide screw shoulder touches the post. If a groove is visible, file it smooth. Re-install the roller and screw. Try to spin the roller again. If it is still hard to spin, replace the tube guide and/or the screw.

12. Check the occlusion mechanism:

    a. Apply a thin coat of grease to the lip of the occlusion mechanism.

    b. Turn the mechanism back and forth. It should turn smoothly and easily. If not, refer to Section 5, Troubleshooting.

    c. Verify that the four screws securing the gauge ring to the lip are tight.

13. Check the tube clamp mechanisms:

    a. Remove both tube clamp mechanisms.

    b. Verify that the screws holding the tubing inserts are tight and that all pins are secure.

    c. Slide the tube clamp mechanisms back onto the black dovetails. It should require some force to do this; if not, replace the dovetail.

14. Set the machine power switch to ON.

15. Check overspeed:

    a. Insert a hand crank into the pump. Turn the flowrate knob fully counter-clockwise.

    b. Press the FORWARD switches on the pump.

    c. Use the hand crank to rotate the pump counter-clockwise at 20-25 rpm. The message display shows OVERSPEED 3 and the pump stops.

    d. Remove the hand crank. Press the FORWARD switches to clear the OVERSPEED 3 condition.

16. Check the cover interlock:

    a. Set the pump flow rate to maximum speed.

    b. Lift the pump cover approximately 1.5 inches (3,81 cm). The pump should stop rotating; if not, see Section 5, Troubleshooting.

    c. Press both FORWARD switches to restart the pump. Then apply a slight clockwise pressure to the flowrate knob. The maximum RPM should be 250 ± 2 (use a digital tachometer to verify the RPM reading); if not, refer to Section 3, Calibrating the Pump Control Board.

2.2.4 Final Inspection

1. Re-enter all the operator settings that were recorded in the Preliminary Inspection.
2. Turn all pump flowrate knobs fully counter-clockwise.
3. Leave the system cleaner than you found it.
4. Measure the system leakage current in normal polarity; switch the system off, reverse the polarity, and recheck the leakage current.
5. Note on the Inspection Report any additional service that needs to be performed.
6. Place the inspection label on the unit.

ALSO ✓ BATTERY (UPS) OPERATION - PAGE 3-12 (SECTION II-8 ON PM FORM)

ALSO ✓ AUX. OUTLETS UNDER A LOAD (SECTION II-9 ON PM FORM)

Table of Contents

Section 3. Adjustment Procedures

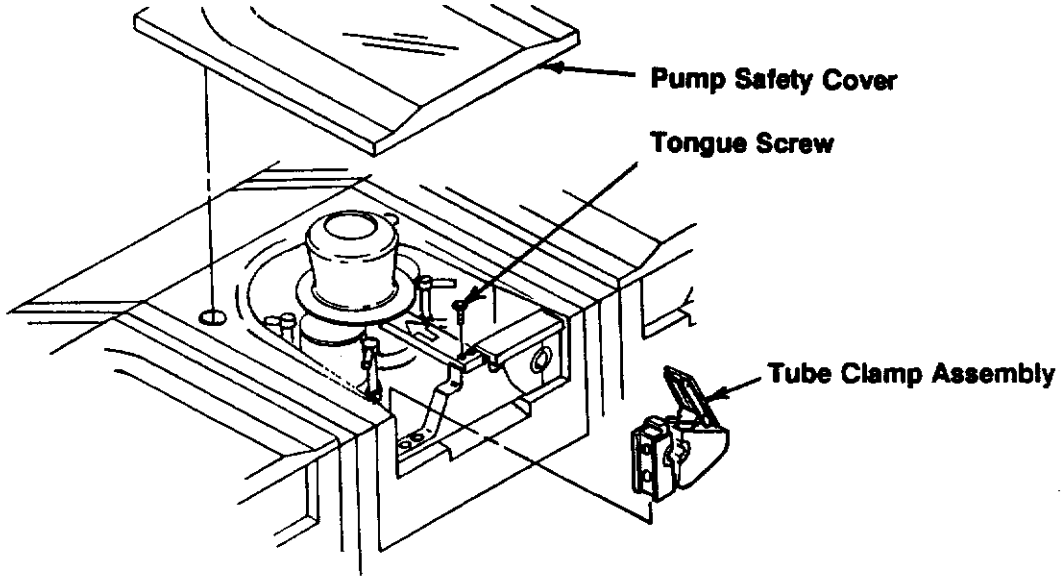
3.1 Roller Pump Adjustments

3.1.1 Checking Roller-to-Roller

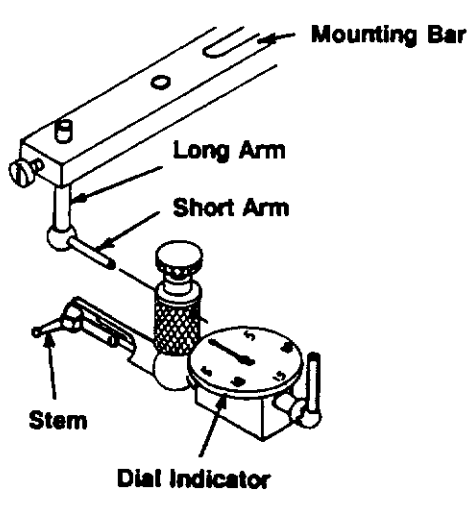
> **Warning:** Occlusion must be set by moving the rollers toward the pump race in order to take up any free play in the mechanism. Do not adjust occlusion by moving the rollers away from the race as under-occlusion may result.

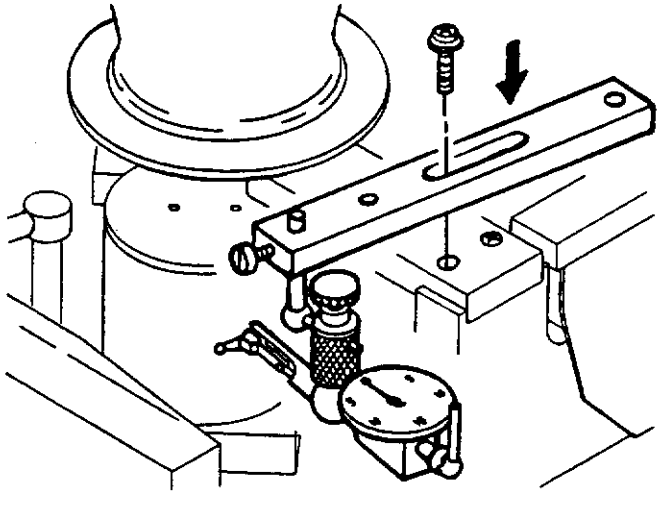
1. Set the occlusion. Note the position of the occlusion adjustment knob in reference to the arrow on the tongue. Except where indicated by these instructions, do not move the knob.

2. Remove the pump safety cover, the right tube clamp assembly, and the right screw from the tongue.



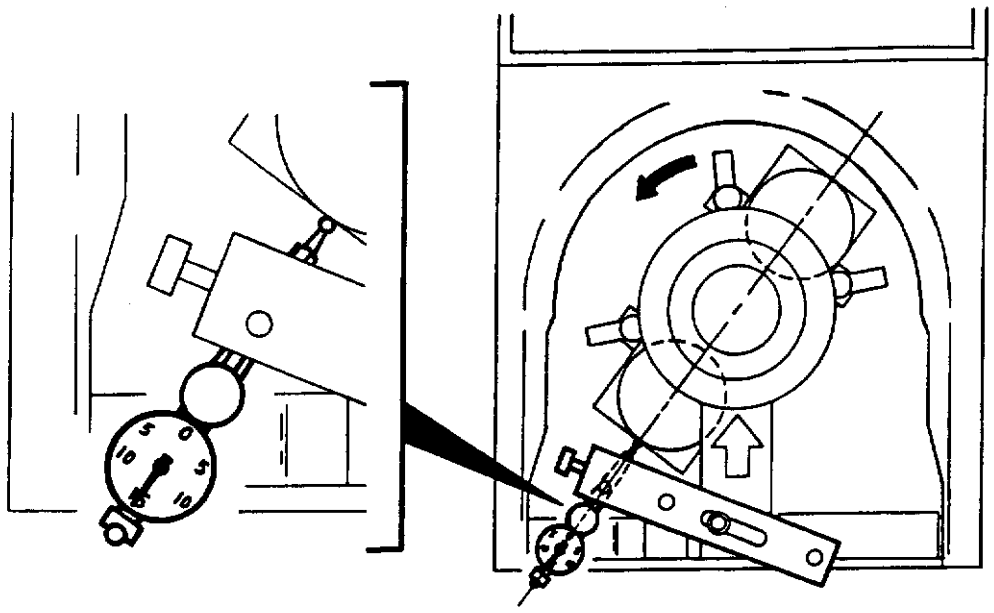
3. Assemble the dial indicator kit and roller-to-roller mounting bar. Secure the dial indicator and mounting bar to the tongue as shown below.





3.1.1 Checking Roller-to-Roller (Continued)

4. Adjust the dial indicator position so that the needle deflects to mid-scale when the stem makes contact with the highest point of one of the rollers. Make sure that the stem is at a 45° angle when it contacts the roller.



5. Choose one roller as a reference. Rotate the roller arm assembly and observe the maximum dial needle deflection caused by the reference roller. Turn the dial scale so that the point of maximum deflection is set to zero.

6. Rotate the roller arm assembly and observe the maximum dial needle deflection caused by the non-reference roller.

7. Turn the occlusion adjustment knob one revolution clockwise and then counter-clockwise to the same point (as noted in Step 1). Repeat steps 5 and 6.

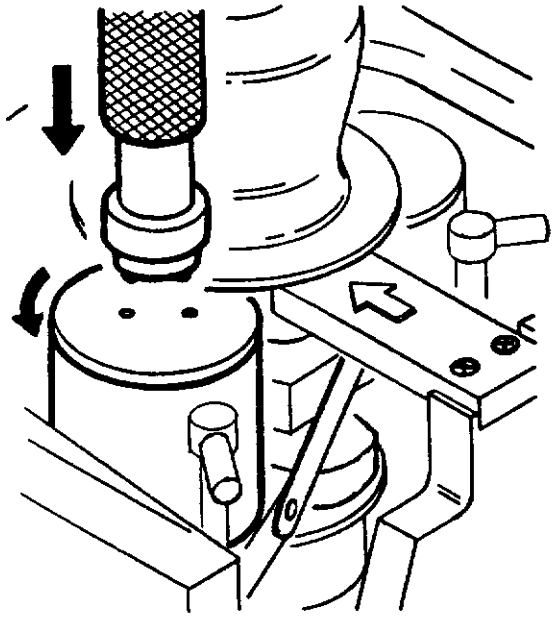
   - If the difference between deflections is less than 0.0015 inch, continue with step 8.
   - If the difference between deflections is more than 0.0015 inch, perform roller to roller adjustment as described in this section.

8. Remove the dial indicator and mounting bar.

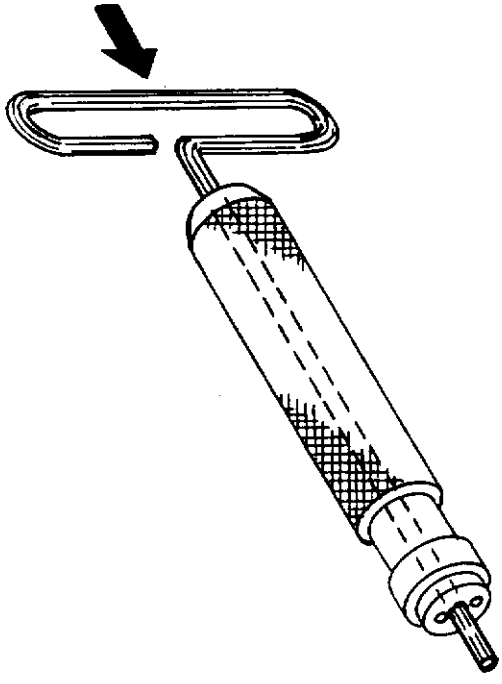
9. Replace the tongue screw, tube clamp assembly, and pump safety cover.

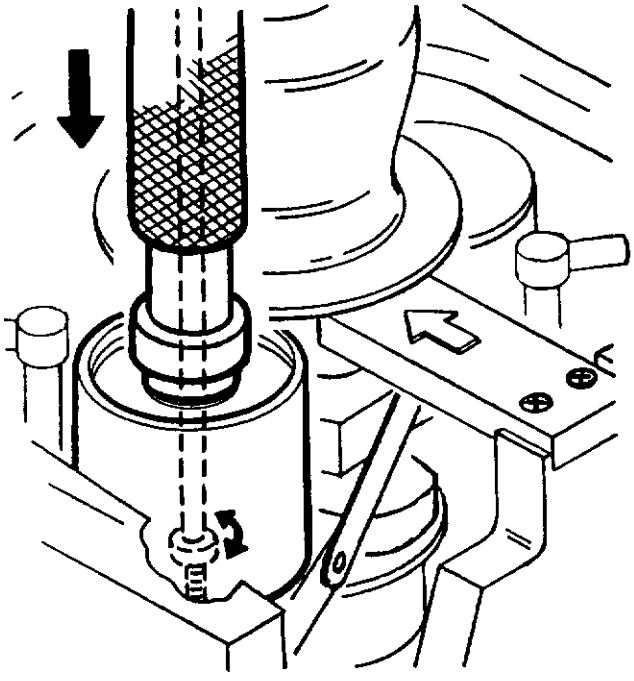
3.1.2 Adjusting Roller-to-Roller

1. Use the roller-to-roller adjustment tool to remove the cap from one of the rollers.



2. Insert the special 3/16" hex wrench into the adjustment tool, and then insert both tools into the center of the roller. Loosen the socket head bolt inside the roller post.





3.1.2 Adjusting Roller-to-Roller (Continued)

3. Turn the occlusion adjustment knob one revolution clockwise, then counter-clockwise to the same point noted in step 1 of Checking Roller to Roller.

4. Use the roller with the cap as the reference. Adjust the dial indicator position so that the needle deflects to mid-scale when the stem makes contact with the highest point on the roller.

5. Rotate the roller arm assembly 180° to line up the non-reference roller with the dial indicator. Use the adjustment tool to move the roller post and adjust the roller position (the roller post is shaped like a cam). Move the roller back and forth against the dial indicator stem until the dial needle deflection is the same as the reference roller. When the roller is properly positioned, use the torque wrench fixture and the torque wrench to tighten the socket head bolt inside the roller post to 65-70 in-lbs.

6. Check the accuracy of the adjustment by rotating the roller arm assembly and observing the maximum dial needle deflection for each roller.

   - If the difference between deflections is less than 0.0015 inch, continue with step 7.
   - If the difference between deflections is more than 0.0015 inch, repeat steps 2 through 6.

7. Turn the occlusion adjustment knob one revolution clockwise to draw the rollers in, and then one revolution counter-clockwise to the same point noted in step 1 of Checking Roller to Roller.

8. Rotate the roller arm assembly until the reference roller lines up with the indicator stem.

9. Repeat step 4.

10. Rotate the roller arm assembly and observe the maximum deflection for the non-reference roller.

    - If the difference between deflections is less than 0.0015 inch, continue with step 11.
    - If the difference between deflections is more than 0.0015 inch, repeat this entire procedure.

11. Remove the dial indicator and mounting bar.

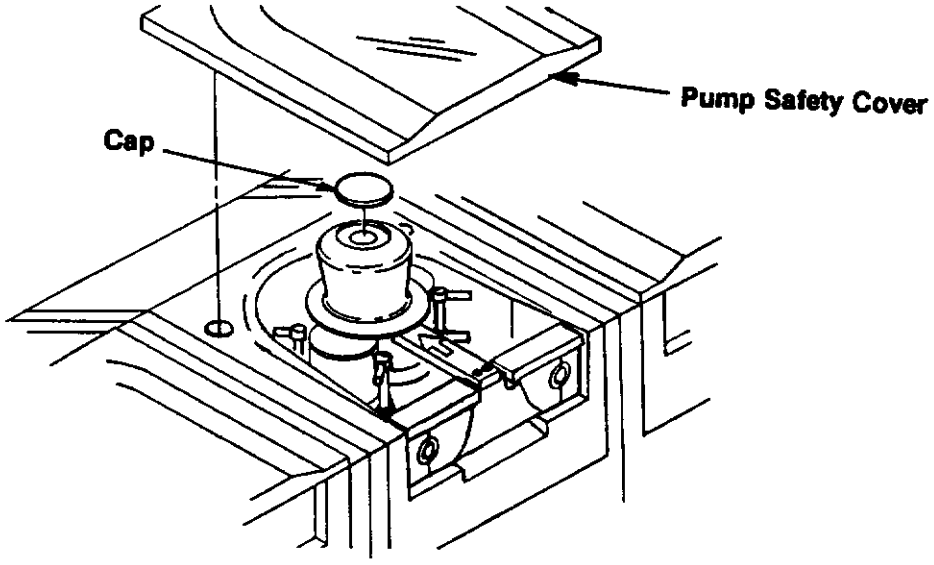
12. Replace the roller cap.

13. Replace the tongue screw, tube clamp assembly, and pump safety cover.

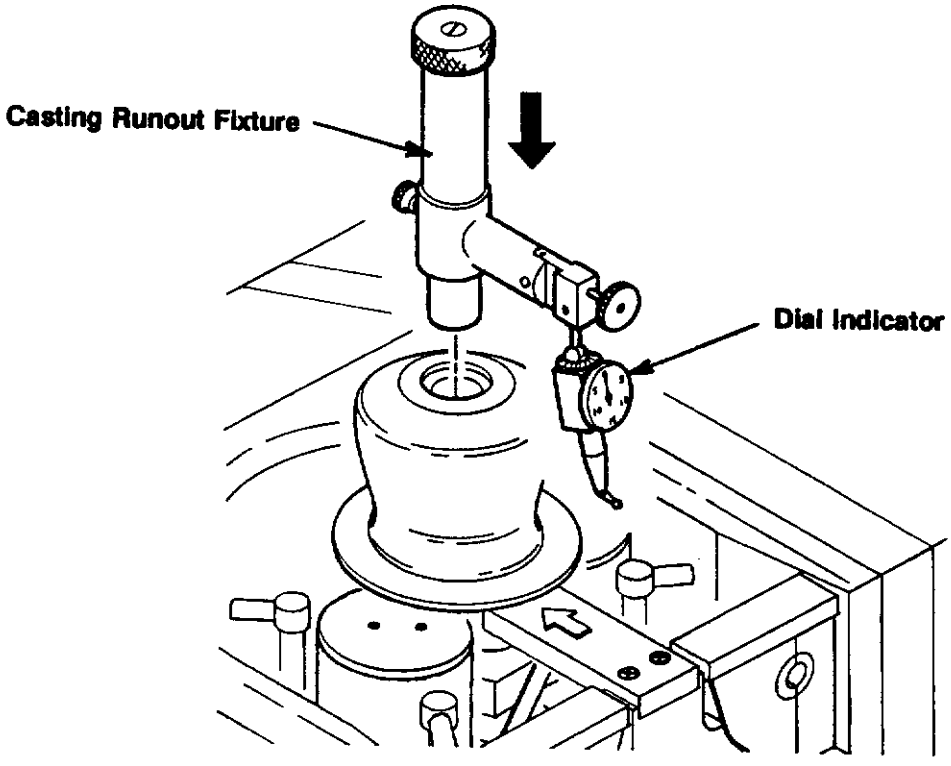
14. Install tubing in the pump. Run the pump with tubing occluded for 20 minutes to ensure normal operation. Repeat Checking Roller to Roller.

3.1.3 Checking/Adjusting Casting Runout

1. Remove the pump safety cover and occlusion adjustment knob cap.

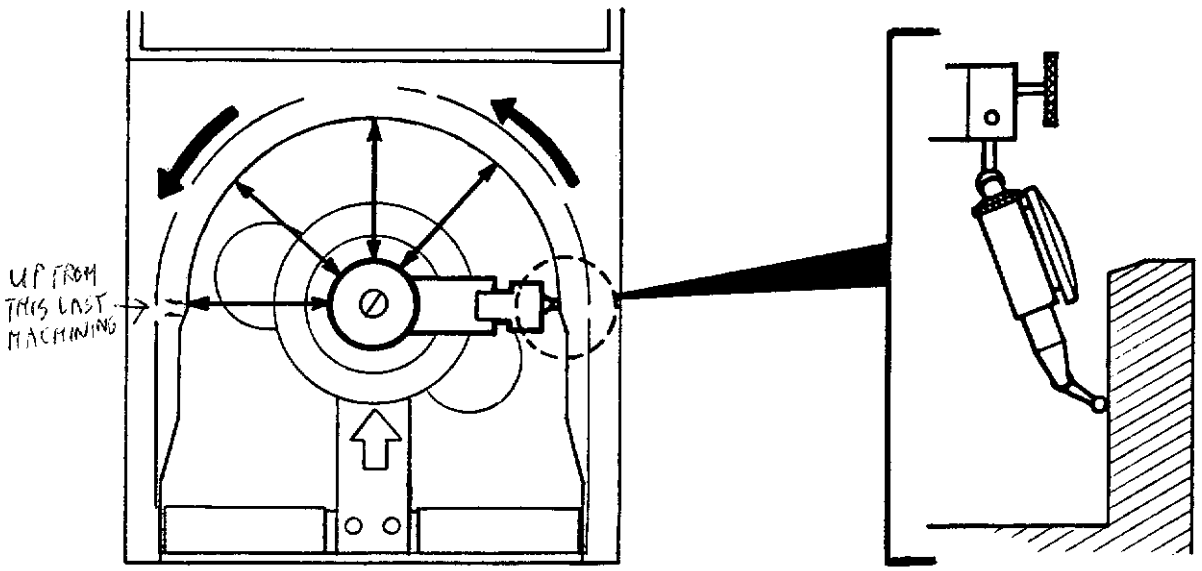


2. Assemble the dial indicator kit and casting runout fixture. Mount the casting runout fixture to the pump shaft assembly as shown below.



3.1.3 Checking/Adjusting Casting Runout (Continued)

3. Adjust the dial indicator position so that the needle deflects to mid-scale when the stem makes contact with the point on the casting shown below.



Top View **Side View**

4. Rotate the roller assembly around the casting, monitoring the dial needle deflection.

   - If the needle deflects less than 0.0015 inch from mid-scale, remove the casting runout fixture. (Loosen the knurled knob, then tap on the top of the fixture to release it.) Inspect the casting for any nicks or scratches in the tubing path. As a guide, the casting should be replaced if a nick or scratch is deep enough to catch a fingernail.
   - If the needle deflects more than 0.0015 inch from mid-scale, ~~continue with step 5.~~

     ORDER A NEW CASTING!

3.1.3 Checking/Adjusting Casting Runout (Continued)

5. Adjust the casting as follows:

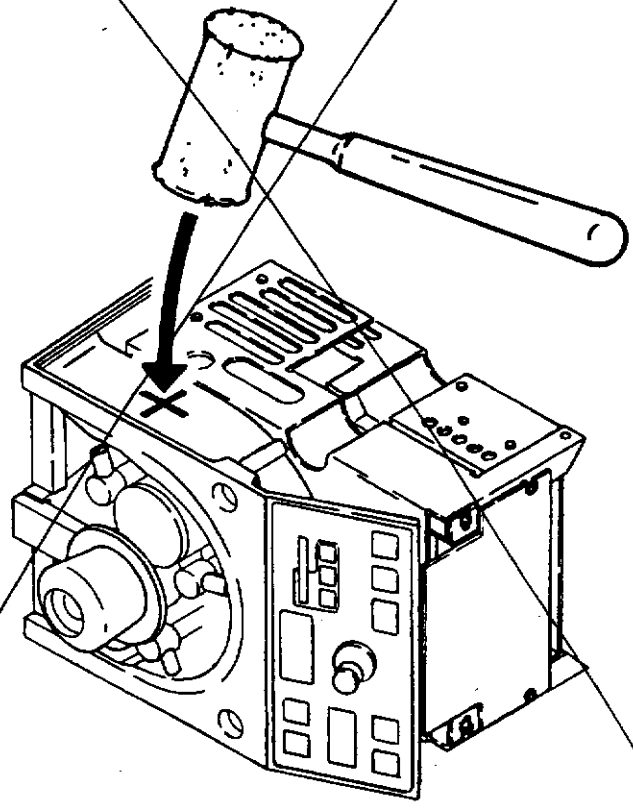
   a. Remove the casting runout fixture from the pump shaft assembly. (Loosen the knurled knob, then tap on the top of the fixture to release it.)

   b. Remove the pump from its housing. Lay the pump on its side.

   c. Use a soft-faced hammer to hit the outside of the casting on the side that caused the greatest deflection of the dial needle.

   d. Recheck the casting runout.

   e. Repeat steps 5a through 5d until the casting runout is brought into specification, then continue with step 6. If the casting cannot be brought into specification, refer to Section 4, Replacing the Casting Bearing Assembly.



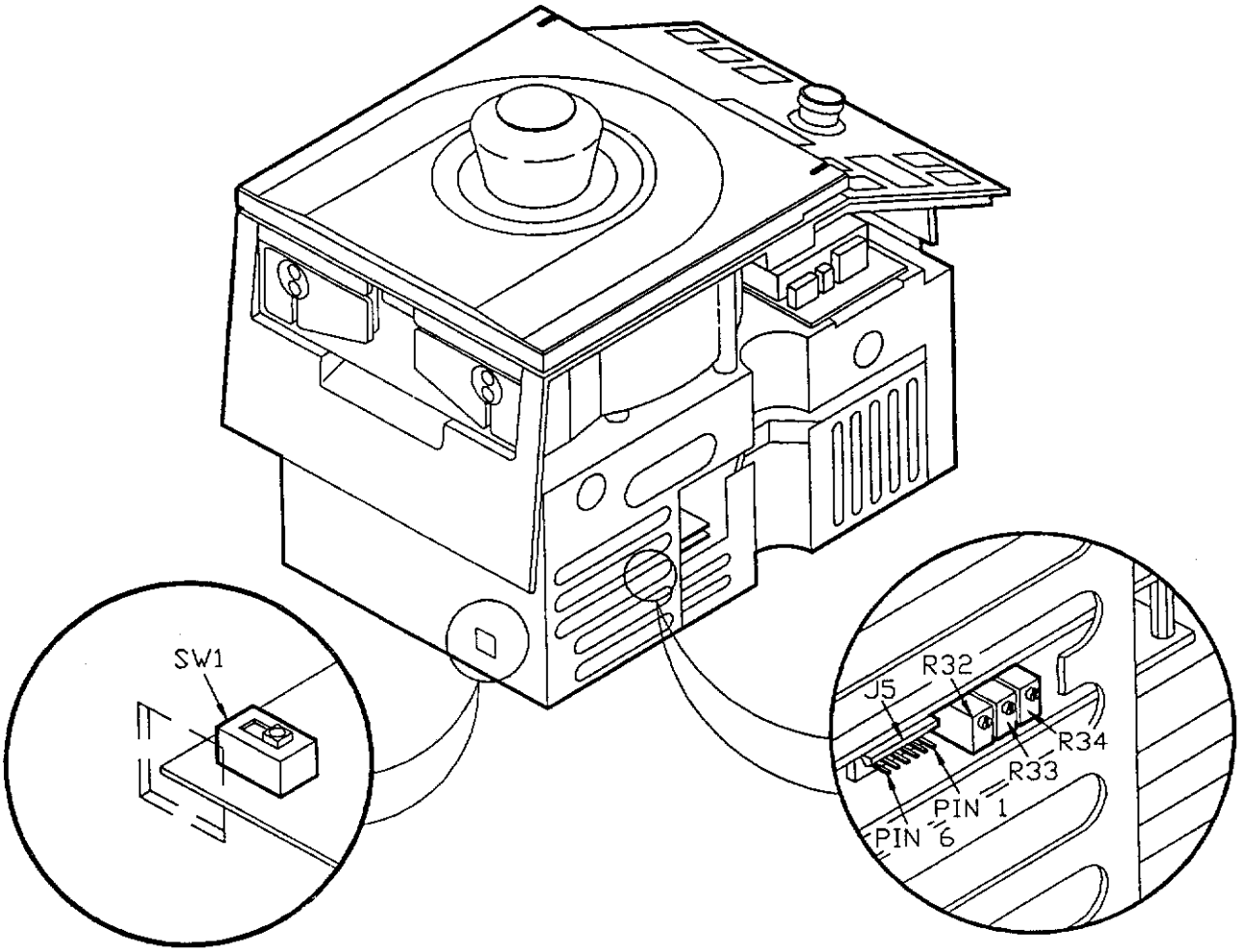
6. Remove the casting runout fixture from the pump shaft assembly. (Loosen the knurled knob, then tap on the top of the fixture to release it.)

7. Replace the pump safety cover and occlusion adjustment knob cap.

8. Check all cable connections to ensure that none were loosened by the pounding.

9. Install tubing in the pump. Run the pump for 20 minutes to ensure normal operation. Repeat steps 1 through 8.

3.1.4 Calibrating the Pump Control Board



1. Remove the roller pump from its housing. Set the pump adjacent to its housing and reconnect the pump cable, if necessary.

2. Press both FORWARD switches. Turn the speed pot fully clockwise. The rollers should turn counter-clockwise at full speed.

3. Perform the following checks at J5 on the pump control board:

   a. Connect the negative lead of the DVM to pin 6 and the positive lead to pin 1. The DMM should read 8.0 ±0.2 VDC (reference voltage). If not, perform the following:

      - Check for 24 to 36 VDC across pins 1 and 9 on connector J1 of the pump distribution board. If not found, refer to Section 5, Troubleshooting Roller Pump Distribution Board.

      - Check for the following voltages at J3 on the pump power supply board: -12 VDC across pins 1 and 4 (common), +12 VDC across pins 2 and 4, +5 VDC across pins 3 and 4. If any of the voltages are missing, replace the pump supply board.

      - Replace the pump control board.

3.1.4 Calibrating the Pump Control Board (Continued)

b. Turn the demand pot fully clockwise and hold. Connect the positive lead to pin 2. The DMM should read 5.00 ±0.05 VDC. Adjust R34 to meet this specification. If the voltage cannot be adjusted to specification, replace the pump control board.

c. Connect the positive lead to pin 4. The DMM should read -5.00 ±0.05 VDC. Adjust R32 to meet this specification. If adjusting R32 cannot bring the voltage into specification, repeat steps 3b and 3c as needed until both voltages meet their specifications. If the voltages cannot be adjusted to specification, replace the pump control board.

d. Push the switch on the pump safety board toward the forty-pin ribbon cable. The DMM should read 0.00 ±0.05 VDC.

e. Push the switch toward the outside of the board. The DMM should read -5.00 ±0.05 VDC.

f. Connect the positive lead to pin 3. The DMM should read -5.00 ±0.05 VDC. If not, replace the pump control board.

g. Connect the positive lead to pin 5. The DMM should read 4.85 ±0.15 VDC. If not, replace the pump control board.

4. Stop the pump.

5. Insert the digital tachometer into the roller assembly.

6. Press both FORWARD switches. Turn the speed pot fully clockwise. The maximum rpm should be 250 ±2.0 rpm (use a digital tachometer to verify the rpm reading). Adjust R33 to meet this specification.

3.2 Occluder Adjustments

3.2.1 Calibrating the Occluder Drive Board

1. Remove the allen screw that secures the occluder cover. Being careful not to damage the conductive seal, pry the cover open at the round end. (The square end of the cover has a lip hinge, so the cover must be opened at the round end.)

> **Caution**: Be careful not to get a piece of the conductive seal on the occluder drive board as this may cause a short circuit on the board.

2. Connect a jumper cable across D8. Also connect the negative lead of the DVM to D8.

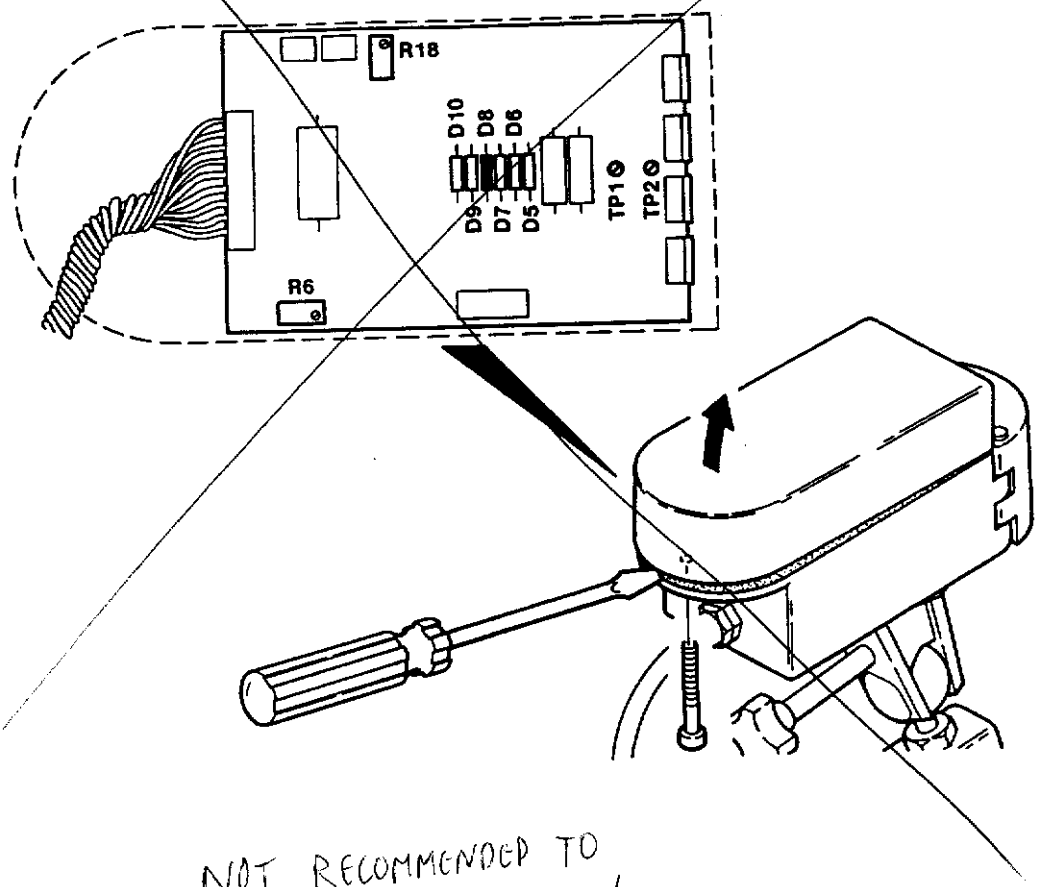
3. Ensure that the occluder cable is connected to the Control Module and that the occluder circuit breaker is turned on. Set the system power switch to on.

> **Note:** For the following steps, note the before and after voltage readings, along with the occluder serial number, on the repair report.

3.2.1 Calibrating the Occluder Drive Board (Continued)

4. Connect the positive lead of the DVM to TP1. Adjust R6 to obtain a reading of 0.40 ±0.025 VDC. If this specification cannot be met, replace the occluder drive board.

5. Connect the positive lead of the DVM to TP2. Adjust R18 to obtain a reading of 0.40 ±0.025 VDC. If this specification cannot be met, replace the occluder drive board.



3.3 Arterial and Cardioplegia Monitor Adjustments

> **Caution:** Use static precautions whenever handling printed or integrated circuit boards.

3.3.1 Calibrating Pressures on the Temperature/Pressure Board

1. Remove and disconnect monitor from system. (Refer to Section 4, Arterial and Cardioplegia Monitors.)
2. Access monitor electronics by separating the housing. (Refer to Section 4, Arterial and Cardioplegia Monitors.)
3. Connect the positive lead of a volt meter to J1-2 and connect the negative lead to J1-4.
4. Reconnect monitor to system.
5. Set the power switch(es) to ON; adjust R47 until the voltmeter reads 7.50 + 0.0005 VDC. If the voltage cannot be adjusted to specification, replace the Temperature/Pressure board.
6. Perform the pressure check portion of the system inspection. (Refer to Section 2, System Inspection)

3.3.2 Calibrating Temperatures on the Temperature/Pressure Board

1. Remove and disconnect monitor from system. (Refer to Section 4, Arterial and Cardioplegia Monitors.)
2. Access monitor electronics by separating the housing. (Refer to Section 4, Arterial and Cardioplegia Monitors.)
3. Connect the positive lead of a volt meter to J2-1 and connect the negative lead to J2-4.
4. Reconnect monitor to system.
5. Adjust R50 unitl the voltmeter reads 0.500 + 0.0005 VDC. If the voltage cannot be adjusted to specification, replace the temperature/pressure board.
6. Perform the temperature check portion of the system inspection, refer to Section 2, System Inspection.

3.4 Battery Charger Adjustments

> **Notes:** The battery status reference voltage should be established prior to adjusting the charging voltage.
> The charging voltage of 27.5 - 28.1 VDC volts is measured from the output of the LM317 regulator to ground, not isoground, and is set by adjusting R6 on the UPS board when the batteries are disconnected from the charger.

3.4.1

1. Set the main circuit breaker to OFF.

2. Disconnect the power supply cord at the wall supply.

3. Remove and disconnect all pump modules from the base. (Refer to section 4, Roller pumps).

4. Remove plastic and metal base covers.

5. Remove battery module form base, leaving cables connected.

6. Remove battery module top cover.

7. Establish reference voltage. Attach negative lead of volt meter to TP4-1 on the battery module board and the positive lead to TP4-2. Turn main Circuit Breaker on. Adjust R23 for +2.325 +/- 0.01 VDC. Turn off circuit breaker.

BATTERY PLUGGED IN, AC UNPLUGGED

8. Disconnect P7 on battery module circuit board.
Turn on circuit breaker.

9. Connect power cord to wall.

10. Adjust the charging voltage. With the batteries disconnected, attach the positive lead of the voltmeter to TP4-3 and the negative lead to TP4-1. Adjust R6 for 27.5 - 28.1 VDC.

11. Reassemble system.

Rev. A. Correct sequence of item 7 and 8.

Table of Contents

Section 4. Replacement Procedures

Note: Perform a complete system inspection after completing any procedure which requires any disassembly of the unit.

4.1 Base Components and Electronics

Note: All electrical components in the base can be accessed when the base cover is removed. The individual components are mounted either to the chassis, or within an enclosure that is bolted to the chassis.

Cautions: Use static precautions when servicing the base power distribution board.

Line voltage is present at fuses F1 and F2 on the power distribution board, and relay K1, on the chassis. Use caution whenever the base cover is removed.

4.1.1 Accessing Base Electronics

1. Set the main circuit breaker to OFF.
2. Remove the power cord from the wall supply.
3. Disconnect all pump cables.
4. Remove any tubing installed in the pumps.
5. Remove each pump from the base; keep them in the same order as found on base.
6. Remove plastic base cover and set aside.
7. Remove the four screws securing the metal cover.
8. With both hands, tilt the front edge of the metal cover up; completely remove cover and set aside.
9. Connect power cord to wall supply before servicing base power distribution board.
10. Disconnect power cord from wall supply before reassembling. Assemble in reverse order of disassembly.

4.2 Roller Pumps

4.2.1 Removing Roller Pump from Base

1. Open the base front door.
2. Grasp both locking levers on the front side of door and rotate towards outer edge of base.
3. Gently lower door to stop.
4. Disconnect all cables at the pump.
5. Remove any installed tubing.
6. Lift the pump module off the base.

4.2.2 Removing Roller Pump from Pump Housing

1. Remove pump module from base as described above.
2. Remove pumphead cover.
3. Remove the two bolts that secure the module to the housing.
4. Lift the module out of the housing.
5. Disconnect module power cord at rear of power supply.
6. Remove eight torx head screws; three on each side, two in rear.
7. Remove and set aside the top portion of the housing.
8. Loosen the two slotted head screws in rear of power supply.
9. Carefully place lower portion of housing on its side and slide the power supply out of the housing.

4.2.3 Accessing the Pump Power Supply Electronics

3 1. Locate the pump distribution board mounted on the large blue capacitor, C1.

4 2. Disconnect the fan and pulse MTA connectors, P2 and P5, on the board.

1 3. Remove the six slotted head screws; there are three along the bottom of the front panel and three along the back of the rear panel.

2 4. Separate the power supply front and rear panels.

4.2.4 Assembling the Pump Power Supply

> **Notes:** The power supply board has an orientation hole that is used to align the board with the positive and negative terminals of the capacitor. When properly aligned, the white dot on the capacitor is visible through the orientation hole.
>
> The fan has washers between the housing and the enclosure to provide adequate clearance for components. These washers must be replaced in the proper position whenever it becomes necessary to remove and replace the fan.

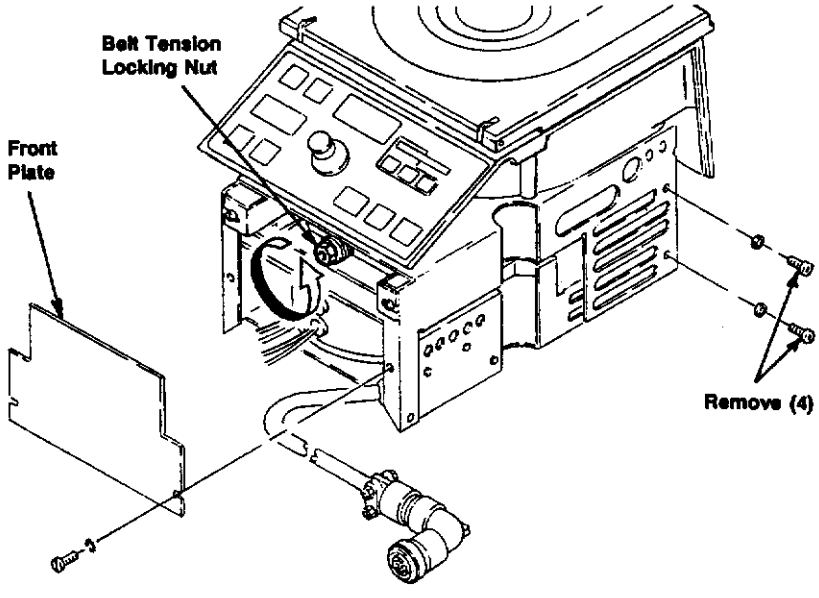
1. Check that the pump distribution board is properly mounted on capacitor C1.
2. Align the front and rear panels of the power supply.
3. Connect the fan and pulse MTA connectors, P2 and P5, to the circuit board.
4. Install the six slotted head screws in to the power supply panels, leaving the two top, outer screws loose.
5. Slide the power supply into position and tighten the remaining two screws.

4.2.5 Replacing the Pump Drive Belt

> **Note:** The pump drive belt should be replaced whenever it is noisy or when a belt slip condition still exists after setting the belt tension.

Removal:

1. Remove the front plate.
2. Loosen the belt tension locking nut (9/16").
3. Remove the four screws at the rear of the pump housing.



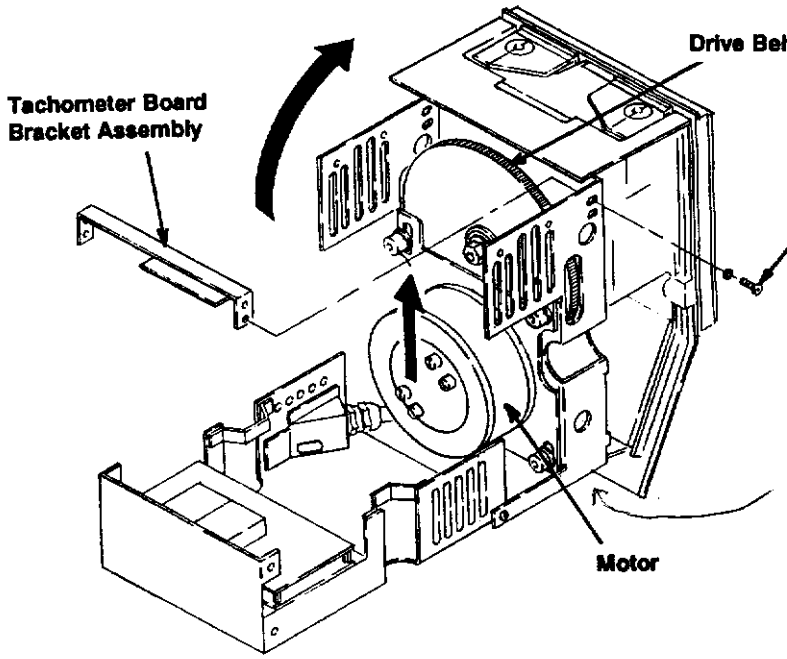
4.2.5 Replacing the Pump Drive Belt (Continued)

4. Hold down the back of the pump assembly and lift up on the casting to hinge open the assembly.

> **Note:** Be careful not to pinch the power cord underneath the casting when the pump assembly is hinged open.

DON'T HAVE TO REMOVE

5. Disconnect TACH-J1 from the tachometer board.
6. Remove four screws, then remove the tachometer board bracket assembly.
7. Lift up on the motor to remove the tension from the drive belt, then slide the drive belt off the pulley and remove it from the pump assembly.

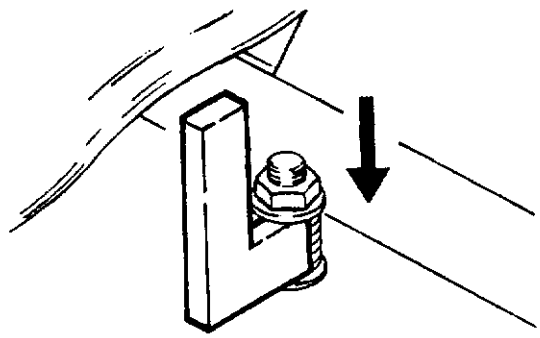


CHECK FOR GREASE ON THE TOPS OF THE 4 MOTOR MOUNT SCREWS - DON'T CONTAMINATE THE NEW BELT!

Installation:

Installation is the reverse of removal, with the following exception:

When tightening the belt tension locking nut, place the belt tension gauge between the two washers, then tighten the nut until the washers make contact with the gauge. Replace the nut if damaged.



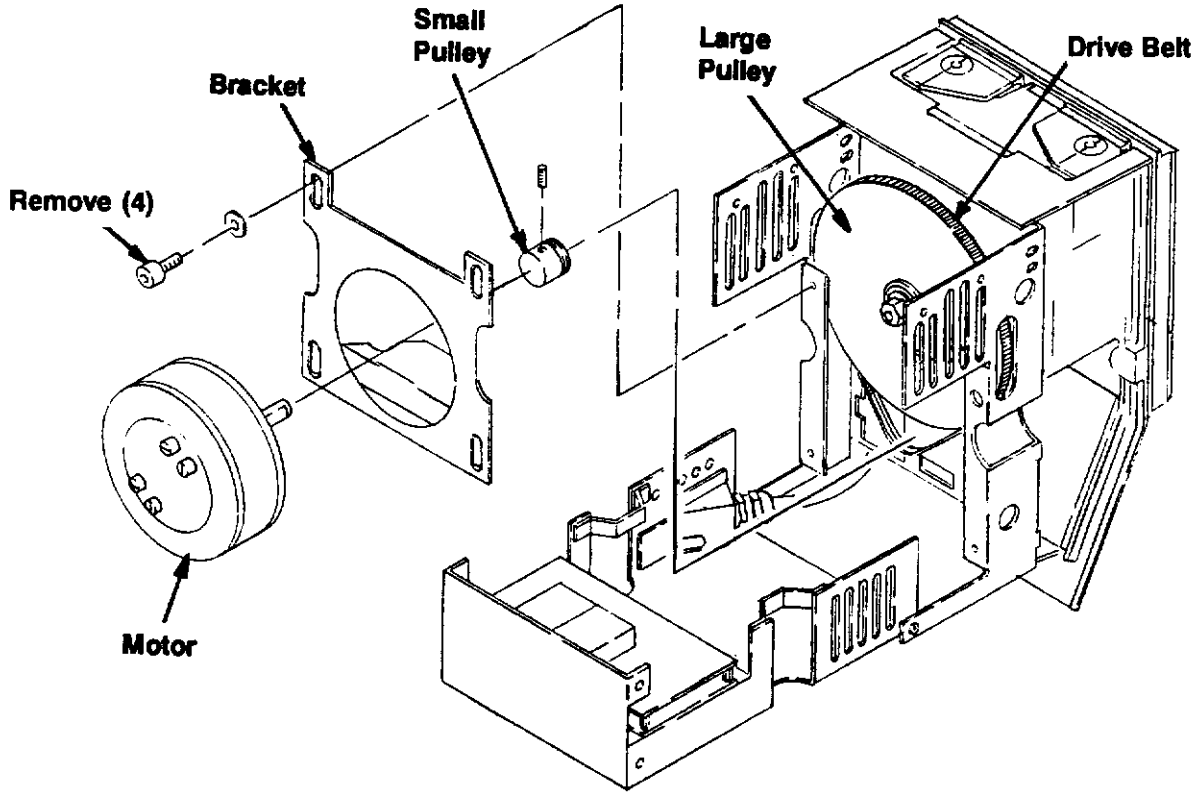
4.2.6 Replacing the Pump Drive Motor

Removal:

1. Remove the pump drive belt, as described in Replacing the Pump Drive Belt.
2. Remove the four bolts (3/16" Allen) that secure the motor bracket assembly to the pump chassis.
3. Disconnect DRV-J4 from the pump drive board and CTRL-J3 from the pump control board. Remove the motor assembly, cutting wire ties as needed.
4. Remove the bracket and small pulley from the old motor.

Installation:

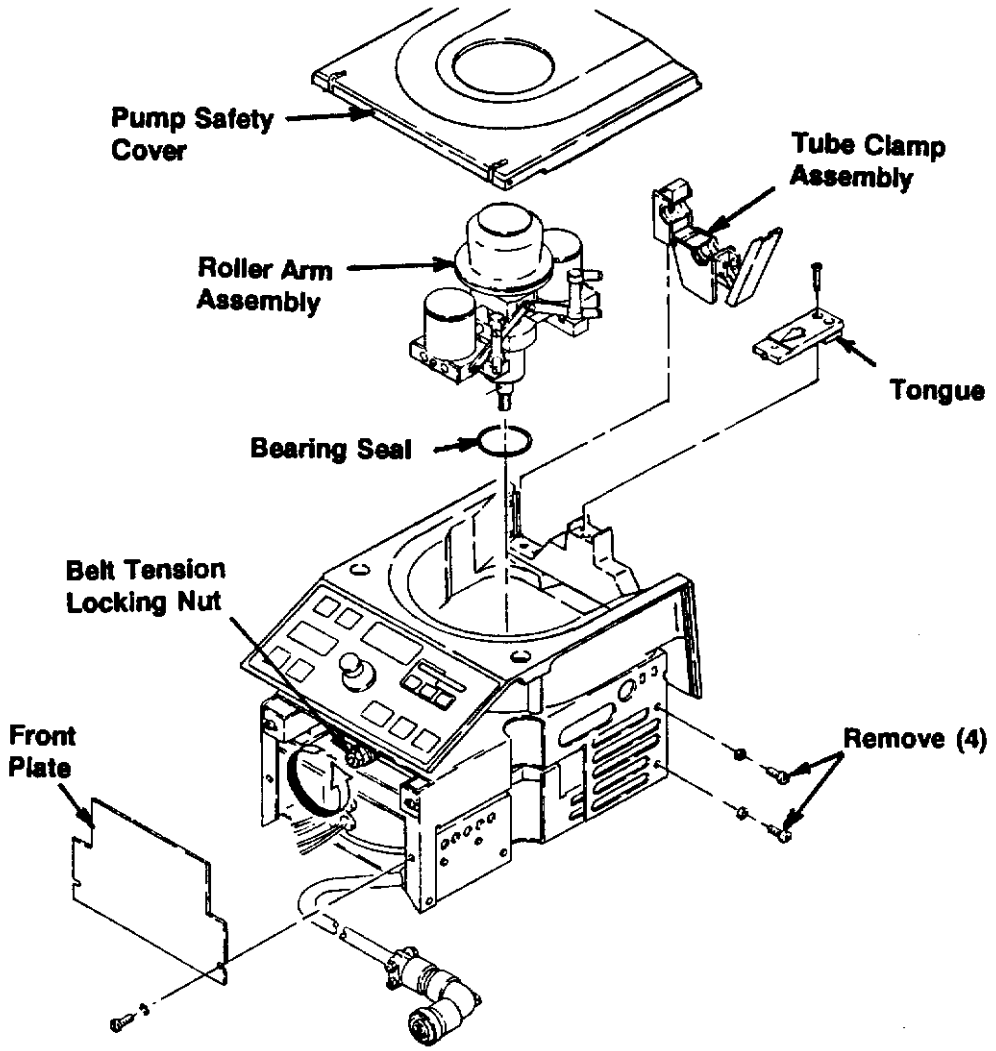
1. Install bracket and small pulley on the new motor. When installing the bracket on the new motor, position the bracket so that the side of the motor from which the wires exit will be toward the front of the pump.
2. Mount the new motor assembly to the chassis. Use shrink tubing and solder to splice the new wires.
3. Align the top of the small pulley with the top of the large pulley.
4. Connect DRV-J4 to the pump drive board and CTRL-J3 to the pump control board. Replace any wire ties that were cut when the motor assembly was removed.
5. Install the pump drive belt as described in Replacing the Pump Drive Belt.
6. Perform all the steps of Section 2, Roller Pump Inspection.



4.2.7 Removing the Roller Arm Assembly

Removal:

1. Remove the pump safety cover.
2. Remove the tube clamp assemblies.
3. Remove the tongue.
4. Remove the front plate.
5. Loosen the belt tension locking nut (9/16").
6. Remove the four screws at the rear of the pump housing.



4.2.7 Removing the Roller Arm Assembly (Continued)

Removal (Continued):

7. Hold down the back of the pump assembly and lift up on the casting to hinge open the assembly.

> **Note:** Be careful not to pinch the power cord underneath the casting when the pump assembly is hinged open.

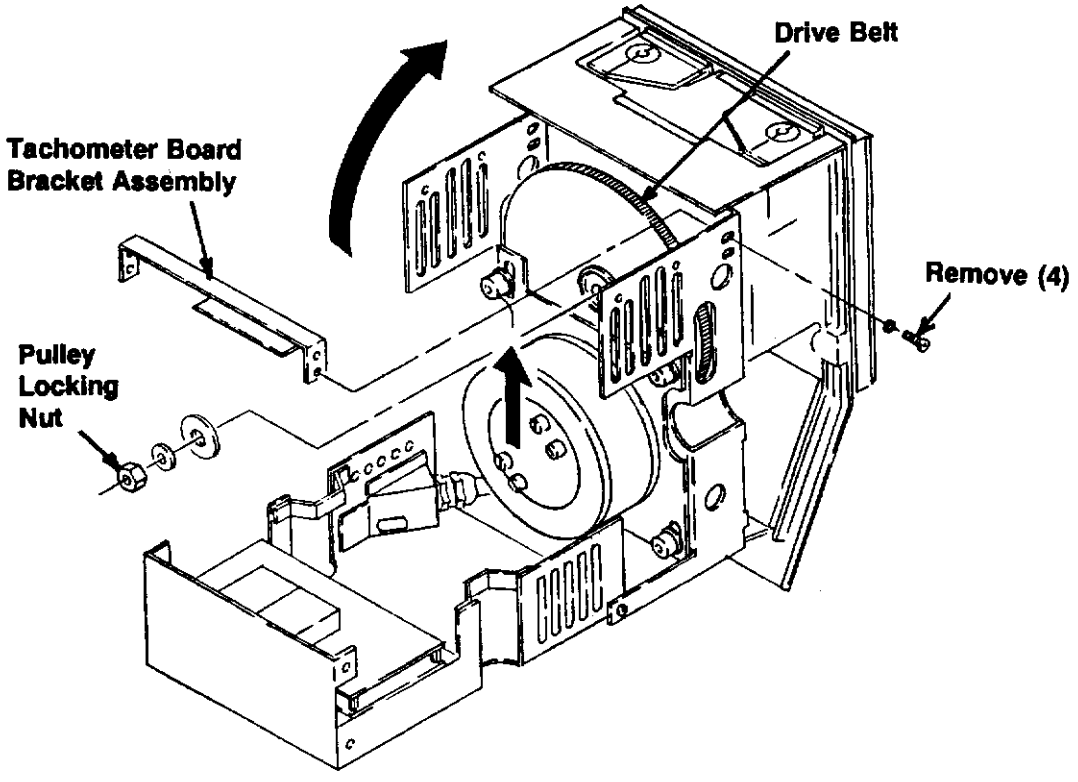
8. Disconnect TACH-J1 from the tachometer board.

9. Remove four screws, then remove the tachometer board bracket assembly.

10. Lift up on the motor to remove the tension from the drive belt, then slide the drive belt off the pulley and remove it from the pump assembly.

11. Remove the pulley locking nut (9/16").

12. Grasp the occlusion adjustment knob and the casting. Pull the roller arm assembly out of the pump assembly. If necessary, lightly tap the pump shaft with a soft-faced hammer to drive the roller arm assembly out of the casting.

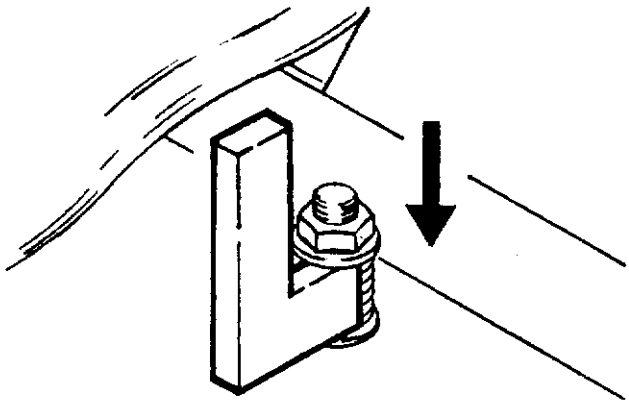


4.2.7 Removing the Roller Arm Assembly (Continued)

Installation:

Installation is the reverse of removal, with the following exceptions:

- Be certain that the pin that passes through the pump shaft is seated properly in the groove in the pulley.
- If the pulley locking nut is damaged, replace it.
- When tightening the belt tension locking nut, place the belt tension gauge between the two washers, then tighten the nut until the washers make contact with the gauge. Replace the nut if damaged.



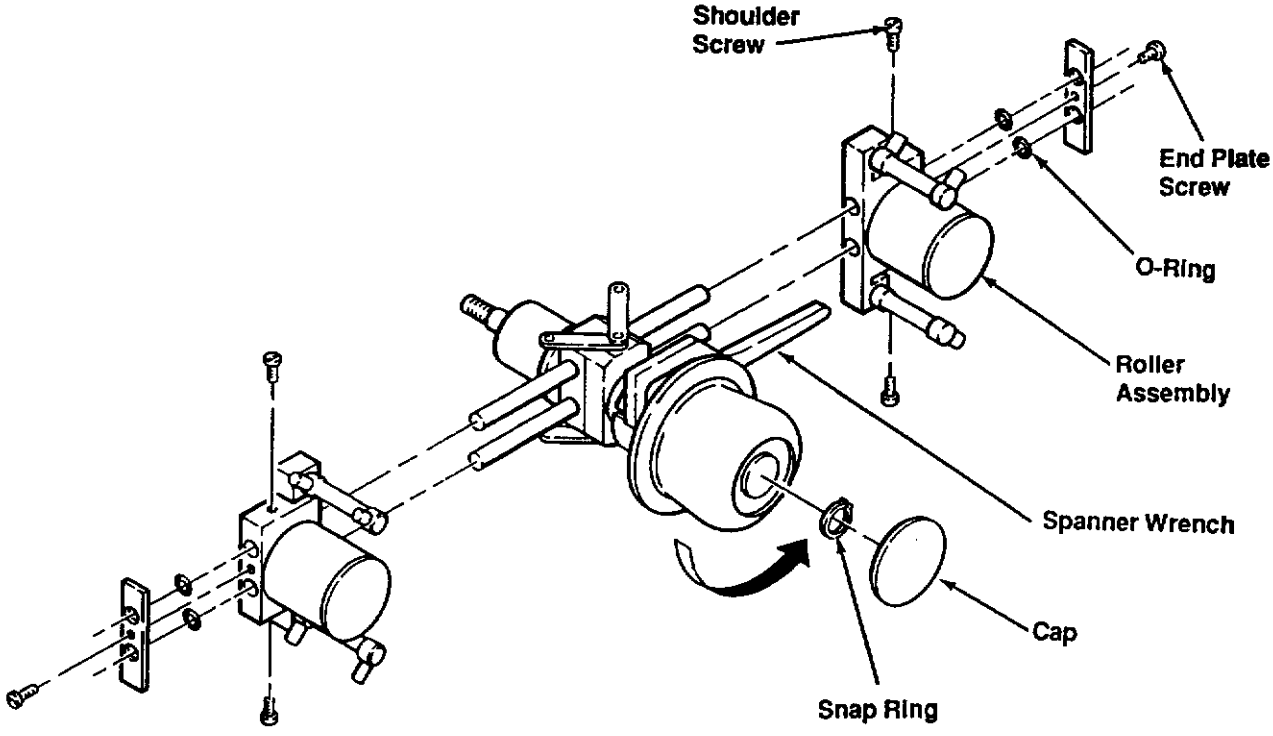
- After completing reassembly, perform the following Section 3,Adjustment Procedures:

  Checking Roller-to-Roller
  Checking/Adjusting Casting Runout

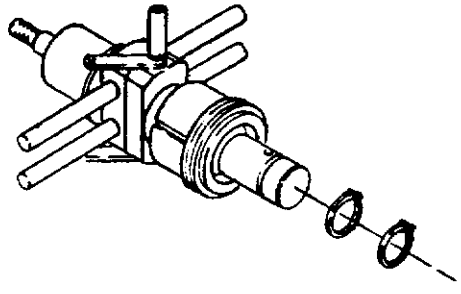
4.2.8 Disassembling the Roller Arm Assembly

Disassembly:

1. Remove the roller arm assembly as described in Removing the Roller Arm Assembly.
2. Remove the four shoulder screws.
3. Remove and discard the two end plate screws.
4. Remove the end plates and O-rings. Discard the O-rings.
5. Remove the roller assemblies.
6. Remove the black cap from the occlusion adjustment knob.
7. Use the external snap ring pliers to remove the first snap ring from the pump shaft.
8. While holding the adjustment nut with the spanner wrench, unthread the occlusion adjustment knob. Clean off any excess grease.

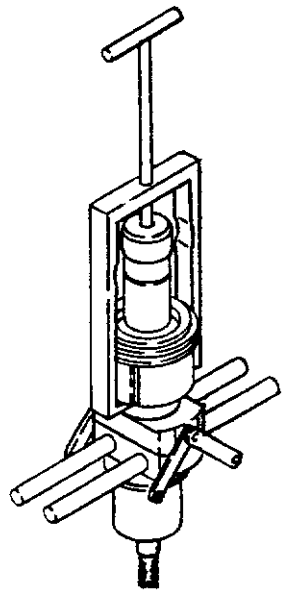


9. Use the external snap ring pliers to remove the second and third snap rings from the pump shaft.



4.2.8 Disassembling the Roller Arm Assembly (Continued)

10. Use the adjustment nut puller to remove the adjustment nut from the pump shaft.



Reassembly:

Reassembly is the reverse of disassembly, with the following exceptions:

- Install new end plate screws and O-rings.
- Torque the four shoulder screws to 17 in/lbs.
- After completing reassembly, perform the following Section 3,Adjustment Procedures:

  Checking Roller-to-Roller
  Checking/Adjusting Casting Runout

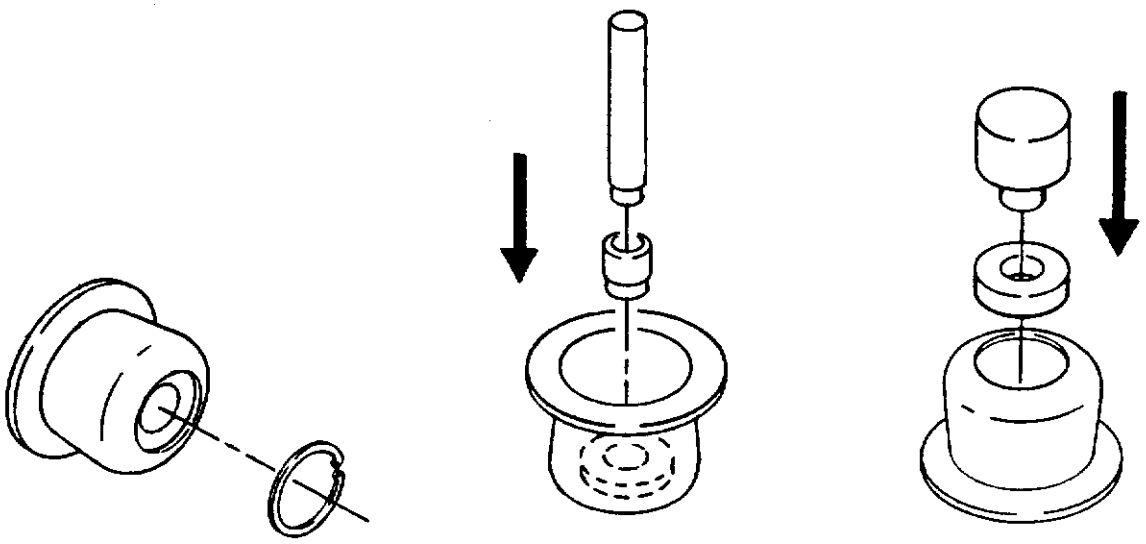
4.2.9 Replacing the Occlusion Adjustment Knob Bearing

Removal:

1. Remove the roller arm assembly as described in Removing the Roller Arm Assembly.
2. Remove the black cap from the occlusion adjustment knob.
3. Use the external snap ring pliers to remove the first snap ring from the pump shaft.
4. Use the internal snap ring pliers to remove the snap ring from the occlusion adjustment knob.
5. Use the R-10 bearing punch and R-12 adapter to knock the old bearing out of the knob. Discard the old bearing.

Installation:

1. Use the 8000 occlusion knob bearing insertion tool to install the new bearing in the knob.



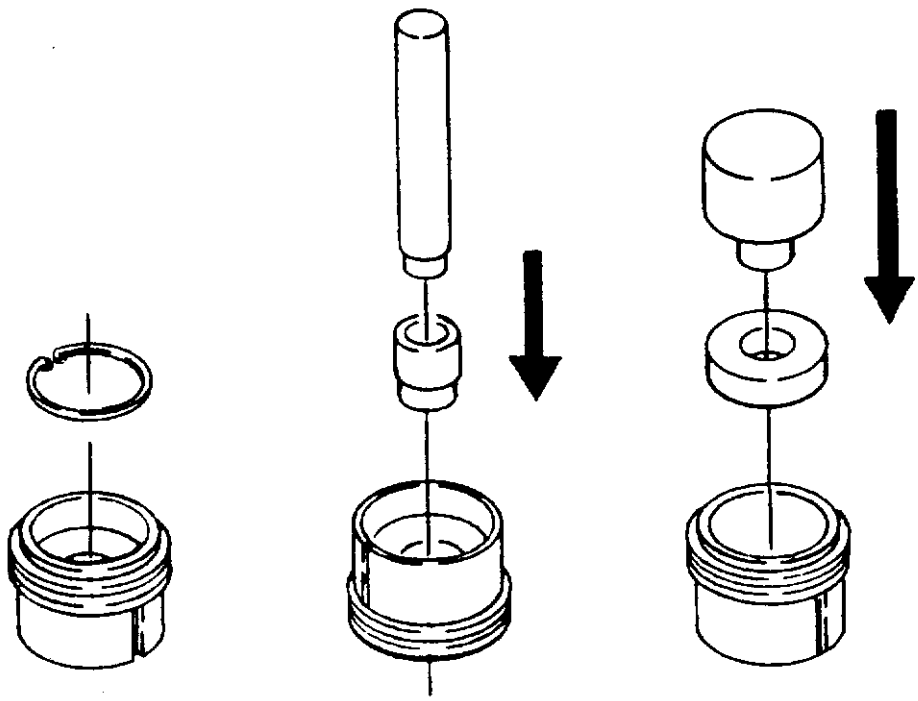
4.2.10 Replacing the Adjustment Nut Bearing

Removal:

1. Remove the arm assembly as described in Removing the Roller Arm Assembly.
2. Disassemble the roller arm assembly as described in Disassembling the Roller Arm Assembly.
3. Use the internal snap ring pliers to remove the snap ring from the adjustment nut.
4. Use the R-10 bearing punch and R-12 adapter to knock the old bearing out of the nut. Discard the old bearing.

Installation:

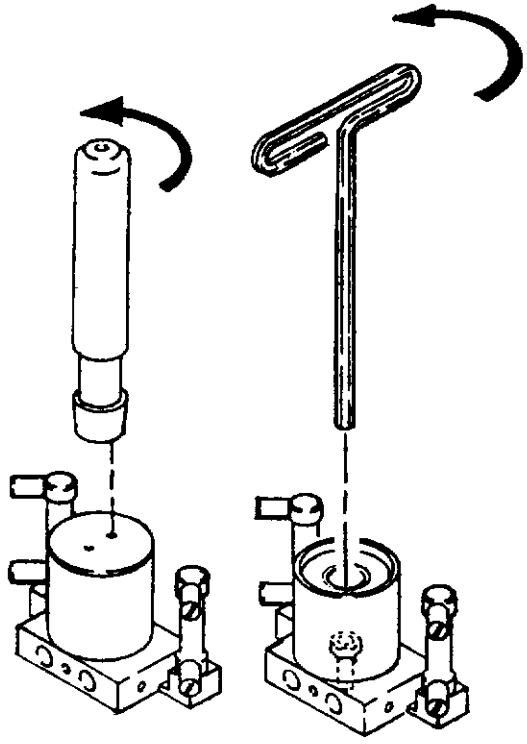
1. Use the 8000 occlusion knob bearing insertion tool to install the new bearing in the nut.
2. Re-install the snap ring.
3. Assemble in reverse order of disassembly.



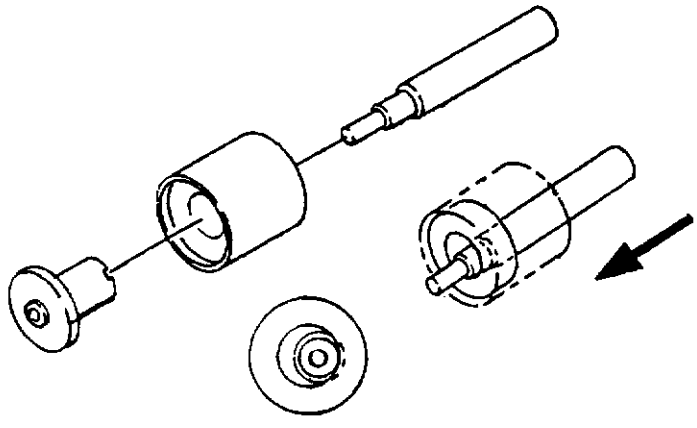
4.2.11 Replacing Roller Bearings

Removal:

1. Use the roller adjustment tool to remove the roller cap. Remove the socket head screw from the center of the roller.



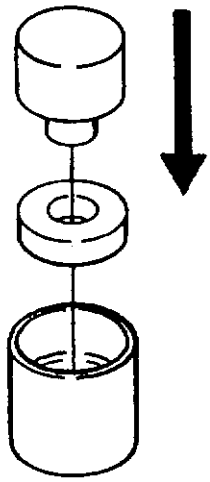
2. Use the roller post punch to remove the roller eccentric post. Use the upper edge of the punch to drive the old bearings out of the roller. Discard the old bearings.



4.2.11 Replacing Roller Bearings (Continued)

Installation:

1. Use the roller bearing insertion tool to install the new bearings.



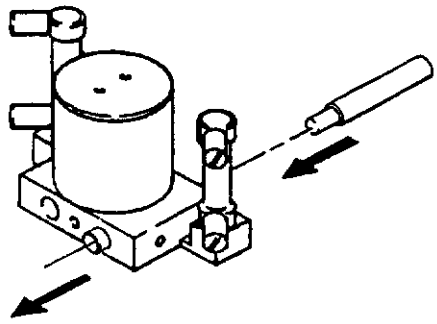
2. Use the soft-face hammer to tap the roller eccentric post back into the roller.
3. Re-install the socket head screw and the roller cap.
4. Perform Section 3, Checking Roller-to-Roller.

4.2.12 Replacing the Roller Slide Bushings

Removal:

> **Note:** It is usually only necessary to replace one set of bushings on each roller slide assembly. Determine which bushings are the most loose on each roller slide and replace them (for a total of two long bushings and two short bushings per roller pump).

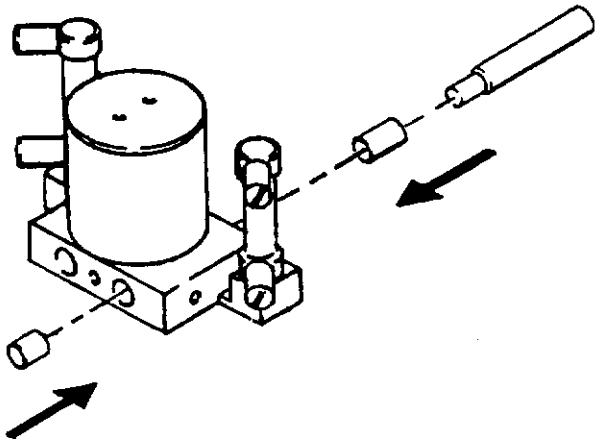
1. Remove the roller arm assembly as described in Removing the Roller Arm Assembly.
2. Disassemble the roller arm assembly as described in steps 1 through 5, Disassembling the Roller Arm Assembly.
3. Use the bushing driver to drive the old bushings out of the roller slide assembly.



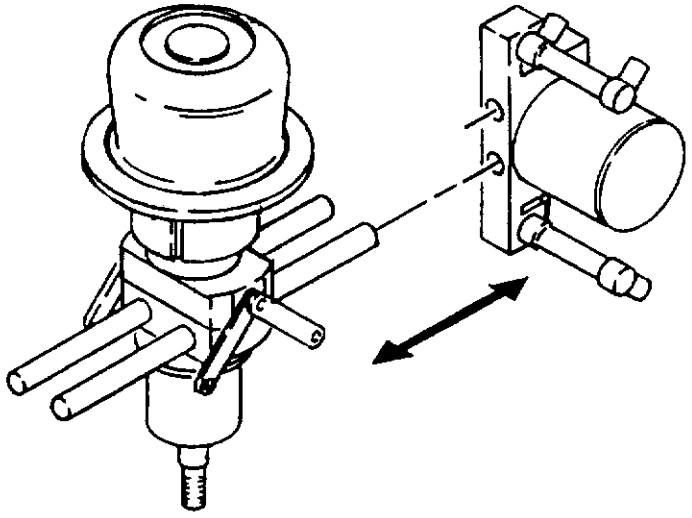
4.2.12 Replacing the Roller Slide Bushings

Installation:

1. Use the bushing driver to install the new bushings. Drive the long bushing flush to the bottom of the roller slide. Drive the short bushing flush to the top of the roller slide.

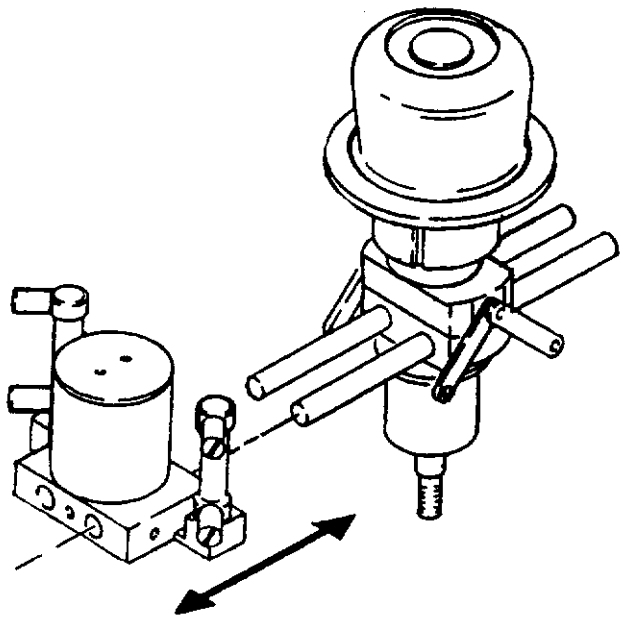


2. Align the hole that has new bushings with its respective support rod. Try to ease the roller slide onto the support rod. The slide should move smoothly on the support rod without binding. If the slide doesn't fit on the support rod or does not move smoothly, the bushings have to be reamed as described in Reaming the Roller Slide Bushings.



4.2.12 Replacing the Roller Slide Bushings (Continued)

3. When the slide moves smoothly on each individual support rod, align both holes with their respective support rods. Ease the slide onto the support rods. The slide should move smoothly without binding. (If measured with a force gauge, it should require 5 to 7 pounds of force to move the slide.)

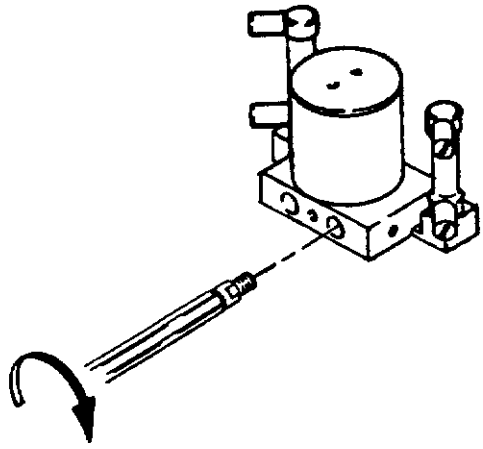


4.2.13 Reaming the Roller Slide Bushings

1. Insert the adjustable reamer into the roller slide hole that needs adjusting.

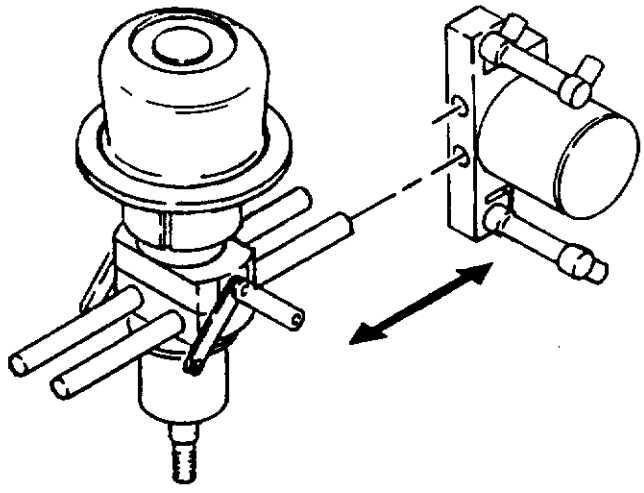
> **Note:** The reamer should be adjusted so that the cutting blades apply a small amount of pressure on the bushings.

2. Slowly turn the reamer clockwise to thread it through the bushings. When the reamer is completely through the hole and out the other side of the roller slide, continue to turn the reamer clockwise while withdrawing it from the hole.



4.2.13 Reaming the Roller Slide Bushings (Continued)

3. Align the reamed hole with its respective support rod. Try to ease the roller slide onto the support rod. The slide should move smoothly on the support rod without binding. If the slide doesn't fit on the support rod or does not move smoothly, the bushings require additional reaming. If the slide appears to be too loose on the support rod, the bushings have been reamed too much and have to be replaced as described in Replacing the Roller Slide Bushings.



4. Reassemble and perform Section 3, Checking Roller-to-Roller and Checking/Adjusting Casting Runout.

4.2.14 Replacing the Casting/Bearing Assembly

Removal:

1. Remove the pump drive motor as described in Replacing the Pump Drive Motor.
2. Remove the roller arm assembly as described in Removing the Roller Arm Assembly.
3. Remove the tongue wall support by cutting the two red wires and removing the four screws.
4. Remove the dovetail slides.
5. Remove the card cage assembly by removing the five bolts that secure it to the casting.
6. Remove the display membrane panel as described in Pump Membrane Panel. Clean off the silastic seal.

Installation:

1. Place a thin bead of silastic seal on the new casting and secure the display membrane panel.
2. Install the pump using the hardware removed in steps 1 through 6.
3. Perform a complete system inspection (refer to Section 2, System Inspection).

4.3 Safety Monitor

4.3.1 Remove Monitor from System

1. Set the main circuit breaker to OFF, but leave the power cord connected to the wall supply.
2. Switch power off at the Safety Monitor.
3. Disconnect all cables associated with the monitor.
4. Lift lock lever and slide monitor left or right until the lever is free of the channel. The lever can now be released.
5. Slide the monitor off the mounting plate.

4.3.2 Accessing Safety Monitor Electronics

1. Place monitor upside down on a clean work surface.
2. Remove the four hex head cap screws from the bottom half of the housing.
3. Carefully set monitor right side up and separate the housing.
4. Assemble in reverse order of disassembly.

4.4 Arterial and Cardioplegia Monitors

4.4.1 Remove Monitor from System

1. Set the main circuit breaker to OFF, but leave the power cord connected to the wall supply.
2. Switch power off at the Safety Monitor.
3. Disconnect all cables associated with the monitor.
4. Lift lock lever and slide monitor left or right until the lever is free of the channel. The lever can now be released.
5. Slide the monitor off the mounting plate.

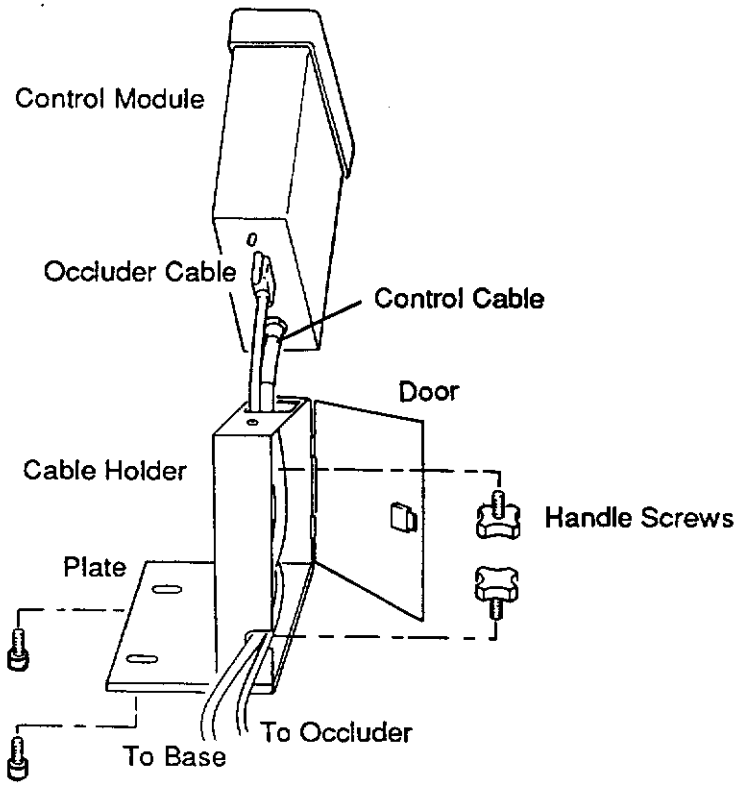
4.4.2 Accessing Monitor Electronics

1. Place monitor upside down on a clean work surface.
2. Remove the two hex head cap screws from the bottom half of the housing.
3. Carefully set monitor right side up and separate the housing.
4. Assemble in reverse order of disassembly.

4.5 Occluder

Notes: The line occluder system contains four main components: control module, support bracket, support plate and occluder head.

Use a swivel mounting bracket and clamping arm to mount the occluder head to a pole.



4.5.1 Remove Occluder from System

1. Switch occluder power off.
2. Disconnect occluder control module power cord at base.
3. Disconnect the occluder head at the connector cable inside the support bracket.
4. Separate mounting plate from support bracket by removing thumbscrew and hardware.
5. Remove mounting plate by removing two 1/4 x 20 bolts from underside of base.

4.5.2 Install Occluder on Opposite Side

> **Note:** Cable clips are available under the base, if the occluder head will not be on the same side as the control module.

1. Remove occluder from system, refer to Remove Occluder from System.
2. Rotate support bracket horizontally, 180 degrees.
3. Rotate support bracket vertically, 180 degrees.
4. Attach support plate to base.
5. Attach support bracket to support plate.
6. Attach control module to support bracket.
7. Attach the occluder head cable connector to the control module.
8. Connect occluder control module power cord to base.
9. Switch occluder power on.

4.6 Membrane Panels

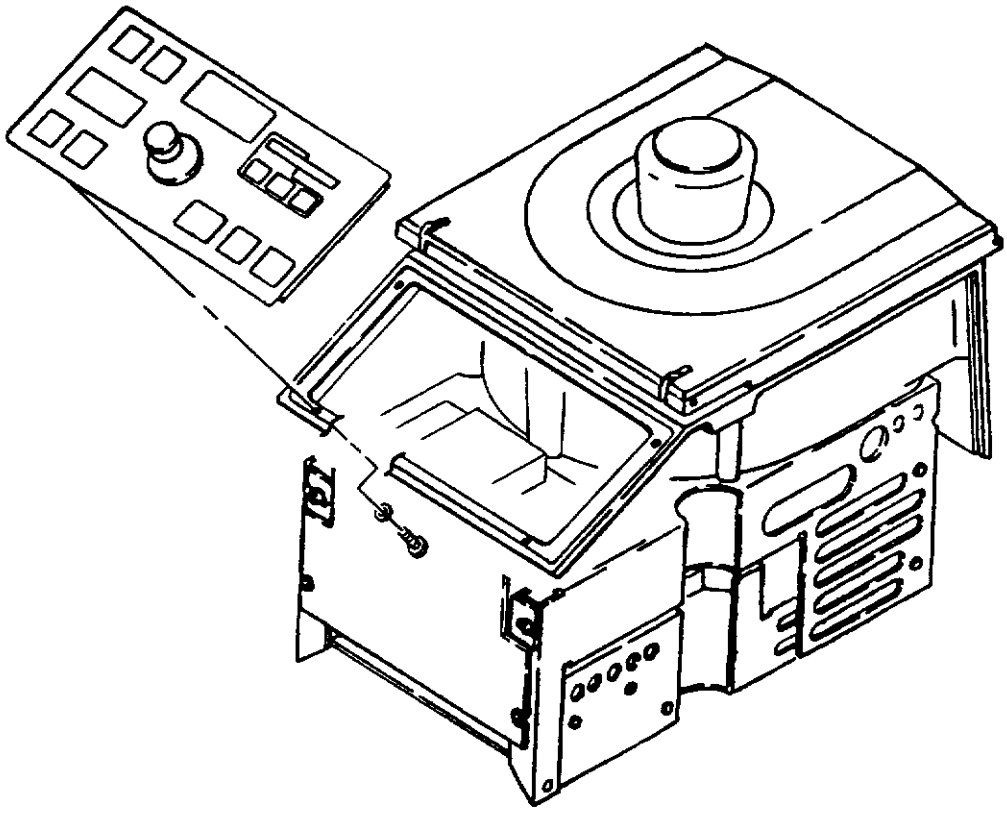
> **Caution:** Use static precautions when handling printed or integrated circuit boards.

4.6.1 Pump Membrane Panel

> **Note:** In order to replace the display board or the membrane panel, both items must be replaced. Order the pump display membrane assembly.

1. Remove the pump from the base.
2. Using the torx driver with the gapped screwdriver bit installed, remove the four screws that secure the display membrane assembly to the casting. Press the assembly out of the casting. It is held in place by adhesive and silastic.

4.6.1 Pump Membrane Panel (Continued)



3. Disconnect DSPL-J1 and DSPL-J3 from the pump display board.
4. Remove the securing screws at the rear of the pump assembly, and then hinge open the assembly.
5. Disconnect CTRL-J4 from the pump control board.
6. Locate and remove the display membrane assembly ground wire from the ground stud.
7. Apply a thin bead of clear silastic to the outer edge of the casting where the new display membrane assembly will be mounted.
8. Route the ground wire from the new assembly through the opening in the casting. Remove the paper from the adhesive on the new assembly. Align the new assembly and press it into place.
9. Reconnect the ground wire, CTRL-J4, DSPL-J1, and DSPL-J3.
10. Secure the display membrane assembly to the casting with the screws removed in Step 2.
11. Close the pump and perform a complete pump inspection.

> **Note:** A "FAIL 4" message may be displayed the first time the pump is powered up. If so, shut the system off and restart it to reset the pump.

4.6.2 Monitor Membrane Panel Replacement

1. Remove monitor from the system as described in Remove Monitor from System.
2. Access the monitor electronics as described in either Accessing the Safety Monitor Electronics or Accessing Monitor Electronics.
3. Place monitor upside down on a clean work surface.
4. Remove two hex head cap screws from the bottom half of the housing. The Safety Monitor has four hex head cap screws that need to be removed.
5. Carefully set monitor right side up and separate the housing.
6. Disconnect P1 on the display board for the Safety Monitor; disconnect P6 on the display board for the Arterial and Cardioplegia monitors.
7. Unseat the rear panel and tilt it away from the display assembly.
8. Remove the display assembly.
9. Remove the four nuts and separate the membrane panel from the display board.
10. Remaining boards can be accessed by removing the appropriate cables and/or hardware.
11. Assemble in reverse order of disassembly.

4.6.3 Occluder Membrane Panel

1. Remove occluder from the system as described in Remove Occluder from System.
2. Place support bracket/control, module assembly on a static mat.
3. Remove four screws that hold the control panel to the control module.
4. Remove the four screws that hold the local processor board to the display board, and remove the local processor board.
5. Disconnect P2, P3 and P4 on the display board.
6. Remove the four nuts holding membrane panel to display panel, and separate the membrane panel by pushing on the screw studs.
7. Assemble in reverse order of disassembly.

4.7 Lamp

> **Note:** The lamp can be mounted on either side of the base. A mounting plate and two bolts are used to mount the lamp to the base.

4.7.1 Remove Lamp from System

1. Switch lamp power off.
2. Disconnect lamp power cord at base connector.
3. Hold lamp with one hand; remove two 1/4 x 20 cap head screws from underside of base.

4.7.2 Install Lamp on Opposite Side

1. Switch lamp power off.
2. Disconnect lamp power cord at base connector.
3. Remove two cap head bolts (1/4 x 20) from underside of base.
4. Rotate lamp horizontally, 180 degrees.
5. Attach lamp to mounting plate with a 1/4 x 20 bolt.
6. Attach mounting plate to base.
7. Connect lamp power cord to base.
8. Switch lamp power on.

4.8 Battery Module

> **Notes:** The battery module is mounted below the base. Screws are aligned with slotted holes in the underside of the base. The slotted holes serve to guide the module into place, prior to being secured.
>
> The battery module is configured for the proper VAC by installing the primary transformer wires in their appropriate positions in P24 on the print circuit board. (Refer to Section 7, Battery Module.)

4.8.1 Battery Module Configuration

CONNECTOR	100V	115V	220V
P4-1	WHT/RED	BRN	BRN
P4-2	- - -	WHT/BRN	- - -
P4-3	- - -	- - -	WHT/RED
P4-4	BRN	WHT/RED	BLK
P4-5	WHT/BRN	- - -	WHT/BRN
P4-6	- - -	- - -	- - -
P4-7	BLK	BLK	- - -
P4-8	WHT/BLK	WHT/BLK	WHT/BLK

4.8.2 Battery Module Installation

1. Remove the plastic and stainless steel covers from the base as described in Base Components and Electronics
2. Replace the 1 3/4 inch plastic hole plug with the 1 3/4 inch plastic grommet.
3. Start the two cables through the grommet before lining up the screws.
4. Start the four 10 X 5/16 screws into the four pem nuts located on top of the module.
5. Guide the four screws into the base key-hole slots, position the module toward the rear of the console.
6. Attach the module with the four screws, tightening the screws accordingly.
7. Connect the cables: 3-pin connector supplies VAC via connector P2/J2 (Batt Conn) on the base; 9-pin connector supplies VDC to P3 on the base distribution board.
8. Replace the base covers.

4.8.3 Remove Battery Module

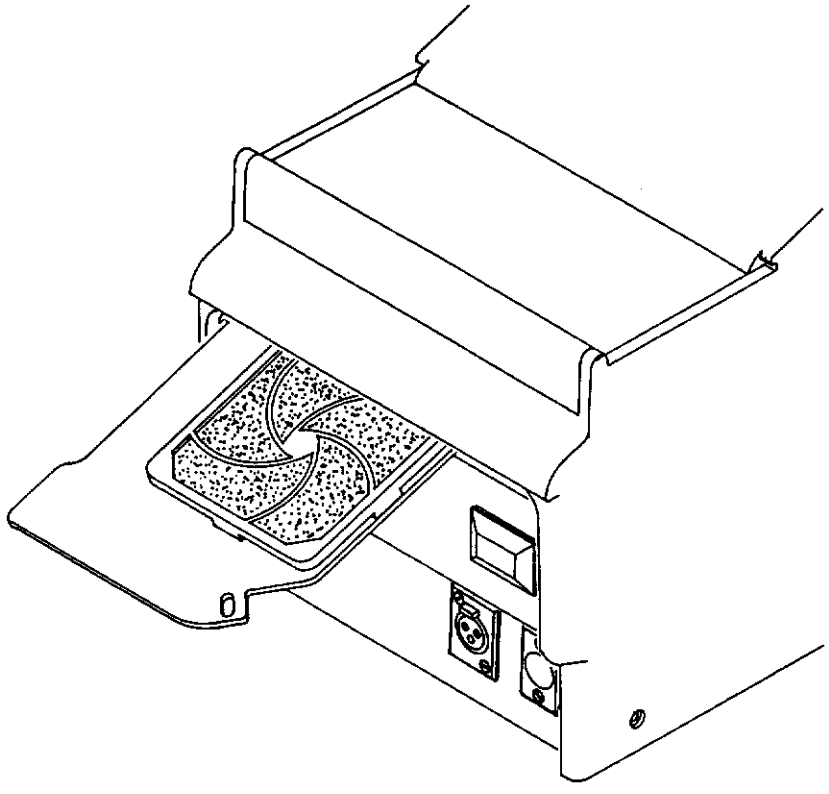
1. Loosen the four screws that hold the battery module to the base.
2. Slide the module forward until clear of the slots.
3. Lower the module to the floor.
4. Remove the module top cover to access the module electronics.
5. To completely disconnect the module from the base, disconnect P3 on the base distribution board and the inline connector P2/J2, labeled Batt Conn.

4.8.4 Replace Battery Module Batteries

1. Remove the battery module from the base as described above.
2. Remove the ten screws that secure the battery module cover to the battery module.
3. Disconnect the black, red and yellow wires, in that order, from the battery terminals.
4. Lift out batteries and replace.
5. Reinstall the yellow, red and black wires, respectively.
6. Replace the cover. Check that the black rubber bumpers are still attached to the cover and no wires are pinched .
7. Reconnect the battery module to the base.

4.9 Miscellaneous

4.9.1 Air Filter Replacement



1. Slide out the air filter holder.
2. Remove the old filter from the holder. Install new filter.
3. Reinstall the holder and filter.

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Section 5. Troubleshooting

5.1 Modular Perfusion System

Problem	Check	Action
Base fuse blows on power distribution board.	✓ wiring configuration of base and modules are the same.	Configure terminal block wiring for mains power.
Only pumps or pole monitors (not both) start on battery power.	✓ yellow indicators on Battery Module.	Reset circuit breaker by de-pressing unlit indicator.
Arterial Module doesn't start.	✓ power circuit breaker on back of Safety Monitor, ✓ internal fuse in module.	Turn breaker on. Replace blown fuse.
Cardioplegia monitor doesn't start.	✓ power circuit breaker on back of Safety Monitor. ✓ internal fuse in module.	Turn breaker on. Replace blown fuse.
Pumps do not stop with safety alarm.	✓ cable connections to pumps, ✓ by connecting cable to another pump, ✓ 4-position switch on rear of Safety Monitor.	Connect arterial and cardioplegia pumps to ART and CPG cables. Switch pumps. Turn to positions 1 or 2.
Pumps won't restart after alarm conditions.	✓ that bubble or level detectors were reset, ✓ for sustained high pressure conditions, ✓ alarm level settings.	Depress reset button for about one second. Relieve pressure to below alarm levels. Raise alarm values.
Standalone pump won't stop with alarm conditions	✓ battery back-up settings on standalone pump ✓ mains connection	Change battery back-up mode.
Pumps won't operate on battery back-up.	✓ cables to pump, ✓ pump circuit breakers on, ✓ battery charge condition, ✓ yellow battery indicators lit.	Connect appropriately. Turn pump circuit breakers on. Charge battery by leaving base on for 24 hours. Reset indicators.
System will not power up.	✓ all circuit breakers are on, ✓ for power at mains outlet.	Turn on all breakers. Use different outlet.
Can't hear audible alarm.	✓ volume setting on rear of Safety Monitor.	Adjust to suit preference.

5.2 Base Electronics

(See Section 6, Base Wiring Diagram)

Problem	Check	Action
No output power (AC) to the 8000 pump(s).	✓ assigned circuit breaker, ✓ terminal blocks 1, 2, 3 & 4, ✓ AC power pig tail cable from base to pump.	Replace component(s), if necessary.
No output power (AC) to the auxiliary outlet with "alarm interrupt" feature.	✓ assigned circuit breaker, ✓ terminal blocks 1, 2 & 4, ✓ solid state relay (input signal from PCB and AC connections).	If TB2 and TB4 OK, replace relay K1; else replace transformer T3; else check related connections.
No output power (AC) to the "auxiliary outlet".	✓ assigned circuit breaker, ✓ terminal blocks 1, 2 & 3.	If TB2 and TB3 OK, replace transformer T2; else check related connections.
No power to monitoring modules.	✓ circuit breaker CB9, ✓ diode assembly D1 & D2, ✓ voltage across capacitor C1, ✓ PCB fuse F1, ✓ terminal blocks 1, 2 & 5, ✓ line filter LF1.	Verify connections. Replace component(s) if necessary.
8000 pump does not stop under an alarm condition (ART or CPG).	✓ pole cable connections, ✓ related pig tail safety cable assembly, ✓ PCB fault table if applicable.	If connections OK, replace PCB if necessary.
Auxiliary outlet with "alarm interrupt" feature does not stop under an alarm condition.	✓ logic low level across terminals 3 and 4 of the solid sate relay K1, ✓ PCB fault table if applicable.	If logic level is low, replace relay; else replace PCB.
No communication between the safety module and the pump.	✓ pole cable connections, ✓ related pig tail safety cable assembly, ✓ PCB fault table if applicable.	Verify continuity from pin to pin.
No power to the occluder module.	✓ circuit breaker CB11, ✓ PCB connections.	Replace component(s) if necessary.
No power to the lamp assembly (left).	✓ circuit breaker CB10, ✓ PCB fault table if applicable.	If connections OK, replace PCB.
No power to the lamp assembly (right).	✓ circuit breaker CB12, ✓ PCB fault table if applicable.	If connections OK, replace PCB.
No power to the arterial or cardioplegia pumps, with installed battery module and AC power lost.	✓ cables from PCB P13-3 & P13-4 to main circuit breaker, ✓ battery power pig tail cable to the related pump, ✓ battery module fault table.	Replace component(s) if necessary.
No power to the safety module and accessories, with installed battery module and AC power lost.	✓ diode assembly D1 & D2, ✓ PCB fault table if applicable, ✓ battery module fault table.	Replace component(s) if necessary.

5.3 Base Distribution Board

(See Section 6, Base Distribution Board Schematic)

Problem	Check	Action
No output power to pump with battery power applied.	✓ battery pig tail cable, ✓ Mate and lock and PBC terminal block, ✓ PCB P13 & main circuit breaker connections, ✓ fault table for battery module.	Replace PCB and/or main circuit breaker, if necessary.
Occluder does not power up.	✓ circuit breaker, ✓ PCB connection, ✓ fuse F1, ✓ heat sink/diode assembly, ✓ Occluder fault table.	Replace component, if necessary.
Fan assembly and lamps do not function.	✓ F1, Q1 & Q3 on PCB, ✓ lamp assembly, ✓ fan assembly, ✓ heat sink diode assembly.	Replace PCB and/or F1 and subassemblies.
Auxiliary outlet with stop does not drop out under an alarm condition.	✓ solid state relay K1, ✓ PCB (U1, U2, U3 & U4), ✓ 5V on PCB (Q2), ✓ power/comm cable assembly (connections), ✓ Safety monitor fault table.	Replace PCB and/or relay and cable assembly.
Arterial pump does not stop under an alarm condition.	✓ PCB (U2, U3 & U4), ✓ 5V on PCB (Q2), ✓ ART/CPG cable assembly , ✓ power/comm cable assembly (connections), ✓ Safety monitor fault table.	Replace components, if necessary.
Cardioplegia pump does not stop under an alarm condition.	✓ PCB (U1, U3 & U4), ✓ 5V on PCB (Q2), ✓ ART/CPG cable assembly , ✓ power/comm cable assembly (connections), ✓ Safety monitor fault table.	Replace components, if necessary.

5.4 Roller Pump

5.4.1 FAIL 1 Displayed (EPROM Test Fail)

1. Switch the system OFF and ON.
2. If the message repeats, check for loose connections inside the pump. If none are found, replace the Local Processor Board.

5.4.2 FAIL 2 Displayed (RAM Test Fail)

1. Switch the system OFF and ON.
2. If the message repeats, check for loose connections inside the pump. If none are found, replace the Local Processor Board.

5.4.3 FAIL 3 Displayed

This test should always pass in a roller pump. If not, replace the Local Processor Board.

5.4.4 FAIL 4 Displayed (EEROM Test Fail)

1. Switch the system OFF and ON. If a new Display Board has been installed, this will reset the error.
2. If the message repeats, check the cable connections to the Display Board and the Safety Board.
3. Replace the Display Board and switch the system OFF and ON twice.

5.4.5 FAIL 5 Displayed (Stop Test Fail)

1. Switch the system OFF and ON.
2. If the message repeats, check for loose connections to the Safety Board and Local Processor Board. If none are found, replace the Safety Board or Local Processor Board.

5.4.6 FAIL 6 Displayed

This test should always pass in a roller pump. If not, replace the Local Processor Board.

5.4.7 RESET Displayed Continually

1. Switch the system OFF and ON.
2. If the message repeats, check for loose connections to the Safety Board and Local Processor Board. If none are found, replace the Local Processor Board.

5.4.8 OVRSPD 1 Displayed

1. Use a digital tachometer to measure the actual RPM.
   - If the maximum measured RPM is greater than 250 +/- 2 RPM, calibrate the Pump Control Board.
   - If the maximum measured RPM is 250 +/- 2 RPM, replace the Pump Safety Board.

5.4.9 OVRSPD 2 Displayed

1. Use a digital tachometer to measure the actual RPM.
   - If the maximum measured RPM is greater than 250 +/- 2 RPM, calibrate the Pump Control Board.
   - If the maximum measured RPM is 250 +/- 2 RPM, replace the Pump Safety Board.

5.4.10 OVRSPD 3 Displayed

1. Check that the speed control pot is properly connected to J4 on the Pump Control Board.
2. Calibrate the Pump Control Board.
3. Replace the Local Processor Board.

5.4.11 PUMP JAM Displayed

1. Press the Stop switches. Remove the tubing or any foreign objects from the pump head.
2. Use a hand crank to turn the head.
   - If it is easy to turn, the motor or the Pump Drive Board is the source of the problem. Also check the drive transistor connected to J2 on the Pump Drive Board.
   - If it is difficult to turn, proceed to Step 3.
3. Remove the pump drive belt. Use a hand crank to turn the head.
   - If it is easy to turn, replace the motor.
   - If it is difficult to turn, replace the casting/bearing assembly.

5.4.12 BELT SLIP Displayed

1. Use a digital tachometer to measure the actual RPM.
2. Compare the actual RPM to the displayed RPM.
   - If the actual RPM is greater than the displayed RPM, replace the Tachometer Board. Also check that the plastic encoder wheel has not been damaged.
   - If the actual RPM and displayed RPM are equal, the source of the problem is the Pump Safety Board, the Pump Control Board, or the Local Processor Board. Refer to the schematics for assistance.

5.4.13 No Flow Display or Message Display

1. Check for the following voltages at J3 on the Pump Power Supply Board: -12 VDC across Pins 1 and 4 (common), +12 VDC across Pins 2 and 4, +5 VDC across Pins 3 and 4. Also check for the following at J2 on the Pump Power Supply Board: +5 VDC across Pins 1 (common) and 2. If any of the voltages are missing, replace the Pump Power Supply Board.
2. Replace the Display Board.

5.4.14 Noisy When Running in Forward or Reverse With Tubing

1. Does the noise stop with the tubing removed? If so, refer to Step 2.
2. Determine whether the noise is coming from the rollers, tube guide rollers, or tube clamps.
   - If the noise is from the rollers, replace the roller bearings
   - If the noise is from the tube guide rollers, grease or replace the rollers per Step 12 or 13 of the Roller Pump Inspection
   - If the noise is from the tube clamps, check for a loose insert screw and/or replace the black dovetail slides.
3. Perform a complete Roller Pump Inspection

5.4.15 Noisy When Running in Forward or Reverse Without Tubing

1. Check for debris in the pump head.
2. Check to see if the tachometer or something else is rubbing against the pulley.
3. Stop the pump. Remove the two screws that secure the black tongue and remove the tongue. Close the pump safety cover and start the pump.
   - If the noise is no longer heard, replace the occlusion knob bearings
   - If the noise is still heard, proceed to Step 4.

5.4.15 Noisy When Running in Forward or Reverse Without Tubing (Continued)

4. Remove the pump drive belt Start the pump.
   - If the noise is no longer heard, proceed to Step 5.
   - If the noise is still heard, replace the motor
5. Install a hand crank in the roller assembly and turn it by hand.
   - If the noise is no longer heard, replace the pump drive belt
   - If the noise is still heard, replace the casting/bearing assembly.
6. Perform a complete Roller Pump Inspection.

5.4.16 Noisy in Reverse Only

Because the motor is normally running in forward, it is typical to hear a different noise when the motor is running in reverse. As long as the motor is running smoothly and steadily, there is no problem. Allow the motor to run in reverse for 10-20 minutes. The motor noise should lessen; if not, replace the motor.

5.4.17 Knocking Sound Heard When Unoccluding Tubing

1. Check that all shoulder screws are torqued to 17 in/lbs and that the shoulder links are not loose.
2. Replace the roller slide bushings.
3. Perform a complete Roller Pump Inspection.

5.4.18 Occlusion Mechanism Hard to Turn

1. Remove the roller arm assembly.

> **Note:** The following three steps involve disassembly of the roller arm assembly.

2. Remove the four shoulder screws.
3. While holding the adjustment nut with the spanner wrench, turn the occlusion adjustment knob back and forth.
   - If it is difficult to turn, replace the occlusion knob bearings
   - If it turns smoothly, proceed to Step 4.
4. Remove the roller slide assemblies.
5. Check for corrosion on the support rods; remove any with fine sandpaper.
6. Align each roller slide assembly with its support rods. Push the roller slide assemblies onto the support rods. It should only require 5 to 7 pounds of force to move the slides on the support rods; if more force is required, ream the roller slide bushings.
7. Reassemble the pump.

5.4.19 Pump Head Will Not Turn

1. Check for the following voltages at J3 on the Pump Power Supply Board: -12 VDC across Pins 1 and 4 (common), +12 VDC across Pins 2 and 4, +5 VDC across Pins 3 and 4. If any of the voltages are missing, replace the Pump Power Supply Board.
2. Check the transistors connected to J1 and J2 on the Pump Drive Board.
3. Check that the resistance of the speed pot varies from 0 to 10K ohms when measured between Pins 2 and 3 of J4 on the Pump Control Board.
4. Disconnect DRV-J4 from the Pump Drive Board. Check for 24-36 VDC across Pins 1 and 3 of J4.
   - If the voltage is present, replace the motor.
   - If the voltage is not present, replace the Pump Drive Board.

5.4.20 Pump Will Not Power Up

1. Check that the pump circuit breaker is ON.
2. Check for 24-36 VDC across pins 1 and 9 on connector J1 of the Pump Distribution Board.
   - If the voltage is present, proceed to Step 3.
   - If the voltage is not present, refer to Roller Pump Distribution Board troubleshooting.
3. Check for 24-36 VDC across Pins 2 and 3 of J1 on the Pump Power Supply Board.
   - If the voltage is present, proceed to Step 4.
   - If the voltage is not present, check the pump cable.
4. Check for the following voltages at J3 on the Pump Power Supply Board: -12 VDC across Pins 1 and 4 (common), +12 VDC across Pins 2 and 4, +5 VDC across Pins 3 and 4. If any of the voltages are missing, replace the Pump Power Supply Board.
5. Replace the Pump Display Board.

5.4.21 Pump Will Not Switch Into Forward or Reverse

1. Check that the pump safety cover is closed and that the magnet is in the cover.
2. Short together Pins 2 and 3 of J5 on the Pump Drive Board. If this works, replace the cover interlock switch.
3. Disconnect the cable from J4 on the Pump Safety Board. Check for open circuits between Pins 9 and 11 and Pins 8 and 10. If either are shorted, replace the pump membrane switch panel.
4. Replace the Pump Safety Board.

5.4.22 Pump Continues to Run with Cover Open

1. Disconnect DRV-J5 from the Pump Drive Board. Check across the two red wires in the cable for a short circuit.
   - If a short is found, replace the cover interlock switch.
   - If an open is found, replace the Pump Drive Board.

5.5 Roller Pump Distribution Board

(See Section 6, Roller Pump Distribution Board Schematic)

Problem	Check	Action
Pump does not function with AC power.	✓ main circuit breaker, ✓ PCB P1, ✓ heat sink diode assembly, ✓ capacitor and PCB connection.	Replace components, if necessary; otherwise, replace PCB.
Pump does not function with battery power.	✓ heat sink diode assembly, ✓ PCB P1, ✓ battery cable on pump, ✓ battery fault table.	Replace components, if necessary; otherwise, replace PCB.
Fan assembly does not function.	✓ fuse F1 on PCB, ✓ fan cable, ✓ power circuit (Q1), ✓ PCB and connections.	Replace components, if necessary; otherwise, replace PCB.
Pulse module does not function.	✓ fuse F1 on PCB, ✓ Q1, ✓ pulse cable, ✓ see pulse fault table.	Replace components, if necessary; otherwise, replace PCB.
Pump shows erratic behavior.	✓ cap/PCB connection, ✓ PCB P1, ✓ main breaker, ✓ pump connection.	Secure connection.
Pump stays in reset mode even after power up.	✓ connection on P1, ✓ pump fault table, ✓ ID lines configuration.	Replace PCB.

5.6 Safety Module Power Board

Notes:
- All measurements made with a Fluke™ multimeter or equivalent.
- All measurements made with respect to power distribution board common (negative multimeter lead on J1 pin 56) unless otherwise stated.

Problem	Check	Action
No LED indicators or audible alarm.	✓ +18.0 to 36.0 VDC, depending on the input line voltage, at connector J4 pin 1 (negative multimeter lead on J4 pin 2), ✓ +5 VDC at connector J1 pins 53, 54 (or J6 pin 6) ✓ +12 VDC at connector J1 pin 29, ✓ -12 VDC at connector J1 pin 31.	If incorrectVDC is at J1 pin 1, trouble-shoot base power supply. With correct VDC at connector J1 pin 1 and incorrect voltage at J1 Pins 53,29 or 31, replace safety power module because of failed DC to DC converter. (Failed DC/DC converter could be caused by other circuit short).
Level detection LED indicators do not light.	✓ level detection board securely installed.	If secure, replace the level detection board.
Air detection LED indicators do not light.	✓ air detection board securely installed.	If secure, replace the air detection board.
No audible output.	✓ connectors.	Replace board OR troubleshoot board per below:
	✓ J6 pin 9, 0/5 VDC (Normally 5 V except during power up or alarm),	If signal is incorrect, replace gate U1. If signal is still incorrect, replace inverters U7 and U9.
	✓ J6 pin 4, 0/5 V 4 Hz square wave (2.5 V avg with multimeter),	If signal is incorrect, replace oscillator U10.
	✓ J6 pin 7, 0/5 V 4 Hz square wave (2.5 V avg with multimeter),	Verify 2 pin header jumper connector is installed at connector J7. If signal is still incorrect replace oscillator U10.
	✓ J6 pin 10, 0/5 V low frequency timing pulse (64 sec repeat) at power up,	If signal is incorrect replace ripple counter U8.

5.6 Safety Module Power Board (Continued)

Problem	Check	Action
No audible output.	✓ J6 pin 3, 0/5 VDC (normally 5 V except during power up or alarm),	If signal is incorrect replace PAL U2. If signal is still incorrect replace gate U1.
	✓ J6 pin 5, 0/5 VDC (normally 5 V except pulses to zero volts DC at powerup and when on switch is pressed,	If signal is incorrect replace PAL U2. If signal is still incorrect replace gate U1.
	✓ J6 pin 1, 0/10.5 V square wave, dual tone 2.5 kHz-3.0 kHz (active only during power up or alarm) 10.5 V during no alarm,	If signal is incorrect, replace piezo transducer driver U11.
	✓ J6 pin 2, 0/10.5 V square wave, dual tone 2.5 kHz-3.0 kHz (active only during power up or alarm) 10.5 V during no alarm.	If signal is incorrect replace piezo transducer X1.
Cardioplegia alarm does not shut down cardioplegia pump.	✓ cardioplegia monitor, ✓ base distribution board, ✓ air detection board, ✓ level detection board,	Replace cardioplegia monitor or board(s) as necessary (see individual board performance specifications).
	✓ J5 pin 2, 2.0 VDC during alarm condition otherwise 0 V.	If 0 volts during alarm, replace current loop transistor Q2. If problem still exists, replace optocoupler U3.
Arterial alarm shuts down arterial pump but not the cardioplegia pump.	✓ J5 pin 2, 2.0 VDC during alarm condition otherwise 0 V.	If 0 volts during alarm replace PCB or current loop transistor Q2.
Arterial alarm shuts down cardioplegia pump but not the arterial pump.	✓ base distribution board, ✓ air detection board, ✓ level detection board, ✓ J5 pin 3, 2.0 VDC during alarm condition otherwise 0 V.	Replace boards as necessary (see individual board specifications). If 0 volts during alarm replace PCB or current loop transistor Q1.
Arterial alarm does not shut down arterial or cardioplegia pump.	✓ J5 pin 3, 2.0 VDC during alarm condition otherwise 0 V.	If 0 volts during alarm replace PCB or optocoupler U4. If problem still exists replace inverters U7 and U9.

5.7 Arterial Monitor

Problem	Check	Action
Monitor does not power On.	✓ main cable connection to safety system,	Replace bad cable.
	✓ voltage level from safety system,	Replace safety system power supply.
	✓ monitor fuse on power interface board,	Replace fuse and recheck monitor electronics for source of excessive current ¥draw.
	✓ main cable to power interface board P1.	Replace bad cable.
Monitor has audio on power up but no displays.	✓ system bus ribbon cable,	Replace ribbon cable.
	✓ display board,	Replace display board.
	✓ power interface board.	Replace power interface board.
Monitor has power but no displays, audio or communication output.	✓ system bus ribbon cable, ✓ power cable internal connection to power interface board,	Replace bus ribbon cable or monitor cable.
	✓ computer board for activity,	Replace computer board if there is no serial output signal.
	✓ power interface board,	Replace power interface board.
	✓ display board.	Replace display board.
Pressure or temperature displays blank(s) after normal power on sequence or during case.	✓ pressure or temperature transducer,	Replace transducer(s) as necessary.
	✓ temperature and pressure measurement board.	Replace pressure and temperature measurement board if transducers are OK.
Missing numbers or characters on any display.	✓ display board, display chip(s),	Replace display board.
	✓ power interface board address decoding.	Replace power interface board.
No audio when monitor is powered On.	✓ volume control cable assembly and rotary switch,	Replace cable assemble or switch.
	✓ volume control cable assembly connection on power interface board connector P2,	Replace power interface board.
	✓ power interface board, tone ringer.	Replace power interface board.

5.7 Arterial Monitor (Continued)

Problem	Check	Action
Membrane key pad button fails to actuate any function or looses its tactile feedback.	✓ membrane switch continuity at connector on display board, ✓ malfunctioning switch.	Replace membrane switch panel if no continuity when switch pressed or when any switch is defective .
The message "DE-FAULTS" shows up in display each time at power On.	✓ check battery backed SRAM on the computer board by verification if alert and alarm set points have not been retained.	Replace battery backed SRAM and or computer board if system will not retain alert and alarm set points.
No communication from the RS-485 port.	✓ main cable, connection to safety system and to power interface board, ✓ communications section on the power interface board, ✓ ribbon cable from computer board to the power interface board, ✓ computer board's serial output.	Replace main cable. Replace power interface board. Replace ribbon cable from computer board to power interface board. Replace computer board.
Pump does not stop when monitor reports an over-pressure alarm condition.	✓ monitor cable and connection to safety system, ✓ monitor cable connection to the power interface board, ✓ for controlling input of and the output from the current loop circuitry on the power interface board.	Replace monitor cable. Replace power interface board if there is no control-ling input or output from circuit.
Pump can not be restarted when over-pressure alarm condition ends.	✓ the input for the current loop circuitry on the power interface board.	Replace power interface board.

5.8 Cardioplegia Monitor

Problem	Check	Action
Monitor does not power On.	✓ main cable connection to safety system,	Replace bad cable.
	✓ voltage level from safety system,	Replace safety system power supply.
	✓ monitor fuse on power interface board,	Replace fuse and recheck monitor electronics for source of excessive current draw.
	✓ main cable to power interface board P1.	Replace bad cable.
Monitor has audio on power up but no displays.	✓ system bus ribbon cable,	Replace ribbon cable.
	✓ display board,	Replace display board.
	✓ power interface board.	Replace power interface board.
Monitor has power but no displays, audio or communication output.	✓ system bus ribbon cable, ✓ power cable internal connection to power interface board,	Replace bus ribbon cable or monitor cable.
	✓ computer board for activity,	Replace computer board if there is no serial output signal.
	✓ power interface board,	Replace power interface board.
	✓ display board.	Replace display board.
Pressure or temperature displays blank(s) after normal power on sequence or during case.	✓ pressure or temperature transducer,	Replace transducer(s) as necessary.
	✓ temperature and pressure measurement board.	Replace pressure and temperature measurement board if transducers are OK.
Missing numbers or characters on any display.	✓ display board, display chip(s),	Replace display board.
	✓ power interface board address decoding.	Replace power interface board.
No audio when monitor is powered On.	✓ volume control cable assembly and rotary switch,	Replace cable assemble or switch.
	✓ volume control cable assembly connection on power interface board connector P2.	Replace power interface board.
	✓ power interface board, tone ringer.	Replace power interface board.

5.8 Cardioplegia Monitor (Continued)

Problem	Check	Action
Membrane key pad button fails to actuate any function or looses its tactile feedback.	✓ membrane switch continuity at connector on display board, ✓ malfunctioning switch.	Replace membrane switch panel if no continuity when switch pressed or when any switch is defective .
The message "DE-FAULTS" shows up in display each time at power On.	✓ check battery backed SRAM on the computer board by verification if alert and alarm set points have not been retained.	Replace battery backed SRAM and or computer board if system will not retain alert and alarm set points.
No communication from the RS-485 port.	✓ main cable, connection to safety system and to power interface board, ✓ communications section on the power interface board, ✓ ribbon cable from computer board to the power interface board, ✓ computer board's serial output.	Replace main cable. Replace power interface board. Replace ribbon cable from computer board to power interface board. Replace computer board.
Pump does not stop when monitor reports an over pressure alarm condition	✓ monitor cable and connection to safety system, ✓ monitor cable connection to the power interface board, ✓ for controlling input of and the output from the current loop circuitry on the power interface board.	Replace monitor cable. Replace power interface board if there is no controlling input or output from circuit.
Pump can not be restarted when over pressure alarm condition ends.	✓ the input for the current loop circuitry on the power interface board.	Replace power interface board.
Alert and/or alarm values are not retained in BBRAM.	✓ battery in SRAM.	Replace board or battery.

5.9 Occluder Display Board

(See Section 6 Occluder Display/Interface Schematic)

Problem	Check	Action
Occluder won't calibrate, no sound, LEDs won't light.	✓ for presence of 24 VDC at connector P3 across pin 2 (+) and pin 6 (ground), ✓ connection between membrane key-pad flat-ribbon cable and connector P1 on the same board.	Troubleshoot base.
Occluder won't calibrate, no sound, LEDs won't light and power at connector P3.	✓ voltage output to occluder head at the D-connector, pin 14 (+12 VDC) and pins 1-4 (GND) , pins 9-10 (+24 VDC) and pins 1-4 (GND), pin 15 (+5 VDC) and pin 7. ✓ continuity of D/MTA cable ✓ contact closure between Close switch, connector P1, pin 2 (+) 5 VDC and pin 5 (ground). ✓ contact closure signal at local processor interface, display board connector P5, pin 17 and pin 19.	Replace cable. Replace display board. Perform diagnostics on occluder head. If no contact closure, replace membrane board. If contact is made, replace local processor.
7-segment LEDs won't light yet occluder is functional.	✓ 5 VDC across LED socket pin 13, or 14(+) and connector P5, pin 50.	Replace LEDs if voltage is present.
7-segment LEDs won't light and no voltage present yet occluder is functional.	✓ connector P5, pin 44 on display board (connector P1, pin 8 on the local processor) for enable signal.	Replace local processor.
Display blanks after recalibration with tubing latched in place.	✓ MTA connector, P4 on display board to assure proper alignment. ✓ connector between local processor and display board.	Perform diagnostics on occluder head. Replace local processor.
Occluder calibrates and LEDs light, but no response from encoder input.	✓ connection between encoder and display board. ✓ for 5 VDC across connector P2 pin 2 (+) and pin 4 (ground). ✓ for 5 VDC signal at local processor interface, display board connector P5, pin 13 and pin 16 while rotating encoder wheel.	Replace encoder if voltage present and no return signal is present during rotation of encoder wheel. Replace local processor.

5.10 Occluder Membrane Keypad

Problem	Check	Action
Open button fails to actuate system.	✔ With a DMM in the continuity check mode, place the negative lead at pin 5 and the positive lead at pin 1. Continuity should be made when button is pressed.	Replace membrane switch if no continuity.
Close button fails to actuate system.	✔ With a DMM in the continuity check mode, place the negative lead at pin 5 and the positive lead at pin 2. Continuity should be made when button is pressed.	Replace membrane switch if no continuity.

5.11 Battery Module

(See Section 6 Battey Module Schematic)

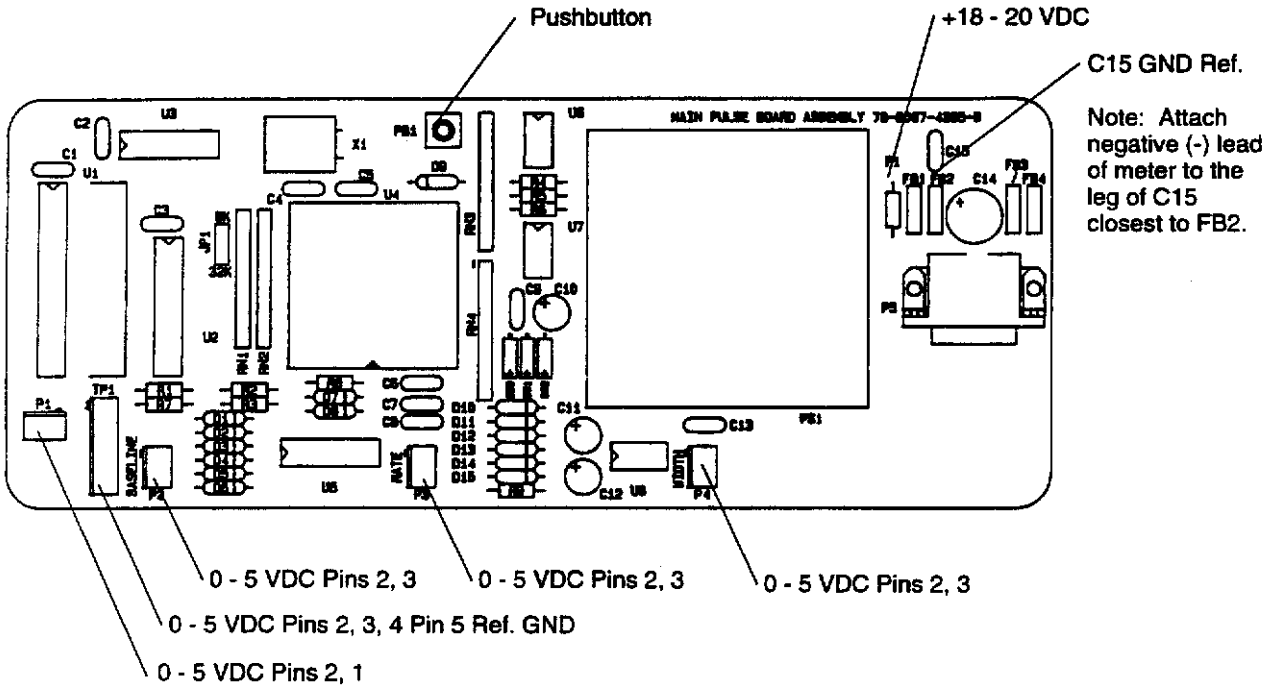
Problem	Check	Action
Battery charger indicator does not light.	✔ lamp, ✔ fuse on base distribution board.	Replace component if necessary.
Batteries will not recharge.	✔ fuse on base distribution board, ✔ "No Load" charge voltage, ✔ battery replacement schedule.	Replace component if necessary. Readjust to 27.6 V if necessary. Replace batteries if necessary.
Inadequate "On Battery" time.	✔ "No Load" charge voltage, ✔ battery replacement schedule.	Readjust to 27.6 V if necessary. Replace batteries if necessary.
Front panel indicators do not illuminate properly.	✔ lamp.	Replace component if necessary.
Circuit breaker blows.	✔ current draw, ✔ peripheral modules.	Replace component if necessary.
Circuit breaker will not reset.	N/A	Replace component if necessary.
Module fails to switch to "On Battery".	✔ battery voltage, ✔ base main circuit breaker ("On").	Recharge batteries, replace if necessary. Replace PCB if necessary.

5.12 Pulse Module

When the regulated 20 volts is supplied to the main board, the microcontroller begins a startup routine to check proper function of the external EPROM, RAM, and A/D conversion circuitry channel 0. After the successful completion of each of these self tests, the microcontroller turns off the board LEDs DS0, DS1, and DS2 respectively. After all three LEDs are off and a satisfactory pump response has been given for a pulse packet, the microprocessor turns on the external LED. The Pulse Module sends pulse parameters to the pump and enables pulse mode; pulse mode is activated only when the pump's computer control buttons are pressed.

Fail-known circuitry has been also added, which includes 3.9 MΩ resistors (R7, R8, R9). If a pot opens or a pot cable disconnects from the main board, the follow condition will occur.

- If Baseline section, the voltage will be 5 V translating to 100%.
- If Rate section, the voltage will be 0 V translating to 30 bpm
- If Width section, the voltage will be 5 V translating to 100%



Pulse Module Main Board

Precautions: Use static precautions whenever handling printed circuit boards or integrated circuit chips.

Use proper tool to remove processor chip.

Do not remove cables from main board when power is on.

5.12 Pulse Module (Continued)

Problem	Check	Action
None of the LEDs turn on.	✓ cable between Pulse Module and pump, ✓ for 18-20VDC at F1, ground reference to C15	Replace cable if necessary. Troubleshoot pump.
LEDs blinking on main board.	✓ for constant 18-20VDC at F1, ground reference to C15 ✓ pushbutton.	Replace main board.
LEDs turn on and then turn off; external LED does not turn on.	✓ for 5VDC between pins 2 & 1 of P1 on main board. ✓ Pulse Module on pump	Replace the LED cable if necessary. If there is 0 volts between pins 2 & 1, replace the board. Troubleshoot Pump
LEDs turn on and then off; external LED on but module not pulsing.	✓ cable between main board and potentiometer for width & baseline. ✓ for varying voltages on TP1-3, TP1-4 with reference to TP5 when potentiometers are turned. ✓ voltage across pins 2 & 3 on P2, P3, and P4 of main board, as knob is turned.	Replace cable if necessary. If voltage not varying, troubleshoot pot. If voltage is varying, replace main board. If either TP does not vary from 5. 0 V while pot turned, pot assembly is broken.
LEDs turn on and then off; external LED on but rate stuck at 30 bpm	✓ rate cable between main board and potentiometer. ✓ for varying voltages on TP1-2 with reference to TP5 when potentiometers are turned. ✓ voltage across pins 2 & 3 on P2, P3, and P4 of main board, as knob is turned.	Replace cable if necessary. If voltage not varying, troubleshoot pot. If voltage is varying, replace main board. If TP does not vary from 0. 0 V while pot is turned, pot assembly is broken.
External LED on but none of knobs function.	✓ pump will pulse, ✓ main board to potentiometer cables, ✓ for varying voltages on TP1-2, TP1-3 TP1-4 with reference to TP1-5 when potentiometers are turned. ✓ voltage across pins 2 & 3 on P2, P3, and P4 of main board, as knob is turned.	If no pulse, try a different pump. Replace cable if necessary. If voltage not varying, troubleshoot pot. If voltage is varying, replace main board.

5.12 Pulse Module (Continued)

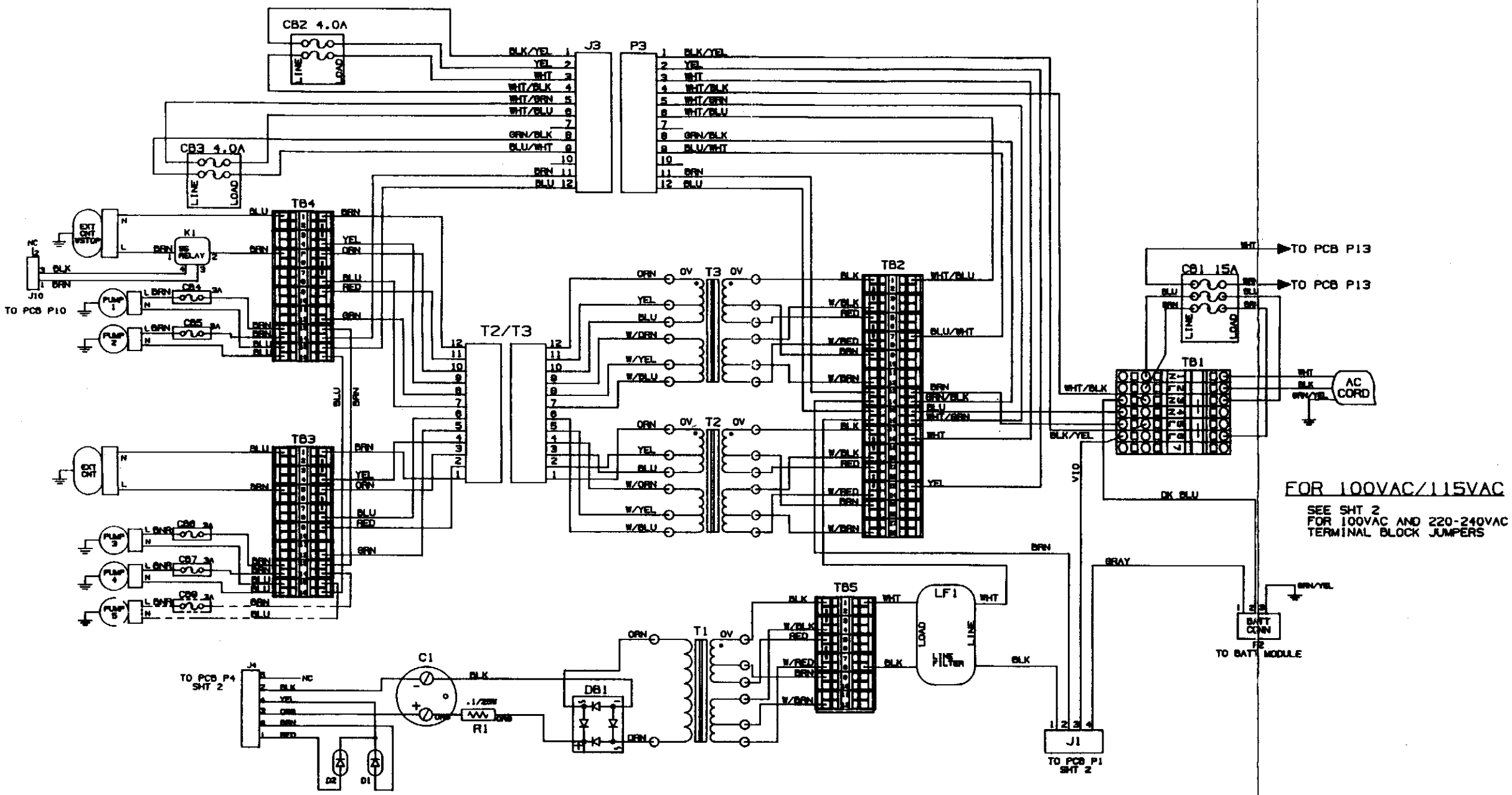
Problem	Check	Action
Pulse module will not operate on pump designated as arterial or cardioplegia	✓ communication lines.	Disconnect the arterial monitor, then the cardioplegia monitor; check for proper operation of the pulse module after disconnecting each monitor. If pulse module operates properly after disconnecting monitor, proceed to "Check internal connections."
	✓ pulse module on alternate pump module.	Connect pulse module to alternate pump module and check for proper operation. If pulse module does not operate properly, replace pulse module.
	✓ internal connections in appropriate monitor.	Verify that the ribbon cable from the CPU to connector P4 on the power board is secure. Connector P3 on the power board should be empty. Secure all connectors to the CPU and the power board. Reassemble the monitor, reconnect monitor to the safety monitor and test for proper operation of monitor and pulse module. Replace appropriate monitor.

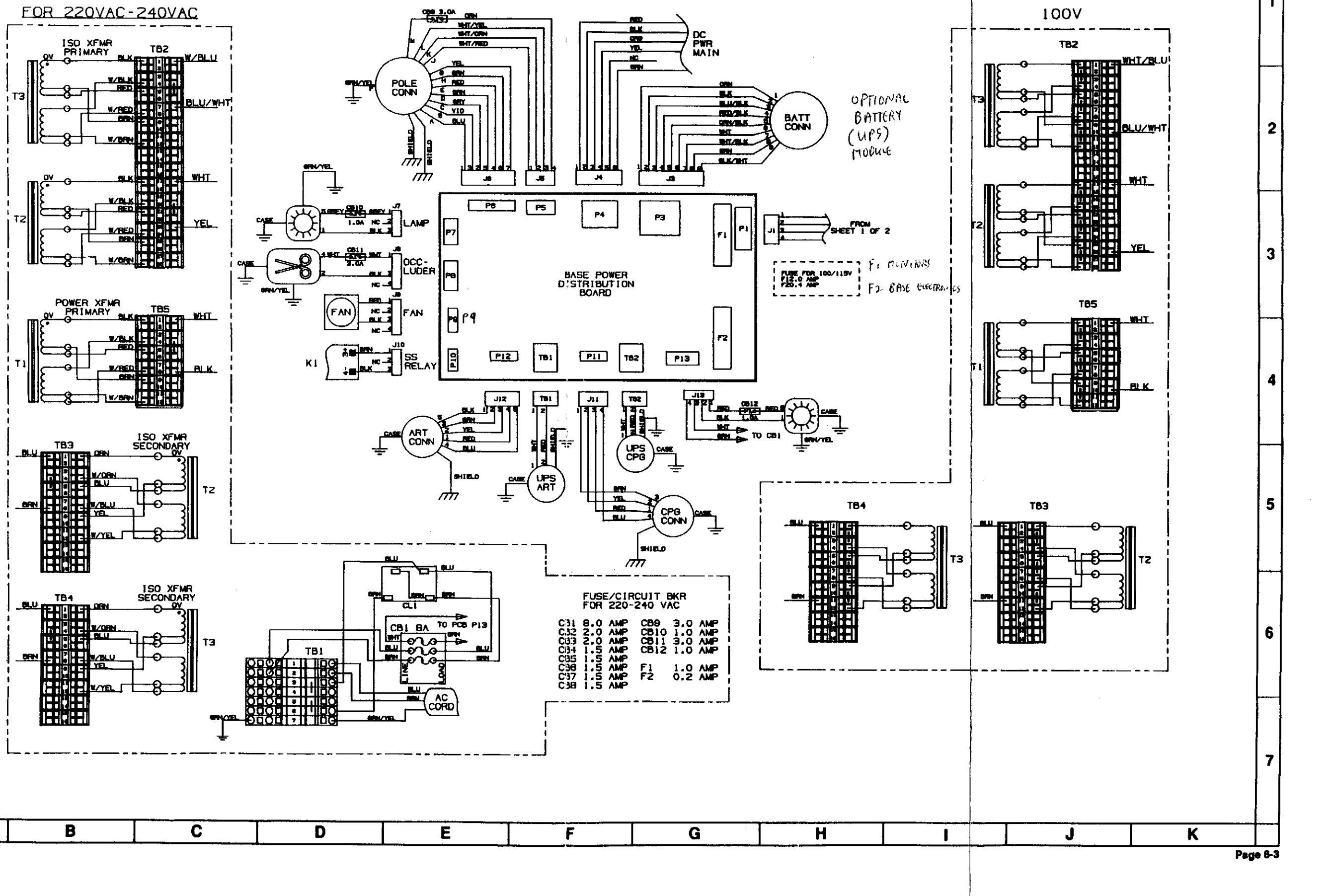
5.13 Communications Module

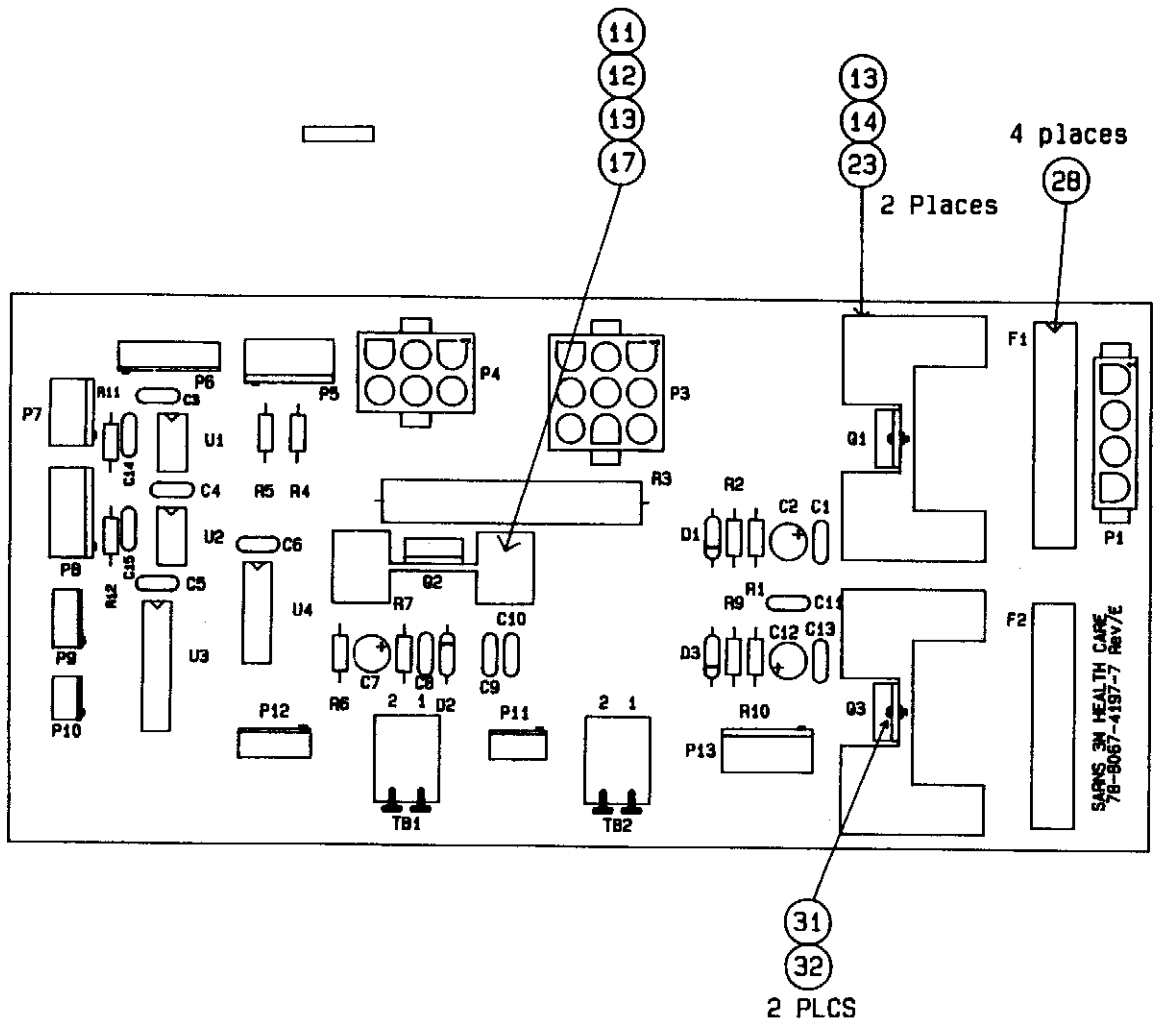
Problem	Check	Action
LED is OFF after 40 second delay	✓ +5VDC at R21 on the communications interface board	Reset the Saftey Monitor circuit breaker If voltage is missing, replace the communications interface board, otherwise replace the LED Replace the computer board
LED is ON, but no data being sent to external computer	✓ cable connections from Communications Module to external computer ✓ users computer serial interface configuration RS-232 or RS 422	Replace cable between Communicaiton Module and external computer Configure COmmunications Module interface to users (refer to System Description, Section 1) Replace communications interface board
No data coming in from arterial network	✓ communications cable connections to the arterial pump, arterial monitor and pulse module	Select another pump as arterial, if communicaitons resume, troubleshoot pump Disconnect pulse module, if communicaitons resume, troubleshoot pulse module Disconnect arterial monitor, if communicaitons resume, troubleshoot arterial monitor Replace communications interface board
No data coming in from cardioplegia network	✓ communications cable connections to the cardioplegia pump and cardioplegia monitor	Select another pump as cardioplegia, if communicaitons resume, troubleshoot pump Disconnect cardioplegia monitor, if communicaitons resume, troubleshoot cardioplegia monitor
Module continullay resets, LED flashes slowly	N/A	Replace computer board Replace communications interface board

Table of Contents

Section 6. System Diagrams

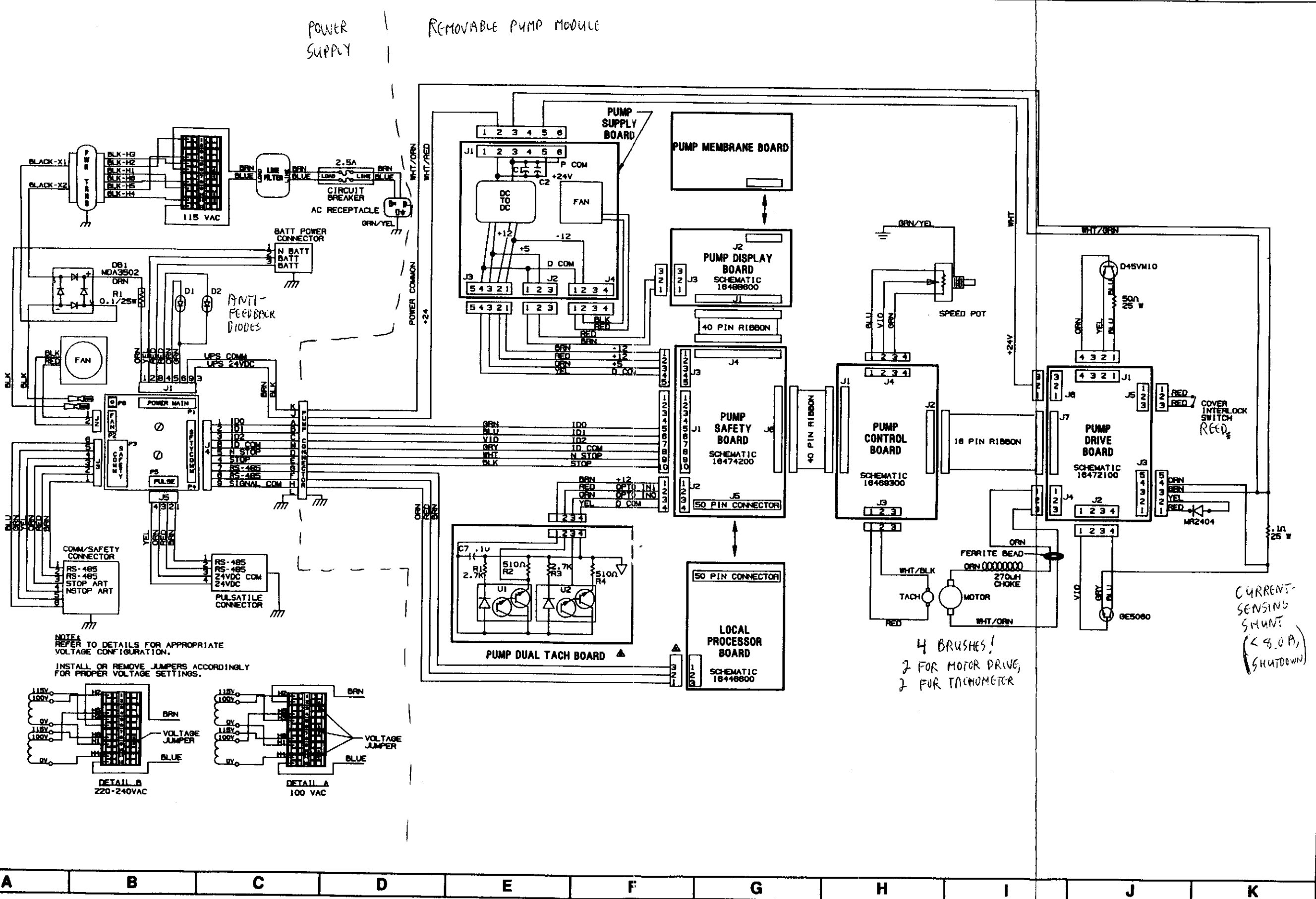

CB2 4.0A
CB3 4.0A
J3
P3
TB4
TB3
TB2
TB5
TB1
T2/T3
T3
T2
T1
K1
RE RELAY
EXT CNT
EXT CNT W/STOP
PUMP 1
PUMP 2
PUMP 3
PUMP 4
PUMP 5
CB4 3A
CB5 3A
CB6 3A
CB7 3A
CB8 3A
J10
TO PCB P10
C1
R1
DB1
D1
D2
J4
TO PCB P4 SHT 2
LF1
LINE FILTER
CB1 15A
TO PCB P13
TO PCB P13
AC CORD
J1
TO PCB P1 SHT 2
BATT CONN
FI2
TO BATT MODULE
FOR 100VAC/115VAC
SEE SHT 2
FOR 100VAC AND 220-240VAC
TERMINAL BLOCK JUMPERS

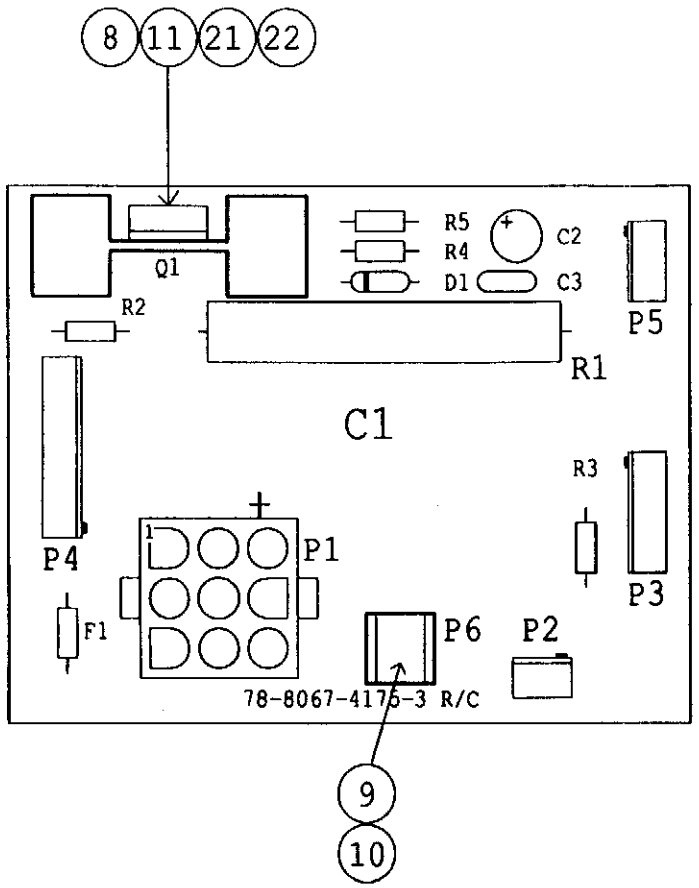

FOR 220VAC-240VAC
ISO XFMR PRIMARY
TB2
W/BLU
BLU/WHT
WHT
YEL
T3
T2
POWER XFMR PRIMARY
TB5
WHT
BLK
T1
TB3
ISO XFMR SECONDARY
T2
TB4
ISO XFMR SECONDARY
T3
POLE CONN
DC PWR MAIN
BATT CONN
OPTIONAL BATTERY (UPS) MODULE
LAMP
OCC-LUDER
FAN
FAN
K1
SS RELAY
BASE POWER DISTRIBUTION BOARD
FROM SHEET 1 OF 2
F1 MOTORS
F2 BASE ELECTRONICS
ART CONN
UPS CPB
UPS ART
CPG CONN
TO CB1
CB1 8A
TO PCB P13
TB1
AC CORD
FUSE/CIRCUIT BKR
FOR 220-240 VAC
C31 8.0 AMP CB9 3.0 AMP
C32 2.0 AMP CB10 1.0 AMP
C33 2.0 AMP CB11 3.0 AMP
C34 1.5 AMP CB12 1.0 AMP
C35 1.5 AMP
C36 1.5 AMP F1 1.0 AMP
C37 1.5 AMP F2 0.2 AMP
C38 1.5 AMP
100V
TB2
TB5
TB4
TB3



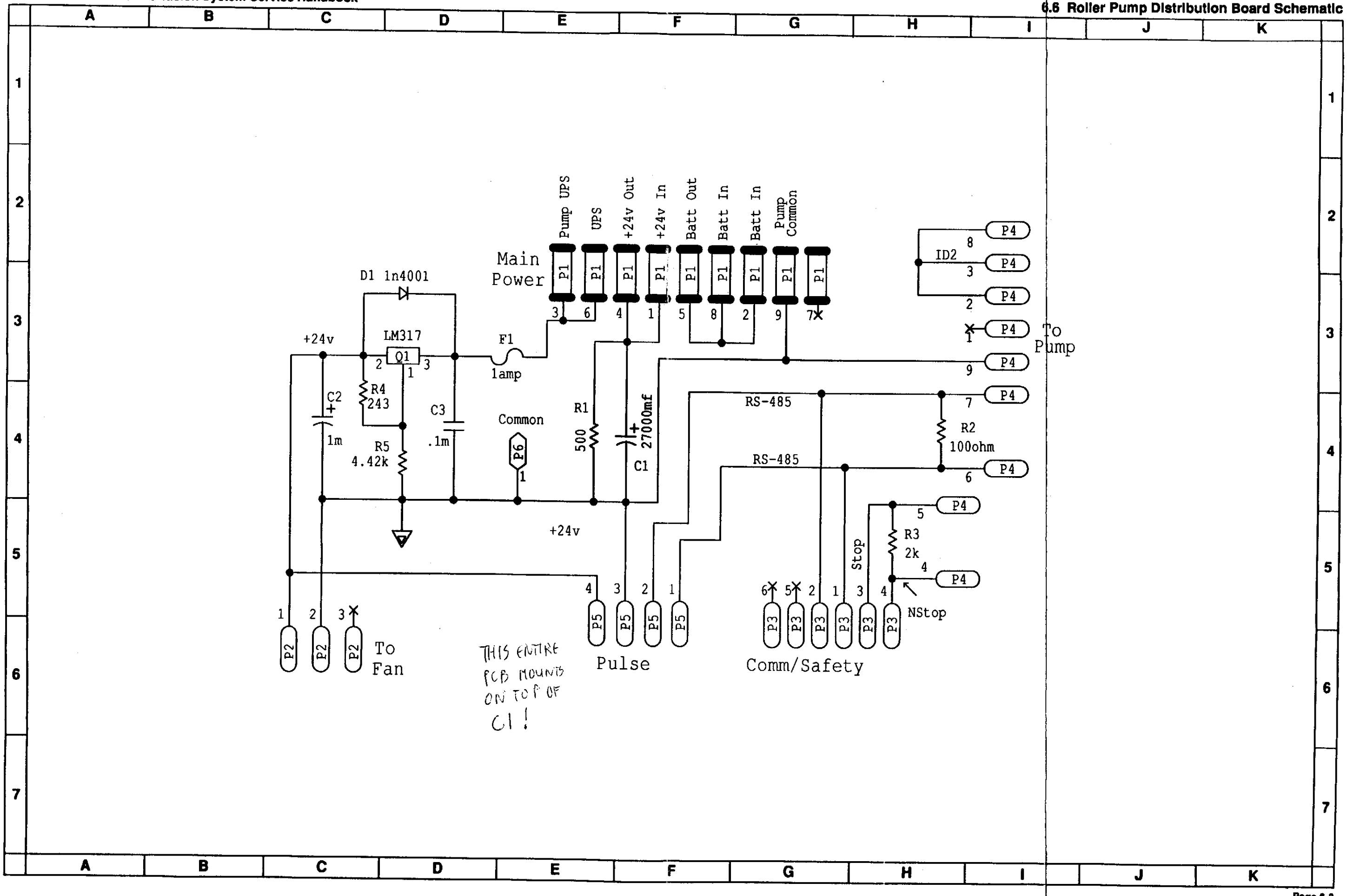
SEQ.	DESCRIPTION	REF. DES.
2	M&L 4 PIN	P1
3	M&L 6 P	P4
4	M&L 9 PIN	P3
5	MTA100 3 PIN	P10
6	MTA100 4 PIN	P9, P11
7	MTA100 5 PIN	P12
8	MTA100 7 PIN	P6
9	MTA156 3 PIN	P7
10	MTA156 4 PIN	P5, P13
15	CAP MONO .1m	C1, C3, C4, C5, C6, C8, C9, C10 C11, C13
16	CAP 10m/35/10%	C2, C7, C12
18	DIODE IN4002	D1, D2, D3
19	RES 243ohm	R2, R7, R9
20	RES 750ohm	R6
21	RES 1K	R4, R5
22	RES 4.42K	R1, R10
24	IC ULN2803A	U3
25	IC HCPL4200	U1, U2
26	IC 74HCT04	U4
27	RES POWER 500ohm	R1
29	PCB TERMINAL BLOCK	TB1, TB2
30	RES 10K	R11, R12
35	CAP .047uf	C14.C15

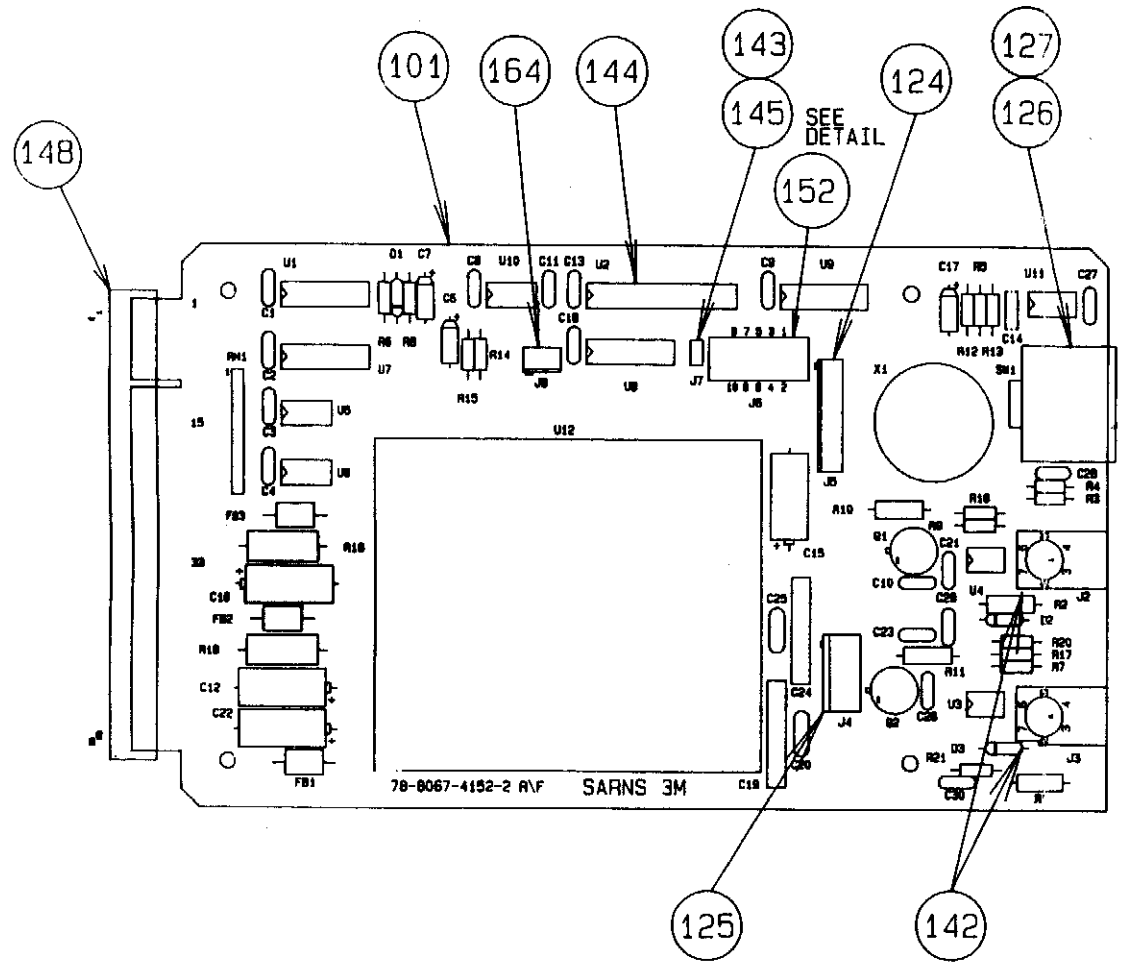
RS-485/P ART
RS-485/N ART
RS-485/P CPG
RS-485/N CPG
To Pole
STOP CPG.
STOP ART.
NSTOP ATR/CPG
U1
U2
HCPL-4200
HCT04 U4
ULN2803 U3
VCC=+5V=PIN 14
VDD=GND=PIN 7
VCC=+5V=PIN 10
VDD=GND=PIN 9
Cardio.
Arterial
To SSR
To Arterial Battery
TO Cardio. Battery
Battery A
NBattery A
Battery B
A.C."ON"
To Main C.B.
To Battery
N Battery B
To Occluder
To Lamp
To Fan
V BATTERY
V UNINTERUPTIBLE
V COMMON
1N4002
LM317TV
LM350TV
12.0A
20.0A
GND

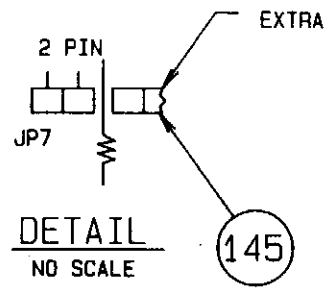

POWER SUPPLY
REMOVABLE PUMP MODULE
PUMP SUPPLY BOARD
PUMP MEMBRANE BOARD
PUMP DISPLAY BOARD
SCHEMATIC 16488600
40 PIN RIBBON
PUMP SAFETY BOARD
SCHEMATIC 16474200
50 PIN CONNECTOR
PUMP CONTROL BOARD
SCHEMATIC 16469300
16 PIN RIBBON
PUMP DRIVE BOARD
SCHEMATIC 16472100
PUMP DUAL TACH BOARD
LOCAL PROCESSOR BOARD
SCHEMATIC 16446600
115 VAC
CIRCUIT BREAKER
AC RECEPTACLE
2.5A
BATT POWER CONNECTOR
N BATT
BATT
BATT
DB1 MDA3502
R1 0.1/25W
D1
D2
ANTI-FEEDBACK DIODES
FAN
UPS COMM
UPS 24VDC
POWER MAIN
COMM/SAFETY CONNECTOR
RS-485
RS-485
STOP ART
NSTOP ART
PULSATILE CONNECTOR
24VDC COM
24VDC
SPEED POT
D45VM10
50Ω 25 W
COVER INTERLOCK SWITCH
REED
MR2404
.1Ω 25 W
FERRITE BEAD
270uH CHOKE
TACH
MOTOR
8E5060
4 BRUSHES!
2 FOR MOTOR DRIVE,
2 FOR TACHOMETER
CURRENT-SENSING SHUNT (< 9.0 A, SHUTDOWN)
POWER COMMON
+24
WHT/ORN
WHT/RED
P COM
+24V
D COM
+12
+5
-12
IDO
ID1
ID2
ID COM
N STOP
STOP
RS-485
RS-485
SIGNAL COM
OPTO IN
OPTO NO
Q COM
NOTE:
REFER TO DETAILS FOR APPROPRIATE VOLTAGE CONFIGURATION.
INSTALL OR REMOVE JUMPERS ACCORDINGLY FOR PROPER VOLTAGE SETTINGS.
DETAIL B
220-240VAC
DETAIL A
100 VAC
VOLTAGE JUMPER
BRN
BLUE



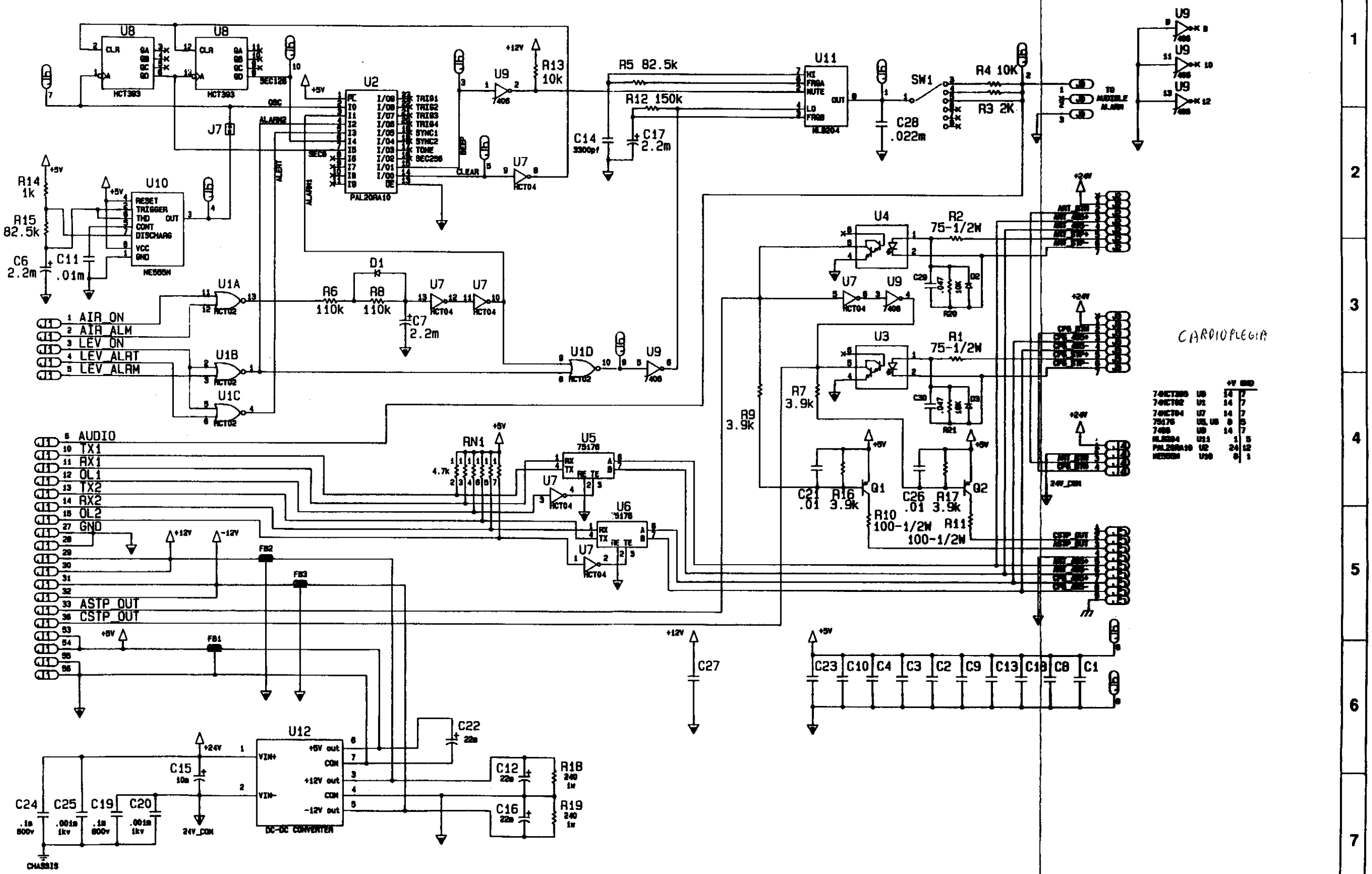
Seq.	Description	Ref.
2	MTA100 4P	P5
3	MTA100 9P	P4
4	MTA100 6P	P3
5	MTA100 3P	P2
6	MATE&LOCK 9P	P1
12	DIODE SIG 1N914	D1
13	RES 500 11WATT	R1
14	RES 100 1/4 WATT	R2
15	RES 2K 1/4 WATT	R3
16	RES 243 1/4 WATT	R4
17	RES 4.42K 1/4 WATT	R5
18	CAP MONO .1M	C3
19	CAP 1M/35/10%	C2
20	FUSE 1 AMP	F1

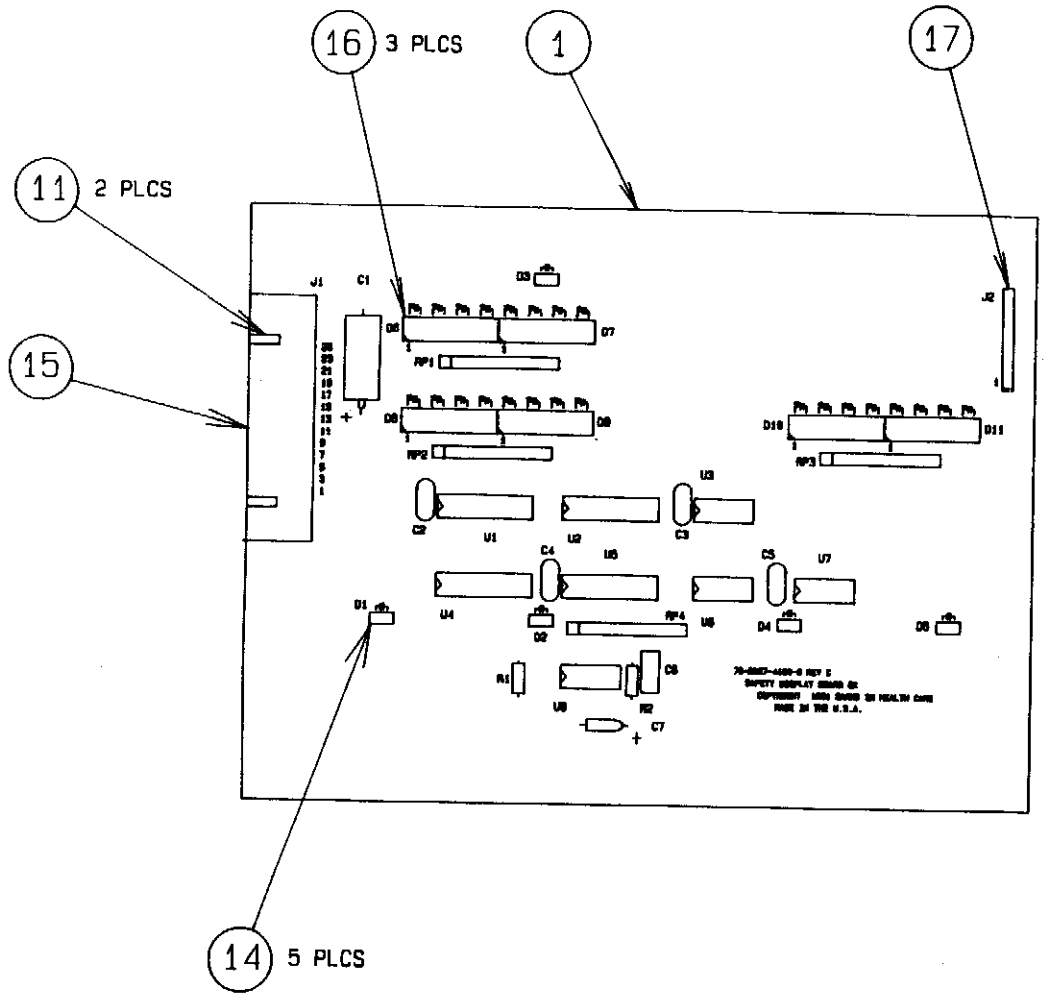

Pump UPS
UPS
+24v Out
+24v In
Batt Out
Batt In
Batt In
Pump Common
Main Power
P1
D1 1n4001
LM317
Q1
+24v
F1
1amp
C2
1m
R4
243
R5
4.42k
C3
.1m
Common
P6
R1
500
C1
27000mf
+24v
ID2
P4
To Pump
RS-485
RS-485
R2
100ohm
R3
2k
Stop
NStop
P2
To Fan
P5
Pulse
P3
Comm/Safety
THIS ENTIRE PCB MOUNTS ON TOP OF C1!



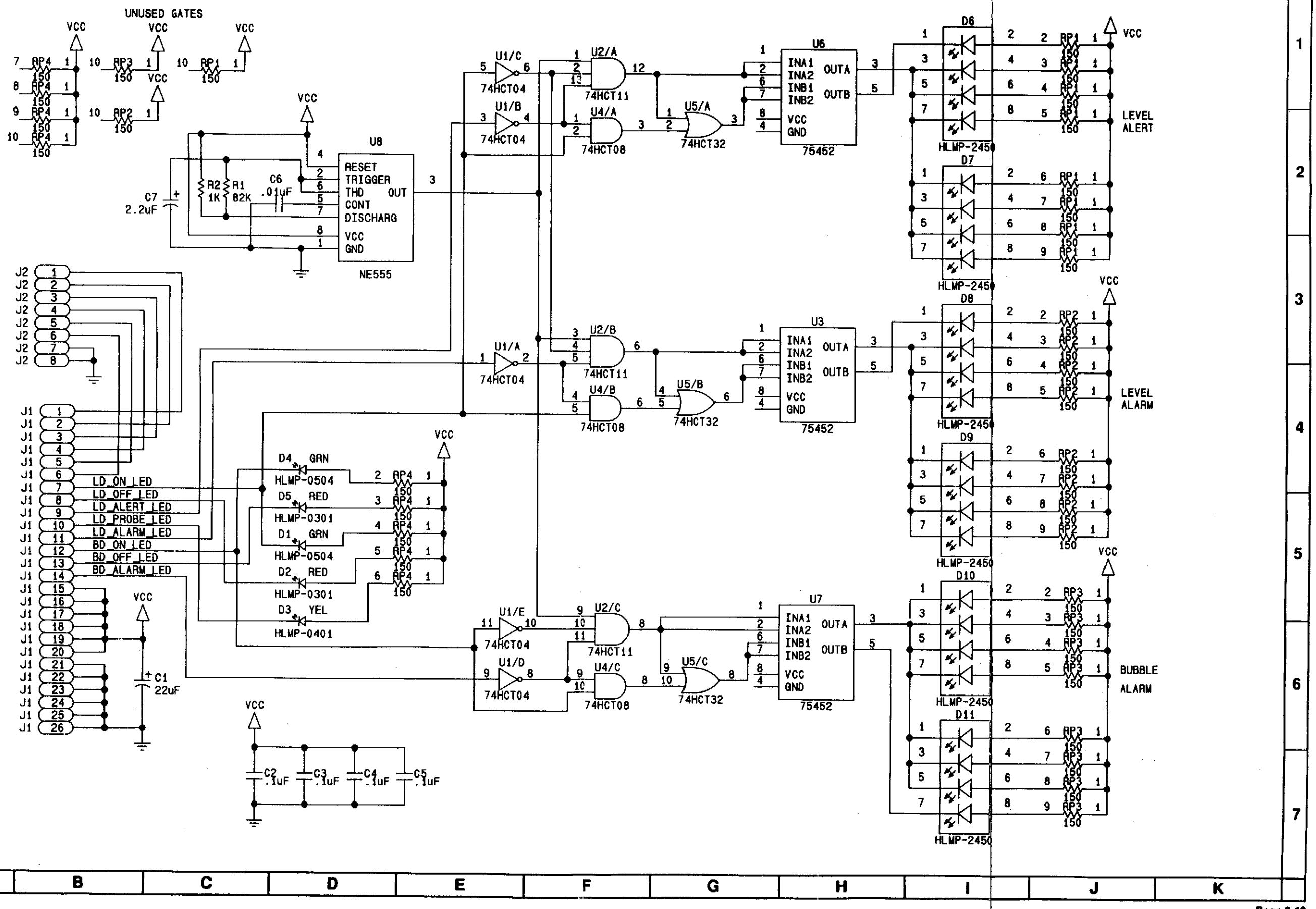


SEQ	DESCRIPTION	REF
102	IC MC1455P1 TIME CIRCT	U10
103	IC 74HCT04 HEX INVERT & NAND	U7
104	IC 4N32 OPTOISOLATOR	U3, U4
105	IC 7406 HEX INVERTER O.C.	U9
106	IC ML8204 TONE GENERATOR	U11
107	RES ARRAY 4.7K X9	RN1
108	TRANS SIG PNP 2N2907	Q1, Q2
109	RES 1K 1/4W 1 %	R14
110	RES 10K 1/4W 1%	R13, R20, R21, R4
111	RES 2K 1/4W 1 %	R3
115	RES 82.5K 1/4W 1	R15, R5
116	CAP MONO CER .1M/50/20%	C1-C4, C8-C10, C13, C18, C23, C27
117	CAP MONO CER .01/50/20%	C11, C21, C26
118	CAP 10M/50/10% TANTALUM	C15
119	CAP 22M/35/10% TANT AX	C12, C16, C22
120	CAP 2.2M/25/10% TANT AX	C6, C17, C7
121	CAP 3300P/50/10 DIP CER	C14
122	DC/DC CONV 24IN +5 +12 _12	U12
124	CONN MTA HDR 100 9P ST	J5
125	HDR MTA 156 STR 4P LK GOLD	J4
126	SWITCH ROT PC MT 2POL 3 POS	SW1
128	CAP MONO .022M/50/20%	C28
129	RES 150K 1/4W 1 %	R12
130	IC 74HCT02 QUAD 2IN NOR	U1
131	IC 74HCT393	U8
132	PROG PALSET SAFETY POWER	U2
134	IC SN75176A RS422 TRANCVR	U5, U6
142	SOCKET 7P RT ANG PNL MT	J2, J3
143	SHUNT 2PIN PCB .1 CENTER	J7
144	IC SOCKET 24 PIN .300 WIDE	
145	HDR 18P SINGLE ROW STR .100	
152	HDR 10P 4W LO-PROOF STR SDR	J6
153	RES 3.92K 1/4W 1%	R7, R9, R16, R17
154	RES 100 OHM 1/2W 5%	R10, R11
155	DIODE SIG IN4148	D1, D2, D3
156	RES 110K 1/4W 1%	R6, R8
157	FILTER PCB HI FREQ 39 1X.3	FB1, FB2, FB3
158	RES 240 OHM 1W 5%	R18, R19
159	CAP .1M/600/80/20%	C19, C24
160	CAP .001M/1000/10	C20, C25
161	RES 75 OHM 1/2W 5 %	R1, R2
163	CAP .047M/50/10	C29, C30
164	CONN MTA100 3P	J8
148	BOARD SHORT	

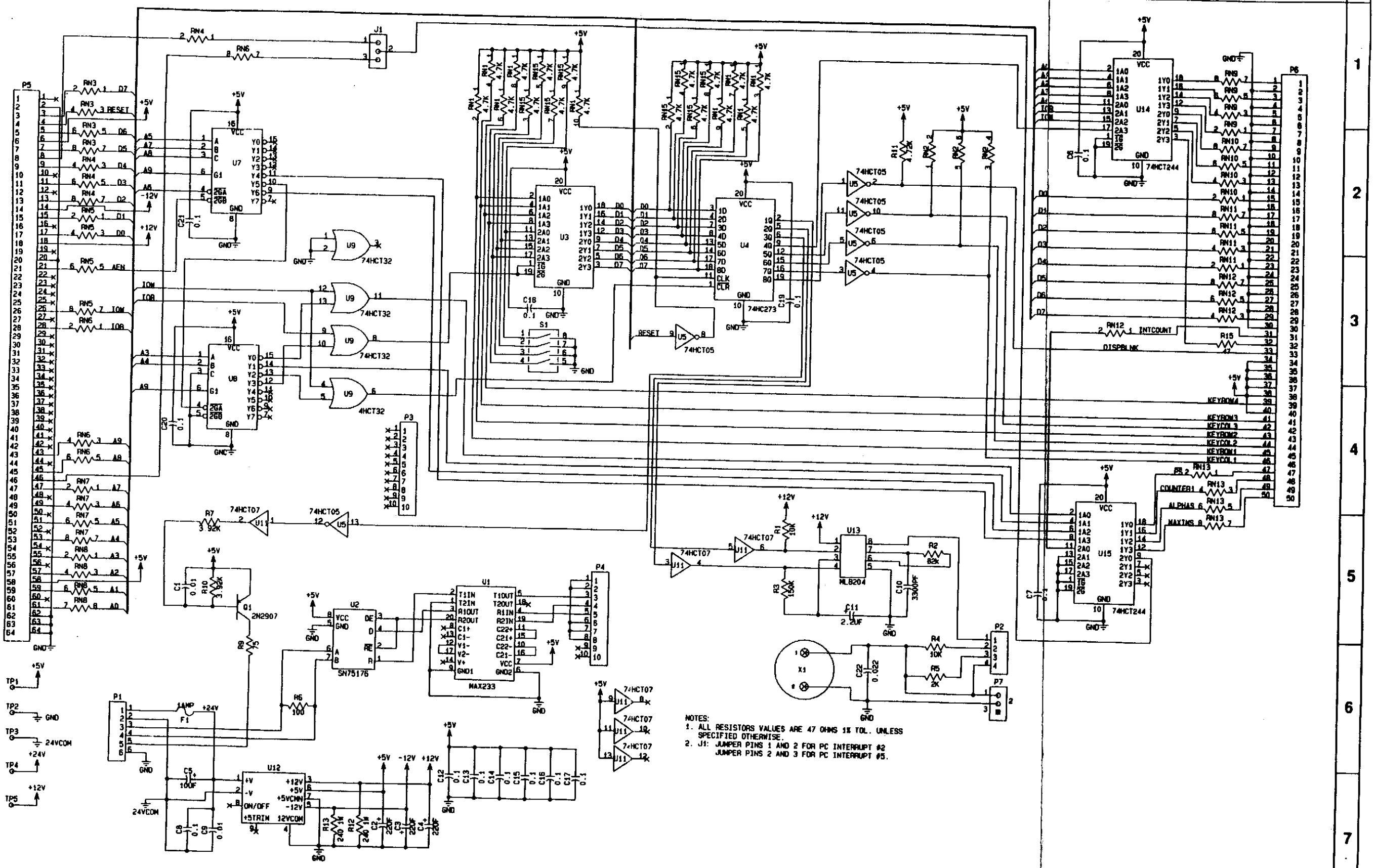

U8
HCT393
U2
PAL20RA10
U9
7406
U7
HCT04
U10
NE555N
U11
HC8204
SW1
R13 10k
R5 82.5k
R12 150k
R4 10K
R3 2K
C14 3300pf
C17 2.2m
C28 .022m
R14 1k
R15 82.5k
C6 2.2m
C11 .01m
U1A
U1B
U1C
U1D
HCT02
D1
R6 110k
R8 110k
C7 2.2m
AIR ON
AIR ALM
LEV ON
LEV ALRT
LEV ALRM
AUDIO
TX1
RX1
OL1
TX2
RX2
OL2
GND
ASTP_OUT
CSTP_OUT
RN1
4.7k
U5
75176
U6
U4
U3
R2 75-1/2W
R1 75-1/2W
R7 3.9k
R9 3.9k
C21 .01
R16 3.9k
C26 .01
R17 3.9k
Q1
Q2
R10 100-1/2W
R11 100-1/2W
C27
C23 C10 C4 C3 C2 C9 C13 C18 C8 C1
U12
DC-DC CONVERTER
C15 10n
C22 22n
C12 22n
C16 22n
R18 240 1w
R19 240 1w
C24 .1n 600v
C25 .001n 1kv
C19 .1n 600v
C20 .001n 1kv
CHASSIS
24V_COM
CARDIOPLEGIA

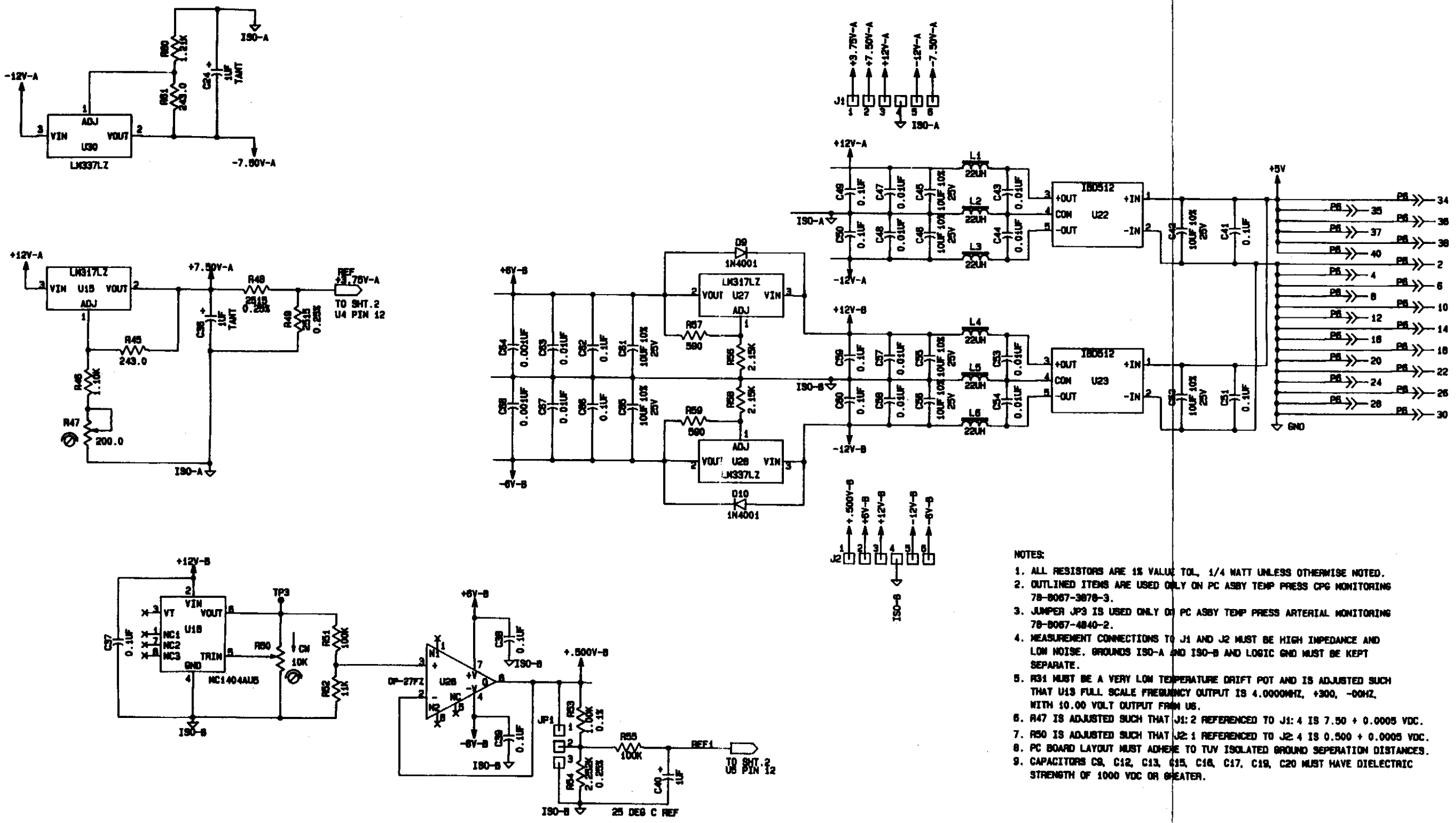


SEQ	DESCRIPTION	REF
2	IC DS75452N DUAL DRIVER	U3, U6, U7
3	RES ARRAY 150X10 BUSSED SIP	RP1, RP2, RP3, RP4
4	CAP 22M/35/10% TANT AX	C1
5	CAP MONO CER .1M/50/20%	C2, C3, C4, C5
6	LED GREEN HLMP-0504 RCT	D1, D4
7	LED YELLOW RECT HLMP0401	D3
8	LED RED RECT HLMP-0301	D2, D5
9	LED YELLOW LED BAR HLMP2450	D6, D7
10	LED RED LED BAR HLMP2350	D8, D9, D10, D11
12	CAP MONO CER .01/50/20%	C6
13	CAP 2.2M/25/10% TANT AX	C7
18	RES 82K 1/4W 5%	R1
19	RES 1K 1/4W 5%	R2
20	IC 74HCT11 +TRIP 3 AND GATE	U2
21	IC 74HCT08 QUAD 2IN + AND	U4
22	IC 74HCT32 QUAD 2IN + OR	U5
23	IC 74HCT04 HEX INVERT AND NAND	U1
24	IC MC1455P1 TIME CIRCT	U8


UNUSED GATES
VCC
RP4 150
RP3 150
RP1 150
RP2 150
U8
NE555
RESET
TRIGGER
THD
OUT
CONT
DISCHARG
R2 1K
R1 82K
C6 .01uF
C7 2.2uF
U1/A
U1/B
U1/C
U1/D
U1/E
74HCT04
U2/A
U2/B
U2/C
74HCT11
U4/A
U4/B
U4/C
74HCT08
U5/A
U5/B
U5/C
74HCT32
U6
U7
U3
INA1
INA2
INB1
INB2
OUTA
OUTB
GND
75452
D6
D7
D8
D9
D10
D11
HLMP-2450
LEVEL ALERT
LEVEL ALARM
BUBBLE ALARM
D4 GRN HLMP-0504
D5 RED HLMP-0301
D1 GRN HLMP-0504
D2 RED HLMP-0301
D3 YEL HLMP-0401
J2
J1
LD_ON_LED
LD_OFF_LED
LD_ALERT_LED
LD_PROBE_LED
LD_ALARM_LED
BD_ON_LED
BD_OFF_LED
BD_ALARM_LED
C1 22uF
C2 .1uF
C3 .1uF
C4 .1uF
C5 .1uF

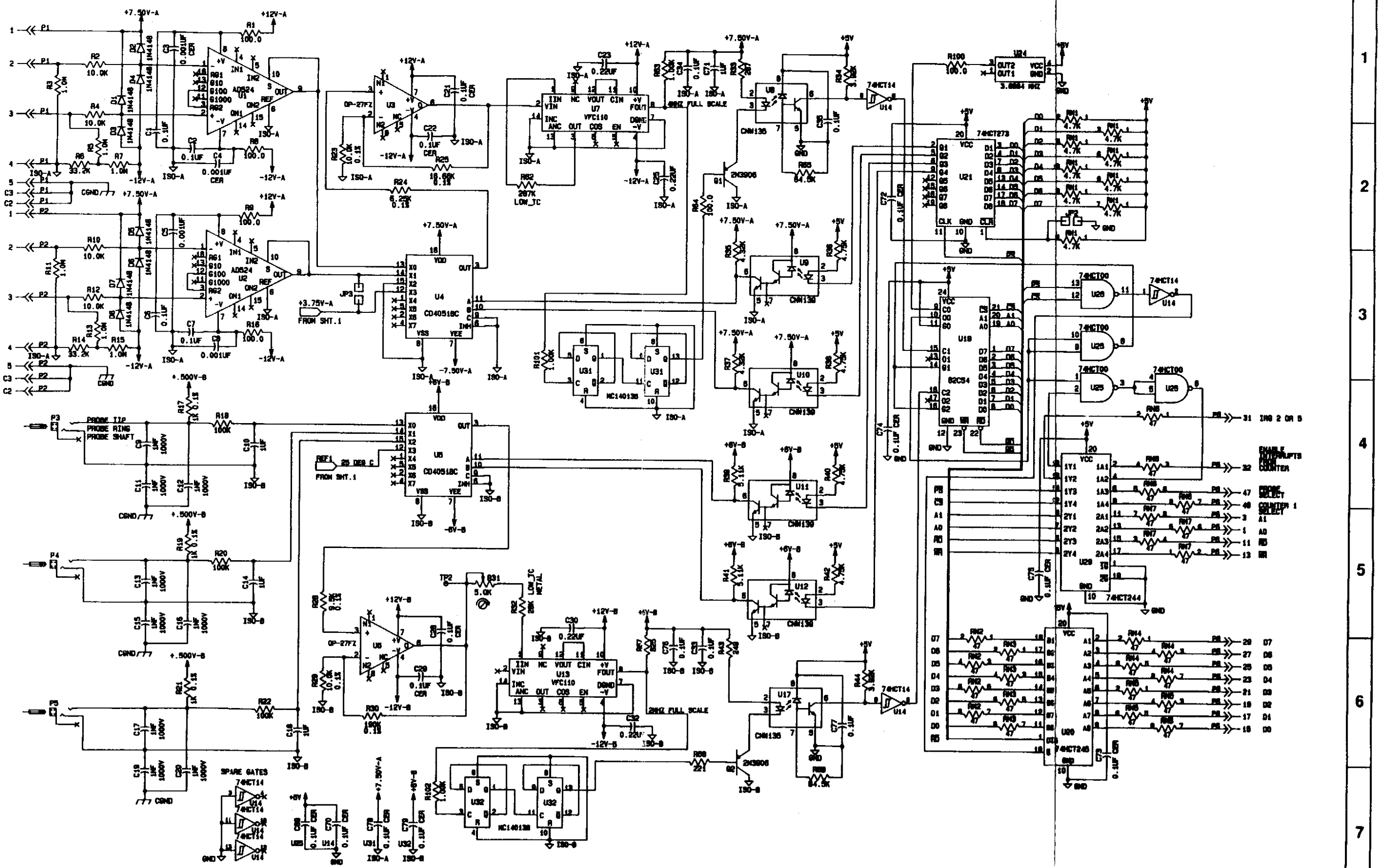
6.11 Monitor Power Interface Schematic

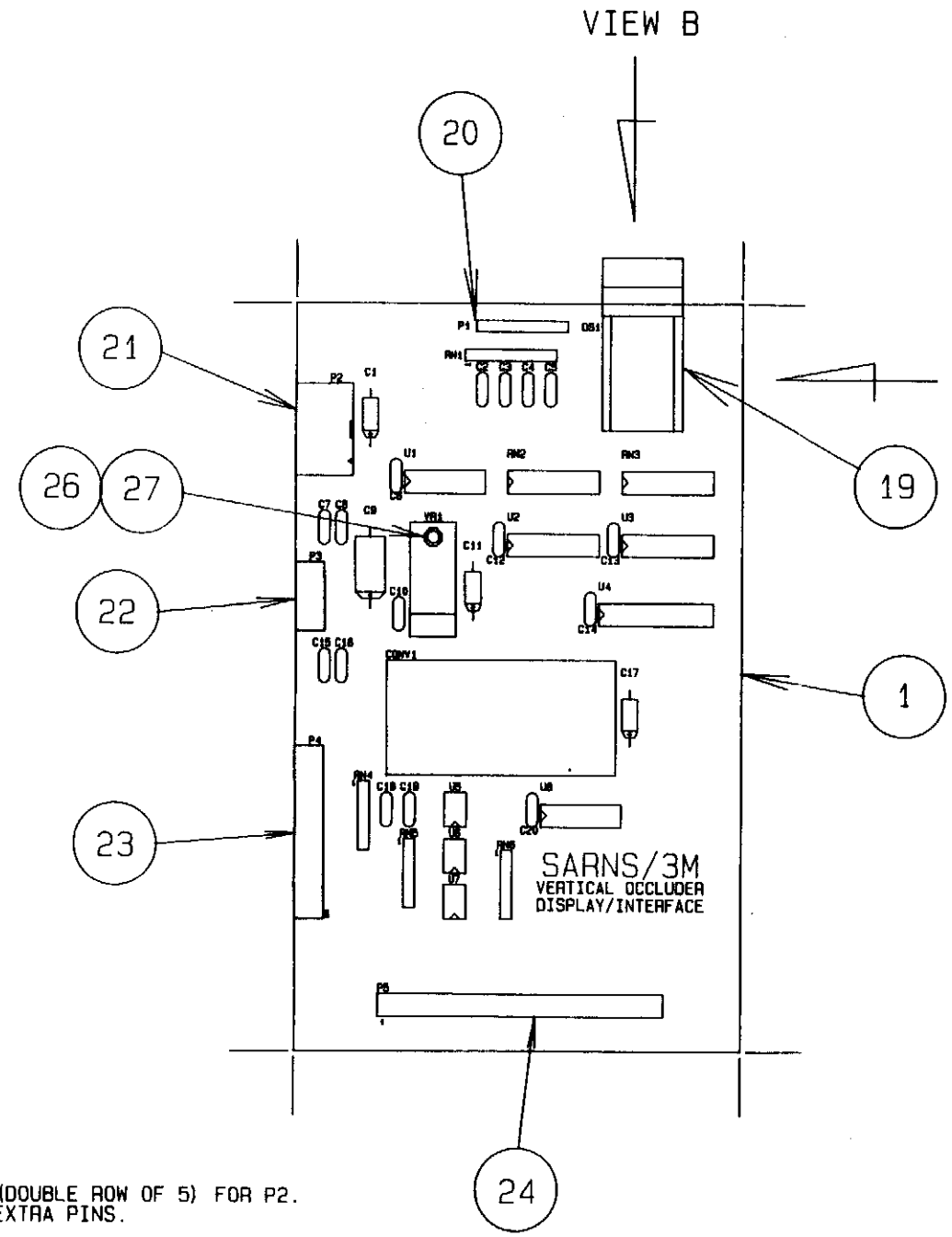




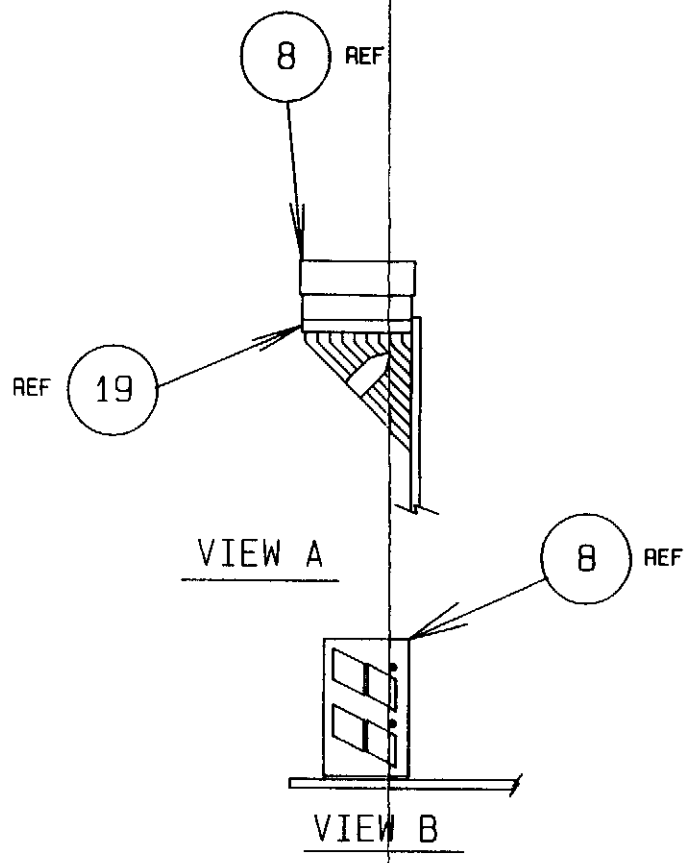
NOTES:

1. ALL RESISTORS ARE 1% VALUE TOL, 1/4 WATT UNLESS OTHERWISE NOTED.
2. OUTLINED ITEMS ARE USED ONLY ON PC ASSY TEMP PRESS CPG MONITORING 78-8067-3878-3.
3. JUMPER JP3 IS USED ONLY ON PC ASSY TEMP PRESS ARTERIAL MONITORING 78-8067-4840-2.
4. MEASUREMENT CONNECTIONS TO J1 AND J2 MUST BE HIGH IMPEDANCE AND LOW NOISE. GROUNDS ISO-A AND ISO-B AND LOGIC GND MUST BE KEPT SEPARATE.
5. R31 MUST BE A VERY LOW TEMPERATURE DRIFT POT AND IS ADJUSTED SUCH THAT U18 FULL SCALE FREQUENCY OUTPUT IS 4.0000MHZ, +300, -00HZ, WITH 10.00 VOLT OUTPUT FROM U6.
6. R47 IS ADJUSTED SUCH THAT J1:2 REFERENCED TO J1:4 IS 7.50 + 0.0005 VDC.
7. R50 IS ADJUSTED SUCH THAT J2:1 REFERENCED TO J2:4 IS 0.500 + 0.0005 VDC.
8. PC BOARD LAYOUT MUST ADHERE TO TUV ISOLATED GROUND SEPERATION DISTANCES.
9. CAPACITORS C9, C12, C13, C15, C16, C17, C19, C20 MUST HAVE DIELECTRIC STRENGTH OF 1000 VDC OR GREATER.

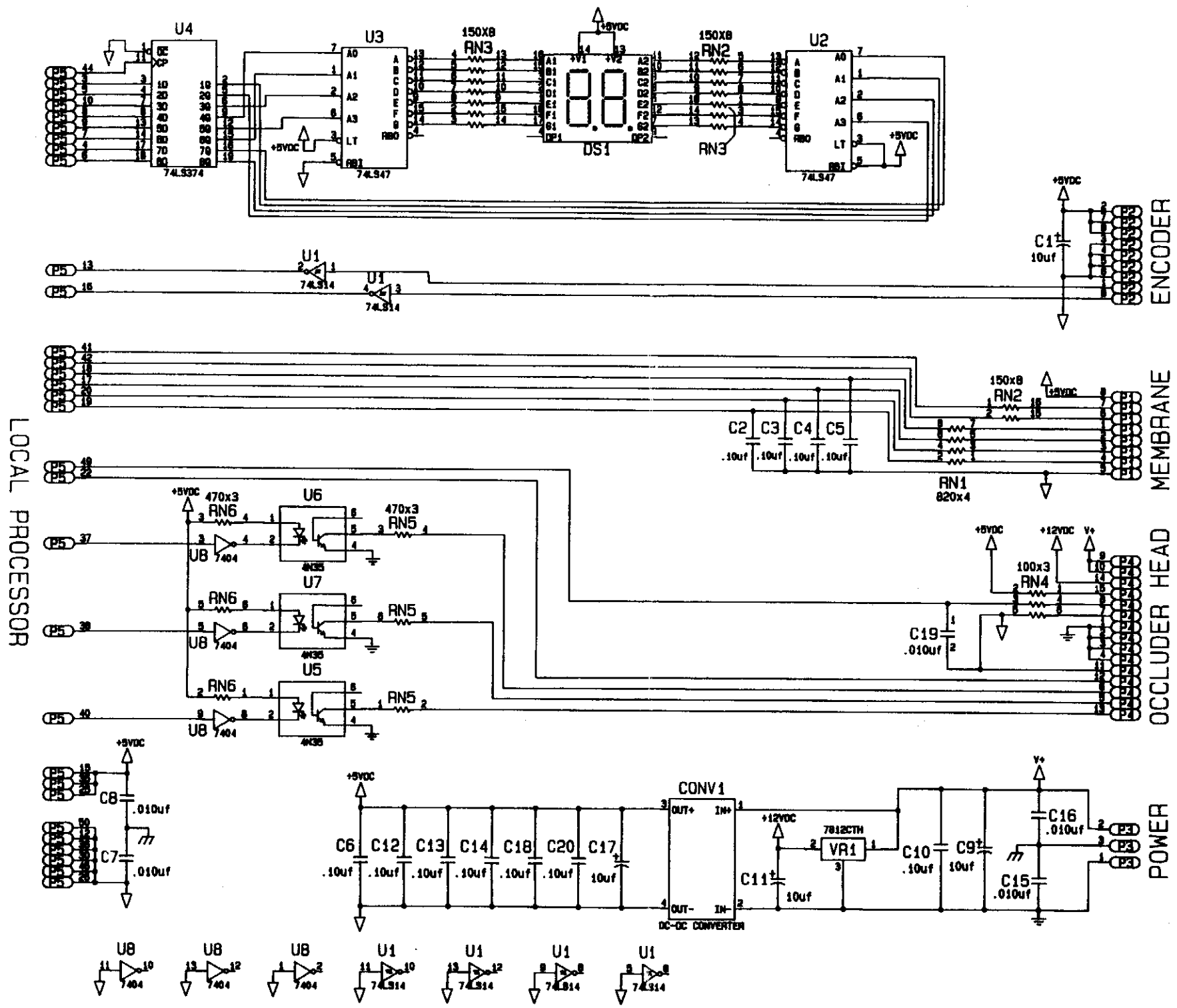

+7.50V-A
+12V-A
+5V
-12V-A
ISO-A
CGND
+.500V-B
ISO-B
-6V-B
+5V-B
+3.75V-A
FROM SHT.1
PROBE TIP
PROBE RING
PROBE SHAFT
SPARE GATES
74HCT14
74HCT00
74HCT273
74HCT244
82C54
CD4051BC
AD624
OP-27FZ
VPC110
HC140138
CNW135
CNW136
CNW139
2N3906
LOW_TC
LOW_TC METAL
28Hz FULL SCALE
ENABLE INTERRUPTS
PROBE SELECT
COUNTER 1 SELECT
ING 2 OR 5

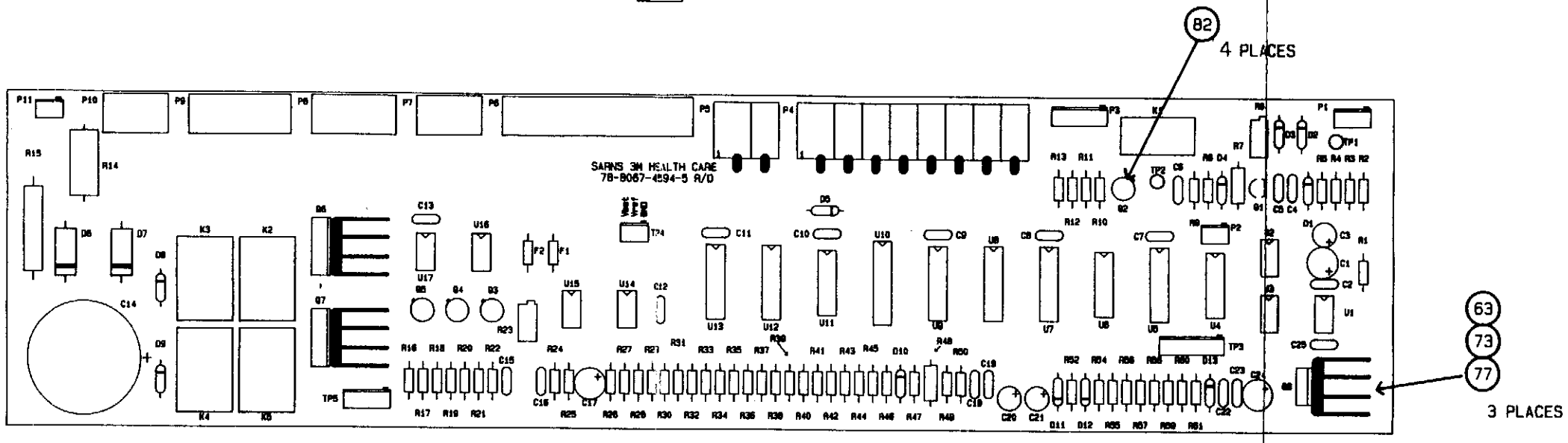


NOTE: USE 10 PINS (DOUBLE ROW OF 5) FOR P2.
DISCARD ANY EXTRA PINS.



SEQ	DESCRIPTION	REF
2	IC 9016 HEX INVERTER 7404	U8
3	IC 74LS374 OCTAL D FLIPFLOP	U4
4	IC 4N35 PHOTO TRANSISTOR	U5, U6, U7
5	IC MC7812 3T+ VOLT REGULATOR	VR1
6	IC 74LS47 BCD-7SEG DEC/DVR	U2, U3
7	IC 74LS14 HEX SCHMT TR	U1
8	LED 7 SEG GREEN HDSP5601	DS1
9	DC/DC CONV 18-36V IN/5V 2A	CONV1
10	RES ARRAY 820X4 ISOL SIP	RN1
11	RES ARRAY 150 OHMX8	RN2, RN3
12	RES ARRAY 100X3 ISOL SIP	RN4
13	RES ARRAY 470X3 ISOL SIP	RN5, RN6
15	CAP 10M/25/10% TANT AX	C1, C11, C17
16	CAP MOMO CER .1M/50/20%	C2-C6, C10, C12, C13, C14 C18, C20
17	CAP MONO CER .01/50/10%	C7, C8, C15, C16, C19
18	CAP 10M/50/10% TANT	C9


U4
74LS374
U3
74LS47
150X8
RN3
+5VDC
DS1
150X8
RN2
U2
74LS47
RN3
+5VDC
U1
74LS14
U1
74LS14
C1
10uf
ENCODER
MEMBRANE
C2
C3
C4
C5
.10uf
150x8
RN2
RN1
820x4
LOCAL PROCESSOR
470x3
RN6
U6
4N35
470x3
RN5
U8
7404
U7
4N35
U5
4N35
+5VDC
+12VDC
V+
100x3
RN4
C19
.010uf
OCCLUDER HEAD
C8
.010uf
C7
.010uf
CONV1
DC-DC CONVERTER
C6
C12
C13
C14
C18
C20
C17
10uf
7812CTH
VR1
C11
10uf
C10
.10uf
C9
10uf
C16
.010uf
C15
.010uf
POWER
U8
U8
U8
U1
U1
U1
U1
74LS14
GROUND SYMBOLS:
CHASSIS (CGND)
DIGITAL (DGND)
ANALOG (AGND)

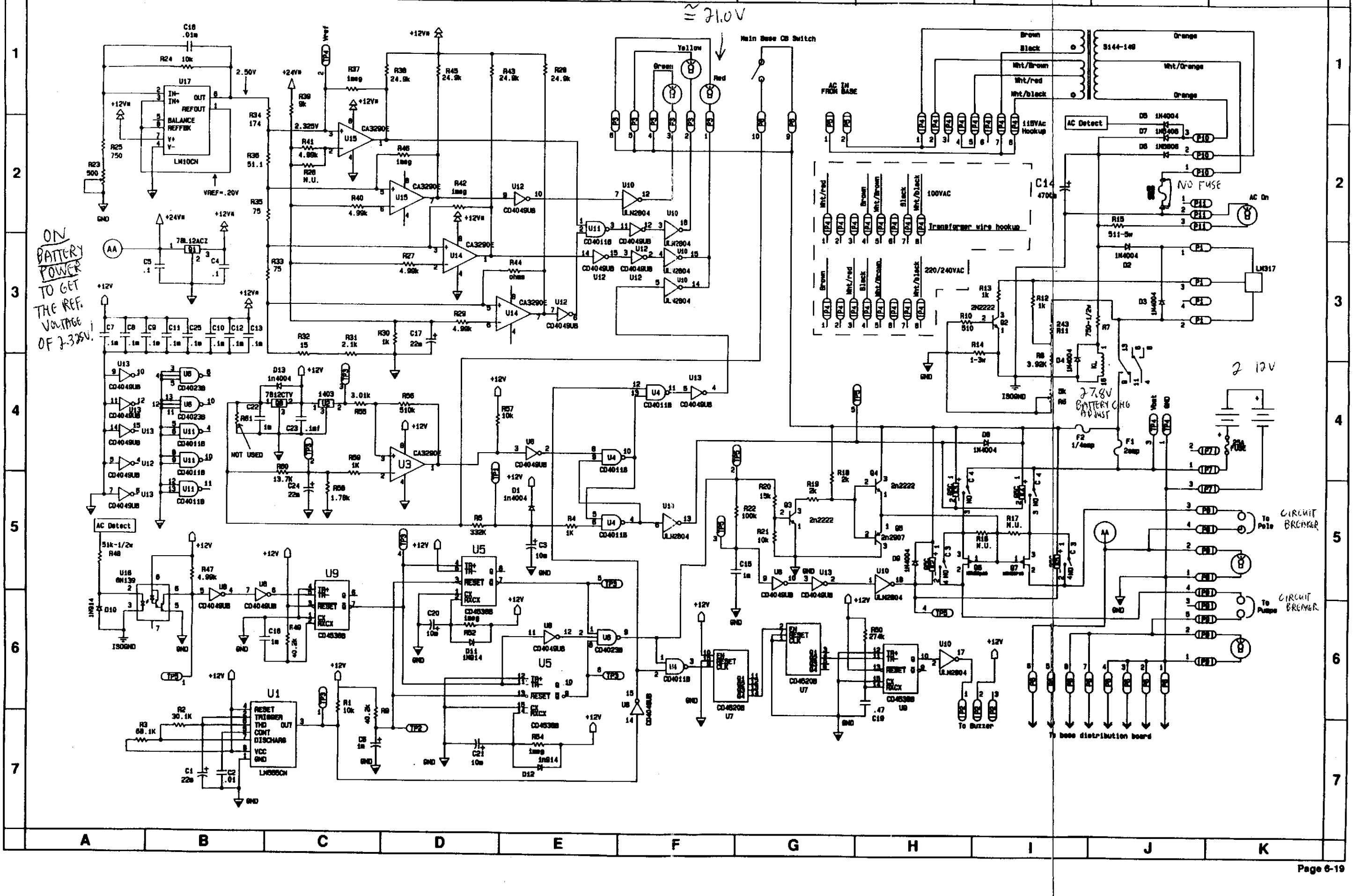


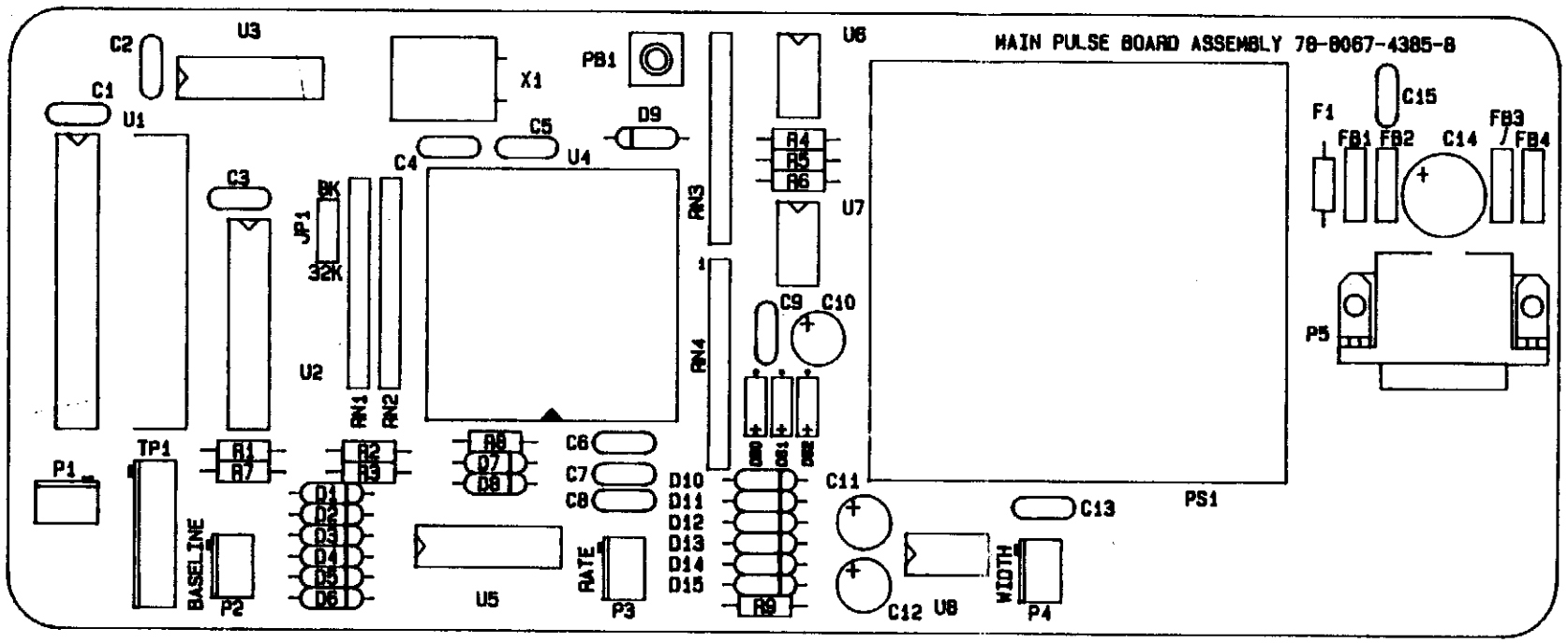
Seq.	Description	Ref. Des.
2	1455	U1
3	IC 1403	U2
4	IC CA3290	U3, U14, U15
5	IC 14011	U4, U11
6	IC 14538	U5, U9
7	IC 14023	U6
8	IC 14520	U7
9	IC 14049	U8,U12, U13
10	IC ULN2804	U10
11	IC LM10	U17
12	IC 6N139	U16
13	IC 78L12	Q1
14	IC 7812	Q8
15	TRANSISTOR 2N2222	Q2, Q3, Q4
16	TRANSISTOR 2N2907	Q5
17	MOSFET MTH20P10	Q6, Q7
18	DIODE 1N4004	D1, D2, D3, D4, D5, D8, D9, D13
19	DIODE 1N5406	D6, D7
20	DIODE 1N914	D10, D11, D12
21	RES 15 1/4W	R32
22	RES 51.1 1/4W	R36
23	RES 75 1/4W	R33, R35
24	RES 174 1/4W	R34
25	RES 243 1/4W	R11
26	RES 510 1/4W	R10
27	RES 750 1/4W	R25
28	RES 1K 1/4W	R4, R12, R13, R30, R59
29	RES 1.78K 1/4W	R58
30	RES 2K 1/4W	R18, R19
31	RES 2.1K 1/4W	R31
32	RES 3.01K 1/4W	R55
33	RES 3.92K 1/4W	R8
34	RES 4.99K 1/4W	R27, R29, R40, R41, R47
35	RES 9.09K 1/4W	R39
36	RES 10K 1/4W	R1, R21, R24, R57
37	RES 13.7K 1/4W	R60
38	RES 15K 1/4W	R20

Seq.	Description	Ref. Des.
39	RES 24.9K 1/4W	R28, R38, R43, R45
40	RES 30.1K 1/4W	R2
41	RES 40.2K 1/4W	R9, R49
42	RES 68.1K 1/4W	R3
43	RES 100K 1/4K	R22
44	RES 274K 1/4W	R50
45	RES 332K 1/4W	R5
46	RES 510K 1/4W 5%	R56
47	RES 1 MEG 1/4W	R37, R42, R44, R46, R52, R54
49	RES 511 5W	R15
50	RES 1.0 1W	R14
51	RES 750 1/2W 5%	R7
52	RES 51K 1/2W 5%	R48
53	POT 5K .5W	R6
54	POT 500 .5W	R23
55	CAP MONO .01	C2, C16
56	CAP MONO .1	C4, C5, C7, C8, C9, C10, C11, C12, , C23
57	CAP MONO .47	C19
58	CAP MONO 1	C6, C15, C18, C22
59	CAP 10M 35V	C3, C20, C21
60	CAP 22M 35V	C1, C17, C24
61	CAP 4700M 63V	C14
62	RELAY OMRON G5CE-1	K2, K3, K4, K5
64	FUSE 2 AMP	F1
65	FUSE 1/4 AMP	F2
66	CONN WAGO MCS-4	P8
67	CONN WAGO MCS-5	P9
68	CONN MTA 100 3P	P2, P11, TP4
69	CONN MTA 100 4P	P1
70	CONN MTA 100 6P	P3
71	CONN WAGO MCS-3	P7, P10
72	CONN WAGO MCS-10	P6
74	RELAY AROMAT ST1EDC24	K1
75	TERM BLOCK 8 POS.	P4
76	TERM BLOCK 2 POS.	P5
78	CONN MTA 100 5P	TP1

Seq.	Description	Ref. Des.
78	CONN MTA 100 5P	TP5
80	CONN MTA 100 7P	TP3
81	TEST POINT	TP1, TP2

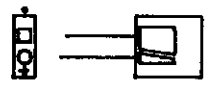
R16, R17 AND R61 ARE NOT USED


≈ 21.0V
Main Base CB Switch
Yellow
Green
Red
AC IN FROM BASE
Brown
Black
Wht/Brown
Wht/red
Wht/black
S144-148
Orange
Wht/Orange
115VAc Hookup
AC Detect
100VAC
220/240VAC
Transformer wire hookup
NO FUSE
AC On
LM317
ON BATTERY POWER TO GET THE REF. VOLTAGE OF 2.325V.
2.50V
2.325V
VREF=.20V
LM10CN
CA3290E
CD4049UB
CD40118
ULN2804
CD4023B
CD4538B
CD4520B
LM555CN
7812CTV
7812ACZ
27.8V BATTERY CHG ADJUST
2 12V
To Pole
To Pulse
To Buzzer
To base distribution board
CIRCUIT BREAKER
CIRCUIT BREAKER
NOT USED
ISOGND
GND

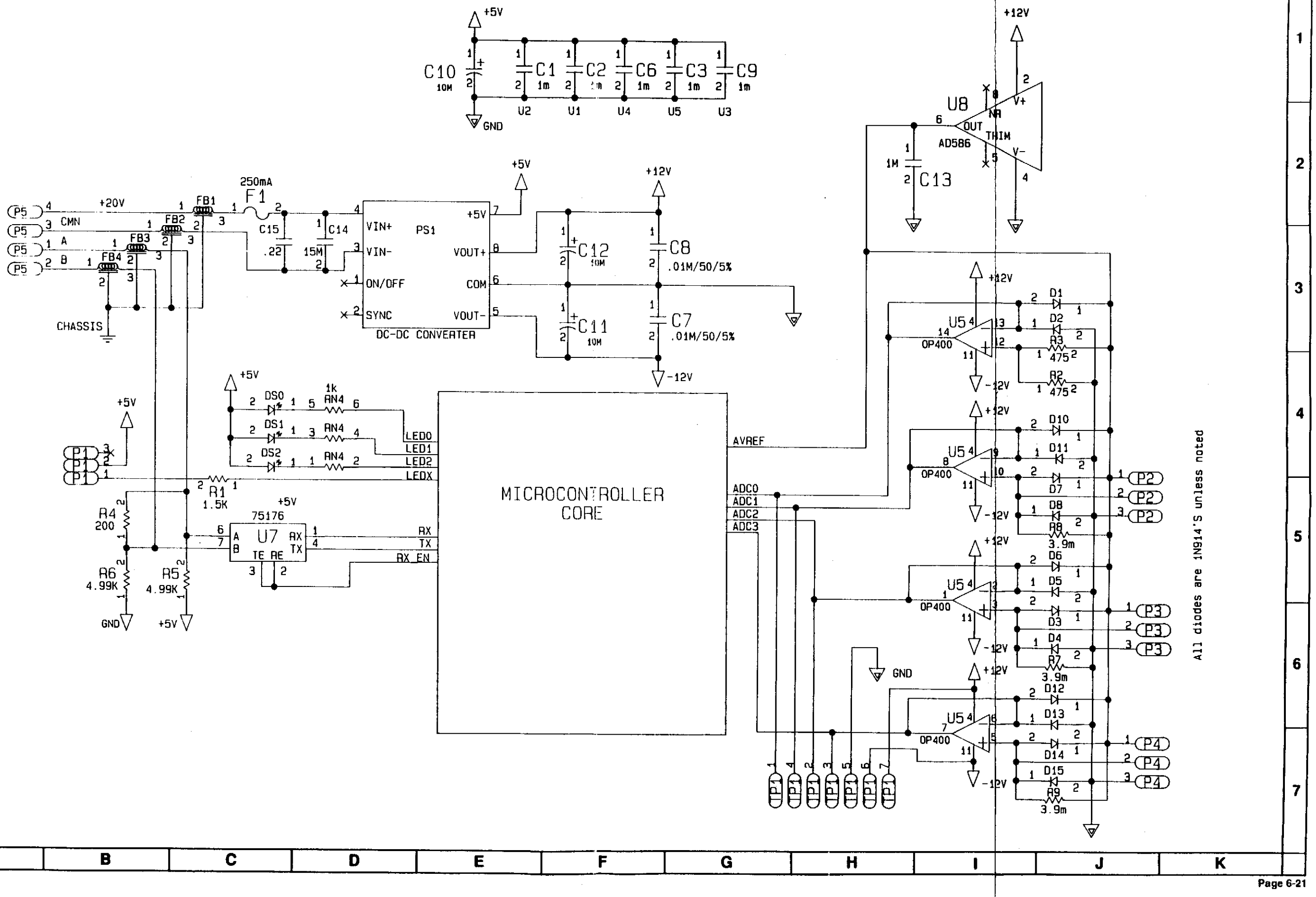


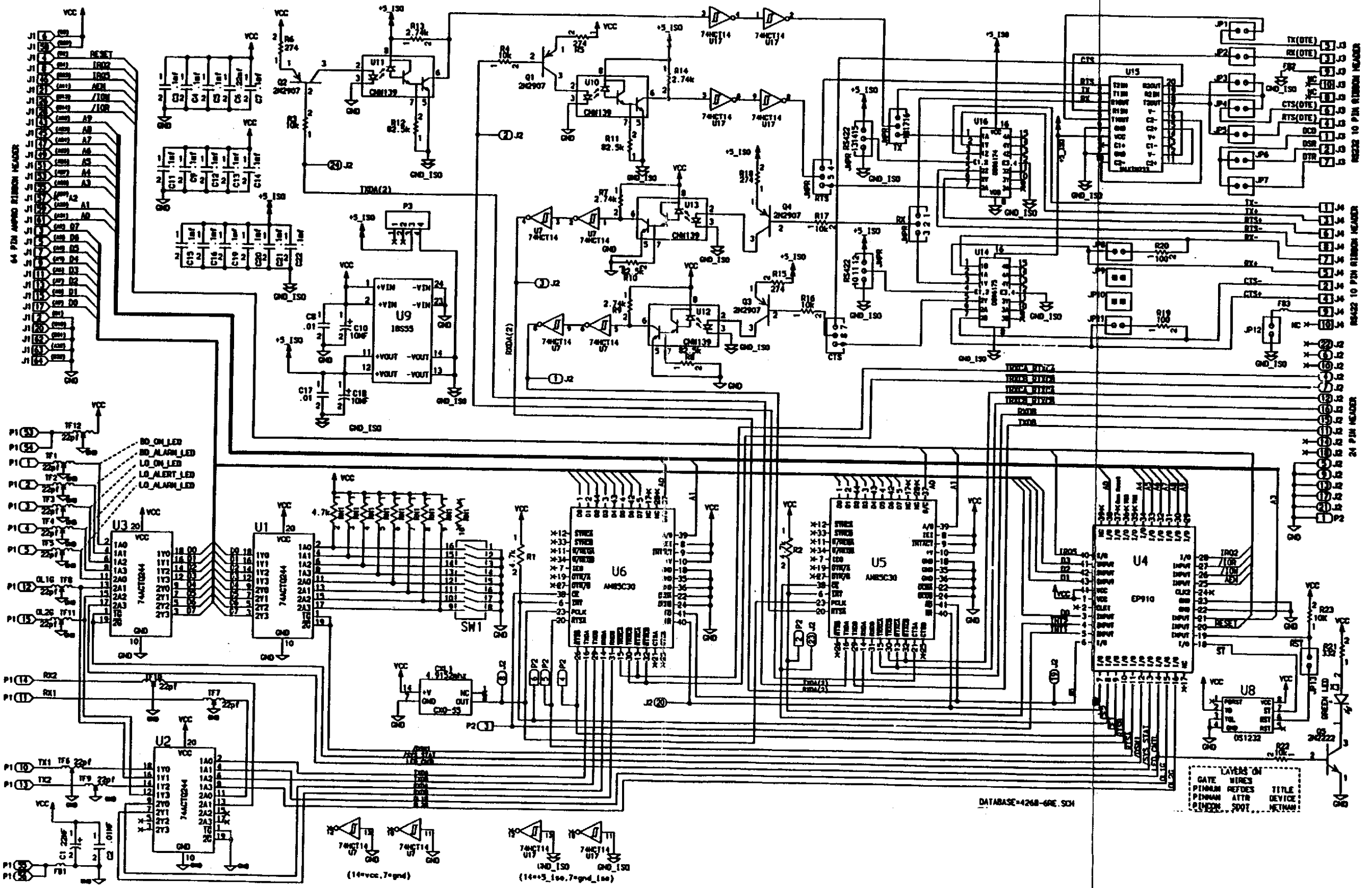
Note: PB1 (Seq 31) orientation not critical

Installation of DS0, DS1 and DS2
Cathode is the short lead
Short lead towards dot



SEQ	REF
2	PS1
3	U4
4	U3
5	U2
6	U1
7	U5
8	U7
9	X1
10	U8
11	U6
13	D1 - D15
14	DS0
15	DS1
16	DS2
17	R2, R3
18	RN1-RN3
19	C10-C12
20	FB1 - FB4
21	C4, C5
22	C1-C3, C6, C9, C13
23	C7, C8
24	C14
27	F1
28	R4
29	R5, R6
31	PB1
32	P5
33	P1-P4
34	R7, R8, R9
35	R1
36	JP1, TP1
39	RN4
40	C15


+5V
C10
10M
C1
1m
C2
1m
C6
1m
C3
1m
C9
1m
U2
U1
U4
U5
U3
GND
+12V
U8
NA
V+
OUT
AD586
TRIM
V-
1M
C13
P5
+20V
CMN
A
B
FB1
FB2
FB3
FB4
250mA
F1
C15
.22
C14
15M
CHASSIS
VIN+
VIN-
ON/OFF
SYNC
PS1
+5V
VOUT+
COM
VOUT-
DC-DC CONVERTER
C12
10M
C11
10M
C8
.01M/50/5%
C7
.01M/50/5%
-12V
+12V
D1
D2
R3
475
R2
475
U5
OP400
D10
D11
D7
D8
R8
3.9m
D6
D5
D3
D4
R7
3.9m
D12
D13
D14
D15
R9
3.9m
P2
P3
P4
GND
All diodes are 1N914'S unless noted
DS0
DS1
DS2
1k
RN4
LED0
LED1
LED2
LEDX
R1
1.5K
R4
200
R6
4.99K
R5
4.99K
75176
U7
TE
RE
RX
TX
RX_EN
MICROCONTROLLER
CORE
AVREF
ADC0
ADC1
ADC2
ADC3
TP1


64 PIN AMMO RIBBON HEADER
RESET
IRQ2
IRQ5
AEN
/IOR
/IOW
A9
A8
A7
A6
A5
A4
A3
A2
A1
A0
D7
D6
D5
D4
D3
D2
D1
D0
U9
1855S
+VIN
-VIN
+VOUT
-VOUT
U3
74ACT244
U1
74ACT244
U2
74ACT244
U6
AM85C30
U5
AM85C30
U4
EP910
U8
051232
SW1
U15
U16
U14
RS232 10 PIN RIBBON HEADER
RS422 10 PIN RIBBON HEADER
24 PIN HEADER
TX(DTE)
RX(DTE)
CTS(DTE)
RTS(DTE)
DCD
DSR
DTR
BD_ON_LED
BD_ALARM_LED
LO_ON_LED
LO_ALERT_LED
LO_ALARM_LED
GREEN LED
LAYERS ON
GATE WIRES
PINNUM REFDES TITLE
PINNAM ATTR DEVICE
PINDEN SODT NETNAM
DATABASE=4268-6RE.SCH
Page 6-22

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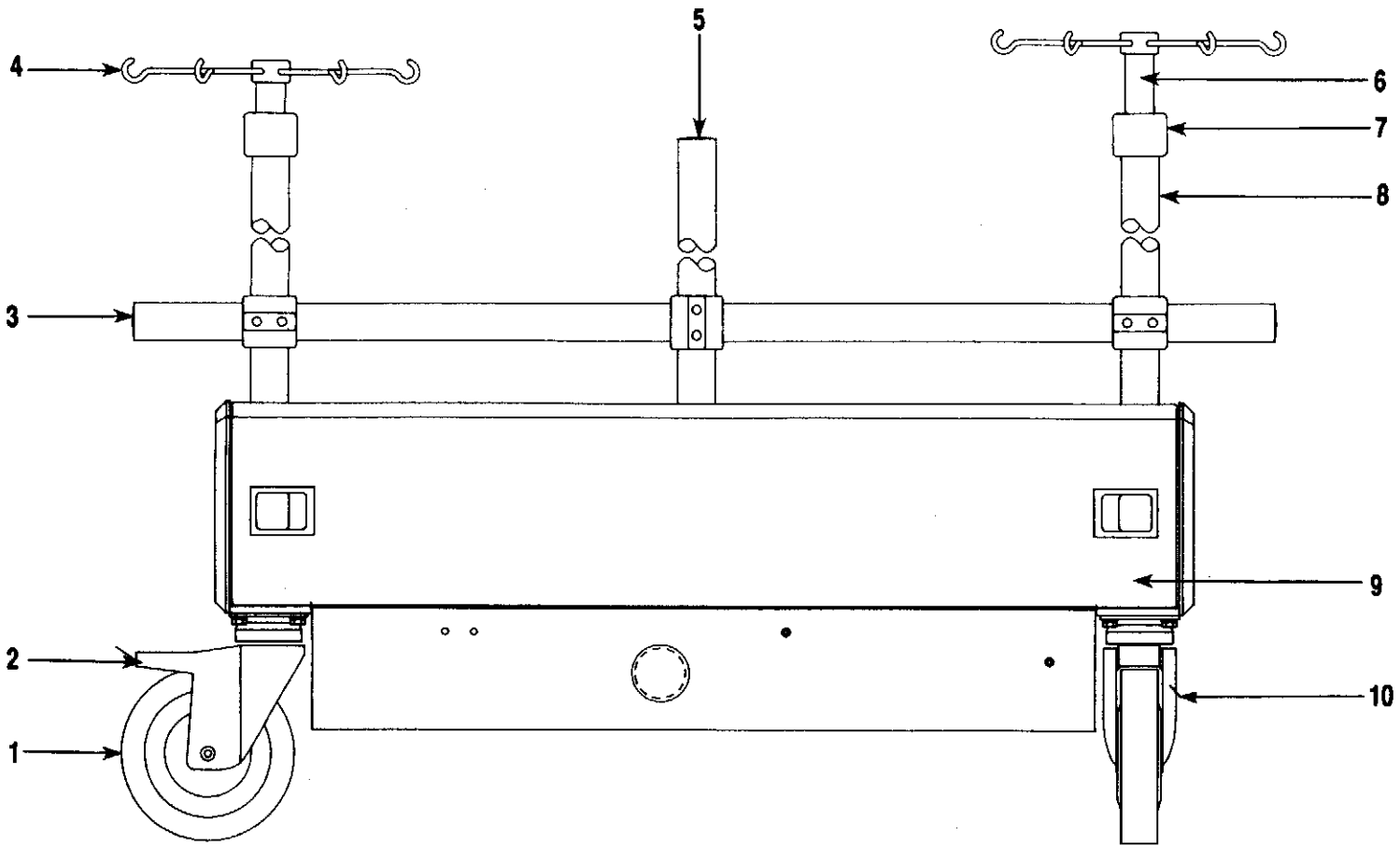
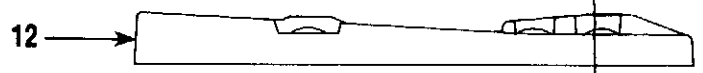
Section 7. Illustrated Parts Breakdown


4
5
6
7
8
3
9
2
10
1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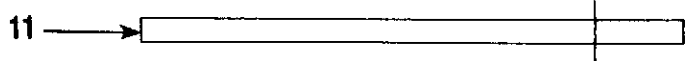
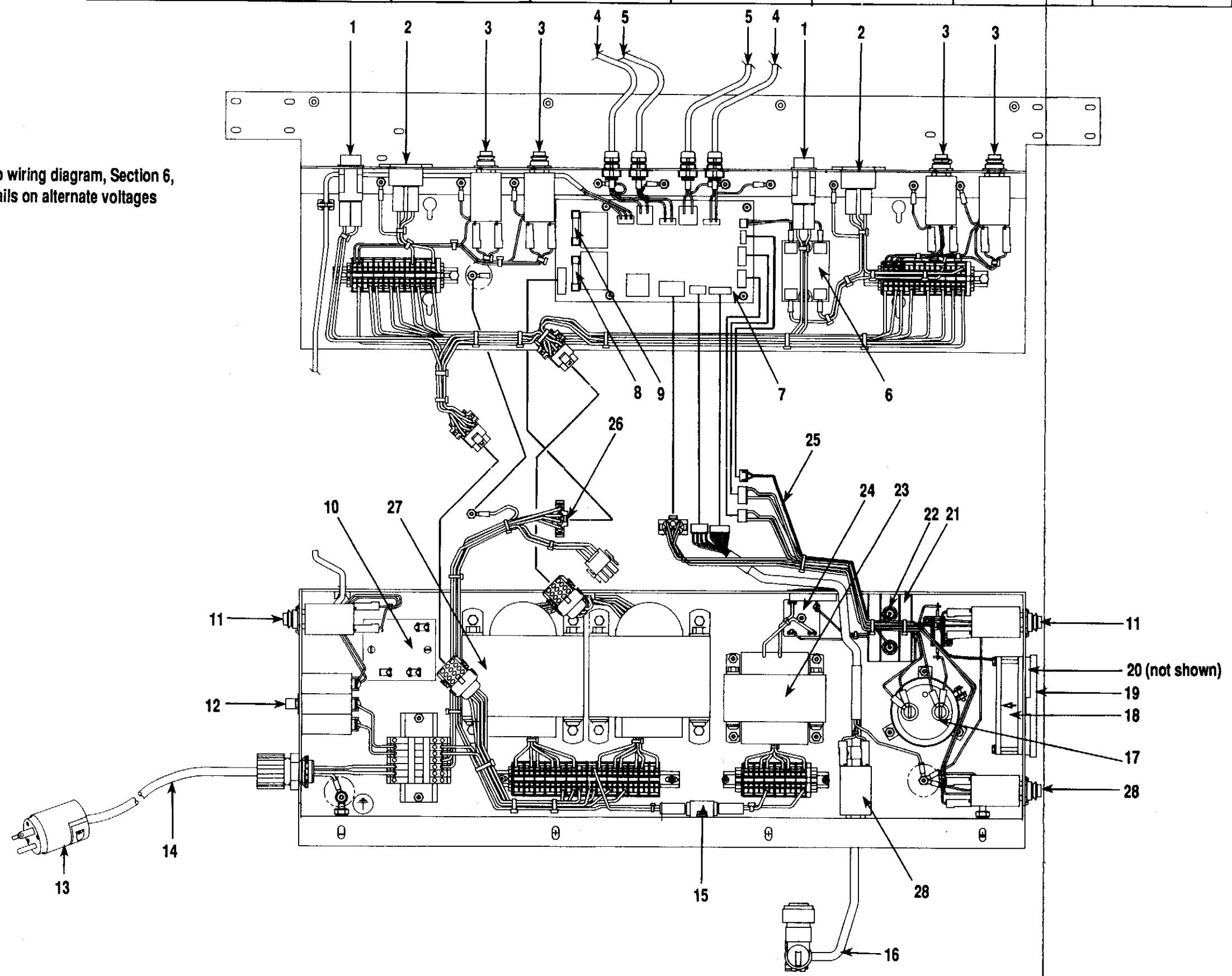

11

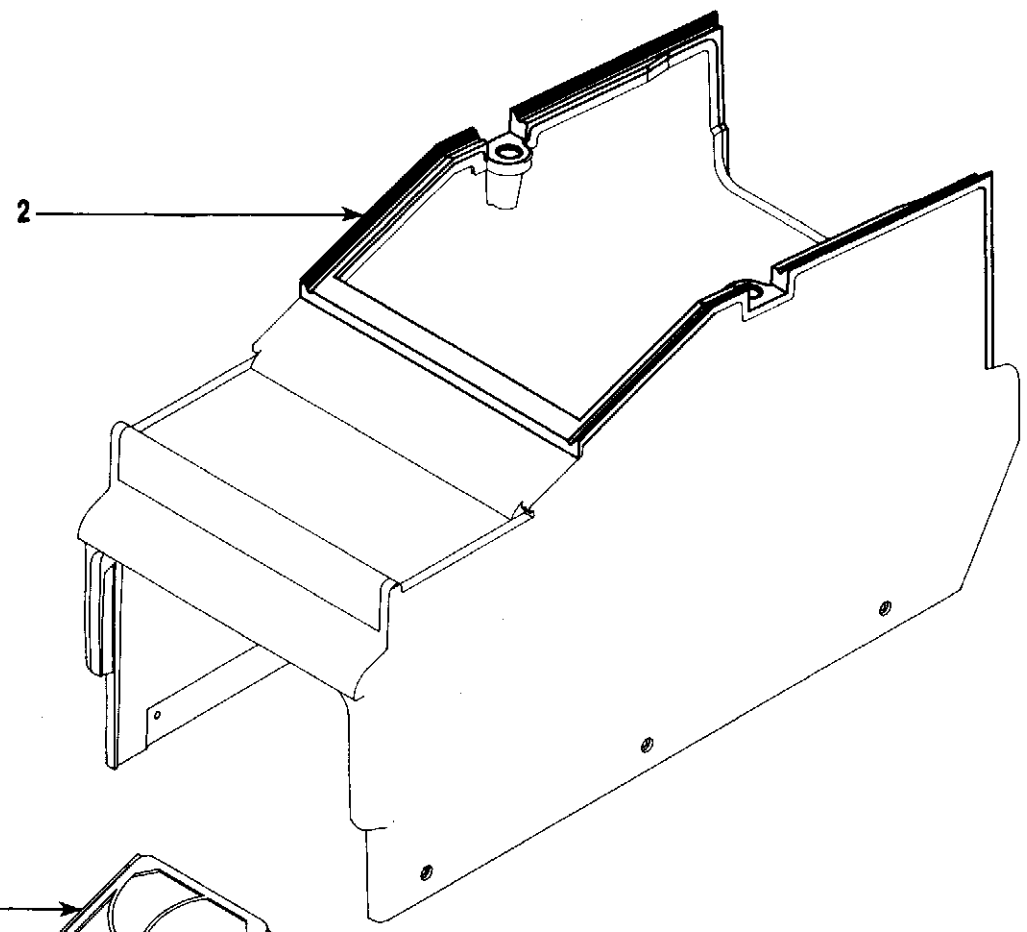
13
14
15
17
16 (not shown)

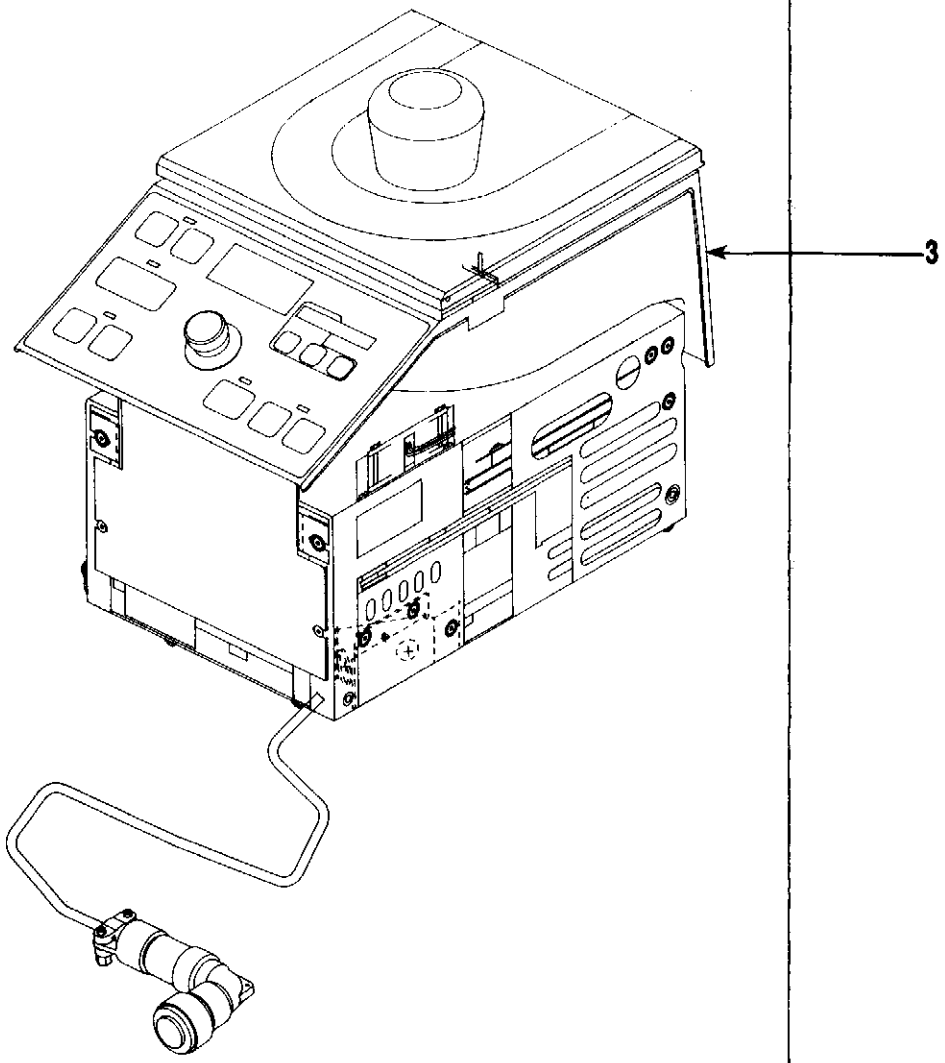
Item No.	3M ID	Description	Qty.
1	26-1008-9139-4	Wheel, 6 inch diameter	4
2	26-1008-6651-1	Caster, Locking, Left	2
3	78-8067-4178-7	Crossbar, 4 Unit	1
	78-8067-4179-5	Crossbar, 5 Unit	1
4	78-8066-7511-8	Solution Bag Rack	2
5	98-0702-0331-4	Pole, 2 ft.	1
6	78-8066-7471-5	Inner Pole	2
7	78-8072-1446-1	Collar	2
8	78-8066-9897-9	Outer Pole	2
9	78-8067-4458-3	Door, 4 Unit	1
	78-8067-4459-1	Door, 5 Unit	1
10	26-1008-6650-3	Caster, Right	2
11	78-8067-4118-3	Metal Cover, 4 Unit	1
	78-8067-4567-1	Metal Cover, 5 Unit	1
12	78-8067-4491-4	Plastic Cover, 4 Unit	1
	78-8067-4499-7	Plastic Cover, 5 Unit	1
13	78-8067-3557-3	Blood Rack Arm	4
14	26-1006-9191-9	Handle, Threaded	2
15	78-8067-4492-2	Crossbar Fitting	3
16	26-1009-6638-6	Occluder Outlet	1
17	26-1009-6639-4	Lamp Outlet	2

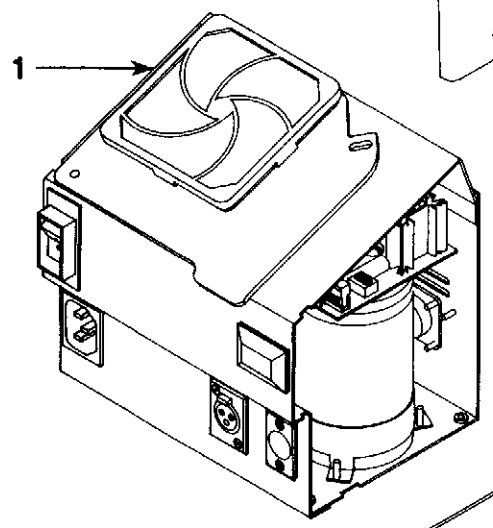
Note: Refer to wiring diagram, Section 6, for wiring details on alternate voltages

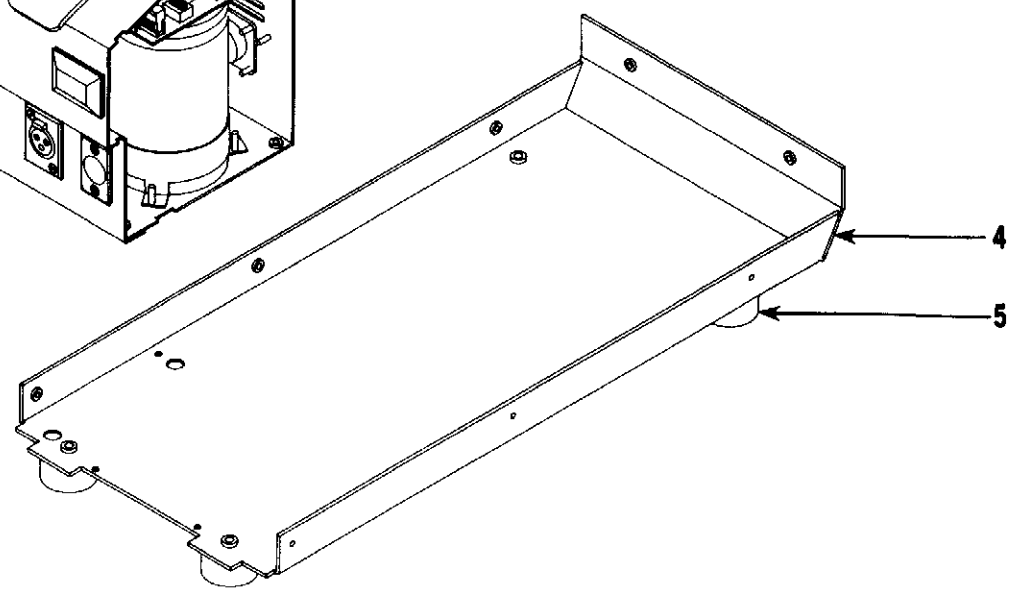


Item No.	3M ID	Description	Qty.
1	26-1009-3531-6	Outlet Circuit Breaker - 4A 100/115 V Units	2
	26-1009-3532-4	Outlet Circuit Breaker - 2A, 220-240 V Units	2
2	26-1007-3845-4	Accessory Power Outlet	2
3	26-1009-3544-9	Circuit Breaker, 3A, Resettable, 100/115 V Units	4
	26-1009-3543-1	Circuit Breaker 1.5A Resettable, 220-240 V Units	4
4	78-8067-4528-3	ART/CPG Cable Assembly	1
5	78-8067-4931-9	Pump/UPS Cable Assembly	2
6	26-1008-1696-1	Solid State Relay, 280VAC 25A	1
7	78-8067-4199-3	Base Distribution Board	1
8	26-1006-7245-5	Fuse, 2A, Slo Blo, 100/115 V Units	1
	26-1009-6695-6	Fuse, 1.2A, 250V, Slo Blo , 220-240 V Units	1
9	12-7997-7648-4	Fuse, 0.4A, 250V, Slo Blo, 100-115 V Units	1
	12-7997-7645-0	Fuse, 0.2A, 250V, Slo Blo, 220-240 V Units	1
10	26-1008-1052-7	Current Limiter, 220-240 V Units	1
11	26-1009-3542-3	Circuit Breaker, 1.0A, Resettable	2
12	26-1007-5624-1	Circuit Breaker, 16A, 100/115 V Units	1
	26-1007-5622-5	Circuit Breaker, 8A/IEL Series, 220-240 V Units	1
13	26-1008-4360-1	Hubbell Connector, 100/115 V Units	1
	26-1006-9314-7	European Wall Plug, 220-240 V Units	1
14	26-1006-7134-1	Power Cord, 100/115 V Units	1
	26-1007-5507-8	Power Cord, 220-240 V Units	
15	26-1010-0856-8	EMI Line Filter, 6A 120V 250V	1
16	78-8067-4494-8	Power/Comm Cable Assembly	1
17	26-1008-2314-0	Capacitor, 27000M/50/75 10%	1
18	26-1010-0770-1	Fan	1
19	26-1010-1890-6	Filter Guard	1
20	26-1010-1889-8	Filter	1
21	78-8067-4244-7	Heat Sink	1
22	26-1009-6563-6	Schottke Diode	2
23	26-1009-3606-6	Transformer, 24VDC @ 5A	1
24	26-1008-0720-0	Bridge Rectifier, 35A 200V	1
25	78-8067-4465-8	Cable Assembly, Base DC	1
26	78-8067-4464-1	Cable Assembly, Base AC	1
27	26-1009-6522-2	Isolation Transformer	2
28	26-1009-3544-9	Circuit Breaker, 3A, Resettable	2

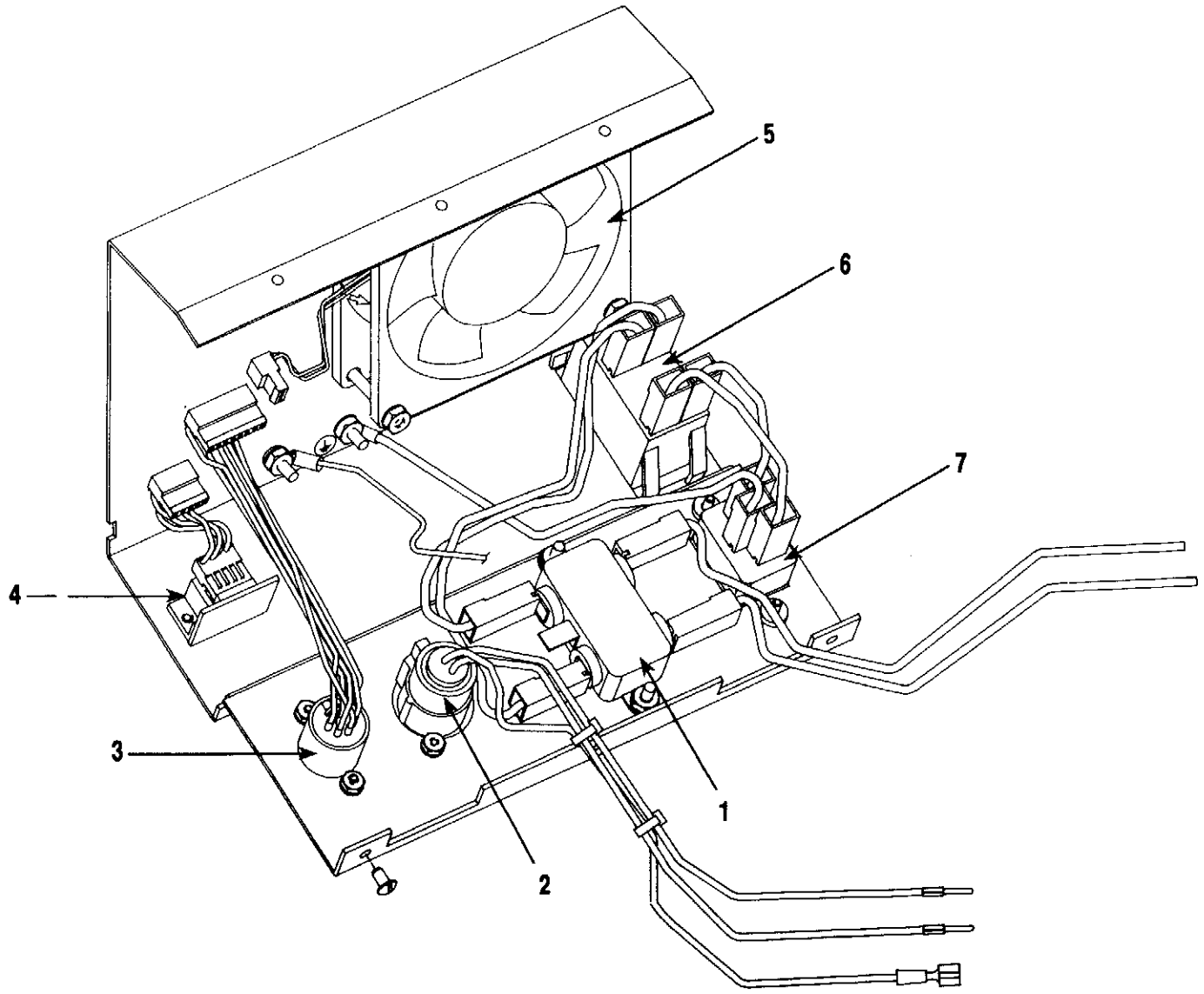








Item No.	3M ID	Description	Qty.
1	78-8067-4467-4	Power Supply Assembly, 100V/115V	1
	78-8067-5234-7	Power Supply Assembly, 220-240V	1
2	78-8067-5463-2	Housing	1
3	98-0702-0241-5	Universal Roller Pump	1
4	78-8067-3930-2	Bottom Cover	1
5	26-1009-6628-7	Bumper	4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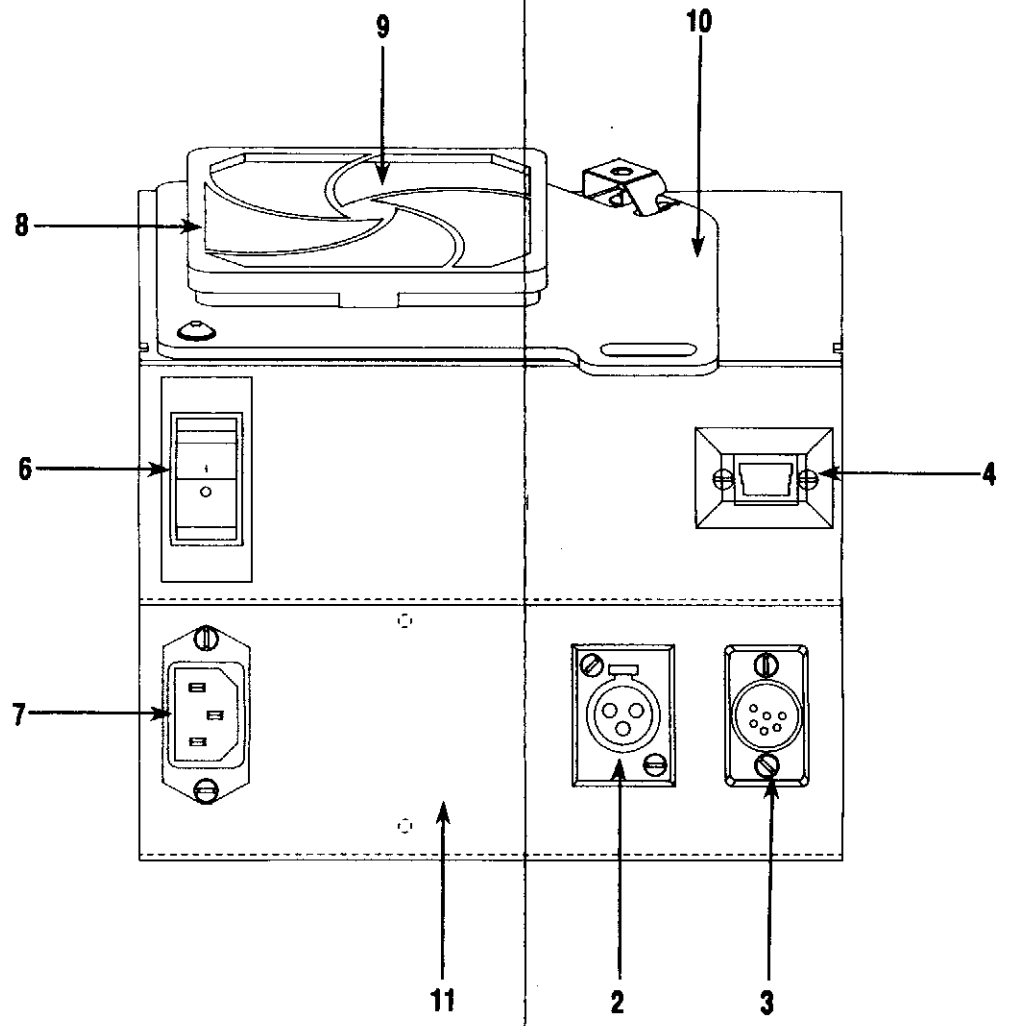
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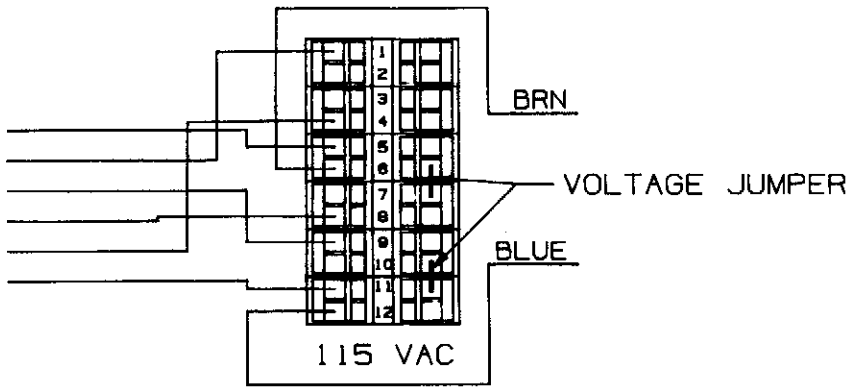
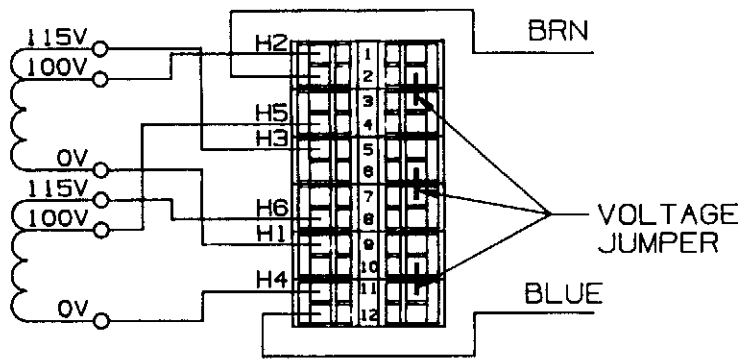
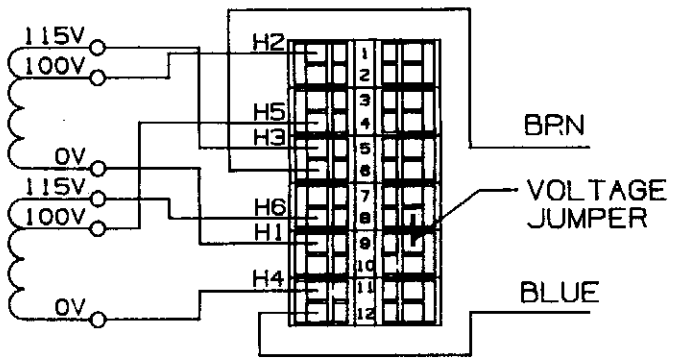
Item No.	3M ID	Description	Qty.
1	26-1010-0856-8	EMI Line Filter	1
2	26-1006-9308-9	Battery Power Connector, Cannon 3 Pin	1
3	26-1009-7026-3	ART/CPG Connector	1
4	78-8067-4647-1	Pulse Connector	1
5	26-1010-0770-1	Fan	1
6	26-1009-6562-8	Circuit Breaker, 2.5 Amp , 100/115V	1
	26-1009-6561-0	Circuit Breaker, 1.25 Amp, 220-240V	1
7	26-1009-6555-2	Power Inlet	1
8	26-1010-1890-6	Filter Guard	1
9	26-1010-1889-8	Filter	1
10	78-8067-4241-3	Filter Holder	1
11	78-8067-3928-6	Front Panel	1

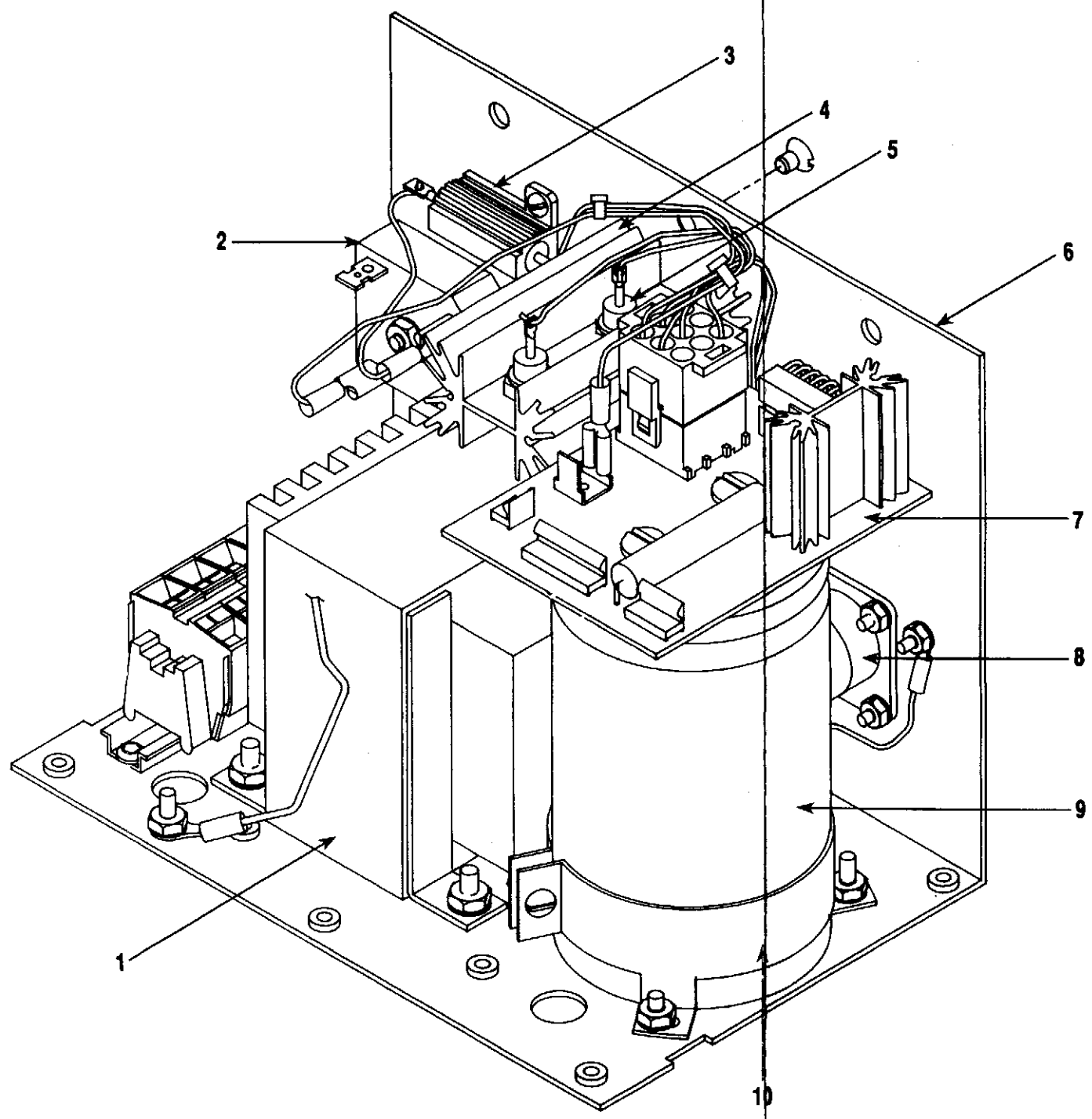




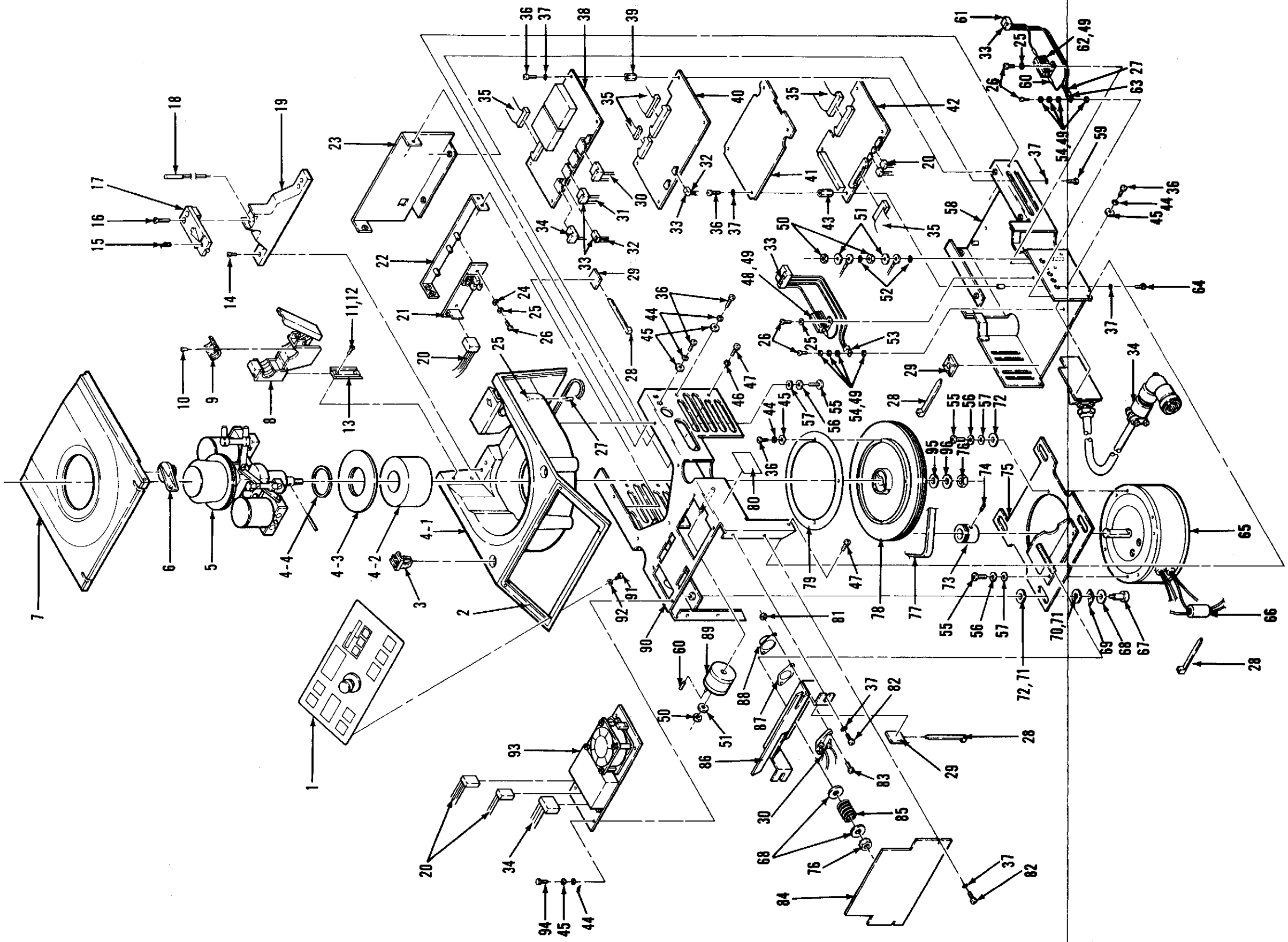
100 VAC



220-240VAC



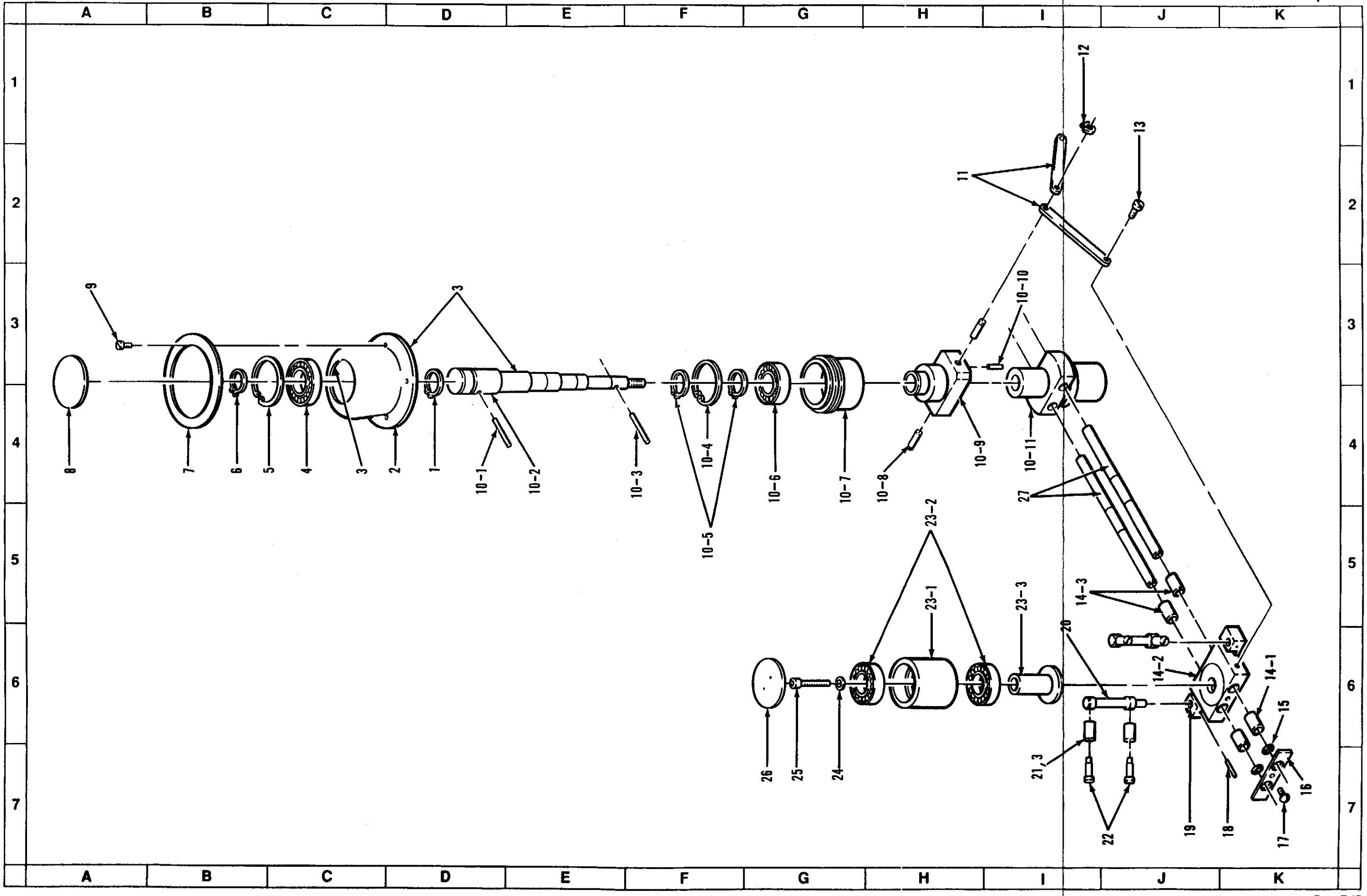
Item No.	3M ID	Description	Qty.
1	78-8067-4242-1	Power Transformer	1
2	26-1008-0720-0	Bridge Rectifier, 35 A, 200V	1
3	26-1008-1038-6	Resistor, 0.1 Ohm	1
4	78-8067-4244-7	Heat Sink	1
5	26-1009-6563-6	Schottke Diode	2
6	78-8067-3929-4	Inner Panel	1
7	78-8067-4177-9	Pump Distribution Board	1
8	26-1006-9313-9	Pump Cable Connector	1
9	26-1008-2314-0	Capacitor, 27000M/50/75, 10%	1
10	26-1006-6844-6	Capacitor Clamp	1



Item No.	3M ID	Description	Qty.
1	78-8066-6289-2	Display Panel Assembly SEE PAGE 7-18	1
2	78-8005-0601-2	Seal, Silastic, Clear UL	0.040
3	26-1006-9168-7	Latch, 1/4 Turn, 0.182 - 0.271 Grp	2
4	78-8067-1688-8	Casting Bearing Assembly	--
4-1	78-8066-7466-5	Pumphead, Machined	1
4-2	26-1008-0599-8	Ball Bearing, 2 Row, 1.2 ID x 2.8 OD	1
4-3	78-8066-7587-8	Cap Bearing, Machined	1
4-4	26-1008-2123-5	Shaft Seal, Teflon	1
5	78-8066-7470-7	Guts Assembly SEE PAGES 7-15 THRU 7-17	1
6	78-8066-6269-4	Cover Hinge	2
7	78-8066-6733-9	Cover Assembly	1
8	78-8066-7520-9	Tube Clamp Assembly	2
9	78-8066-7723-9	Tubing Insert, 11/16	4
10	12-7996-6665-1	Screw, Flat Head, 4-40 x 5/16	4
11	70-7023-4040-0	Screw, Flat Head, 6-32 x 5/16	4
12	26-1008-1633-4	Loctite 242	0.002
13	78-8066-6271-0	Dovetail Slide	2
14	12-7997-9109-5	Screw, Flat HEad, 8-32 x 1/2	4
15	78-8066-6248-8	Drag Insert, Buna N	1
16	26-1008-4686-9	Screw, Phillips Oval Head, 8-32 x 1	2
17	78-8066-9919-1	Tongue, Molded	1
18	26-1008-9049-5	Sensor, Magnetic Proximity	1
19	78-8072-1495-8	Tongue, Wall Support	1
20	78-8067-0262-3	Cable Assembly, MTAS	1
21	78-8066-6282-7	Dual Tachometer Board	1
22	78-8066-9894-6	Encoder Board Mounting Bracket	1
23	78-8067-0869-5	Bracket, Back	1
24	26-1008-9069-3	Washer	3
25	26-1000-3349-2	Split Washer, #4	7
26	26-1008-8040-5	Screw, Button Head Torx, 4-40 x 0.25	9
27	26-1006-7179-6	Shrink Tubing, 1/8, Clear, UL	0.750
28	26-1008-4315-5	Tie- Wrap	13
29	26-1008-0845-5	Cable Mount, Adhesive	6
30	78-8067-0259-9	Cable Assembly, Trans Socket	1

Item No.	3M ID	Description	Qty.
31	26-1008-2032-8	Connector, MTA Housing, 3 Pin, 18 Gage	1
32	26-1004-0455-2	Connector, MTA Housing, 3 Pin, 22 Gage	2
33	26-1007-8660-2	Label	5
34	78-8066-6746-1	Cable Assembly	1
35	78-8067-0261-5	Ribbon Cable Assembly	1
36	26-1008-8044-7	Screw, Button Head Torx, 6-32 x 0.38	21
37	18-9851-0603-0	Lock Washer, Exteranl, #6	18
38	78-8066-6279-3	Pump Drive Board	1
39	26-1007-5719-9	Standoff, 6-32 x 0.5, M/F	4
40	78-8066-6278-5	Pump Control Board	1
41	78-8066-6268-6	Local Processor Board	1
42	78-8066-6280-1	Pump Safety Board	1
43	26-1006-9292-5	Standoff, Hexagonal, Nylon, 6-32 x 3/4	4
44	26-1000-0078-0	Split Washer, #6	17
45	18-9813-0675-8	Flat Washer, #6	17
46	18-9832-0875-4	Split Washer, #8	2
47	26-1008-8047-0	Screw, Button Head Torx, 8-32 x 0.38	4
48	26-1008-1038-6	Resistor, 0.1 Ohm, 25 Watt, 1%	1
49	26-1006-7082-2	Thermalcote Compound 251	0.001
50	26-1000-6654-2	Keps Nut, 8-32	3
51	26-1008-1921-3	Flat Washer, #8	3
52	18-9851-0803-6	Lock Washer, External Tooth, #8	2
53	26-1008-0735-8	Rectifier, Diode, MR240F	1
54	26-1008-0809-1	Kit, Insulation Mounting	2
55	26-1008-8051-2	Screw, Button Head Torx, 10-32 x 0.50	9
56	77-8007-6245-0	Split Washer, #10	9
57	26-1008-1929-6	Flat Washer, #10	9
58	78-8067-0884-4	Enclosure, Bracket Bottom	1
59	26-1008-8043-9	Screw, Button Head Torx, 6-32 x 0.25	2
60	26-1006-7180-4	Shrink Tubing, 3/16, Clear, UL	0.500
61	26-1008-2009-6	Connector, MTA Housing, 4 Pin, 22 Gage	1
62	26-1008-1041-0	Resistor, 50 Ohm, 25 Watt, 1%	1
63	26-1008-1097-2	Power Transistor, PNP, 8 Amp, 50 Watt	1
64	26-1008-8046-2	Screw, Button HEad Torx, 6-32 x 0.63	4

Item No.	3M ID	Description	Qty.
65	26-1008-0601-2	Motor/Tachometer	1
66	26-1007-5202-6	Ferrite Bead, 0.25 ID x 1.1 Long	1
67	26-1008-2419-7	Shoulder Screw, 5/16 Thread x 0.375	4
68	26-1008-1891-8	Washer, 0.75 OD x 0.318 ID x 0.075	6
69	26-1005-7759-7	Spring	4
70	26-1008-1892-6	Washer, 0.75 OD x 0.720 ID x 0.105	4
71	26-1008-4062-3	Lubricam SL2	0.050
72	26-1008-1895-9	Washer, 0.12 T x 0.315 ID	6
73	78-8066-6720-6	Small Pulley, Machined	1
74	18-3414-5015-5	Set Screw, 1/4-20 x 1/4	1
75	78-8072-1425-5	Motor Mount	1
76	26-1008-4384-1	Stop Nut, 3/8 - 16	2
77	26-1006-6708-3	Belt, Polyflex Joined	1
78	78-8066-6740-4	Large Pulley, Machined	1
79	78-8067-0059-3	Encoder Wheel	1
80	78-8067-0156-7	Nameplate Label	1
81	26-1003-4052-5	Keps Nut, 4-40	2
82	78-8005-5342-8	Screw, Truss Head, 6-32 x 3/8	4
83	26-1008-8042-1	Screw, Button Head Torx, 4-40 x 0.50	2
84	78-8067-0868-7	Bracket, Front	1
85	26-1008-2134-2	Compression Spring, 0.61 OD x 0.75 L x 0.091	1
86	78-8072-1426-3	Spring Bracket	1
87	26-1008-0823-2	Insulator, Mica	1
88	26-1008-0700-2	Power Transistor, NPN	1
89	26-1008-4134-0	Choke, 270 Microhenry, 11 Amp	1
90	78-8067-0761-4	Bracket, Top Enclosure	1
91	78-8067-0539-4	Panel Nut, Slotted, 4-40	4
92	26-1008-6546-3	Shoulder Washer, Nylon	4
93	78-8066-6283-5	Pump supply Board	1
94	26-1002-5367-8	Screw, Hex Head, 6-32 x 3/8	4
95	18-9832-2403-3	Flat Washer, 3/8	1
96	12-7991-1789-5	Split Washer, 3/8	1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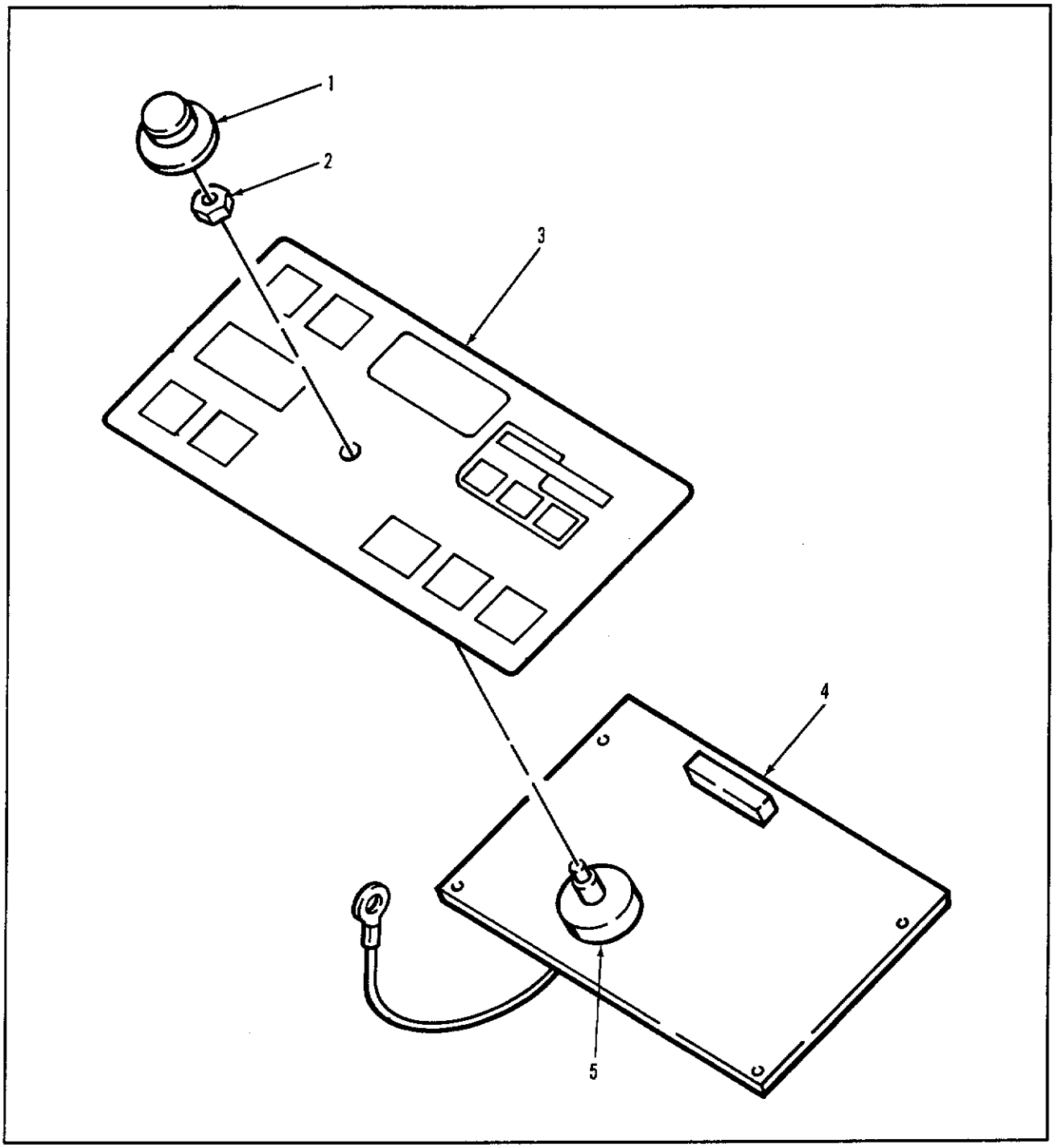
Item No.	3M ID	Description	Qty.
1	26-1006-6722-4	Snap Ring, 0.78 ID	1
2	78-8067-0380-3	Knob, Adjustable, Acme Thread	1
3	26-1008-4423-7	Lubricant, Distributor Cam	0.100
4	26-1006-6720-8	Ball Bearing, Deep Groove, 0.79 ID	1
5	26-1006-6721-6	Snap Ring, Bow/Internal 1.45 Housing	1
6	26-1006-6723-2	Snap Ring, External, 0.781 ID	1
7	78-8067-0058-5	Dial, Roller Pump Indicator	1
8	78-8066-7958-1	Cap, Adjustment Knob	1
9	78-8005-9317-6	Screw, Pan Head	4
10	78-8066-9896-1	Roller Pump Shaft Assembly	1
10-1	26-1002-4557-5	Roll Pin, 1/8 x 3/4	1
10-2	78-8066-9889-6	Main Shaft	1
10-3	26-1000-3216-3	Roll Pin, 1/8 x 1.0	1
10-4	26-1006-6722-4	Snap Ring, 0.78 ID	2
10-5	26-1006-6721-6	Snap Ring, Bow/Internal 1.45 Housing	1
10-6	26-1006-6720-8	Ball Bearing, Deep Groove, 0.79 ID	1
10-7	78-8067-0381-1	Stub, Adjustable Screw, Acme Thread	1
10-8	78-8066-7711-4	Pin	2
10-9	78-8066-9888-8	Block,Guide Bar	1
10-10	26-1005-0955-8	Roll Pin, 1/16 x1/2	2
10-11	78-8066-9887-0	Support Collar	1
11	78-8066-6233-0	Shoulder Link	4
12	26-1008-3139-0	Snap Ring	2
13	78-8066-7182-8	Shoulder Screw, Machined	4
14	78-8067-0336-5	Slide/Bushing Assembly	2
14-1	26-1008-5040-8	Bushing, Oilube, 0.3145 x 0.4405 x 1/2	2
14-2	78-8067-0335-7	Slide, Machined	1
14-3	26-1008-5041-6	Bushing, Oilube, 0.3145 x 0.4405 x 5/8	2
15	26-1006-6667-1	O-ring, Nitrile, 0.375 ID	4
16	78-8066-7178-6	Plate, Slide Drag	2
17	26-1008-2179-7	Truss Head Screw, 8/32 x 0.38 with lock	2
18	18-9260-5815-9	Roll Pin, 3/32 x 5/8	4
19	26-1004-6165-1	Loctite, Super Bond 420	0.010
20	78-8066-9886-2	Post, Guide	4

Item No.	3M ID	Description	Qty.
21	78-8066-6266-0	Tube Guide Roller	8
22	78-8066-6288-4	Shoulder Screw, Tube Guide Roller	8
23	78-8067-0191-4	Eccentric Roller Assembly	2
23-1	78-8066-9885-4	Roller	1
23-2	26-1006-6672-1	Ball Bearing, 17mm ID 35mm OD	2
23-3	78-8066-7467-3	Eccentric Roller Post	1
24	26-1006-7566-4	Wave Washer, 0.26 x 0.36	2
25	12-7997-6279-9	Capscrew, Socket Head, 1/4-20 x 1 1/4	2
26	78-8066-8792-3	Eccentric Roller Cap	2
27	26-1008-2187-0	Shaft, 0.374 diameter x 5.68	2



Item No.	3M ID	Description	Qty.
1	26-1008-6870-1	Knob,1.25 Diameter, Black	1
2	26-1008-0613-7	Seal, APM, 1/4 Shaft, N-9030	1
3	78-8066-6697-6	Membrane, Roller Pump Switch Panel	1
4	78-8066-7501-9	PC Assembly, Roller Pump Display Board	1
5	78-8066-8951-5	Potentiometer and Cable Assembly	1

3M HEALTH CARE

TO: Field Service
Service Center
Technical Support

cc: Al Hajek
Tom Torice

From: Carroll DeLancey

Date: 3-March-1994

8000 Safety Monitor - model 16404 P/N 98-0702-0660-6

The membrane switches turning off the Air and Level detection systems to the 8000 Safety Monitor have LEDs above them that are currently Red. These will be changed to Yellow LEDs starting with the next production batch.

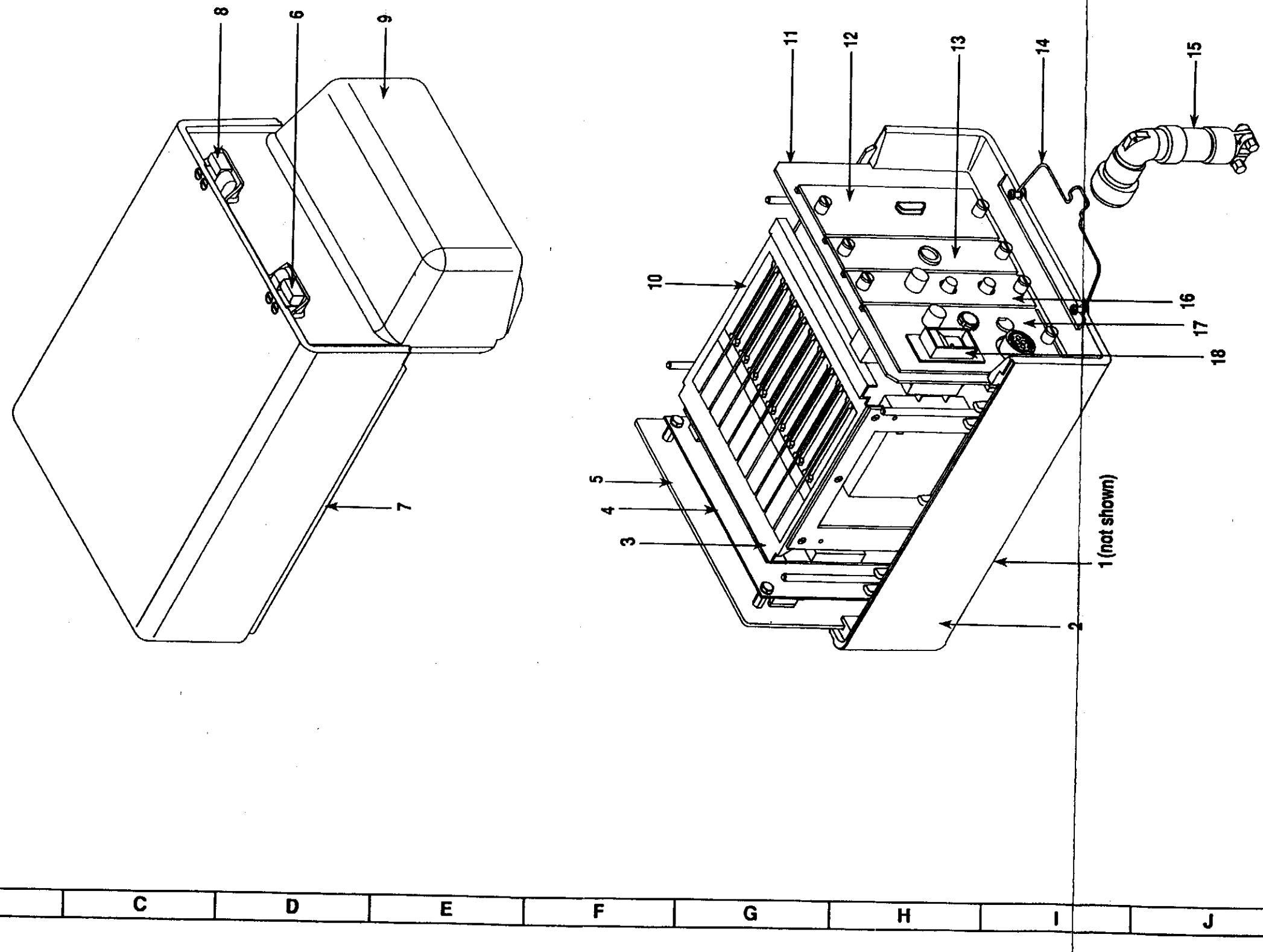
This change will make the product agree with the original design intent and the instructions in the operators manual. A green LED will indicate the safety system is turned on (enabled) and a yellow LED will indicate the safety system is turned off (disabled).

Those Safety monitors currently in the field and in stock not yet shipped will not be changed. We will replace the LEDs of those in the field when they fail and need replacement. We will also replace the LEDs if a customer purchases a new Safety Monitor and wants them to be the same. This would be done at the next service visit, we would not make a special trip to make this change.

If you have any questions, please contact:
Carroll DeLancey at 313/663-4145 ext. 6247
or Greg Illeck at 313/663-4145 ext. 6109

Fax number 313/741-6449

3M Health Care
6200 Jackson Rd.
Ann Arbor, Mi. 48103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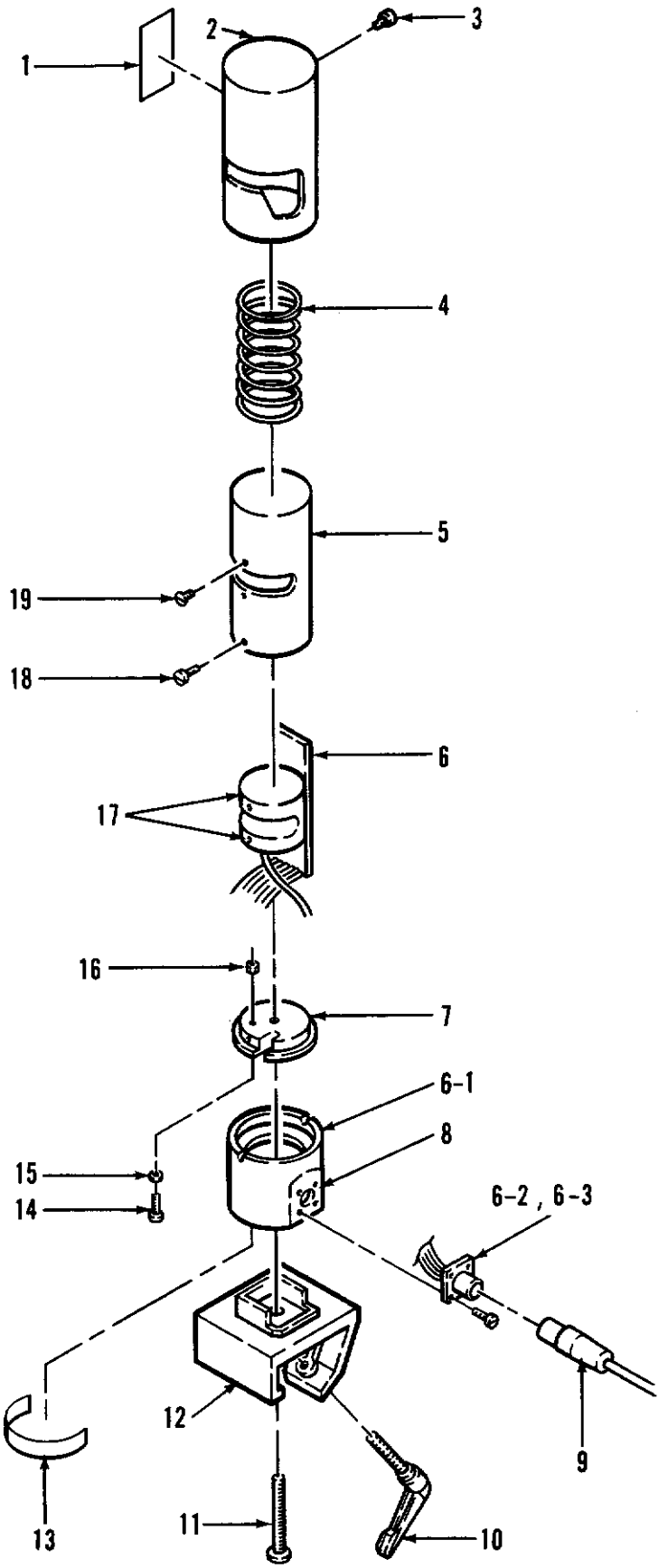
Item No.	3M ID	Description	Qty.
1	78-8067-4506-9	Spring Latch Module Mount	1
2	78-8067-4516-8	Lower Housing	1
3	78-8067-3954-2	Mother Board	1
4	78-8067-3953-4	Display Board	1
5	78-8067-4147-2	Membrane Panel	1
6	26-1009-6588-3	Left Hinge	1
7	78-8067-4517-6	Upper Housing	1
8	26-1009-6587-5	Right Hinge	1
9	78-8067-4471-6	Splash Shield	1
10	26-1009-6556-0	Card Cage	1
11	78-8067-4049-0	Rear Panel	1
12	98-0702-0661-4	Communications Module	1
12a	26-1011-8509-3	External Cable (Not shown)	1
12b	78-8067-4217-3	Interface Board (Not shown)	1
12c	78-8067-5254-5	Computer Board (Not shown)	1
12d	26-1011-2607-1	LED, Green (Not shown)	1
13	78-8066-6748-7	Air Detector	1
14	78-8067-5215-6	Spring Latch	1
15	78-8067-4494-8	Power/Comm Cable	1
16	78-8066-7955-7	Level Detector	1
17	78-8067-4193-6	Safety Power Module	1
18	26-1009-6562-8	Circuit Breaker, 2.5A	1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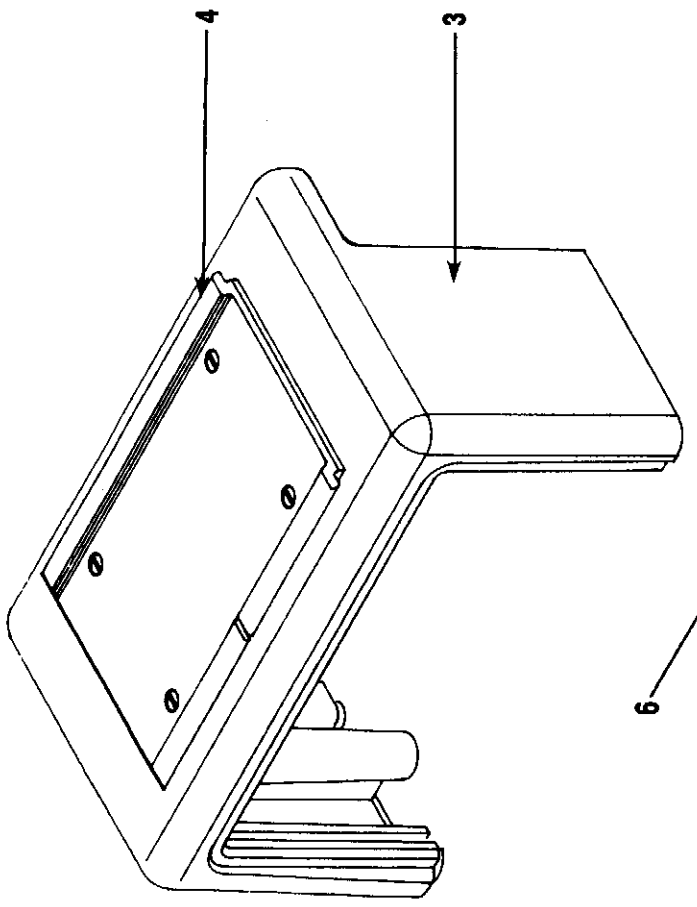
Item No.	3M ID	Description	Qty.
1	78-8066-7269-3	Nameplate	1
2	78-8066-9130-5	Outer Case, 1/4 Sensor	1
	78-8066-7270-1	Outer Case, 3/4 Sensor	1
3	26-1008-2176-3	Pan Head Screw, 4-40 x 3/8	1
4	78-8066-7107-5	Compression Spring	1
5	78-8066-9129-7	Inner Case, 1/4 Sensor	1
	78-8066-7268-5	Inner Case, 3/4 Sensor	1
6	78-8066-9131-3	PC Board, 1/4 Sensor	1
	78-8066-7272-7	PC Board, 3/4 Sensor	1
6-1	78-8066-7265-1	Connector Housing	1
6-2	26-1008-2105-2	Viking Connector, 7 Pin	1
6-3	26-1008-2106-0	Pin	7
7	78-8066-7267-7	Cap, Connector Housing	1
8	26-1008-1631-8	Loctite Superbond 495	AR
9	78-8066-6734-7	Cable Assembly	1
10	26-1008-3421-2	Thumb Screw, 1/4-20 x 2.0, Nylon	1
11	26-1008-4395-7	Binder Head Screw, 1/4-20 x 2.0	1
12	78-8066-7266-9	Pole Clamp	1
13	26-1008-1562-5	Label	1
14	26-1007-2341-5	Pan Head Screw, 2-56 x 5/8	1
15	26-1000-3190-0	Split Washer, #2	1
16	18-1728-0775-4	Hex Nut, 2-56	1
17	78-8005-0601-2	Sealant, Silastic, Clear	AR
18	12-7995-0779-8	Pan Head Screw, 6-32 x 1/2	2
19	12-7996-8113-0	Flat Head Screw	2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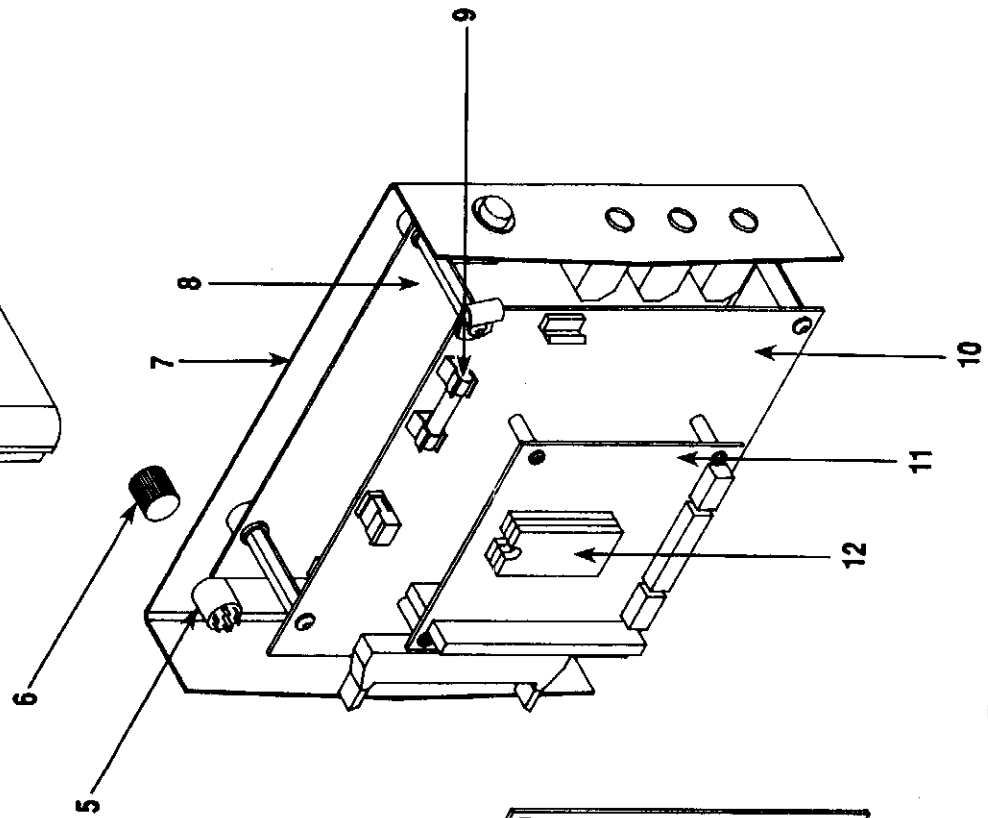
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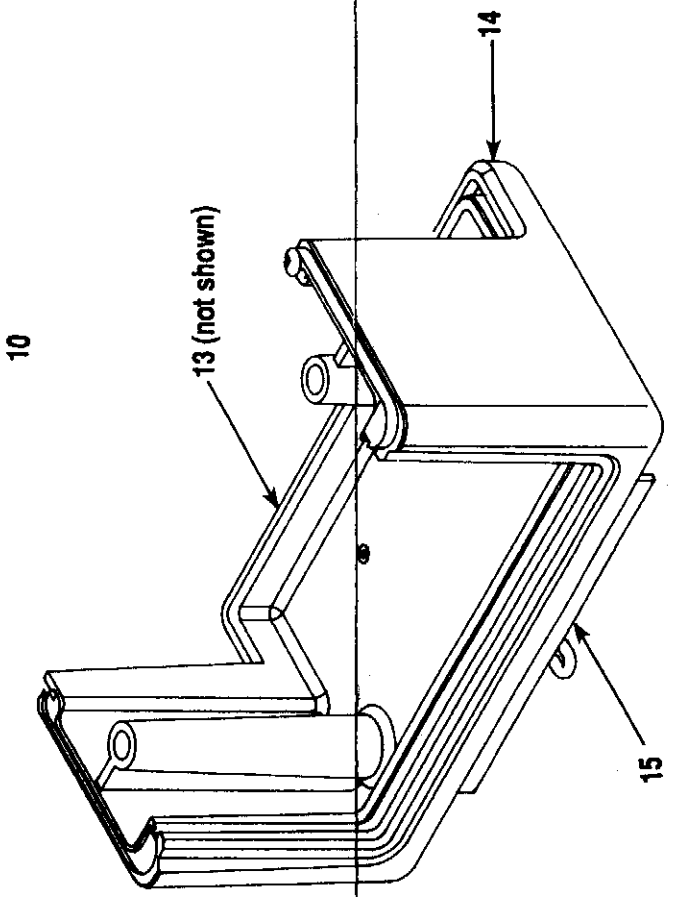
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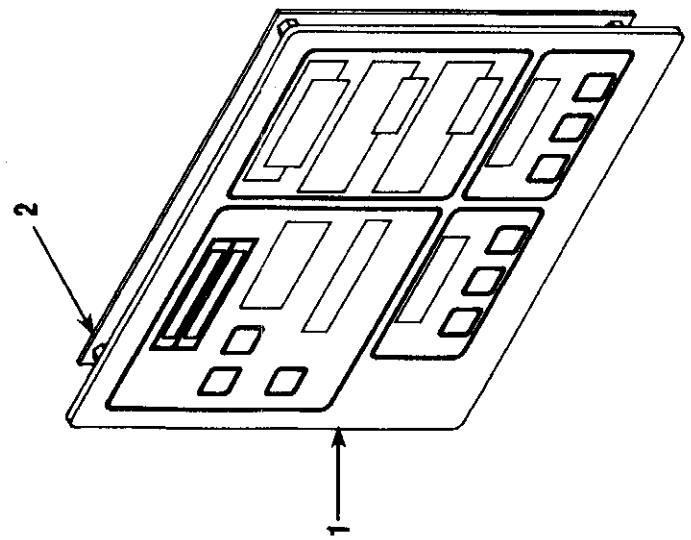
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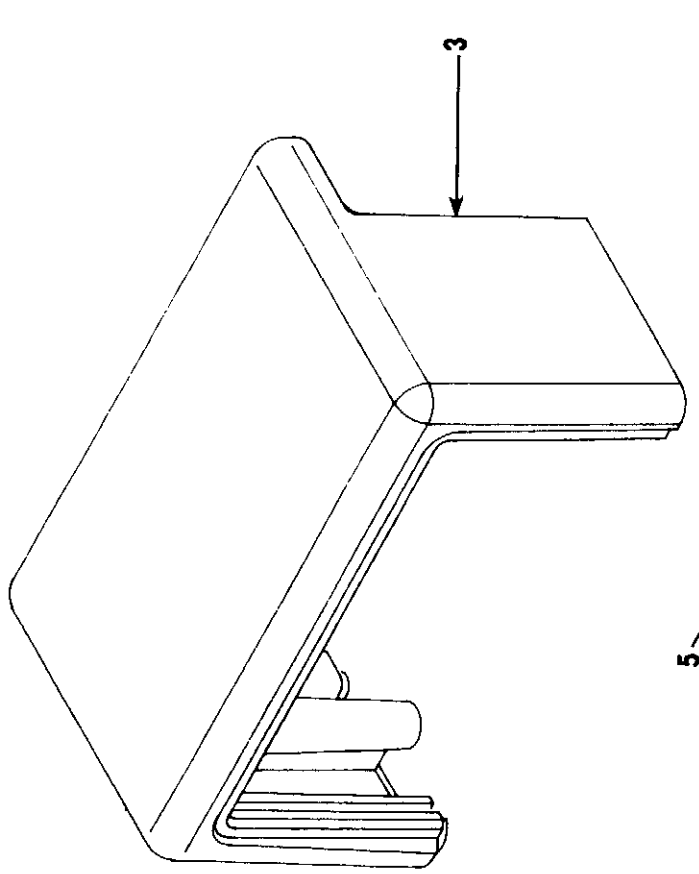
Item No.	3M ID	Description	Qty.
1	78-8067-4211-6	Membrane Panel	1
2	78-8067-4110-0	Display Board	1
3	78-8067-4496-3	Upper Housing	1
4	26-1009-6512-3	Mounting Plate	1
5	78-8067-4591-1	Volume Control Switch Assembly	1
6	26-1009-6729-3	Knob	1
7	78-8067-4209-0	Rear Panel	1
8	78-8067-4840-2	Temp/Press Board	1
9	26-1006-7244-8	Fuse, 3AG, 1 Amp	1
10	78-8067-3880-9	Power Interface Board	1
11	78-8067-5254-5	Computer Board	1
12	78-8067-4214-0	Romset	1
13	78-8067-4206-6	Power/Stop/Comm Cable Assembly	1
14	78-8067-4482-3	Lower Housing	1
15	78-8067-4506-9	Spring Latch Module Mount	1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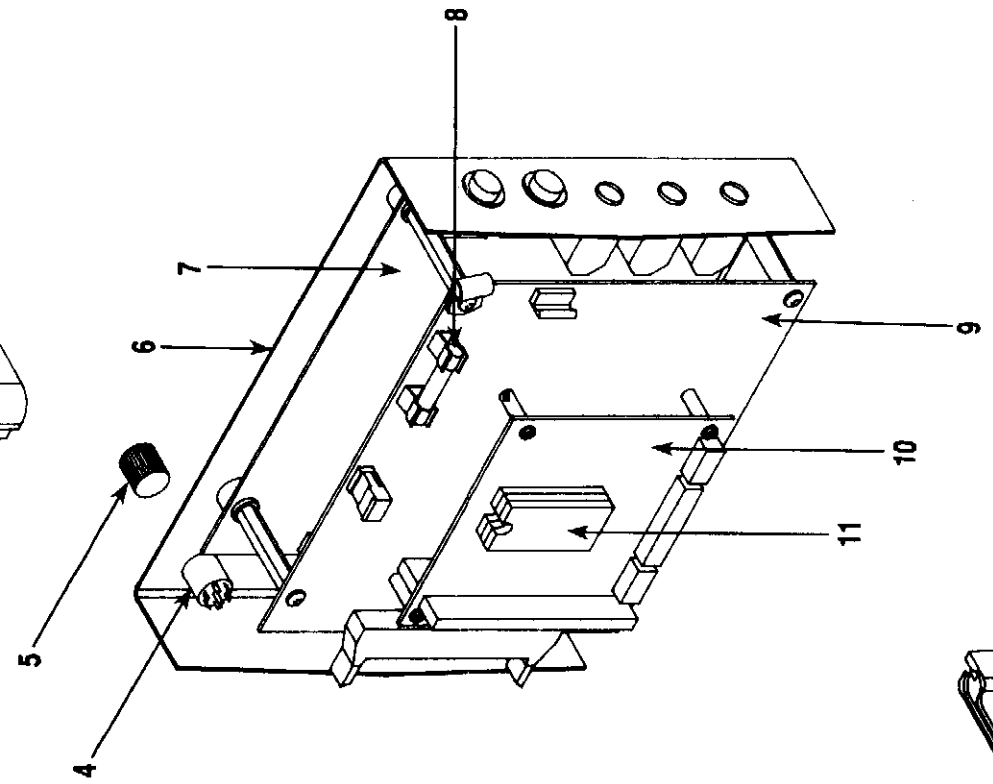
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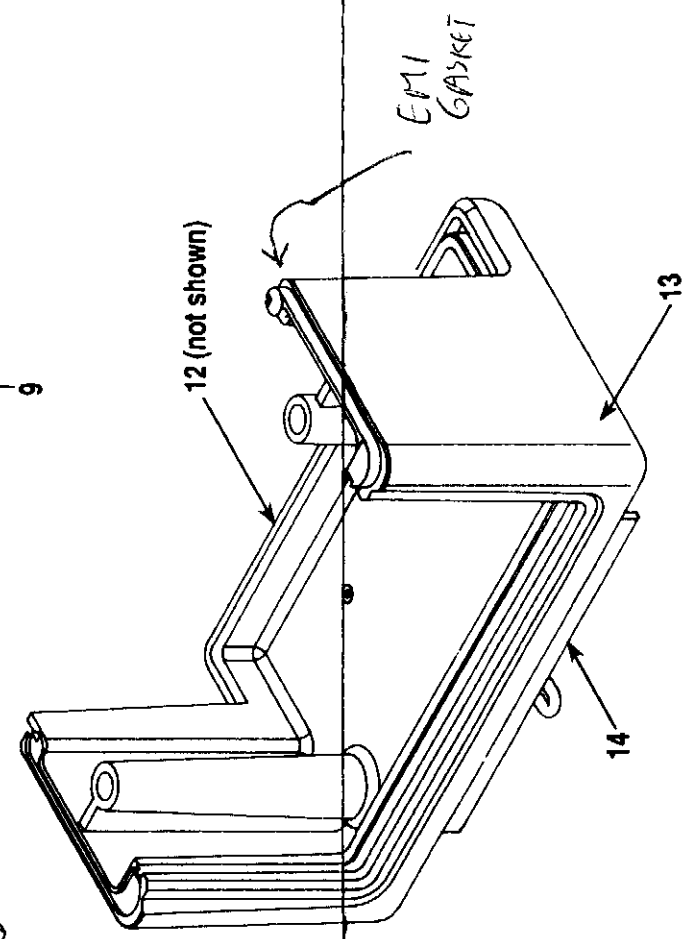
EMI GASKET
12 (not shown)
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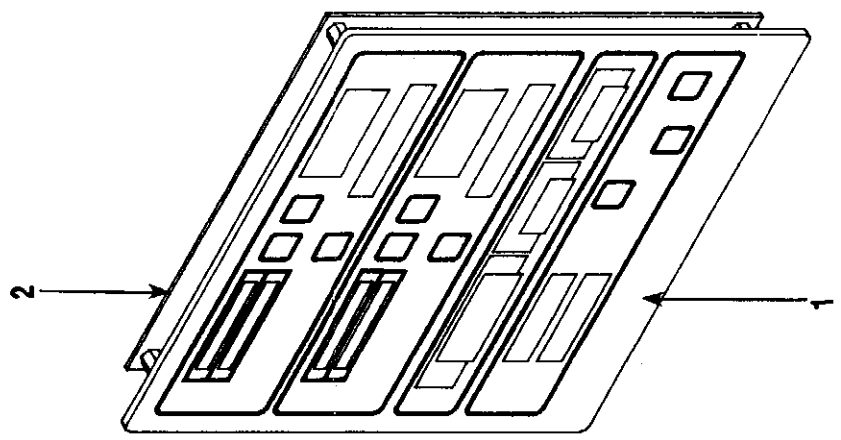
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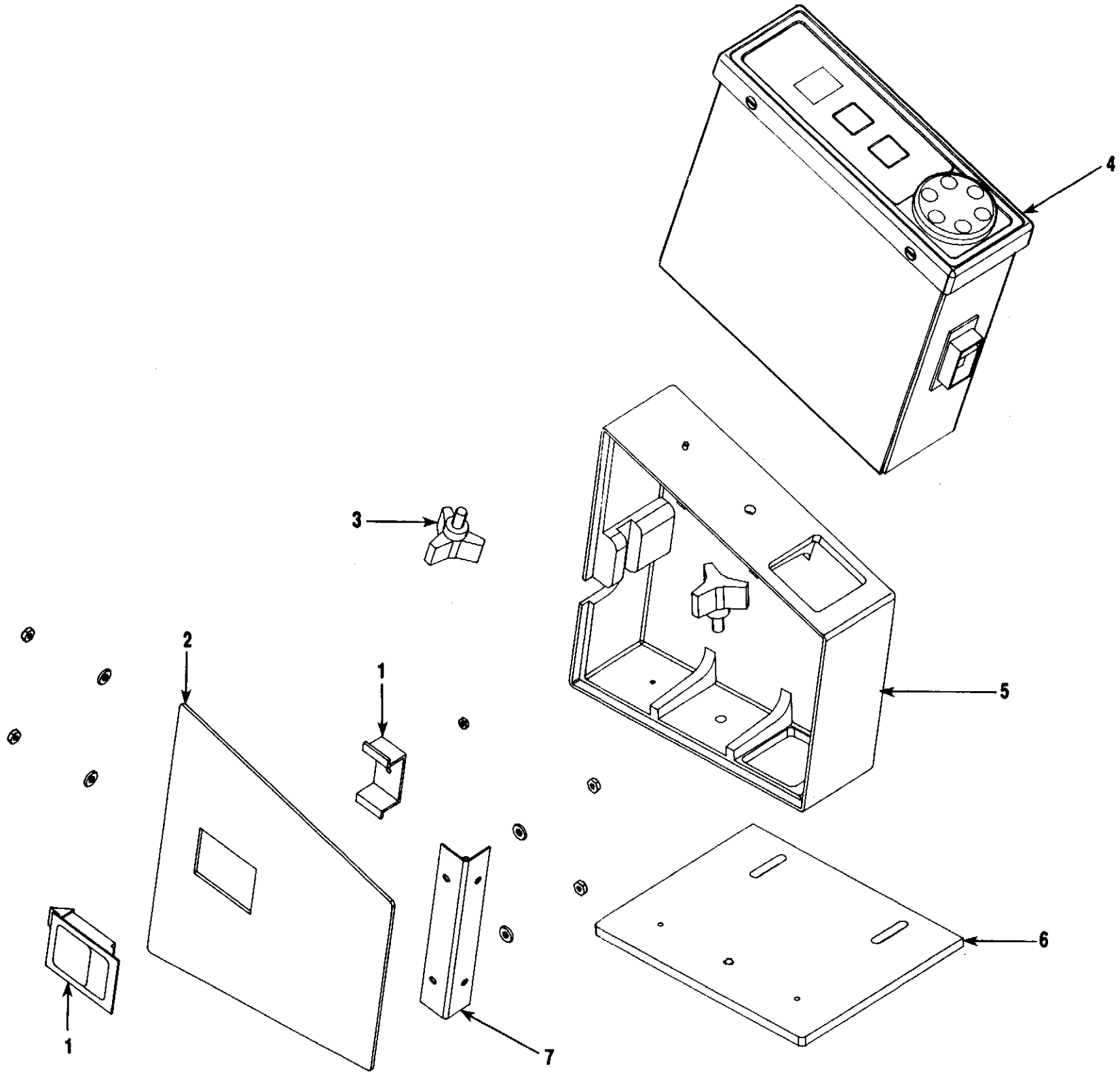
Item No.	3M ID	Description	Qty.
1	78-8067-4212-4	Membrane Panel	1
2	78-8067-3876-7	Display Board	1
3	78-8067-4497-1	Upper Housing	1
4	78-8067-4591-1	Volume Control Switch Assembly	1
5	26-1009-6729-3	Knob	1
6	78-8067-4210-8	Rear Panel	1
7	78-8067-3878-3	Temp/Press Board	1
8	26-1006-7244-8	Fuse, 3AG, 1 Amp	1
9	78-8067-3880-9	Power Interface Board	1
10	78-8067-5254-5	Computer Board	1
11	78-8067-4216-5	Romset	1
12	78-8067-4206-6	Power/Stop/Comm Cable Assembly	1
13	78-8067-4495-5	Lower Housing	1
14	78-8067-4506-9	Spring Latch Module Mount	1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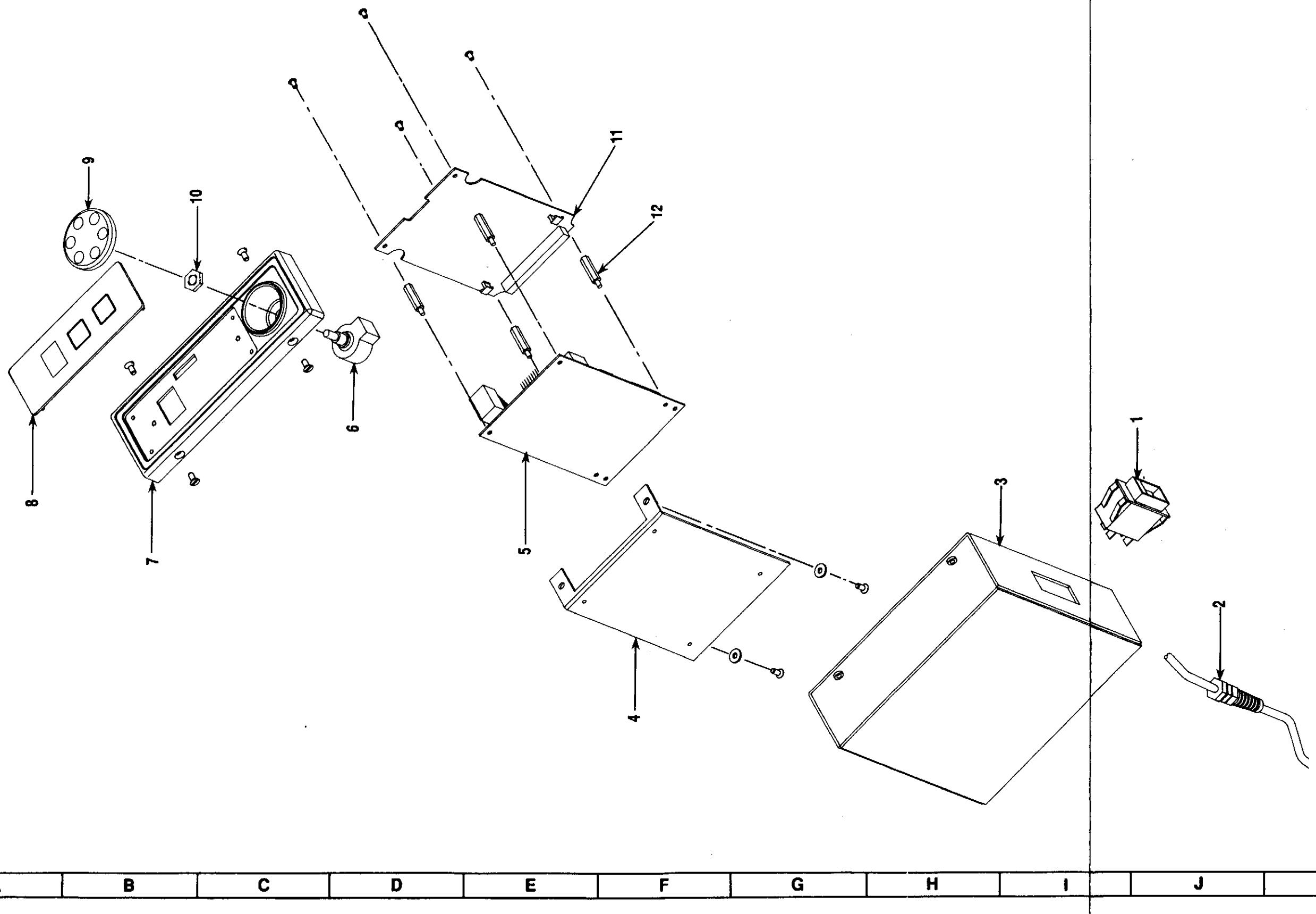
Item No.	3M ID	Description	Qty.
1	26-1009-3829-4	Latch	1
2	78-8067-4603-4	Door	1
3	26-1008-1996-5	T-Knob	2
4	78-8067-4511-9	Occluder Control Module	1
5	78-8067-4970-7	Support Bracket	1
6	78-8067-4602-6	Support Plate	1
7	78-8066-8990-3	Door Hinge	1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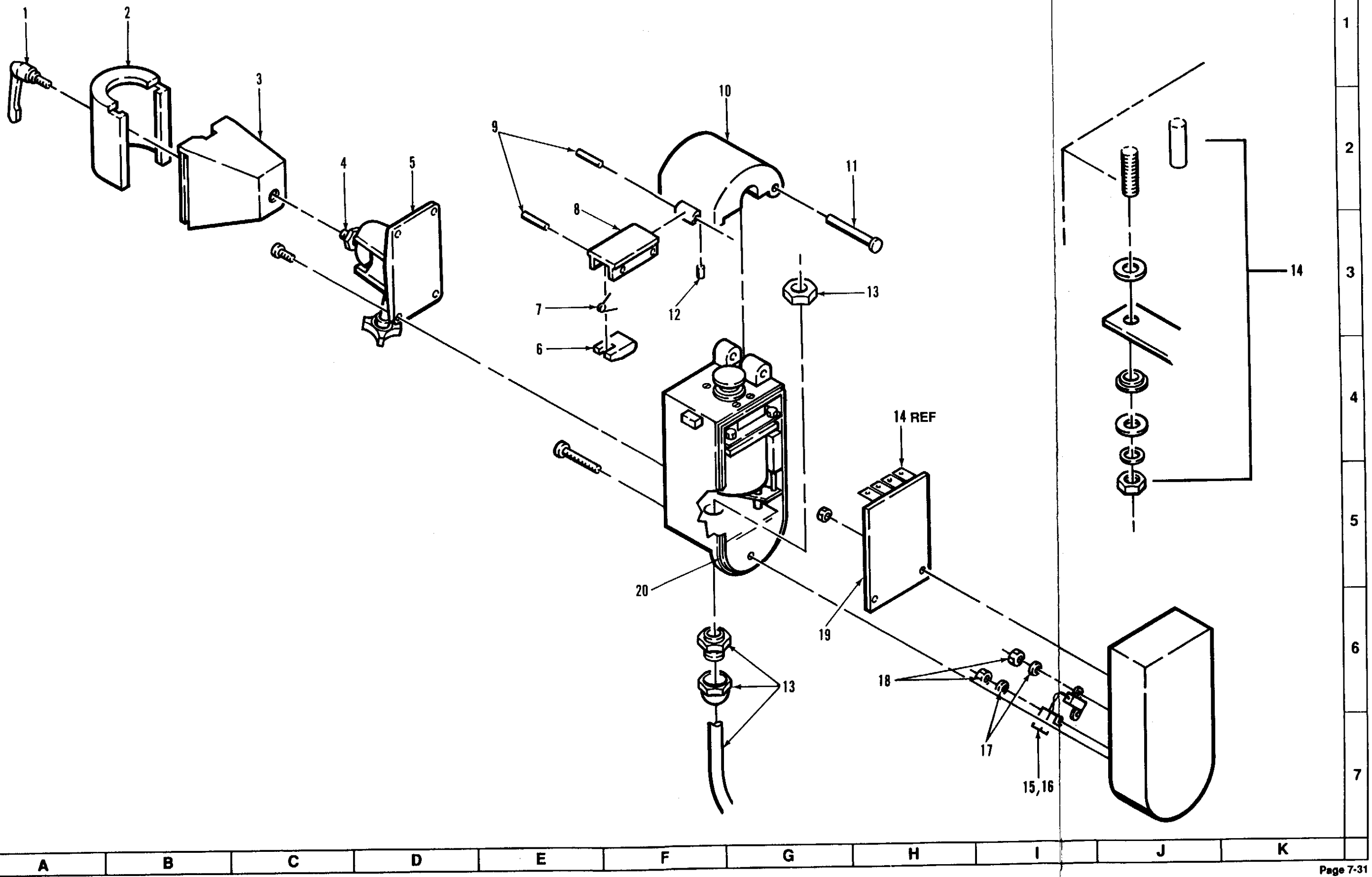
Item No.	3M ID	Description	Qty.
1	26-1009-6562-8	Circuit Breaker, 2.5 Amp	1
2	78-8067-4510-1	Power Cable	1
3	78-8067-4372-6	Housing	1
4	78-8067-4373-4	Mounting Bracket	1
5	78-8067-4487-2	Display Board	1
6	26-1008-4333-8	Potentiometer	1
7	78-8067-4968-1	Bezel	1
8	78-8067-4337-9	Membrane Panel	1
9	78-8066-7530-8	Control Knob	1
10	26-1008-0613-7	Amp Seal	1
11	78-8066-6268-6	Local Processor Board	1
12	26-1007-5719-9	Standoff	4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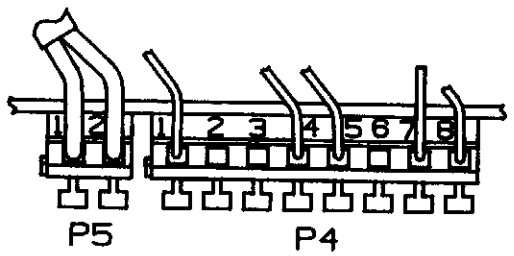
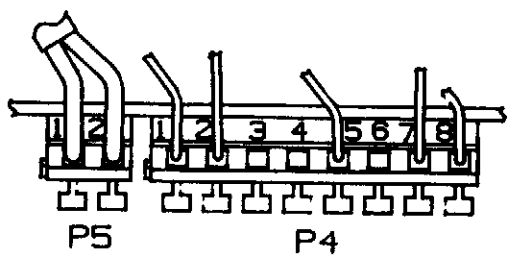
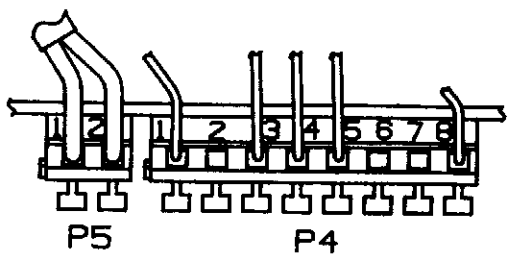
Item No.	3M ID	Description	Qty.
1	26-1006-9191-9	Threaded Handle	1
2	78-8066-7509-2	Mounting Clamp	1
3	78-8066-7508-4	Mounting Bracket	1
4	26-1006-6771-1	Loctite, RC/609	0.002
5	26-1008-0974-3	Mount/Handle Assembly	1
6	78-8066-7187-7	Flipper, Molded	1
7	26-1008-2132-6	Torsion Spring, Tube Clamp	1
8	78-8066-7186-9	Clasp, Machined	1
9	78-8066-6237-1	Pin	2
10	78-8066-7682-7	End Cover	1
11	26-1008-4064-9	Clevis Pin, Self Locking, 3/16	1
12	78-8066-6248-8	Drag Insert, Buna N	1
13	78-8067-0278-9	Cable Assembly	1
14	26-1008-0809-1	Insulating Mounting Kit	4
15	26-1007-5513-6	Power Resistor, 10 Ohm, 10 Watt, 1% ww	2
16	26-1006-7082-2	Thermalcote Compound 251	0.001
17	26-1000-3190-0	Split Washer, #2	10
18	26-1006-5237-4	Hex Nut, 2-56	4
19	78-8066-6732-1	Occluder Drive Board	1
20	26-1007-5206-7	EMI Caulking	0.020



100 V

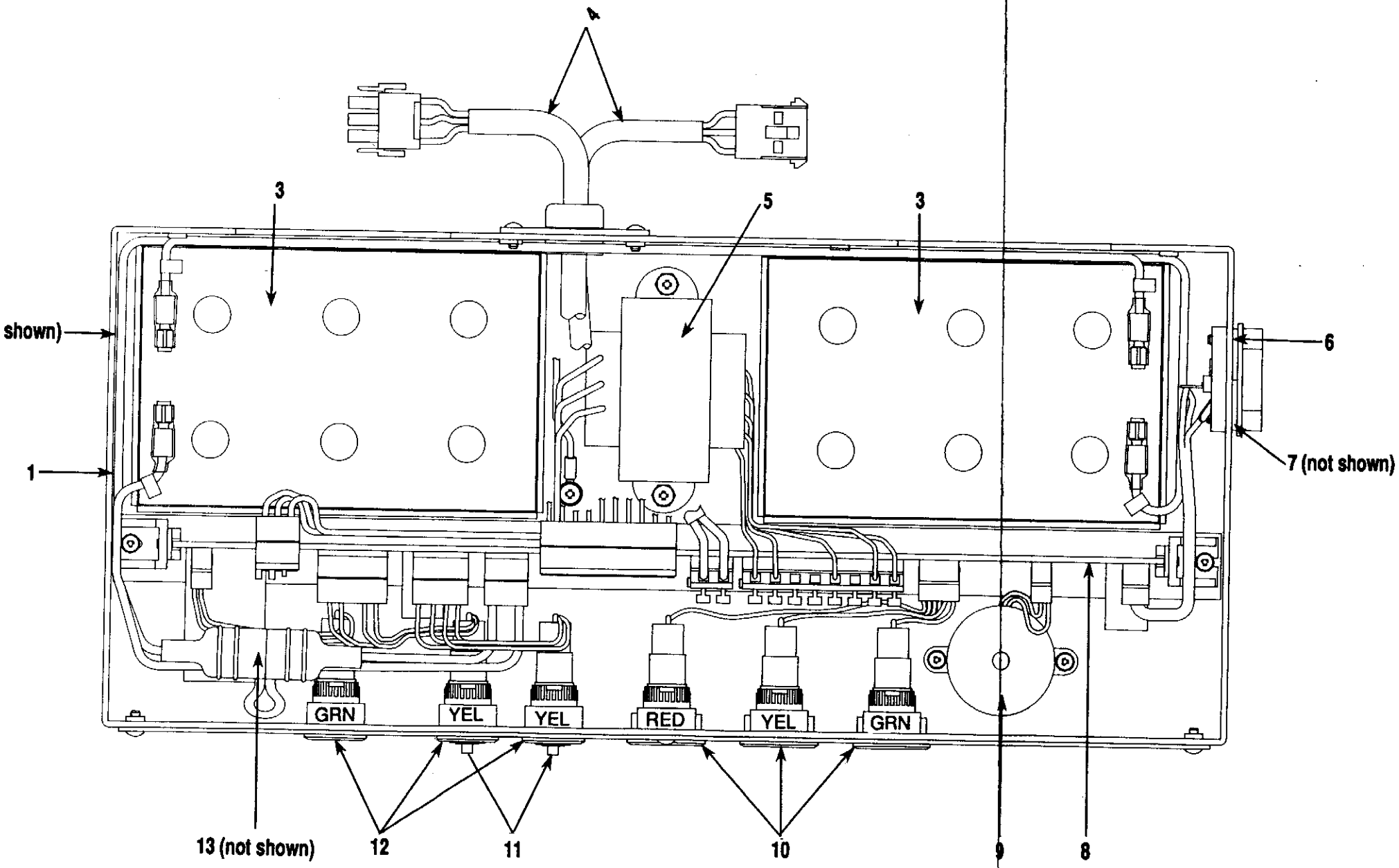


115 V

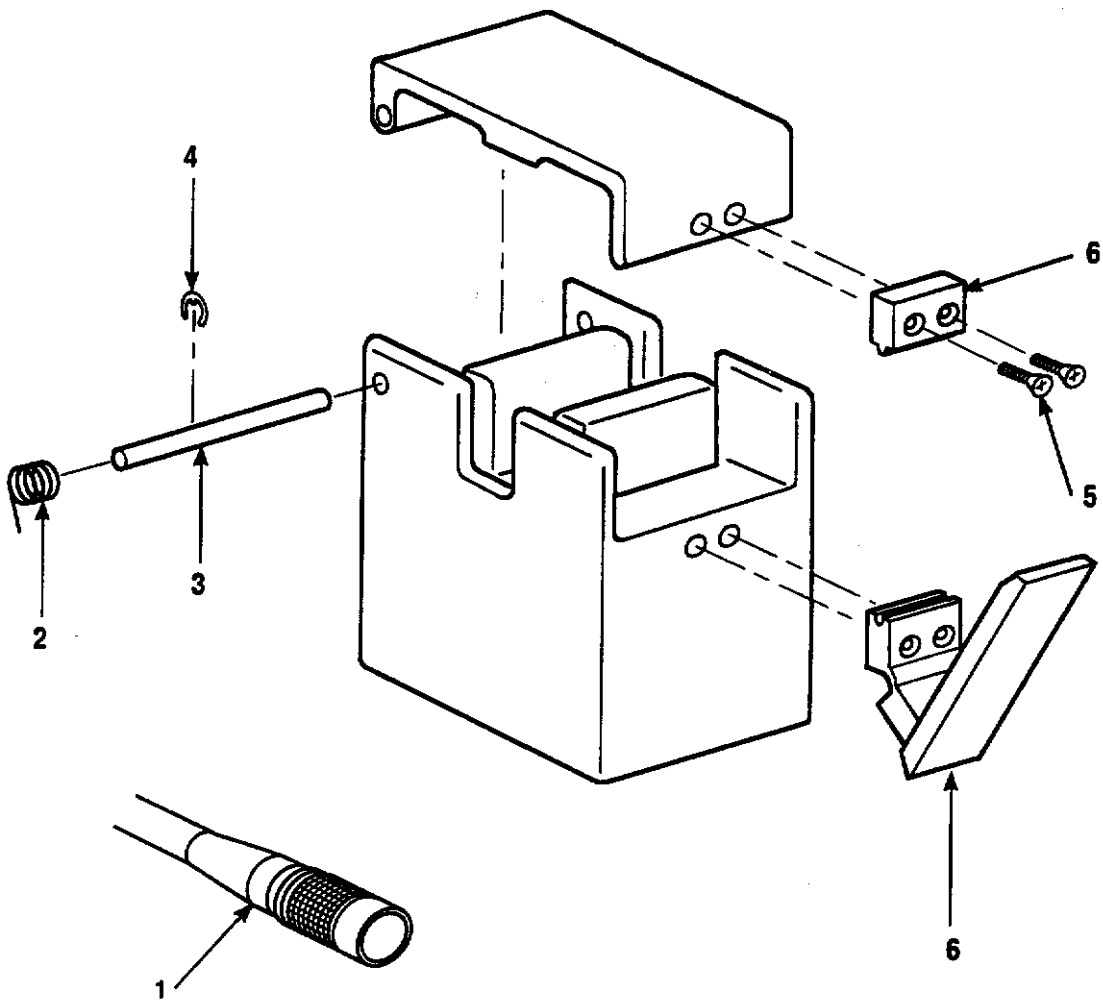


220 - 240 V

TERMINAL BLOCK CONNECTIONS

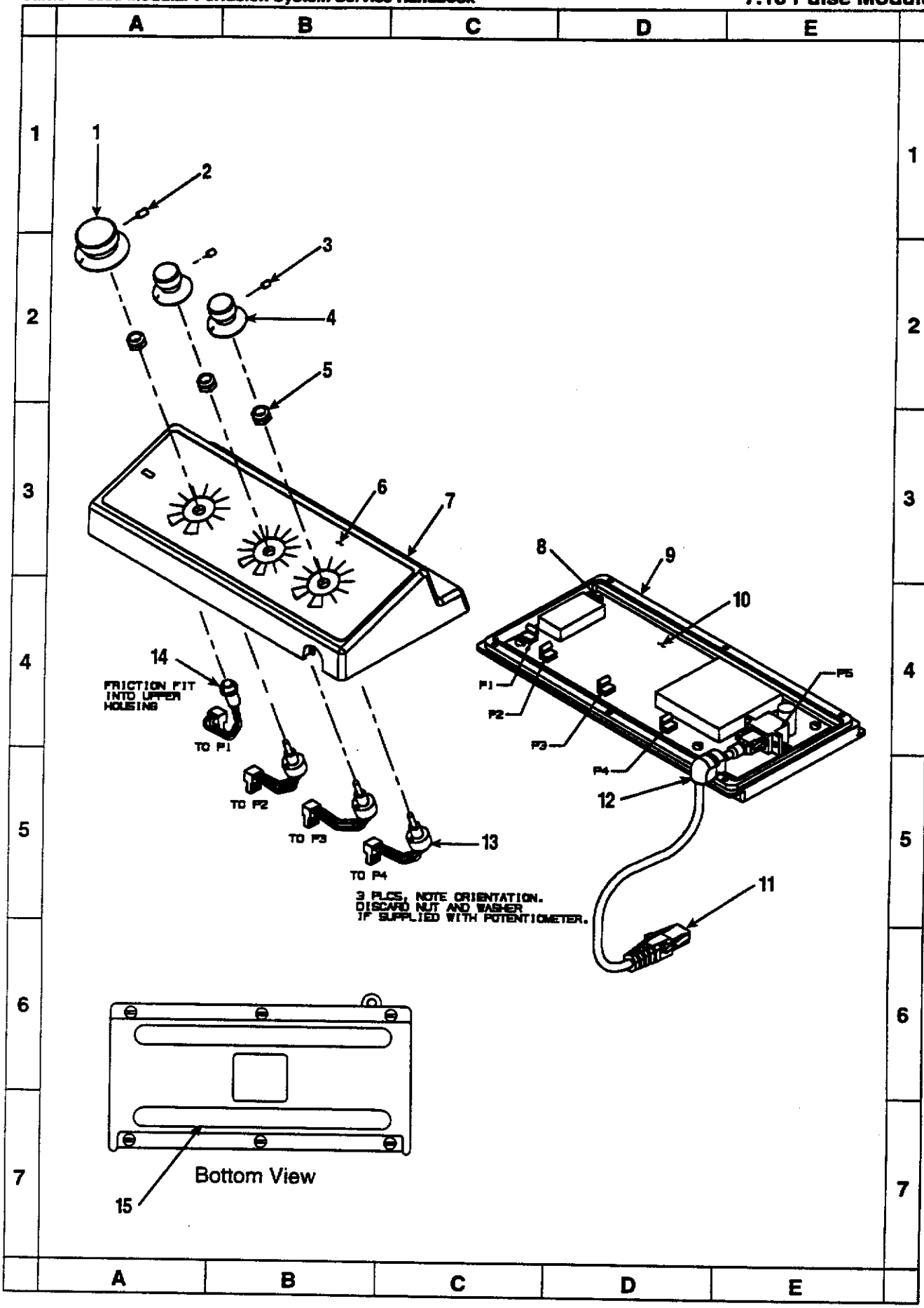


Item No.	3M ID	Description	Qty.
1	78-8067-4882-4	Enclosure	1
2	78-8067-4881-6	Enclosure Lid	1
3	26-1008-4252-0	Battery	2
4	78-8067-4945-9	UPS/Base Cable Assembly	1
5	26-1009-3607-4	Transformer,100/115/230 CT 35V	1
6	26-1007-6542-4	Voltage Regulator	1
7	26-1008-0823-2	Insulator, Mica	1
8	78-8067-4595-2	UPS Board	1
9	26-1006-6894-1	Audio Alarm	1
10	26-1009-3768-4	Lighted Indicators, Rectangular	3
10-1	26-1007-3548-4	Bulb, 28V 388 BULB	3
10-2	26-1009-3766-8	Green Lens, Rectangular	1
10-3	26-1009-3765-0	Yellow Lens, Rectangular	1
10-4	26-1009-3767-6	Red Lens, Rectangular	1
11	26-1009-3785-8	Circuit Breaker, 10A, 28VDC	2
12	26-1009-3787-4	Lighted Indicators, Square	3
12-1	26-1007-3548-4	Bulb 28V 388 BULB	3
12-2	26-1009-3763-5	Yellow Lens, Square	2
12-3	26-1009-3762-7	Green Lens, Square	1
13	26-1008-7577-7	Fuse, 25A, 125V	1



	3M I.D. Number	Description	Qty
1.	78-8067-7375-6	Cable Assembly	1
2.	26-1011-2608-9	Spring	1
3.	78-8067-7541-3	Hinge Pin	1
4.	26-1011-2609-7	Retaining Ring	1
5.	26-1011-2610-5	Screw, Phillips, Flat Head	4
6.	26-1009-9964-3	Latch	1

COMPLETE SENSOR ASSEMBLY # 78-8067-6923-4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FRICTION FIT INTO UPPER HOUSING
TO P1
TO P2
TO P3
TO P4
3 PLCS, NOTE ORIENTATION. DISCARD NUT AND WASHER IF SUPPLIED WITH POTENTIOMETER.
P1
P2
P3
P4
P5
Bottom View

Item No.	3M ID	Description	Qty.
1.	26-1009-9282-0	Knob for BASELINE	1
2.	78-8005-3304-0	Set Screw, 6-32 x 1/4	1
3.	18-3412-1915-4	Set Screw, 6-32 x 3/16	2
4.	78-8067-7172-7	Knob for RATE, WIDTH	2
5.	26-1009-9104-6	APM Seal	3
6.	78-8067-4387-4	Graphics	1
7.	78-8067-4349-4	Upper Housing	1
8.	12-7996-8598-2	Truss Head Screw,4-40 x 3/16	4
9.	78-8067-6149-6	Lower Housing	1
10.	78-8067-4385-8	PC Asby, Main Board	1
11.	78-8067-4666-1	Cable Asby, Pulse/Pump	1
12.	26-1008-0213-6	Strain Relief	1
13.	78-8067-4379-1	Cable Asby, Internal Pulse	3
14.	78-8067-7068-7	Cable Asby, LED for Pulse	1
15.	78-8067-6392-2	Foot	2