user manual

# MegaBACE

Service Manual
Revision 2
March 2001

um 63003662 (MD# 325-202)

molecular dynamics
part of Amersham Pharmacia Biotech

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March 2001

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# Part One

## Instrument Description

# Chapter 1 General Information

## 1.1 About This Manual

### 1.1.1 Overview

MegaBACE is a system of instrument models that provides the customer with different levels of performance. The basic instrument is the Flexible MegaBACE 1000. The other models are the Flexible MegaBACE 1000, the MegaBACE 2000, and MegaBACE 500. The three models are nearly identical and, with few exceptions, the data in this manual applies to all models. When differences between the basic model and one of the other models occur, these differences are described in the manual. Technical overviews for the instrument's components and subsystems include the following:

- ***Part One—Instrument Description:*** A functional and physical description of the instrument, including environmental requirements and instrument specifications.
  - Chapter 1—General Information
  - Chapter 2—Physical and Functional Overview
- ***Part Two—Theory of Operation:*** Identification and discussion of the instrument's optical, mechanical, pneumatic, and electronic components and assemblies. Detailed block diagram analyses of the instrument printed circuit boards are included.
  - Chapter 3—Optics
  - Chapter 4—Mechanics
  - Chapter 5—Electronics
- ***Part Three—Maintenance:*** Procedures for operating, troubleshooting, servicing, and repairing the instrument. Also includes procedures for upgrading the basic instrument and procedures for converting the basic instrument to one of the two other models.
  - Chapter 6—Operation
  - Chapter 7—Troubleshooting
  - Chapter 8—Service, Alignment, and Conversions
  - Chapter 9—Repair

***Service Bulletins:*** A location for follow-up information.

### 1.1.2 Note, Caution, and Warning Statements

**Note**, **Caution**, and **Warning** statements appear throughout this manual and are defined as follows:

- **Note**—Emphasizes or expands upon the information presented.
- **Caution**—Informs personnel of actions that may result in equipment damage.
- **Warning**—Alerts personnel to potentially hazardous conditions that may result in personal injury.

## 1.2 Before Proceeding

### 1.2.1 Required Reading

Before attempting any service or repair to the MegaBACE instrument, you must read, fully understand, and fully comply with the following publications supplied with the instrument:

- *Sequence Analyzer User's Guide*
- *Genetic Profiler User's Guide*
- *Instrument Operator's Guide*
- *Instrument Administrator's Guide*
- *Instrument Maintenance and Troubleshooting Guide*

Only by reading these publications and fully understanding the proper installation and use of the instrument can you determine, isolate, and correct problems. Frequent reference will be made to these publications throughout this manual.

### 1.2.2 Intent

This service manual is intended for use by qualified and authorized Service Personnel for the maintenance and repair of the MegaBACE instrument, hereinafter referred to as the "instrument."

### 1.2.3 Warranty

Any attempt to use the information in this manual by unauthorized personnel for the repair of these systems will void the system warranty.

## 1.3 Assistance

When calling for assistance, be prepared to supply the serial number of your instrument. The serial number is located on the lower right side of the instrument near the plug. Please use one of the telephone numbers below.

**United States and Canada**
Molecular Dynamics
928 East Arques Avenue
Sunnyvale, California 94085-4520
Telephone (1) (800) 743-7782 or (1) (408) 773-1222
Fax (1) (408) 773-0152
Ask for Molecular Dynamics (MD) MegaBACE Technical Support

**United States and Canada**
800 Centennial Avenue
P.O. Box 1327
Piscataway, New Jersey 08855
Telephone (1) (800) 526-3593
Fax (1) (732) 457-0557

**United Kingdom**
Amersham Pharmacia Biotech UK Limited
Amersham Place, Little Chalfont
Buckinghamshire, England HP7 9NA
Telephone (44) (1494) 544000
Fax (44) (1494) 542266

**Scandinavia**
Amersham Pharmacia Biotech AB
SE-751 84 Uppsala Sweden
Telephone (46) 18 612 0000
Fax (46) 18 612 1920

**Europe**
Amersham Pharmacia Biotech Europe GmbH
Munzinger Strasse 9
Postface 5480
D-790 21 Freiburg Germany
Telephone (49) 761 490 30
Fax (49) 761 490 3159

**Eastern Europe and CIS**
Amersham Pharmacia Biotech Export GmbH
Wurzbachgasse 18
A-1152 Vienna Austria
Telephone (43) (1) 982 3826
Fax (43) (1) 985 8327

**Middle East and Africa**
Amersham Pharmacia Biotech GmbH
P.O. Box 70051
GR-166 10 Glyfada Greece
Telephone (30) (1) 9600687
Fax (30) (1) 9600687

**Asia Pacific**
Amersham Pharmacia Biotech Asia Pacific
15/F, North Cornwall House, Taikoo Place
979 King's Road
Quarry Bay, Hong Kong
Telephone (852) 2811-8693
Fax (852) 2811-5251

**Japan**
Amersham Pharmacia Biotech K.K.
Sanken Bldg
3-25-1, Hyakunincho
Shinjuku-ku Tokyo
Japan 169-0073
Telephone (81) (3) 5331-9344
Fax (81) (3) 5331-9368

**Australia and New Zealand**
Amersham Pharmacia Biotech
Unit 38 5-7 Anella Avenue
Castle Hills New South Wales 2154
Australia
Telephone (612) 9894-5188

**Latin America**
Amersham Pharmacia Biotech do Brasil Ltda
Rua Brigadeiro Galvao, 288
Barra Funda
SP Brazil 01151-001
Telephone (55) 11 3667-5700
Fax (55) 11 3667 5899

**Web site**
http://www.mdyn.com

## 1.4 Safety

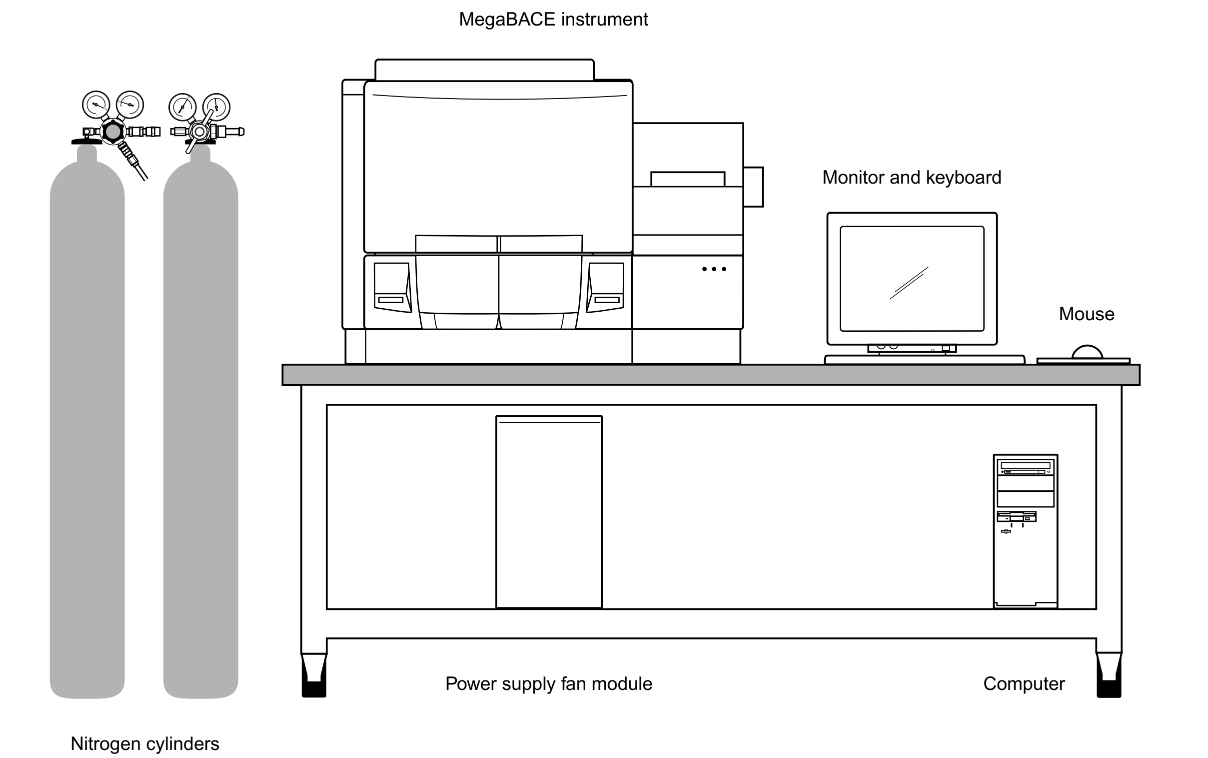
The primary hazard involved with the maintenance or repair of the instrument is exposure to dangerous chemicals, hot surfaces, laser light, high-pressure gas, and broken glass. Safety labeling on the instrument warns of these conditions.

Follow all procedures, warnings, and cautions when servicing this instrument.

# Chapter 2 Physical and Functional Overview

## 2.1 Introduction

The MegaBACE instrument (figure 2-1) is a high-throughput capillary array electrophoresis (CAE) system that performs automated DNA sequencing and automated genotyping/fragment analysis. DNA fragments labeled with up to four different fluorescent dyes are detected in real time in up to 16-capillary arrays. Emission data are analyzed and the result is either DNA sequence information or DNA fragment/genotype information.




**Note:** In addition to the components shown, an uninterruptible power supply (UPS) is recommended.

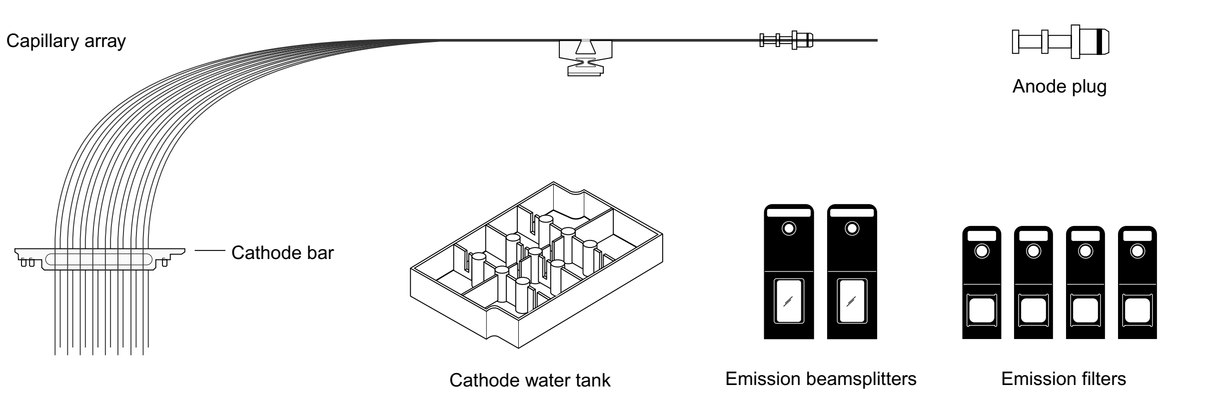



Figure 2-1. The MegaBACE Instrument.

## 2.2 Hardware Components

The instrument hardware includes the following components:

- **The MegaBACE Instrument**—Electrophoresis components and temperature-regulation system, lasers and light collection optics, and scanner electronics.
- **Power Supply Fan Module—**Blue-laser power source and fan for cooling the laser.
- **Computer—**Computer, monitor, keyboard, and mouse (bar-code scanner recommended).
- **Other Components Shipped with all MegaBACE (MB) Instruments—**Capillary arrays, cathode tank, anode blockers, and emission beamsplitters and filters.
- **Other Components Shipped with the Flexible MB 1000 and MB 500 Instruments—** Cathode plunging tools, window blanks, anode sleeves, and plastic anode cover (MB 500 only).

The instrument also requires a locally acquired source of compressed nitrogen.

## 2.3 System Functions

The MegaBACE instrument and the computer work interactively to perform the following functions—

- Fill the capillaries with matrix, remove spent matrix, and maintain the capillaries between runs and during inactive periods.
- Load and electrophorese samples, continuously scan the array of capillaries, and collect and record current and fluorescent readings for each capillary.
- Display the capillary array four-color fluorescence data during the run.

The instrument has a cathode stage that holds a sample plate for loading samples into the capillaries. The cathode stage can also hold a multiwell tank that is used to collect water or spent matrix when the capillaries are cleaned after a sample run. The instrument also has an anode stage that holds vessel(s) from which matrix or water is pushed through the capillaries. Each stage is raised and lowered by pneumatic (nitrogen) pressure. After a stage is lowered, it is accessible from the front of the instrument through an access door.

## 2.4 Capillary Array Electrophoresis

### 2.4.1 Capillary Arrays

Figure 2-2 is a simplified illustration of one 16-capillary array and its relationship to the other major scanning components.

The capillaries are grouped in arrays, each containing 16 capillaries. At the anode end of each array, the 16 capillaries are grouped together and epoxied into an anode plug. The capillaries extend from the ends of the anode plugs, which are clamped into recesses at the top of the anode cover. The anode cover and the anode vessel holder make up a high-pressure chamber. The anode vessel holder contains recesses for sample vessel(s). The vessel(s) can be changed to allow matrix or water to be injected into the capillaries. During operation, the anode vessel holder is raised to press against the top of the anode cover and sealed to form a high-pressure chamber. The capillaries extend into the vessel(s), and when the chamber is pressurized, the mixture in the vessel(s) is forced through the capillaries. Each capillary has a clear detection window, through which the sample is scanned. The window is located a fixed distance from the sample loading point, and the capillaries are glued to a small plastic bracket called a window holder. Multiple window holders are mounted side by side.

At the other end of the array, the capillaries are separated into two rows of eight and secured in a cathode array holder (also called a cathode bar.) Multiple arrays are clamped together to form the complete capillary array. The end of each capillary extends down into a well of a multiwell sample plate. Next to each capillary is an electrode that extends into the same sample well.

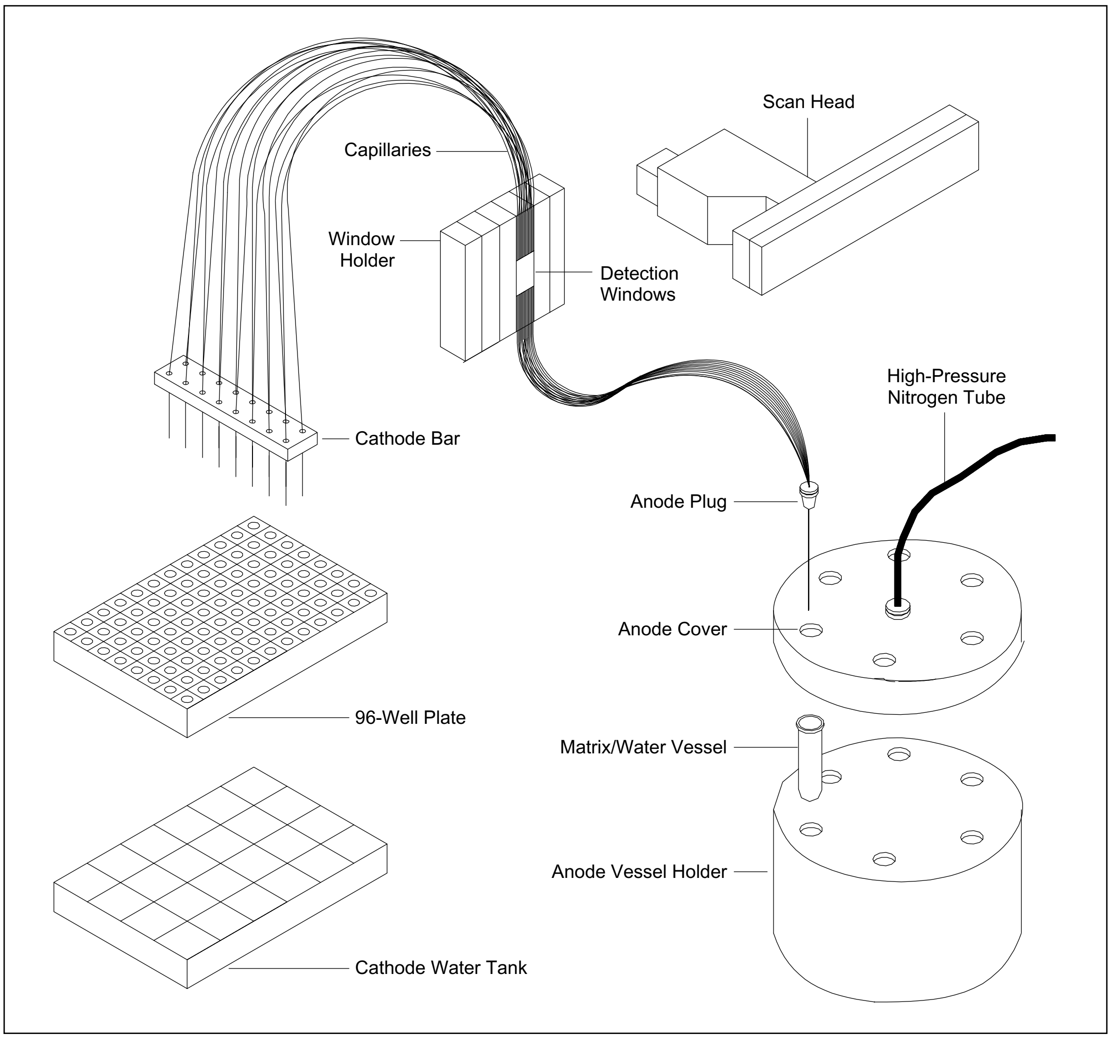



Figure 2-2.  Capillary Array.

### 2.4.2 Capillary Electrophoresis

In capillary electrophoresis, a sieving matrix is injected into the capillaries in the high-pressure chamber. A small amount of DNA material is pulled into the other end of the capillaries by a pulse of electric current. When a high voltage is applied through the capillaries, electrophoresis occurs, and the samples migrate through the capillaries. The detection window is scanned, and the components of the sample are detected as they migrate past the detection window.

### 2.4.3 Replaceable Matrix

The matrix in the capillaries can be replaced without replacing the capillaries. Capillaries can be emptied and refilled using a semi-automated, pressure-controlled process. Typically, after a run, the multiwell sample plate is replaced with a cathode tank. The spent matrix is forced out of the capillaries, and the capillaries are then rinsed with water. The water is injected into the capillaries from the high-pressure chamber and collected at the other end of the capillaries. New matrix can then be injected into the capillaries.

## 2.5 Instrument Models

There are three different MegaBACE instrument models. They are:

- **MegaBACE 1000—**This is the basic model, hereafter called the MB 1000. It has a capacity of 96 capillaries, grouped in six 16-capillary arrays.
- **Flexible MegaBACE 1000—**This is the basic model that has been designed to work with from one to six capillary arrays. It has a total capacity of 96 capillaries, grouped in a maximum of six 16-capillary arrays. When using less than six capillary arrays, the array positions are filled in descending order starting with position six. In the flexible MB 1000, the anode uses anode blockers to fill in for the reduced number of arrays and cylindrical anode sleeves are inserted in the unused anode stage receptacles. These sleeves prevent the insertion of vials of buffer into reservoirs that do not have a matching set of capillaries. Cathode plunging tools, used for cleaning the cathode holes, are added to the array stage to fill the spaces left by the missing capillary arrays. The cathode plunging tools prevent the evaporative loss of buffer. Window blanks are used on the window holder platform to fill in for the missing capillary windows. Each of the window blanks has 16 short pieces of capillary epoxied to them to simulate actual capillaries. The pieces of capillary are filled with a fluorescent material that enables the instrument to register the relative positions of the real capillaries.
- **MegaBACE 2000—**Hereafter called the MB 2000, this model is also sometimes called the 4x96 and is based on the MB 1000. It has the same capacity of 96 capillaries but has a modified cathode assembly that can handle a 384-well plate. The MB 2000 cathode assembly has pneumatic pistons that move the well plate in the y direction (forward and back) and in the x direction (side to side) to select one of four sets of 96 wells. There is also a pneumatic piston that raises the capillaries out of the sample plate wells before the sample plate is moved and lowers the capillaries after the move. Another pneumatic piston is actuated to lock the sample-plate slide in position during repositioning of the sample plate. These pneumatic pistons are actuated by a system of solenoids under software control. The cathode assembly has several additional sets of sensors (optical) that indicate the x and y positions of the 384-well plate. The interface board has been modified to

provide additional drivers for the solenoids and a new 50-wire interface cable is provided to support the expanded interface. The new interface board is backwards compatible and can be used with the original version of the cathode assembly.

- **MegaBACE 500—**Hereafter called the MB 500, this model is an MB 1000 that has been modified during installation to accept only one, two, or three 16-capillary arrays giving it a capacity of only 16, 32, or 48 capillaries. Like the flexible MB 1000, the MB 500 uses anode blockers, cylindrical sleeves, window blanks, and cathode plunging tools to fill the spaces left by the missing capillary arrays. A plastic anode cover is provided with the MB 500 to cover the three unused anode blockers leaving three available positions open for use. The MB 500 can be converted by a service engineer back to a MB 1000 by removing the plastic anode cover, removing the anode blockers and sleeves, removing the cathode plunging tools and window blanks, and installing the full complement of capillary arrays.

## 2.6 Instrument Characteristics

The instrument consists of five main functional areas—the enclosure, optics, mechanics, pneumatics, and electronics.

### 2.6.1 Enclosure

The physical dimensions are:

- **Height**—812 mm (32 in)
- **Width**—1028 mm (40.5 in)
- **Depth**—711 mm (28 in)
- **Weight—**Uncrated: 273 kg (600 lb), Crated: 318 kg (700 lb)

Figure 2-3 illustrates the location of the doors and lid used during routine operation of the instrument.

The instrument has the following access ports:

- **Service Door—**Provides access to the electrophoresis compartment for cleaning and for replacing the capillary arrays.
- **Cathode Door**—Provides access to the cathode for loading sample plates or collection tanks.
- **Anode Door**—Provides access to the anode for loading vessels of matrix or water.
- **Filter Door**—Provides access to the filter compartment for changing filters and beamsplitters.
- **Air Filter Port**—Provides access for removing or replacing the instrument air filter.

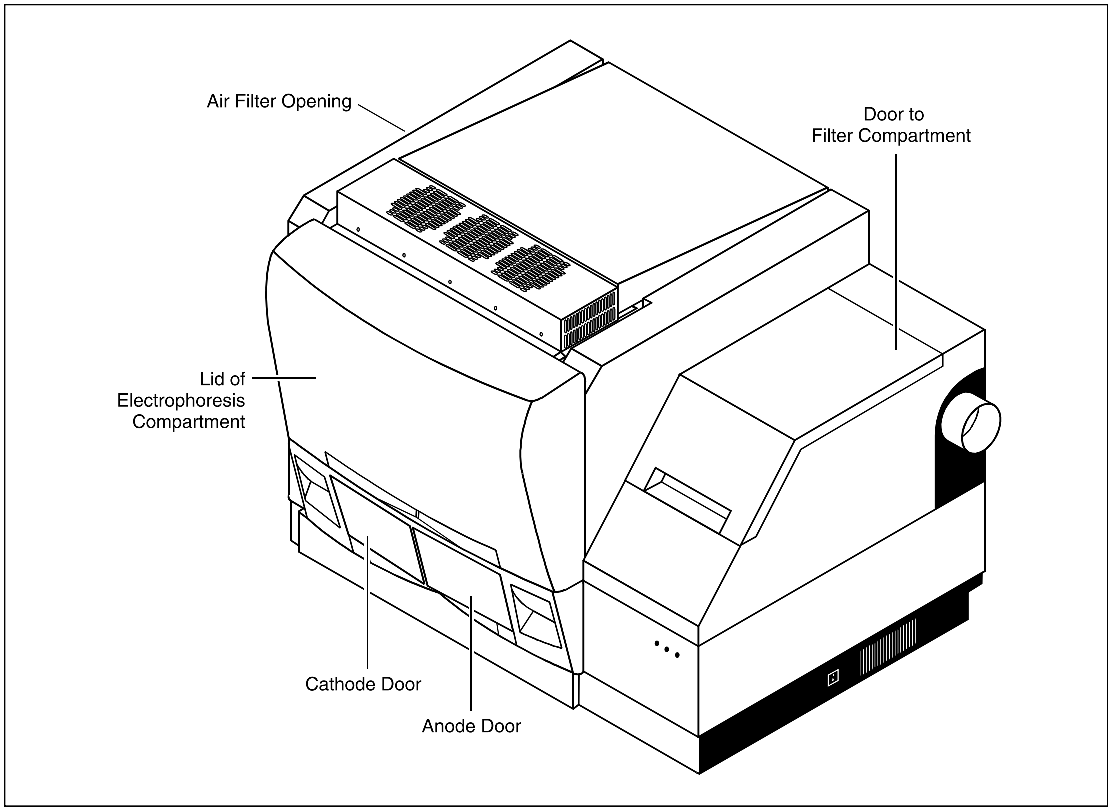



Figure 2-3. Instrument Enclosure.

### 2.6.2 Optics

The instrument is capable of simultaneously detecting up to four different wavelengths of light emitted from the excited samples in the capillaries. Figure 2-4 is a simplified block diagram of the instrument optics. The instrument optics consist of:

- A blue and/or a green laser to provide excitation.
- A three-position motor-driven shutter that selects between the two lasers or stops the laser light from both lasers. When both lasers are used, one laser is selected when the scan head is making its forward pass, and the other laser is selected when the scan head is making its reverse pass.
- Three mirrors and a beam combiner to direct the laser beams.
- A motor-driven primary beamsplitter changer that switches between the blue and green laser beams in synchrony with the scan head. The beamsplitter passes the associated excitation light and reflects the emitted light. Each beamsplitter has an accompanying filter that blocks the excitation light from the emission path.
- A motor-driven scan head that contains an objective lens that is moved back and forth across the capillaries. The objective lens focuses the laser light onto the capillaries and collects the resulting emitted fluorescent light.
- A motor-driven focusing system that moves the capillaries closer to or farther from the objective lens to focus the laser light accurately into the capillaries.

- A capillary detection system, consisting of a beamsplitter, filter, and photodiode, that uses excitation light reflected from the capillaries to provide an accurate position of the capillaries.
- Two achromatic lenses and a pinhole. This group of optical components defines the wavelength and beam size of the emitted light.
- A motor-driven secondary beamsplitter changer that selects one of two replaceable beamsplitters in synchrony with the scan head. Each beamsplitter passes one of a pair of emitted wavelengths of light and reflects the other wavelengths.
- Two motor-driven filter changers, each of which selects one of two replaceable filters. These filter changers operate in synchrony with the scan head.
- Two photomultiplier tubes (PMTs) that detect the emitted light and generate signals that represent the intensity of the light detected.

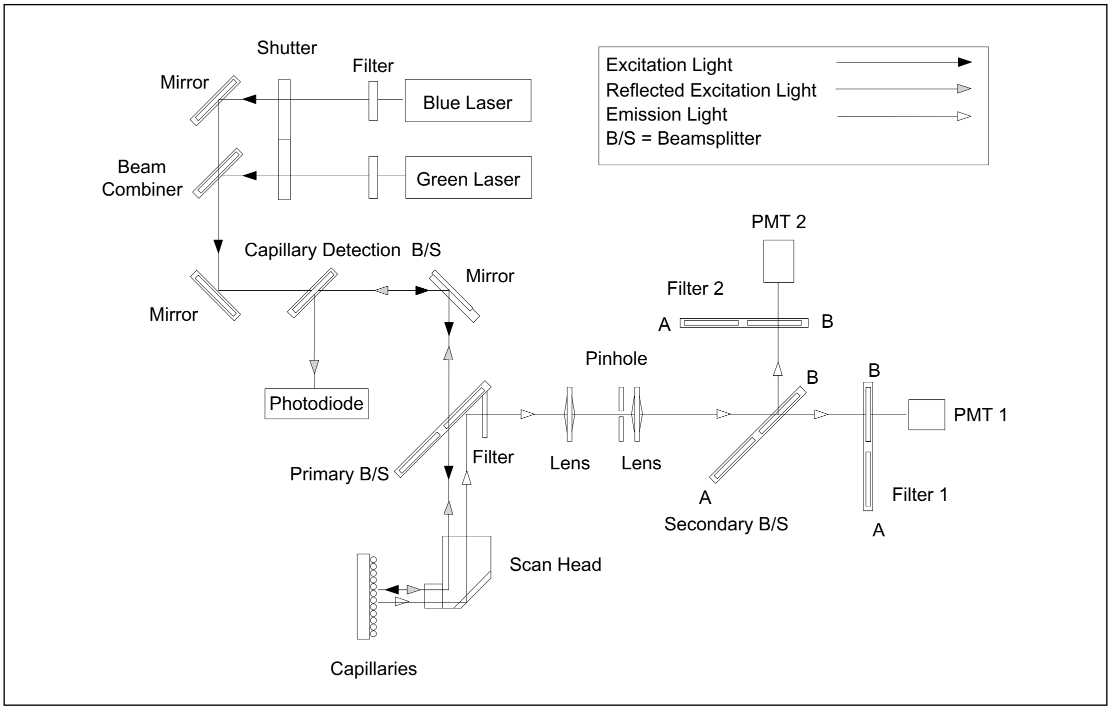



Figure 2-4. Optics, Simplified Block Diagram.

With two lasers, a three-position shutter, and switchable beamsplitters and filters, the instrument provides a variety of scanning modes. The scan head collects data in the forward and reverse directions. Switching of the optical components occurs while the scan head is changing directions.

### 2.6.3 Mechanics

The instrument mechanics consist of the following components:

- **Scan-head drive assembly—**The scan-head drive assembly consists of the scan head, stepper motor, drive belt and pulleys, and position sensors. One of the sensors is the home sensor, and the other two sensors signify the start and end of data collection for the forward and reverse strokes of the scan head.
- **Motor-driven focusing system—**The focusing system consists of a drive motor, pulleys, drive belt, screw assembly, and position sensors. As the drive motor turns, the drive belt turns the screw assembly, which moves the capillary window platform closer to or farther from the objective lens. The operator performs the focusing procedure by performing a short test scan and then using the diagnostic software to evaluate the data collected to determine the optimum position of the capillaries with respect to the objective lens. The operator then uses the software to command the appropriate changes to the position of the capillary window platform.
- **Three-position shutter assembly—**The three-position shutter assembly consists of the shutter, stepper motor, and position sensor. The position sensor detects the home position of the shutter. The shutter has three positions. In the home position, the beams from both lasers are blocked. In the other two positions, the shutter places a hole in the path of one laser beam and blocks the other laser beam. When both lasers are used, the shutter operates in synchrony with the scan head to pass the beam from one laser while blocking the beam from the other laser.
- **Primary beamsplitter changer assembly—**The primary beamsplitter changer assembly consists of a stepper motor, an arm that holds two beamsplitters, and a position sensor. The beamsplitter changer has three positions. The home position allows operator access to the beamsplitters. The other two positions place one of the beamsplitters in the path of the laser beam.
- **Secondary beamsplitter changer assembly—**The secondary beamsplitter changer assembly consists of a stepper motor, an arm that holds two beamsplitters, and a position sensor. The beamsplitter changer has three positions. The home position allows operator access to the beamsplitters. The other two positions place one of the beamsplitters in the path of the emitted light.
- **Filter changer assemblies—**The filter changer assemblies are identical and consist of a stepper motor, an arm that holds two filters, and a position sensor. The filter changer has three positions. The home position allows operator access to the filters. The other two positions place one of the filters in the path of the emitted light.
- **Cathode and anode pneumatic positioning systems—**The cathode and anode pneumatic positioning systems are very similar. Each system has a piston operating inside a cylinder. The piston is moved up and down by the application and/or release of pneumatic pressure. Each system has sensors that detect the positions of the stages. The cathode assembly for the MB 2000 has additional pneumatic systems for positioning the 384-well plate, locking the slide assembly during well plate positioning, and raising and lowering the array stage during and after well plate positioning.
- **Anode cover clamp-lock assembly—**The clamp-lock assembly is driven by a motor and drive belt to clamp the anode cover to the anode vessel.

- **Laser and enclosure cooling fans—**Cooling for the blue laser comes from a fan located in the blue-laser power supply fan module. The enclosure fan blows air through the electrophoresis compartment for both cooling and heating.

### 2.6.4 Electronics

Figure 2-5 is a simplified functional block diagram of the electronics system. The electronics system of the instrument is built around an Echelon™ Neuron™ network. An internal computer provides system control and consists of a passive backplane with a standard ISA bus, Pentium™ CPU, SCSI interface, two analog interface boards, and an Echelon Neuron network interface board. The internal computer is connected to an external workstation via a SCSI interface.

One analog interface board processes the data from the two PMTs and a second analog interface board processes the data from the capillary detection photodiode. Each of these boards interfaces with the internal computer through one of the ISA slots.

The optical sensors and solenoids in the dashed box in figure 2-5 are only used in the MB 2000 instrument.

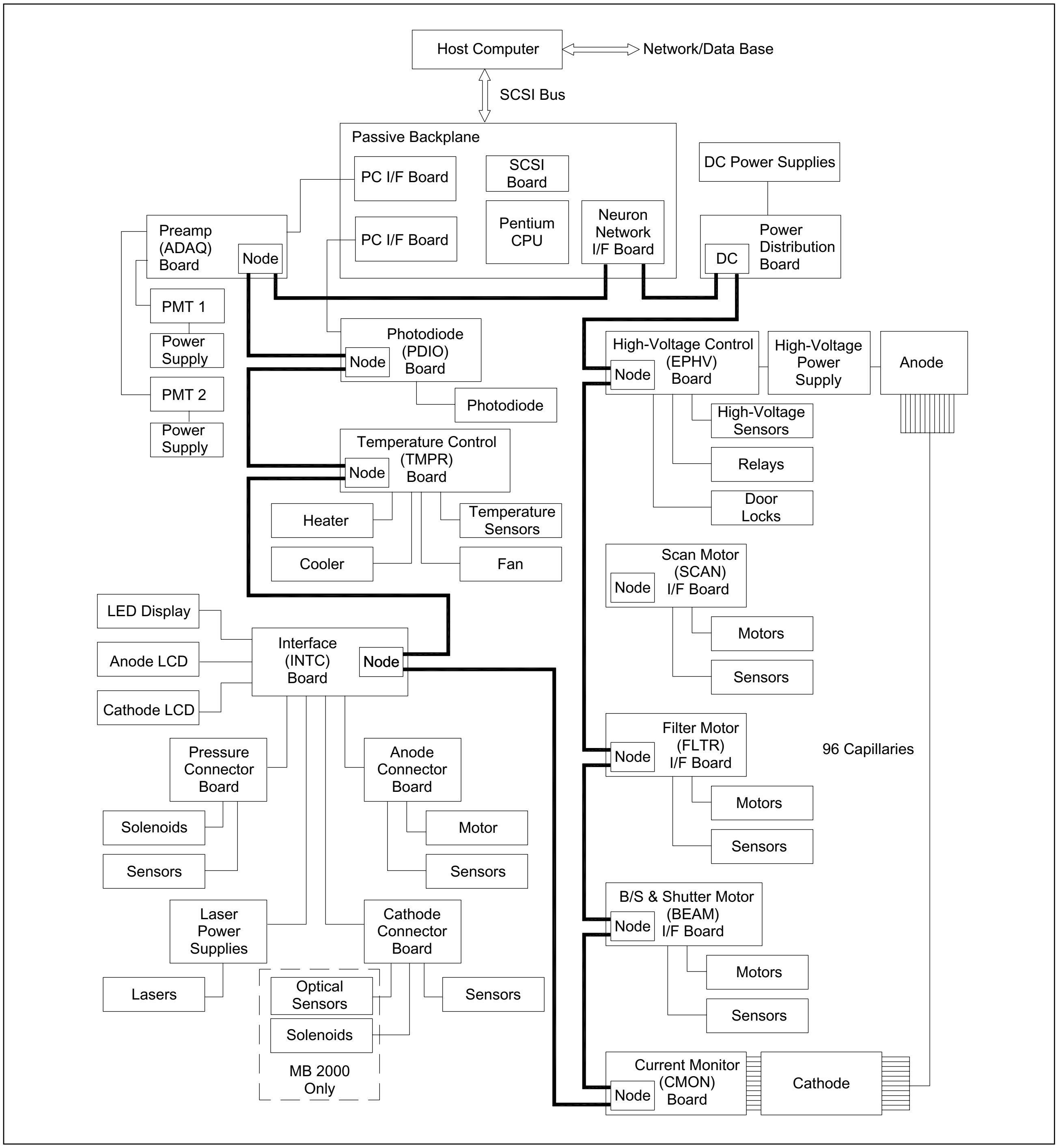



Figure 2-5. Electronics, Simplified Block Diagram.

The Echelon Neuron network interface board also interfaces with the internal computer through one of its ISA slots. This board controls the Neuron network, which consists of the following components:

- Power-distribution board. (This board is not part of the Neuron network. It is connected into the network to provide DC power to some of the network boards.)
- High-voltage control (EPHV) board.

- Scan-motor interface (SCAN) board.
- Filter-motor interface (FLTR) board.
- Beamsplitter (B/S) and shutter-motor interface (BEAM) board.
- Current monitor (CMON) board.
- Interface (INTC) board.
- Temperature-control (TMPR) board.
- Preamp (ADAQ) board.
- Photodiode (PDIO) board.

Each board in the Neuron network has an Echelon microprocessor that controls the board and a flash memory chip that identifies the characteristics of the board. The microprocessor and flash memory comprise a node, and all nodes are connected together by a daisy chain of serial cables. Each board in the Neuron network is wired directly to the functions that it controls and to the various circuits that provide the board with information. In nine of the boards listed above, the abbreviated name of the board appears in capital letters in parentheses. These abbreviations are used throughout the manual.

### 2.6.5 Pneumatics

Figure 2-6 is a simplified functional block diagram of the pneumatics assembly. The pneumatics assembly provides high- and low-pressure nitrogen to the anode stage and low-pressure nitrogen to the cathode stage. Control of the pneumatic assembly is from the sensor-interface board. A low-pressure connection is also provided to release the latch to the service door. The latch is released using software controlled from either the Scan diagnostic software or the Instrument Control Studio.

The pneumatic assembly has two pressure input lines at 1000 psi and at 100 psi. The instrument comes with a regulator to reduce the pressure to 12 psi for low pressure.

The pneumatic assembly performs the following functions:

- Pressurizes the anode stage to 1000 psi to force the matrix solution through the capillaries.
- Uses a pressure transducer to provide a voltage feedback to the pressure control system that is proportional to the pressure in the high-pressure line.
- Supplies 100 psi of pressure to raise and lower the anode stage.
- Senses the pressure in the 100-psi line and provides an error signal if the pressure falls too low.
- Regulates the 100-psi pressure to 12 psi or 30 psi and supplies this pressure to raise and lower the cathode stage.
- Pressurizes the anode stage to 12 psi or 30 psi to force water through the capillaries during the capillary-cleaning process.
- Purges the high-pressure and low-pressure lines.
- Opens the service door.

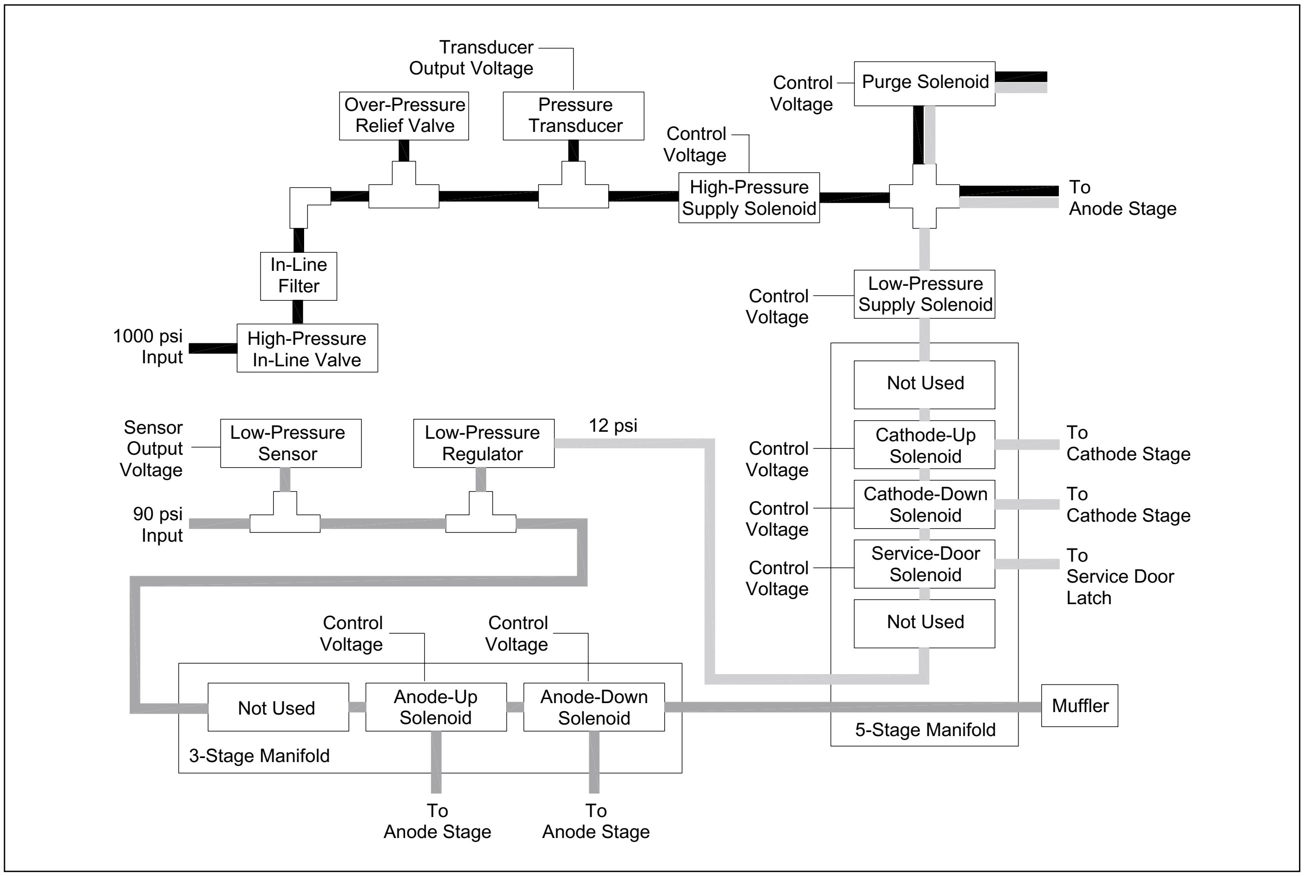



Figure 2-6. Pneumatics, Simplified Block Diagram.

### 2.6.6 Pneumatics (MB 2000)

Figure 2-7 is a simplified functional block diagram of the pneumatics located on the MB 2000 cathode assembly. Besides the system for raising and lowering the cathode, the MB 2000 cathode assembly has four additional pneumatic systems that control the indexing of the 384-well plate. Two of the pneumatic systems control the x and y positions of the well plate, one system controls the up and down movement of the array stage, and one system controls the movement of a slide assembly lock. The pneumatic systems are controlled by supplying nitrogen pressure from seven pneumatic solenoids attached to an 8-port air manifold. The nitrogen pressure comes from a tee connector on the 100-psi line near the main pneumatics module. The control voltages that energize the solenoids are from connectors on the cathode interface board.

The pneumatic system that controls the raising and lowering of the array stage has flow controls on both of the pressure lines. The flow controls adjust the speed at which the array stage raises and lowers.

The slide assembly lock consists of a cylinder with a one-way, spring-loaded piston. Before the well plate is moved, the piston in the slide assembly lock is extended into a hole in the slide assembly. This piston holds the slide assembly steady while the well plate is moved to a new position.

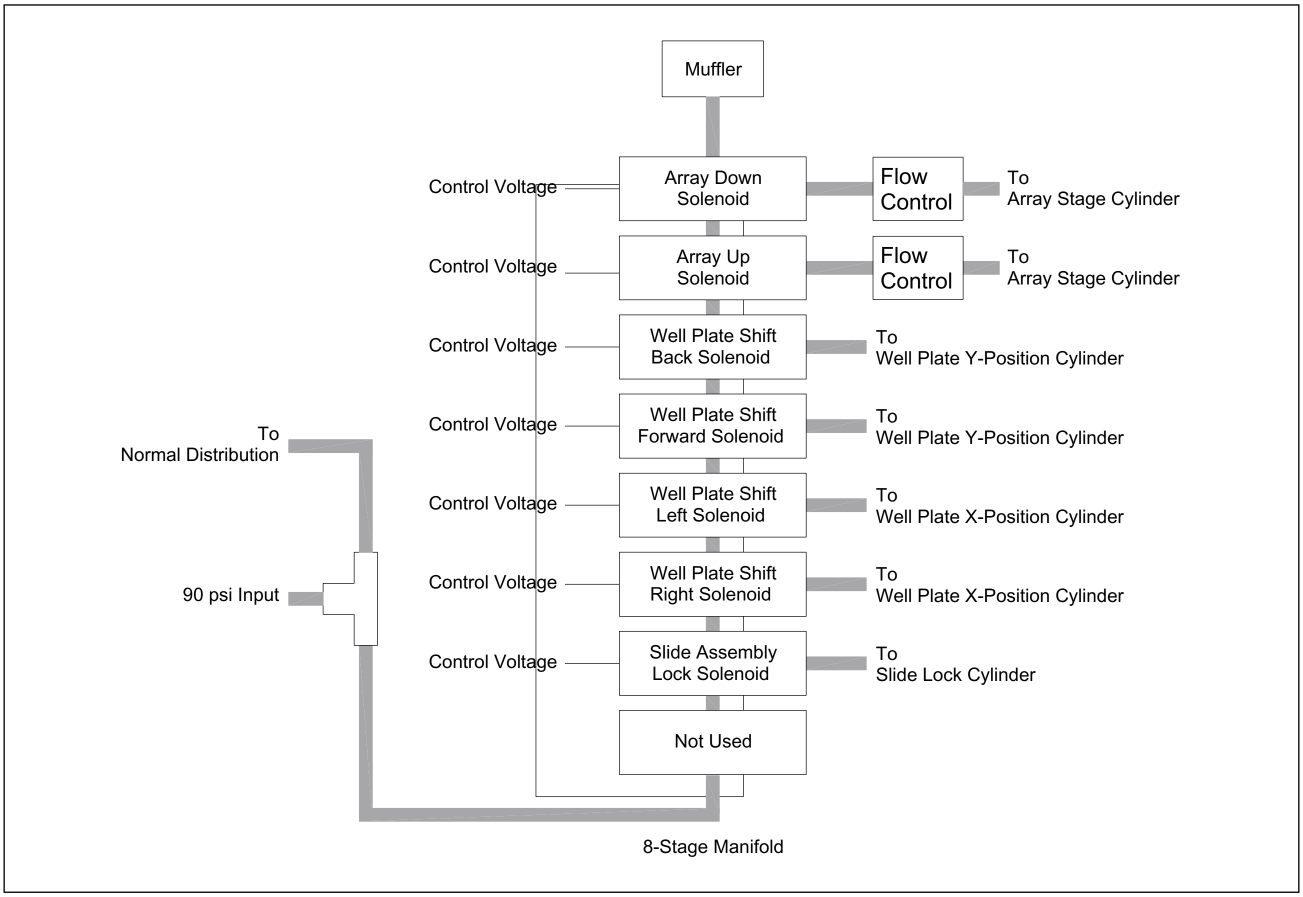



Figure 2-7.  MB 2000 Cathode Pneumatics, Simplified Block Diagram.

## 2.7 Instrument Specifications

### 2.7.1 Environmental Requirements

- **AC Power**
  - **Instrument**—200 to 240 VAC, 6 Amps, 50 to 60 Hz, single phase
  - **Power Supply Fan Module**—180 to 229 VAC or 230 to 264 VAC, 10 Amps, 50 to 60 Hz, single phase
- **Operating Temperature Range—**20 to 25˚ C
- **Operating Humidity Range—**≤ 80% noncondensing
- **Vibration—**Special isolation devices are not necessary, but specified spatial reproducibility may not be obtained

### 2.7.2 Chamber Operating Temperature

Controllable from room temperature to 44˚ C

### 2.7.3 Light Sources

- **Blue—**488 nm, 20 mW argon ion laser
- **Green—**532 nm, 40 mW solid-state diode laser

### 2.7.4 Detection

Two PMTs, four color channels

### 2.7.5 Dynamic Range

16 bits (65,556), linear to +/–5%

### 2.7.6 Sensitivity

1.0 fmole fluorescein and HEX end-labeled DNA (23-mer) primer in 15% polyacrylamide gel

### 2.7.7 Capacity

- **Flexible MB 1000—**16, 32, 48, 64, 80, or 96 samples
- **MB 1000 and MB 2000—**96 samples per run
- **MB 500—**16, 32, or 48 samples

### 2.7.8 Capillary Arrays

- **MB 1000 and MB 2000—**six arrays, 16 capillaries per array
- **Flexible MB 1000—**one through six arrays, 16 capillaries per array
- **MB 500—** one, two, or three arrays, 16 capillaries per array

### 2.7.9 Electrophoresis

Up to 500 V/cm (20,000 V)

### 2.7.10 Turnaround Time, Sequencing

Less than 2 hrs

### 2.7.11 Analysis Time (Software)

Less than 5 min per run (96 capillaries)

### 2.7.12 Sequencing Read Length

Greater than 600 bases

### 2.7.13 Sequencing Accuracy

Greater than 98.5% @ 500 bases

### 2.7.14 Total Capacity, Sequencing (MB 1000)

384 samples per day (4 runs) x 500–600 bases = 192–230 kb/day

### 2.7.15 Unattended Operation (MB 1000)

96 samples per run = 48–57 kb

### 2.7.16 Sizing Accuracy

100–600 bases @ +/– 0.2 bp

#### 2.7.17  Sizing precision

100–600 bases @ +/– 0.2 bp

#### 2.7.18  Dyes

Energy transfer labeled primers

#### 2.7.19  Biological reagents

Thermo Sequenase™, DYEnamic™ primers (Amersham), DNA Sequencing kits, termination mixes

#### 2.7.20  Gel Reagents

Linear polyacrylamide (LPA)

#### 2.7.21  Data Display

Real time, all samples

## 2.8  Host Computer System Specifications

MegaBACE supports the Microsoft™ Windows NT™ configuration which allows for both instrument control and data analysis.

Each MegaBACE instrument was shipped with a computer system capable of running the needed software. The latest computer specifications are:

- **Operating and Data Analysis System—**Microsoft Windows NT 4.0 (Workstation or Server)
  - Dell™ OptiPlex™ GX1 600 (9/99)
  - 600MHz Pentium III (Intel 440BX 100MHz chipset)
  - RAM: 128MB, non-ECC SDRAM 100MHz (1 DIMM)
  - Hard Drive: 13.6GB DMA/EIDE Hard Disk Drive (minimum)
  - CD ROM: 17/40X EIDE or faster
  - Floppy Disk Drive: 3.5”
  - O/S: Windows NT 4.0 SP5
  - Third Party Software: Microsoft Office 2000 Professional Edition
  - Video Adapter: Integrated 2X AGP ATI Rage™ Pro with 8 MB
  - SCSI Adapter: Adaptec™ AHA-2930U
  - Network Adapter: Integrated 3Com™ 10/100 Fast Etherlink™
  - Sound Card: Integrated CrystalWare Pro

### 2.8.1 Diagnostics Software

Three diagnostic software programs are available. One of these programs is called Scan and is run on the workstation in a DOS window. Scan consists of a series of nested menu screens from which you can select commands that perform most of the instrument's mechanical and electrical operations. Many of the commands read back instrument parameters to the screen.

The second of these programs is called the Instrument Control Studio (ICS). The ICS is a Windows Graphical User Interface that allows you to perform many of the same operations as Scan, by selecting from a series of icons in the ICS window.

The third program is called Echtest. This program tests the instrument Neuron network.

# Part Two

## Theory of Operation

# Chapter 3 Optics

This chapter describes the optical system used in the MegaBACE instrument. However, to understand fully how the optics function in relation to the electrophoresis process, refer to chapter one and appendix A of the administrator's guide.

## 3.1 Introduction

The instrument uses a confocal optical system to detect the fluorescent properties of the treated DNA samples. The optical system detects the DNA samples as the samples electrophorese past the capillary detection windows.

## 3.2 Excitation and Emission Wavelengths

The instrument uses two lasers, an argon-ion laser that emits 488-nm (blue) light and a diode laser that emits 532-nm (green) light. During an electrophoresis run, the instrument can use either laser alone or can alternate between the two lasers. In the latter case, the instrument illuminates the capillaries with the blue light as the scan head sweeps in one direction and with the green light during the return scan. In some instruments only a single laser is available.

To allow accurate detection and separation of the signals, the instrument uses a set of fluorescent dyes that are:

- Excited at the 488-nm or 532-nm laser lines.

  For a four-color sample, the operator can use any of the following combinations:

  - Four dyes excited at 488 nm.
  - Four dyes excited at 532 nm.
  - Two dyes excited at 488 nm plus two dyes excited at 532 nm.

- Emitting light of significantly different wavelengths.

## 3.3 Emission Beamsplitters and Filters Overview

The instrument uses beamsplitters and filters (figure 3-1) to determine the wavelengths of light recorded in each channel of the detection system. The operator selects and loads the emission beamsplitters and filters.

### 3.3.1 Emission Beamsplitters

Dichroic beamsplitters separate light by wavelengths. Each beamsplitter has a specified wavelength cutoff—

- Light with wavelengths longer than the cutoff passes through the beamsplitter.
- Light with wavelengths shorter than the cutoff is reflected by the beamsplitter.

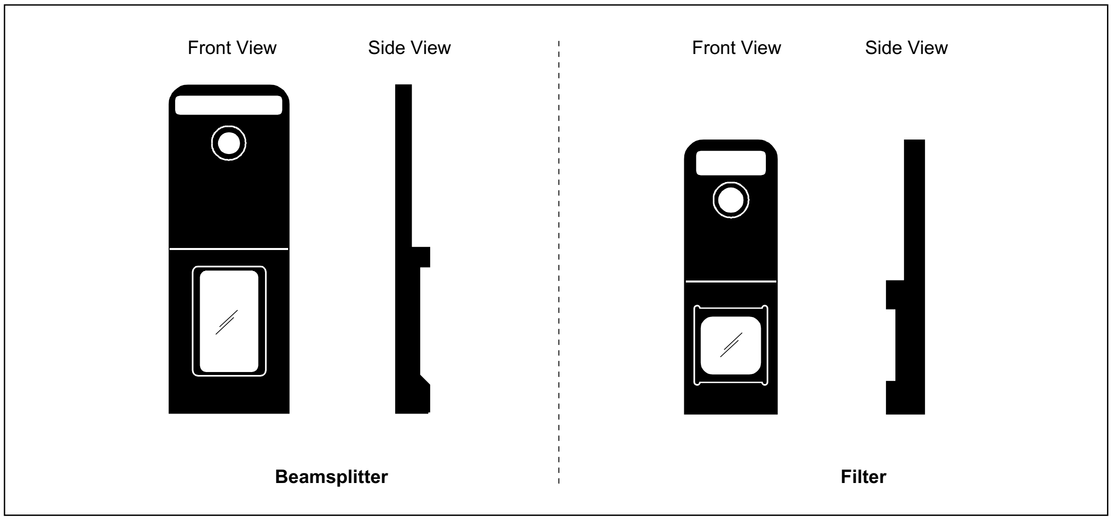



Figure 3-1. Emission Beamsplitter and Filter.

### 3.3.2 Emission Filters

Emission filters are used in the instrument because—

- The separation of light by the beamsplitter is imperfect.
- When the sample contains three or four dyes, the light leaving the beamsplitter will include the emissions from several dyes.

The two types of emission filters used in the instrument are—

- **Band-pass**—Rejects most of the light with wavelengths shorter than a specified wavelength cutoff and longer than a second specified cutoff. Allows light of wavelengths between the two cutoffs to pass through.
- **Long-pass**—Rejects light with wavelengths shorter than a specified cutoff and allows light of longer wavelengths to pass through.

### 3.3.3 Photomultiplier Tubes (PMTs)

The instrument uses two photomultiplier tubes (PMTs) to collect the filtered light. The PMTs convert light energy into an electrical current. Increasing the voltage applied to a PMT increases the signal amplification. Proper selection of the PMT voltage is necessary for optimal recording of the dyes. The operator selects the PMT voltages as part of the instrument run parameters.

## 3.4 Four-Dye Recording

Figure 3-2 illustrates the paths of excitation and emission light through the components of the instrument optical system.

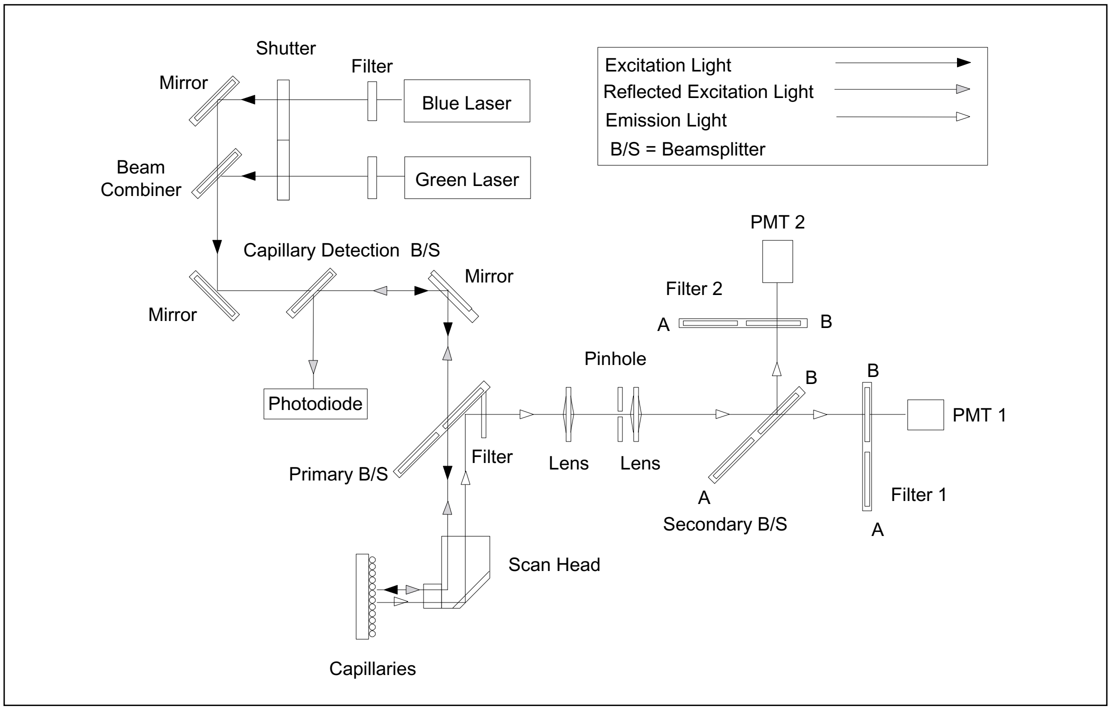



Figure 3-2. Excitation and Emission Paths, Functional Block Diagram.

### 3.4.1 Lasers

The instrument can use two lasers when recording four dyes. However, if only one laser is selected to excite all four dyes, a three-position shutter blocks the other laser during the entire electrophoresis run. Only one laser beam can enter the optical path at a time.

If the run parameter uses both lasers, the movement of the three-position shutter is synchronized with the movement of the scan head. This scenario is used when two of the dyes in the sample are excited by the 488-nm line of the blue laser and two are excited by the 532-nm line of the green laser. Typically, during the forward scan, the 488-nm line excites the two dyes with shorter-wavelength emission peaks (dyes one and two). The shutter switches to the 532-nm line for the return scan to excite the two dyes with longer-wavelength emission peaks (dyes three and four).

### 3.4.2 Excitation Path

The light from each laser travels through a filter and an opening in the shutter. The blue light is reflected by a mirror and travels through the beam combiner. The green light is reflected by the beam combiner to a path that is coaxial with the blue light. Both lights are then reflected by another mirror, pass through the capillary detection beamsplitter, are reflected by a third mirror, and then pass through the primary beamsplitter. The primary beamsplitter is motor-driven in synchrony with the shutter to select the appropriate beamsplitter for the blue or green laser. The light passes through the beamsplitter to the scan head, where the light is reflected and then focused onto the capillaries.

### 3.4.3 Reflected Excitation Path

The instrument uses the excitation light that is reflected at the center of the capillaries to detect the position of the capillaries accurately. The reflected excitation light travels back along the excitation path to the capillary detection beamsplitter, where it is reflected onto a photodiode, which produces an output current that is proportional to the strength of the light reflected from the capillaries.

### 3.4.4 Emission Path

The fluorescent light emitted by the sample is collected by the scan head and reflected back to the primary beamsplitter. The primary beamsplitter reflects the emitted light through a laser-blocking filter, lens, pinhole, and a second lens to the secondary beamsplitter. The emitted light contains light of two different wavelengths. The secondary beamsplitter passes one wavelength through a filter and into a PMT and reflects the second wavelength through a second filter and into a second PMT.

### 3.4.5 Beamsplitters and Filters

To record the emitted light of up to four dyes separately, the instrument uses two optical sets, each consisting of a secondary beamsplitter and two filters (figure 3-3). A beamsplitter changer and two filter changers move synchronously with the scan head to place one optical set at a time in the light path.

- **During the forward scan (figure 3-3a)—**The instrument records channels 1 and 2 using beamsplitter A and filters 1A and 2A.
- **During the return scan (figure 3-3b)—**The instrument records channels 3 and 4 using beamsplitter B and filters 1B and 2B.

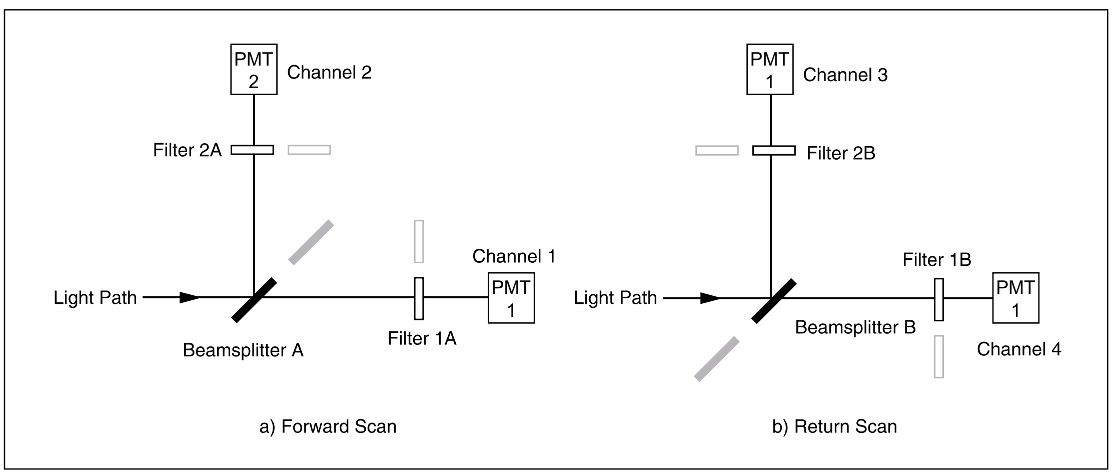



Figure 3-3. Emission Paths Functional Block Diagram.

## 3.5 Capillary Arrays

The capillary acts as a transmission medium, a voltage conduit, and an optical lens. The capillary's small-bore properties allow it to act as a transmission medium for the DNA samples and the matrix. The properties of the capillary glass allow it to hold approximately 15 kV DC along its entire length. The properties and construction of the glass allow the capillary to act as a cylindrical lens.

The cylindrical lens of the capillary is at a clear detection window, through which the detection system scans the sample during the electrophoresis run. The detection window is created by removing the coating on the capillary. Each of the 16 prepared capillaries is glued to a window holder with the clear detection window across the center of the holder. The window holders are clamped into a capillary window platform. The detection window is located at a fixed distance from the sample-loading point (40 cm from the cathode), so that the components of a sample are detected at a constant separation distance. The ideal focal plane of the capillary is in the center of the capillary at the detection window. To achieve this focus, the capillary window platform is adjusted relative to the objective lens of the scan head.

### 3.5.1 Capillary Array Components

Each capillary array is made up of 16 capillaries, a cathode bar, a window holder, and a anode plug (figure 3-4). On the cathode end, the capillaries are separated into two rows of eight and glued to a cathode bar. The capillaries are gathered together at the detection windows and glued side-by-side across the center of the window holder. At the anode end, the capillaries are inserted into an anode plug and then secured with a sealing compound.

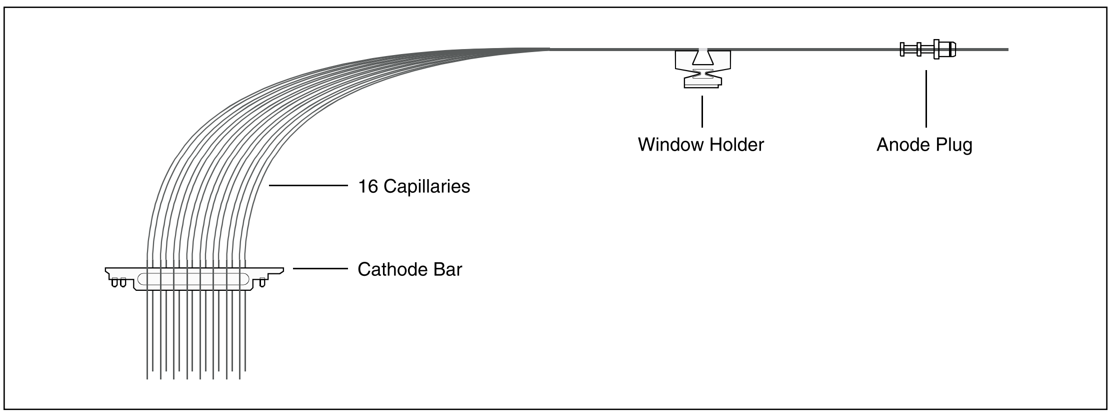



Figure 3-4. Capillary Array Components.

### 3.5.2 Cathode Array Stand

The cathode array stand (figure 3-5) provides the mounting for the six cathode bars. With the cathode-bar holder in the up position, the operator inserts each cathode bar into notches in the cathode-bar holder and secures the cathode bars with arms and thumbscrews. When the operator lowers the cathode-bar holder, the capillary ends extend down through a 96-hole plate. The holes in the plate are counter-sunk to direct and align the capillary ends.

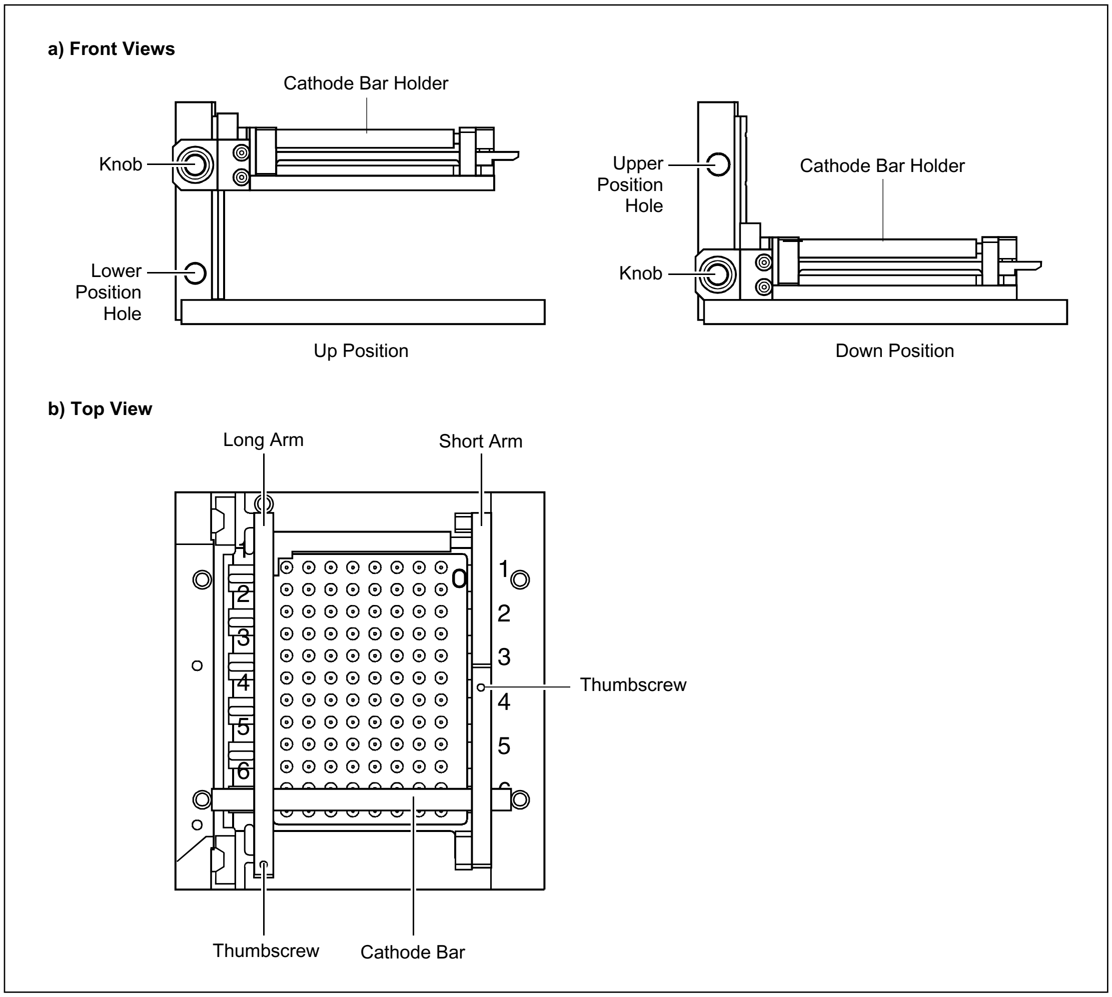



Figure 3-5. Cathode Array Stand.

When the instrument is used with fewer than six capillary arrays, the empty cathode bar positions are filled with dummy cathode bars. The dummy cathode bars are actually cathode plungers that are used to clean the capillary access holes. These dummy cathode bars act as replacements for the missing capillary arrays.

### 3.5.3 Capillary Window Platform

The capillary window platform (figure 3-6) holds the capillary windows in place and allows the focal plane of the capillary window to be adjusted. The operator inserts the window holders into the window platform and then locks them in place with the clamping handle. The cover rotates, moving the notch to the six window positions.

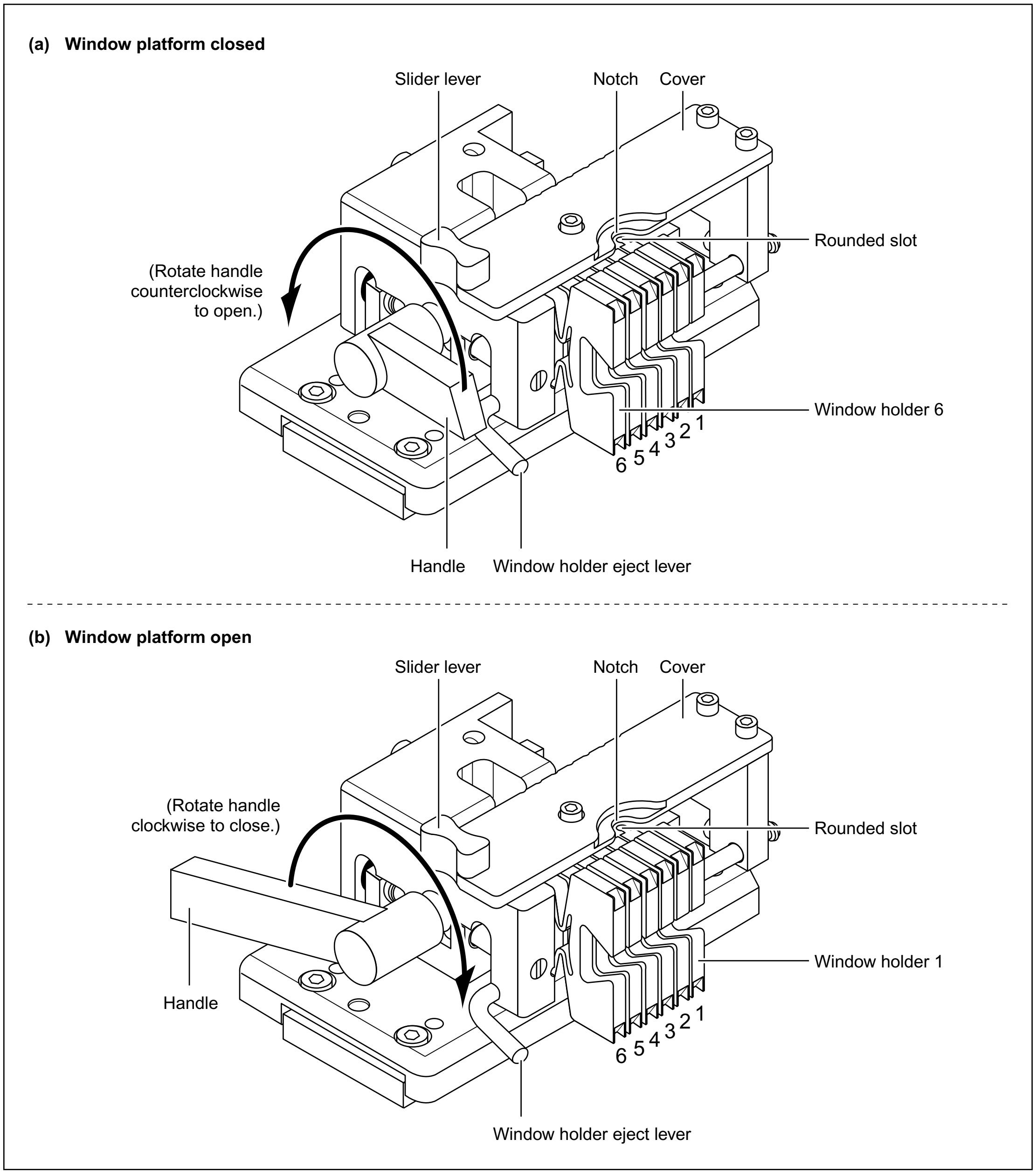



Figure 3-6. Capillary Window Platform.

When the instrument is used with fewer than six capillary arrays, the empty window positions are filled with blank window holders. The blank window holders are identical to the real window holders but they contain only short lengths of capillary that are filled with a fluorescent material. These blank window holders act as replacements for the missing capillary arrays.

### 3.5.4 Anode Cover

The anode plugs are inserted into the openings of the anode cover (figure 3-7). The operator pulls up on the knob to unlock the anode cover and then rotates the anode cover counterclockwise to free the anode plugs. When the anode plugs have been inserted and firmly seated, the operator rotates the cover clockwise to secure the anode plugs and pushes the knob down to lock the anode cover.

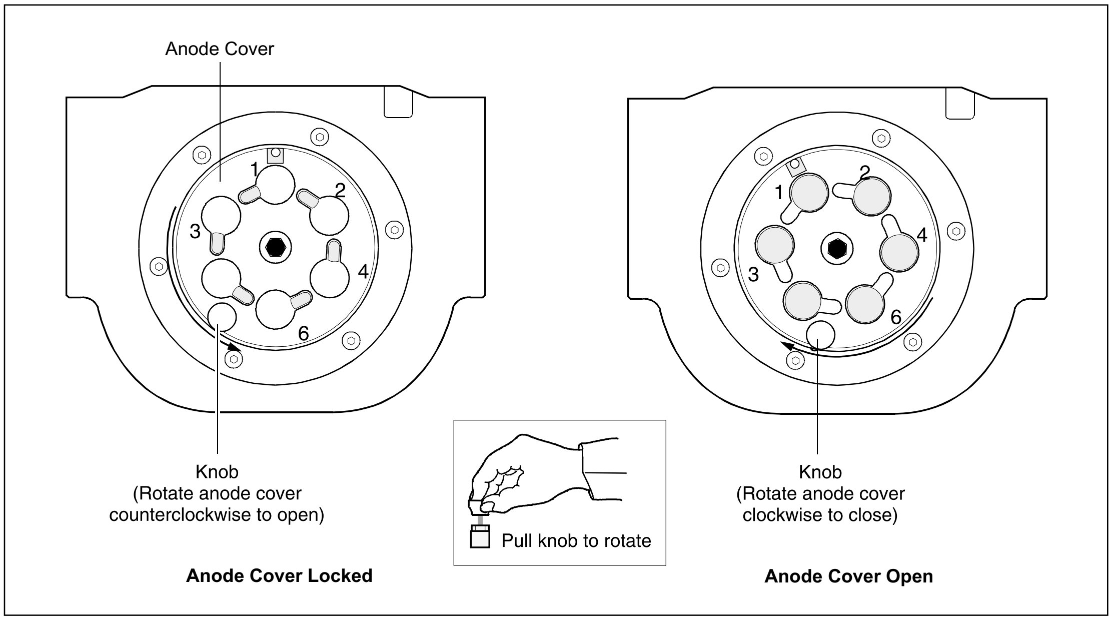



Figure 3-7. Anode Cover.

There must be an anode plug or anode blocker in each of the six anode plug openings. The anode blocker (figure 3-8) is a solid plug. Anode blockers are used when less than six capillary arrays are installed. The anode blockers prevent pressure from escaping when the anode vessel is pressurized.

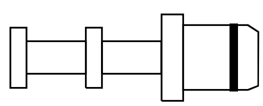


Figure 3-8. Anode Blocker.

### 3.5.5 Anode Cover (MB 500)

Three of the openings in the anode cover for the MB 500 (figure 3-9) are sealed by dummy anode plugs. A plastic cover is fitted over these dummy anode plugs to remind the user that these three openings are not used in the MB 500.

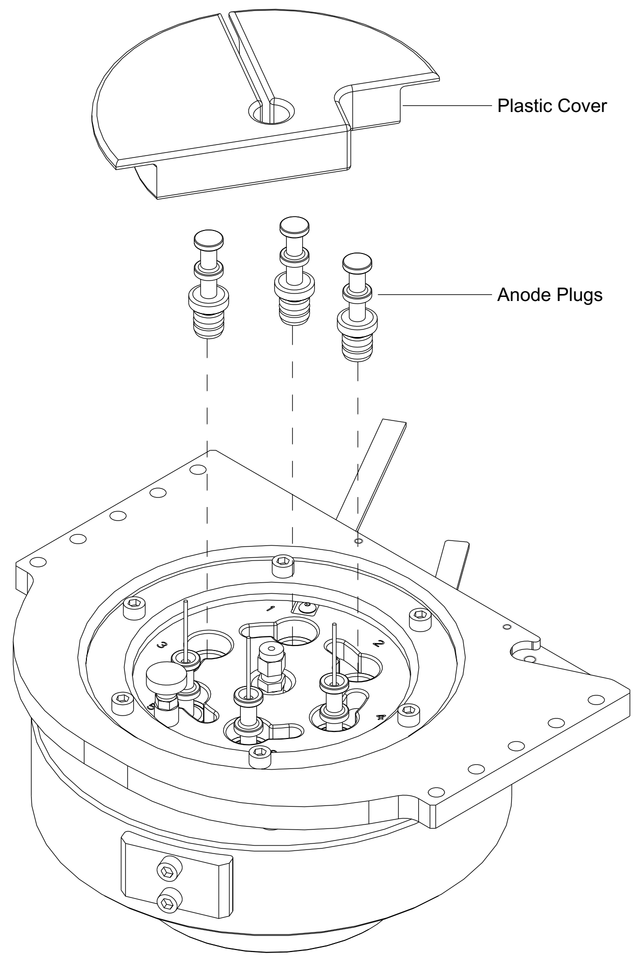



Figure 3-9.  Anode Cover (MB 500).

## 3.6 Laser Systems

The instrument uses a blue laser and a green laser for the excitation light sources. Each laser has an associated narrow-band filter that allows light of a certain wavelength to pass through and rejects light of other wavelengths. Most of the optical components in the system are linked to the excitation wavelength, and changing the lasers requires a complete optical system modification and alignment.

The blue laser is an argon-ion laser operating at 488 nm and capable of 20 mW. The laser is mounted in a cradle on the optical plate at the rear of the instrument. The laser is powered by the external power supply fan module. Cooling air for the laser is supplied by a fan located in the power supply fan module.

The green laser is a solid-state diode laser, operating at 532 nm and capable of 40 mW. The green laser mounts to an adjustable platform that is secured to the optics plate next to the blue laser. The adjustable platform allows the elevation of the green laser beam to be adjusted. The green laser has a separate power supply that is mounted on the underside of the optics plate.

## 3.7 Optical Path Components

The optical path components consist of the three-position shutter, blue and green laser line filters, green laser neutral-density (ND) filter assembly, three mirrors, the beam combiner, capillary detection optics, primary beamsplitter changer, scan head, achromatic lens and pinhole, secondary beamsplitter changer, filter changer, and PMTs.

### 3.7.1 Laser Line Filters

The blue and the green laser beams are initially filtered by a narrow-band filter (figure 3-10) to reject light that is not at the desired wavelength. These filters have a 10-nm band pass with greater than 80% transmission of the desired wavelength. The filter assemblies for the blue and the green filters are identical except for the actual filter lens.

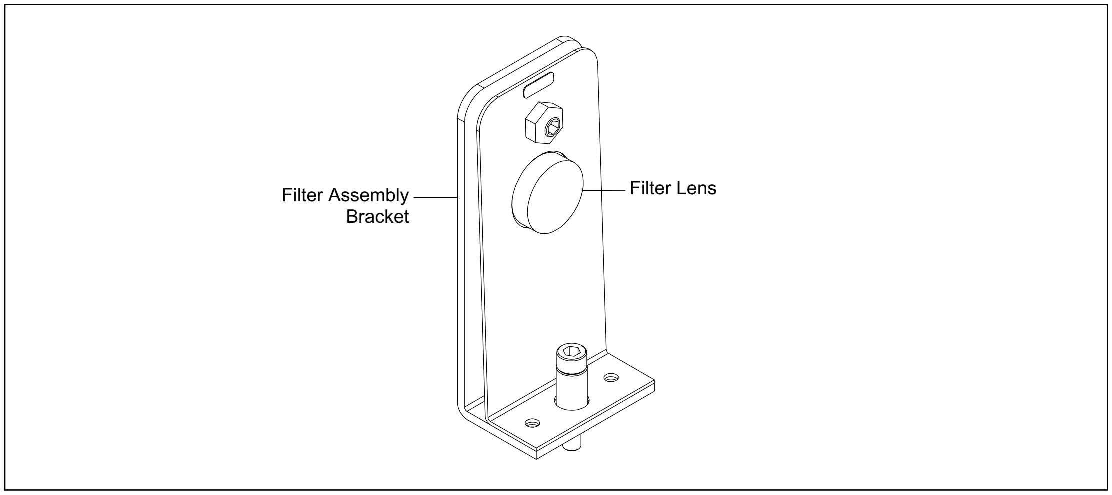



Figure 3-10. Laser Line Filter.

### 3.7.2 Neutral-Density (ND) Filter

The ND filter assembly (figure 3-11) immediately follows the green laser line filter. This filter controls the power of the green laser beam. It has an adjustment screw that moves the filter up or down, putting more or less attenuation in the path of the beam. The ND filter assembly also has an aperture in the path of the blue and green beams, following the second mirror. This aperture blocks scattered light, allowing only collimated light to pass through.

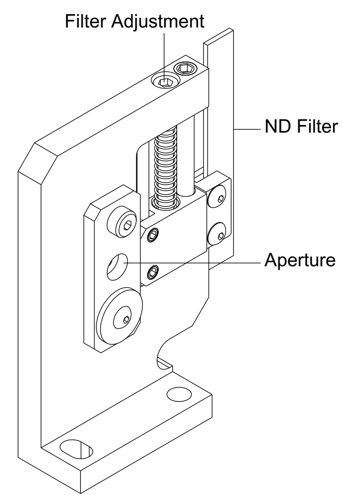



Figure 3-11. ND Filter.

### 3.7.3 Three-Position Shutter

The three-position shutter (figure 3-12) consists of the mounting bracket, stepper motor, and shutter. The stepper motor is mounted to the bracket, and the shutter is mounted to the stepper-motor shaft. The laser openings in the shutter are moved to their respective positions by turning the stepper motor shaft a predetermined number of degrees from the home position. The home position is determined by a home-position sensor. The shutter selects between the two lasers or blocks both beams. The shutter blocks both beams on power up, reset, or when a system interlock is opened.

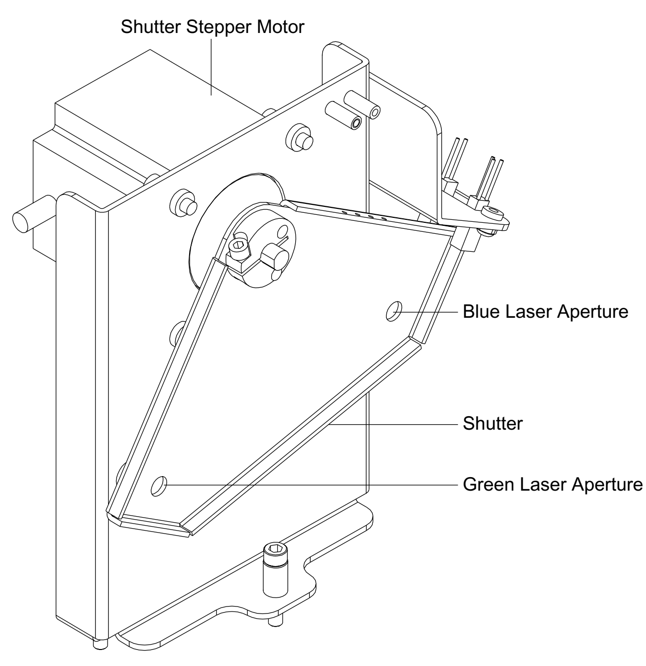



Figure 3-12. Three-Position Shutter.

### 3.7.4 Mirrors

The instrument uses three identical mirrors (figure 3-13) to redirect the laser beams. The mirror is mounted in a frame that is secured to an adjustment mechanism. The adjustment mechanism has three screws that allow the mirror to be adjusted in the X, Y, and Z planes. The first mirror is positioned in front of the blue laser and turns the beam toward the beam combiner. The second mirror turns the blue and the green beams toward the third mirror. The third mirror turns both beams toward the primary beamsplitter.

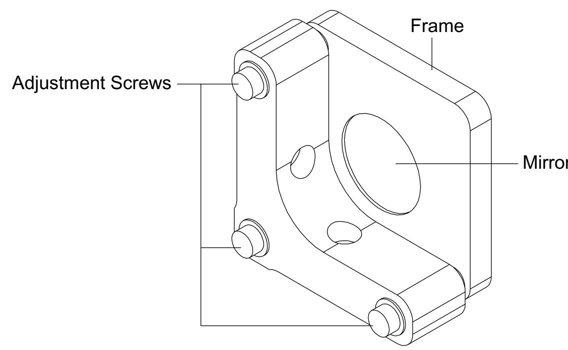



Figure 3-13. Mirror.

### 3.7.5 Beam Combiner

With the exception of the type of lens mounted in the frame, the beam combiner (figure 3-14) is identical to the mirrors. The beam combiner is mounted in front of the green laser. The beam combiner passes the blue laser beam and redirects the green laser beam. The three adjustment screws allow for coaxial alignment of the blue and green laser beams. A label on the rear of the beam combiner assembly denotes the optical characteristics of the lens.

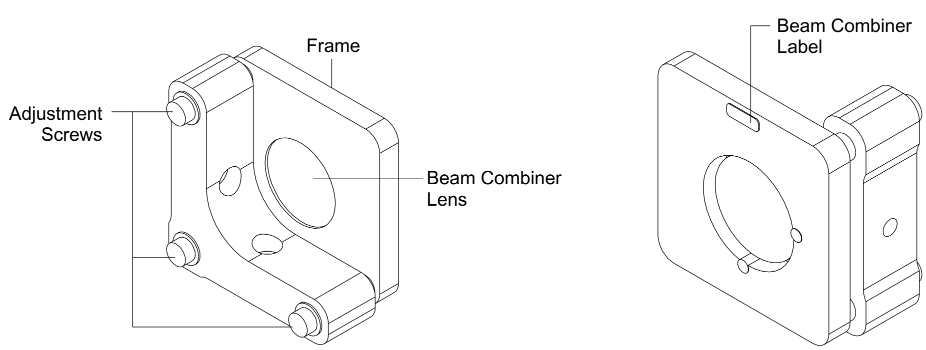



Figure 3-14. Beam Combiner.

### 3.7.6 Capillary Detection Optics

The capillary detection optics (figure 3-15) consist of an adjustable beamsplitter and a photodiode. The beamsplitter passes the excitation light and the light that was reflected from the center of the capillaries. The photodiode provides an output current that is proportional to the light hitting the photodiode. The photodiode and a coaxial connector are mounted to a small circuit board. The circuit board is mounted to a bracket that is secured to a base plate. A coaxial cable carries the current from the photodiode to the PDIO board for processing. The beamsplitter is also mounted to the base plate, and the base plate is secured to the optics plate in the path of the laser beams. The beamsplitter is mounted in a frame that is secured to an adjustment mechanism. The adjustment mechanism has three screws that allow the beamsplitter to be adjusted in the X, Y, and Z planes.

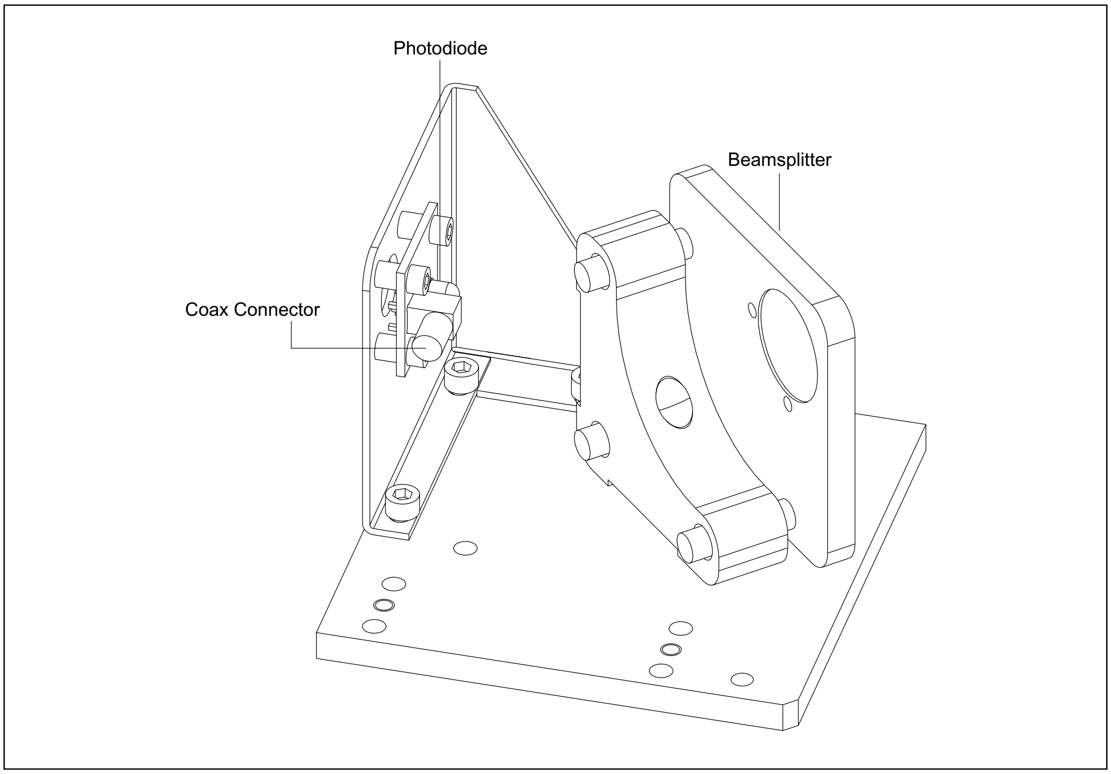



Figure 3-15.  Capillary Detection Optics.

### 3.7.7 Primary Beamsplitter Changer

The primary beamsplitter changer (figure 3-16) consists of a beamsplitter arm assembly (figure 3-17) mounted to the shaft of a stepper motor. The changer assembly places either the blue or green beamsplitter in the laser beam path. The beamsplitter transmits greater than 95% of the associated laser beam and reflects greater than 95% of the emission spectra. The beamsplitters are laser-wavelength specific, and switching is synchronized with the three-position shutter. Each beamsplitter has a laser-blocking filter mounted to it. The filter blocks the laser light from the emission path. The beamsplitters are mounted in an adjustable frame that allows them to be adjusted in the X, Y, and Z planes.

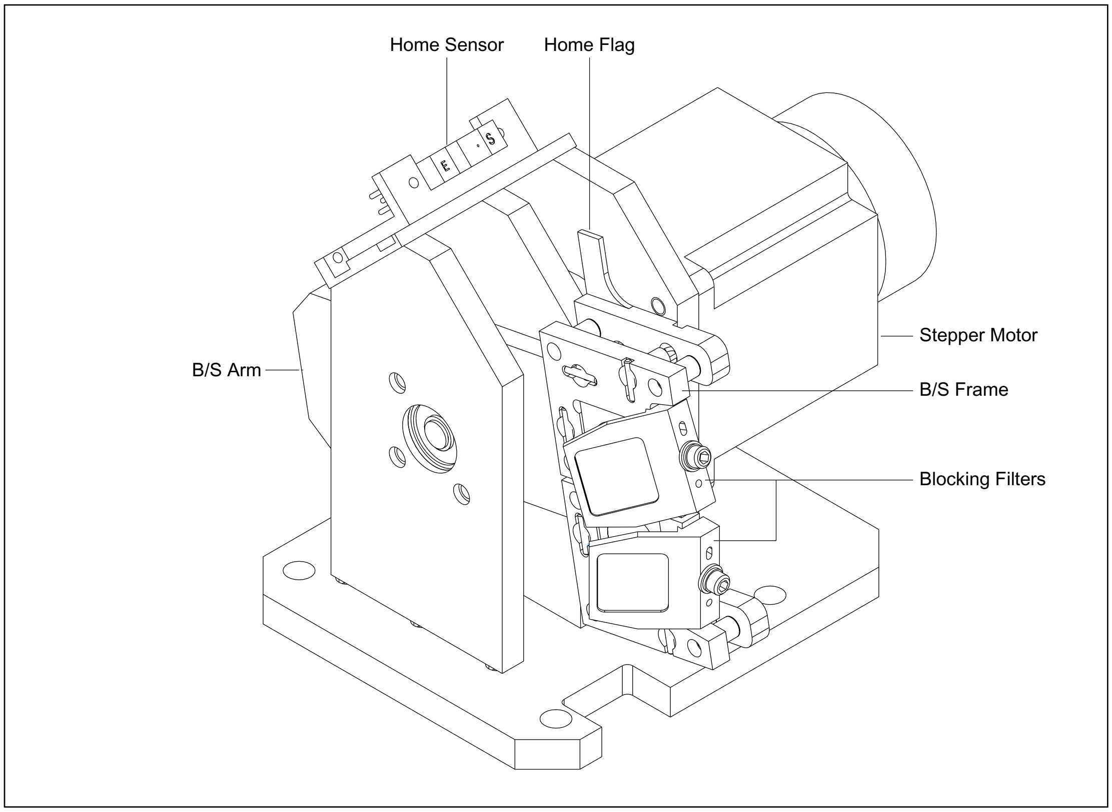



Figure 3-16. Primary Beamsplitter Changer.

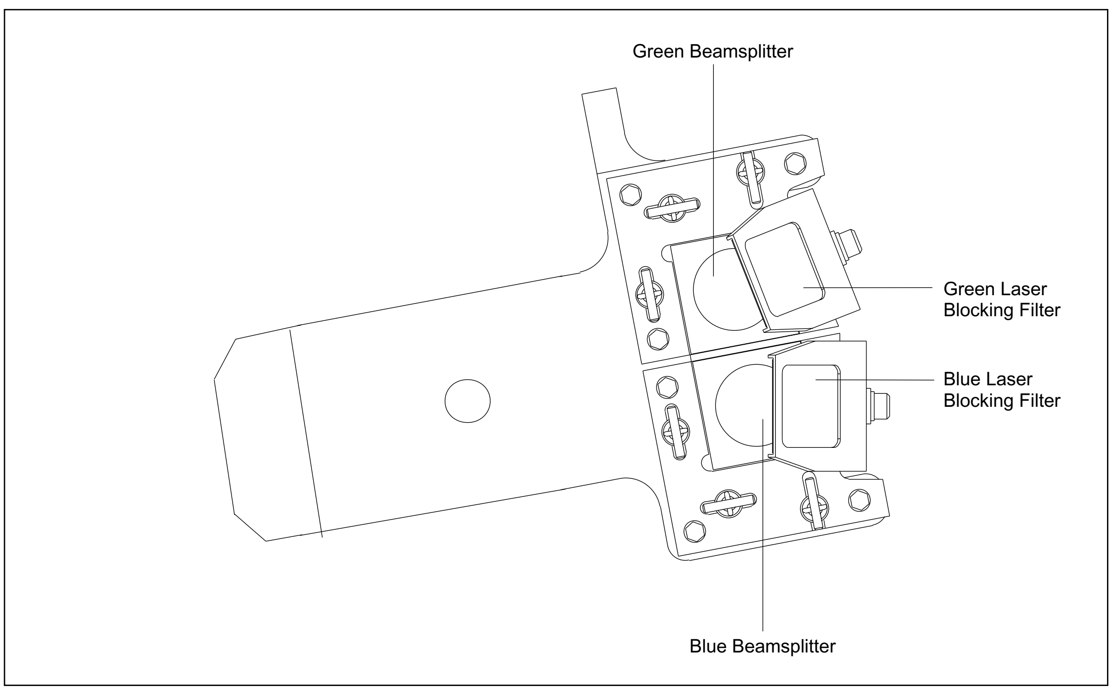



Figure 3-17. Beamsplitter Arm Assembly.

### 3.7.8 Scanning Stage

The scan head consists of an objective lens, turning mirror, and bearing assembly mounted on a scanning stage. Figure 3-18 illustrates the scan head, the scanning stage, and the scanning stage drive components. The scan head is moved back and forth by a stepper motor and a drive belt. The turning mirror reflects the laser beam through the objective lens. The objective lens is an aspheric acrylic lens with an NA of 0.5 and focal length of about 4.5 mm. The objective lens focuses the laser beam into the capillaries. The fluorescent light emitted by the sample is collected by the objective lens and reflected by the turning mirror back to the primary beamsplitter.

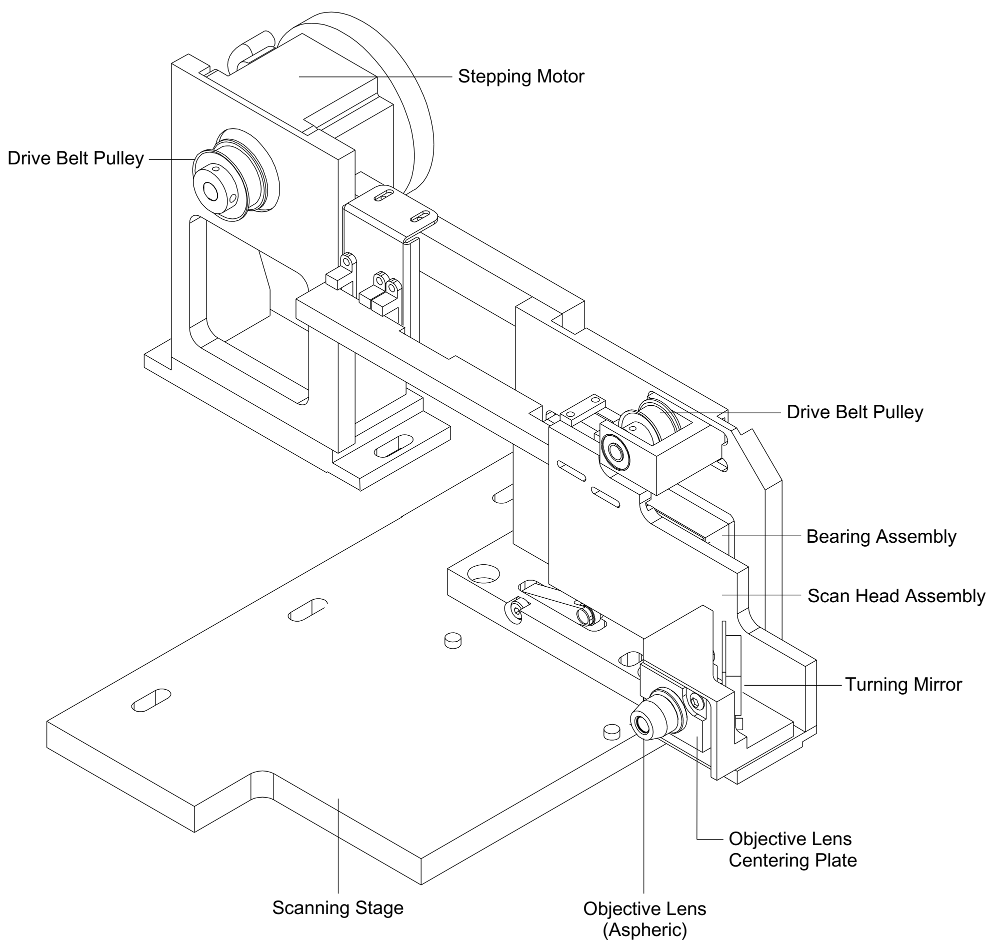



Figure 3-18. Scanning Stage.

The scanning stage has adjustments that enable the tilt (front-to-back) of the stage and the yaw (side-to-side) to be adjusted. The scan head has an adjustment for centering the objective lens and another adjustment for the X and Y of the turning mirror.

Figure 3-19 is an illustration of the scanning stage as viewed from the top. The illustration shows the path of the laser beam as it is reflected by the turning mirror through the objective lens. The illustration also shows the relationship between the scanning stage and the capillary window platform.

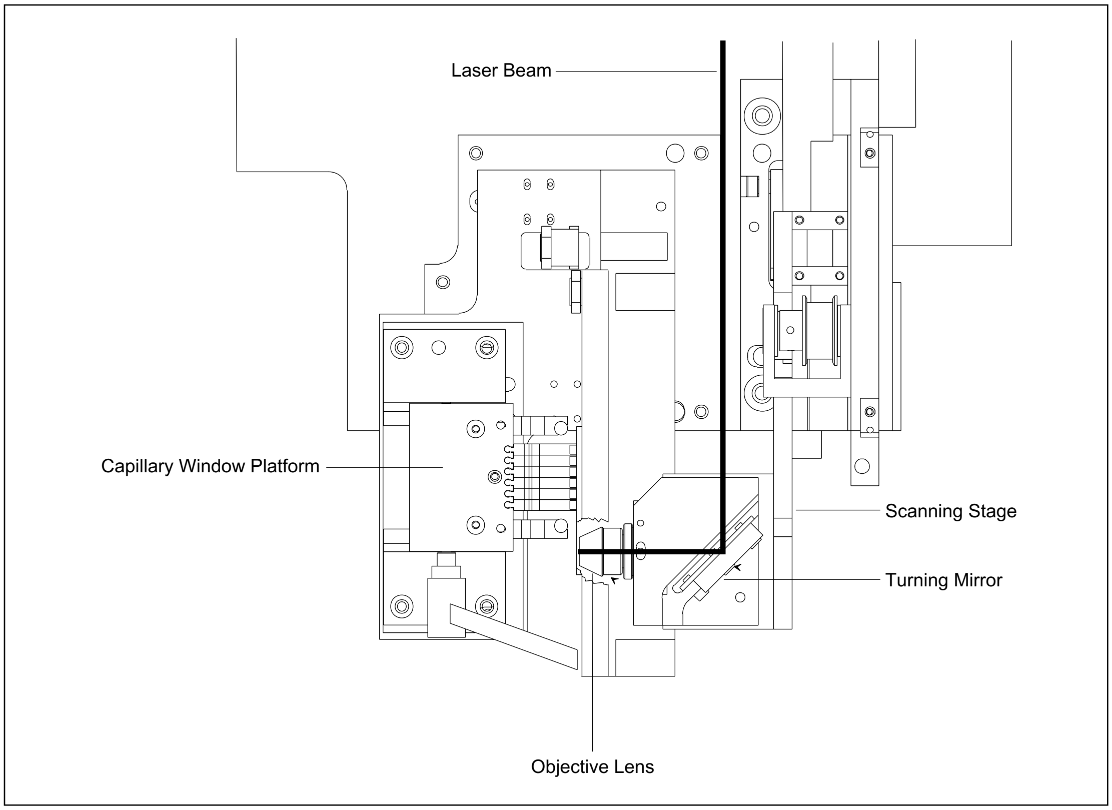



Figure 3-19. Top View of Scanning Stage.

### 3.7.9 First Achromatic Lens

The first achromatic lens (figure 3-20) focuses the emitted light into the pinhole. The lens has adjustments for the X and Y directions and a lens focus adjustment.

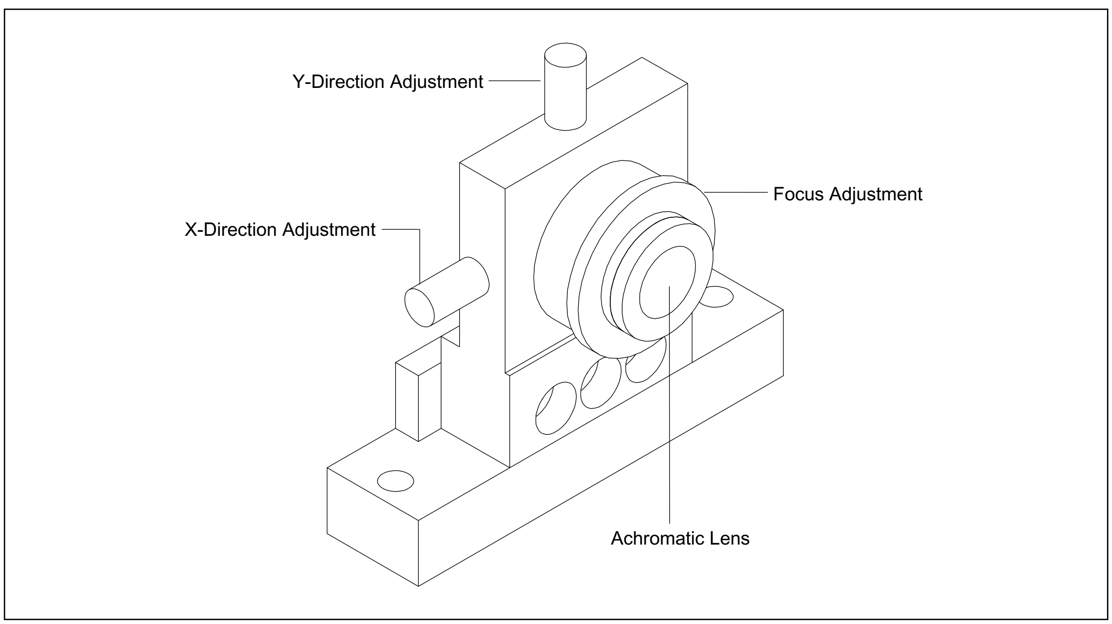



Figure 3-20. First Achromatic Lens.

### 3.7.10 Pinhole and Second Achromatic Lens

The pinhole and second achromatic lens are mounted in the same assembly (figure 3-21). The pinhole collimates the emitted light by blocking any scattered light from the sample. The pinhole directs the light into the second achromatic lens. The assembly has adjustments for X and Y and for focus.

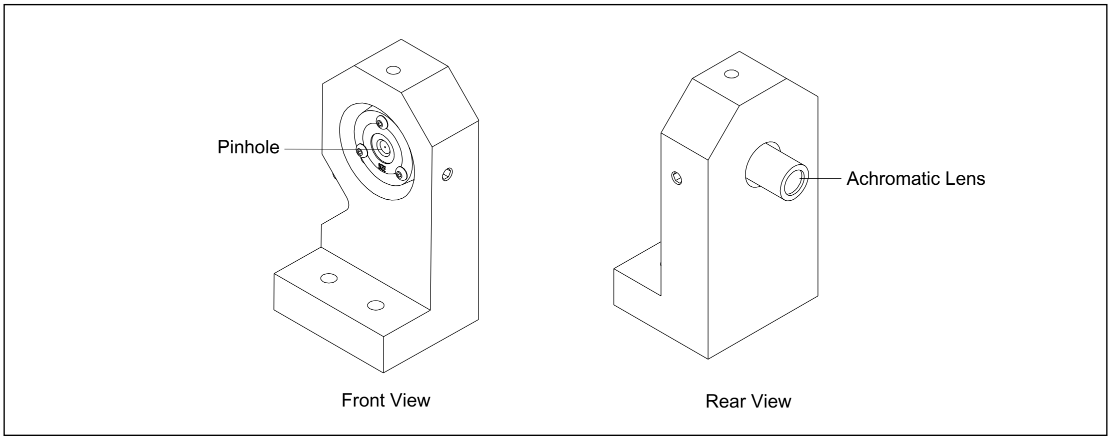



Figure 3-21. Pinhole and Second Achromatic Lens.

### 3.7.11 Secondary Beamsplitter Changer

The secondary beamsplitter changer (figure 3-22) consists of a stepper motor with a beamsplitter arm that has slots for two replaceable beamsplitters (A and B). The frame that holds the beamsplitters is adjustable to align the beamsplitters with the path of the emitted light. The beamsplitter divides the emission spectra in two by reflecting one wavelength of light through a filter into PMT 2 and passing a second wavelength through a filter into PMT 1. The secondary beamsplitter changer selects the appropriate beamsplitter in synchrony with the shutter, primary beamsplitter changer, and scan head.

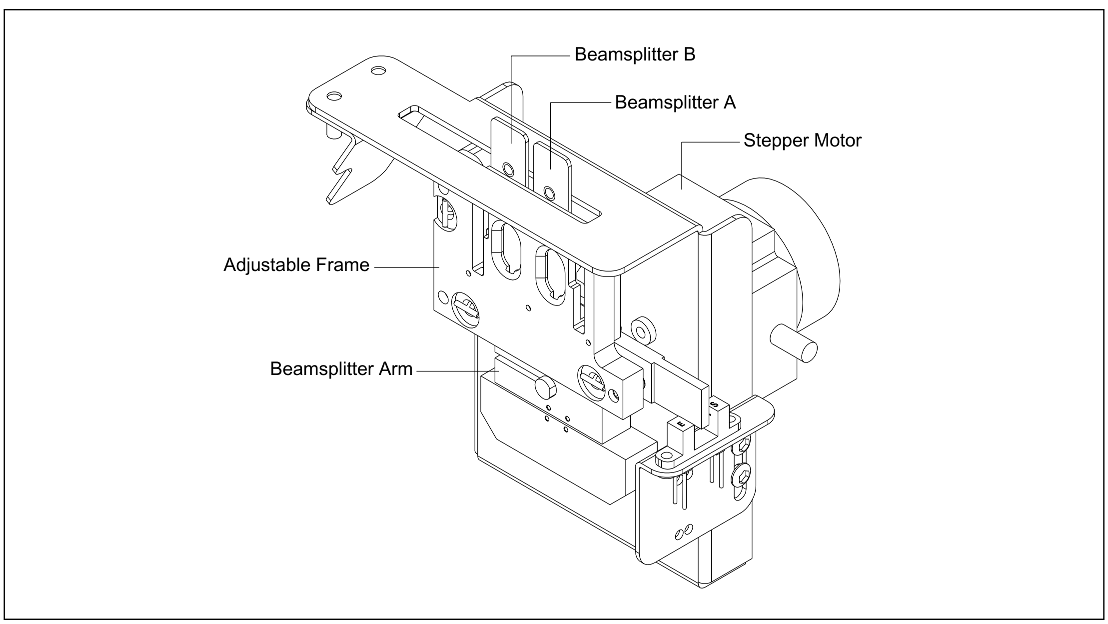



Figure 3-22. Secondary Beamsplitter Changer.

### 3.7.12 Filter Changers

The filter changer assembly (figure 3-23) consists of two filter changers secured to an L-shaped mounting bracket. Each filter changer has two slots to hold replaceable filters. The filters block all but the desired wavelength of light. The light passes through the filter and through an aperture in the mounting bracket into the collection window of a PMT.

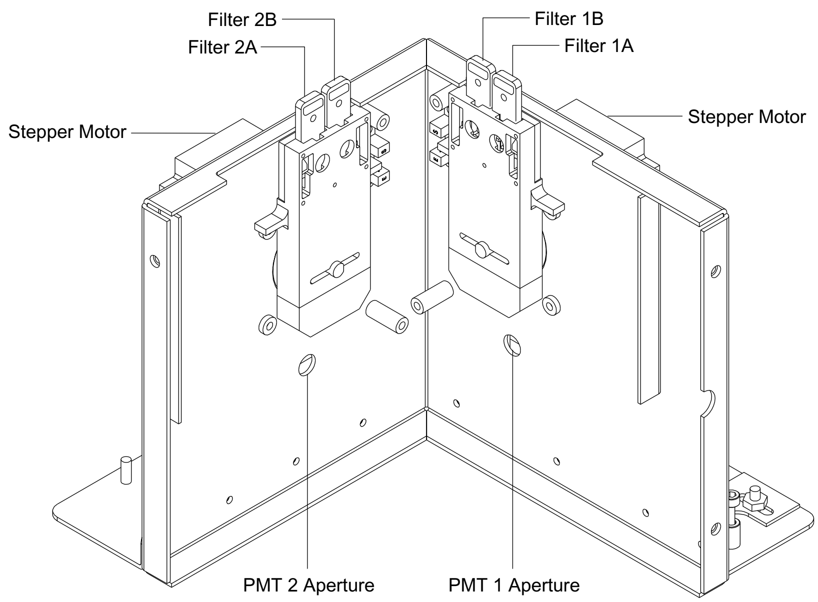



Figure 3-23. Filter Changers.

### 3.7.13 PMTs

The instrument has two identical PMTs (figure 3-24) that are mounted against the rear of the filter changer mounting bracket under the filter changer stepper motors. The PMTs provide low-level output current signals that are proportional to the amount of light at the collection windows. The PMT assemblies have adjustments to align the PMT collection windows in the X and Y directions, and the PMTs can be rotated in their mounting brackets to capture the maximum light. The PMTs can also be moved up and down and back and forth.

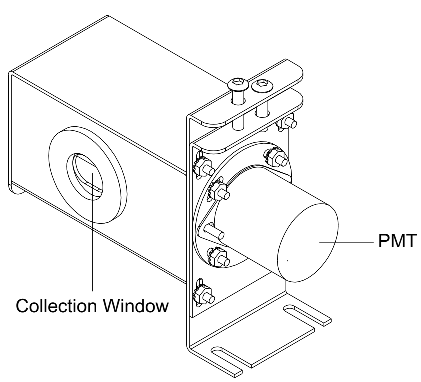



Figure 3-24. PMT Assembly.

# Chapter 4 Mechanics

## 4.1 Introduction

The instrument consists of eight major components: enclosure, power supply box, internal PC, optics plate assembly, electrophoresis chamber assembly, cathode assembly, anode assembly, and pneumatic control assembly. Figure 4-1 is an exploded view of the instrument.

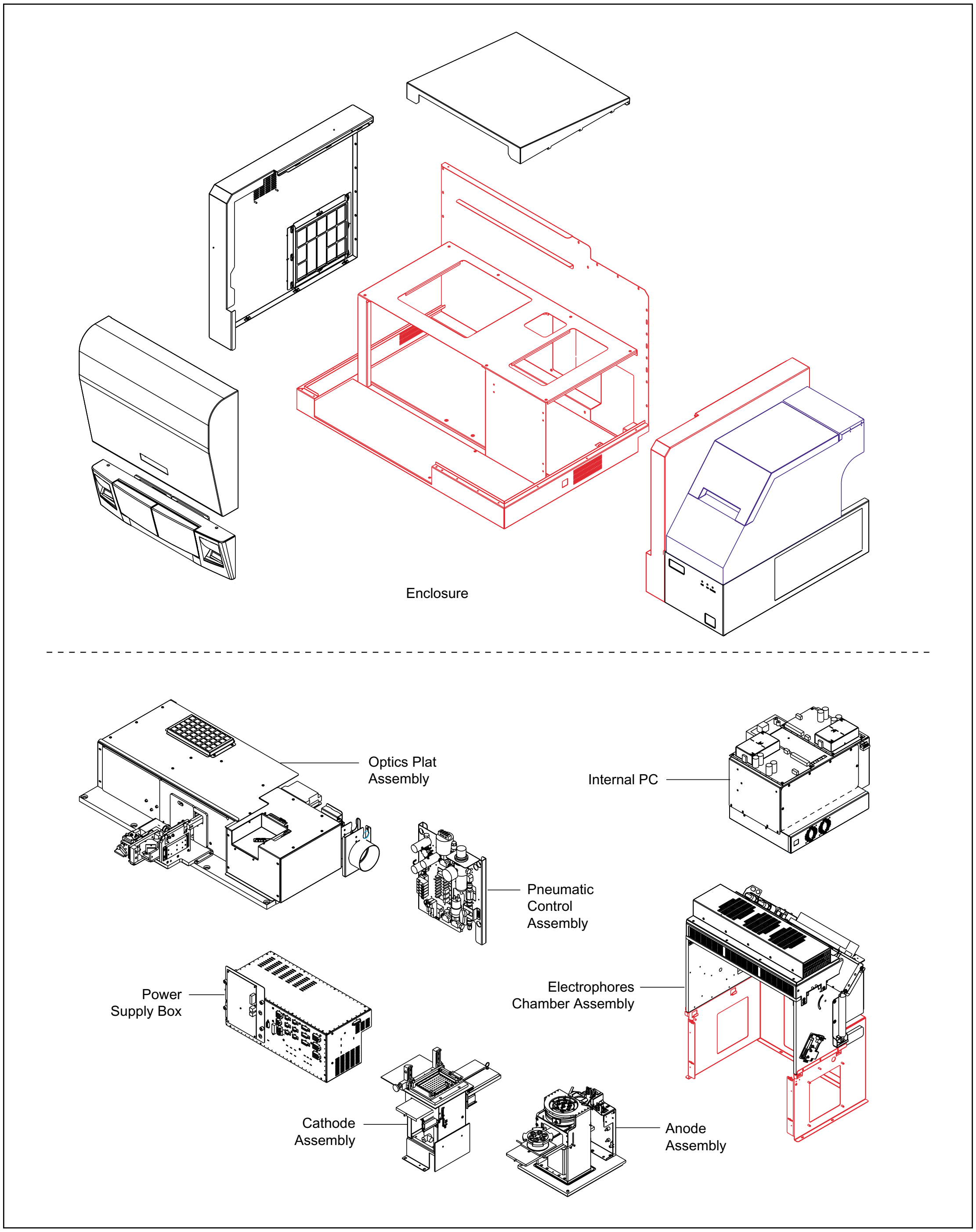



Figure 4-1. MegaBACE Instrument Assembly.

## 4.2 Enclosure

The enclosure (figure 4-2) consists of the sheet-metal chassis, top cover, left panel assembly, right panel assembly, service door assembly, and front panel assembly.

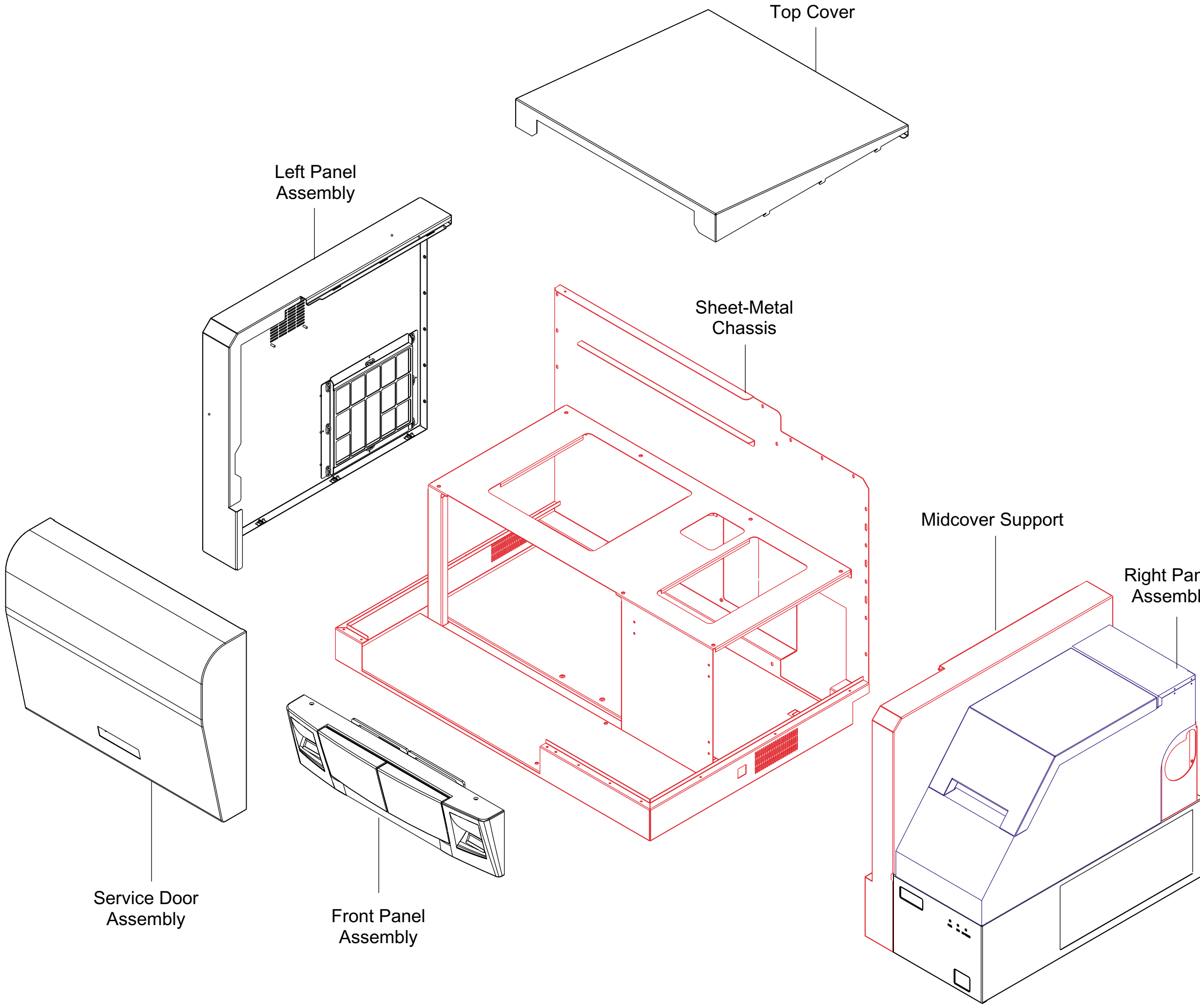



Figure 4-2. Enclosure Assembly.

### 4.2.1 Sheet-Metal Chassis

The sheet-metal chassis provides the mounting for the optics plate assembly, power supply box, internal PC, electrophoresis chamber assembly, cathode assembly, anode assembly, and pneumatic control assembly.

### 4.2.2 Top Cover

The top cover (figure 4-3) has three tabs on the left and right edges that fit into three slots cut into the right edge of the left side panel and the left edge of the midcover support. The detail in figure 4-3 shows how the tabs on the top cover fit into the slots on the left panel assembly. The top cover is secured to the rear panel of the sheet-metal chassis with two screws through two tabs on the rear edge of the top cover.

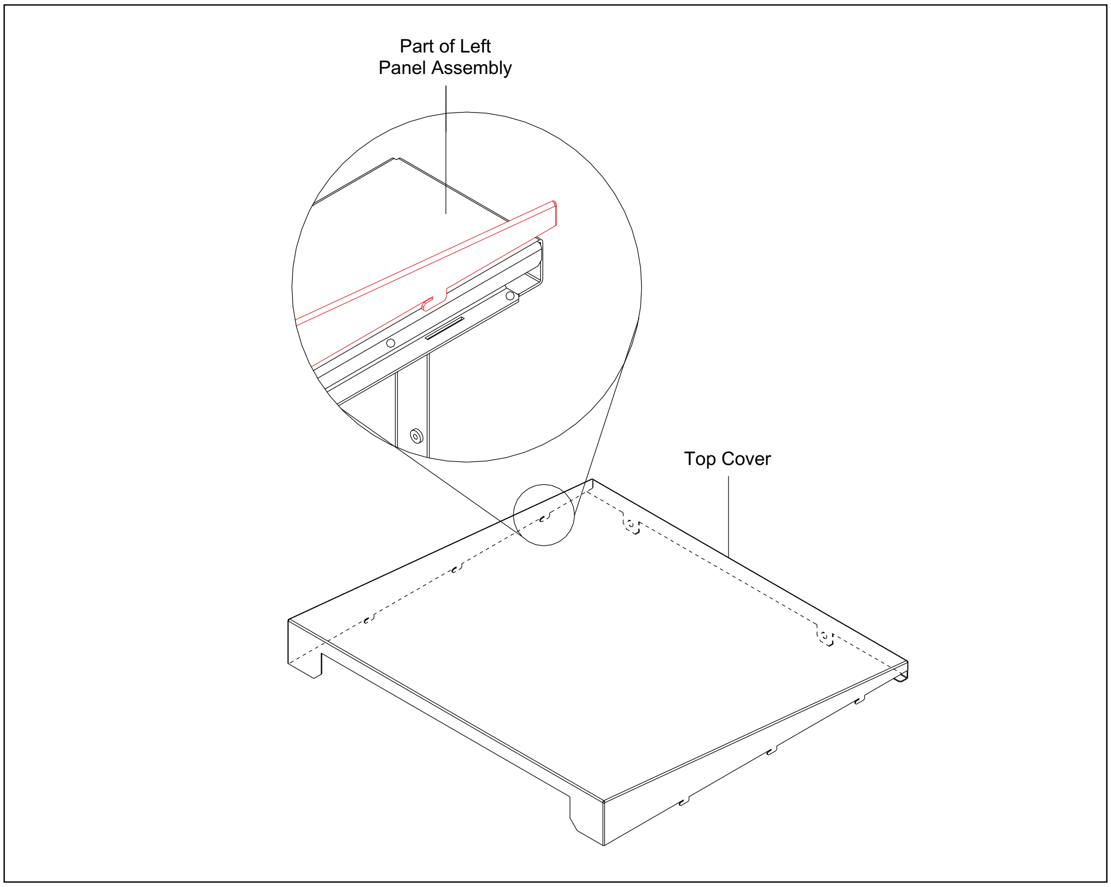



Figure 4-3. Top Cover Assembly.

### 4.2.3 Left Panel Assembly

The left panel assembly (figure 4-4) consists of the left-side panel, air filter, and filter cover. The left-side panel attaches to the left side of the sheet-metal chassis with five ball studs and ball-stud receptacles; three along the left edge of the panel and two along the front edge of the panel. The left-side panel is then secured to the rear of the sheet-metal chassis with six screws. The filter cover secures the air filter to the left-side panel with eight 1/4-turn studs.

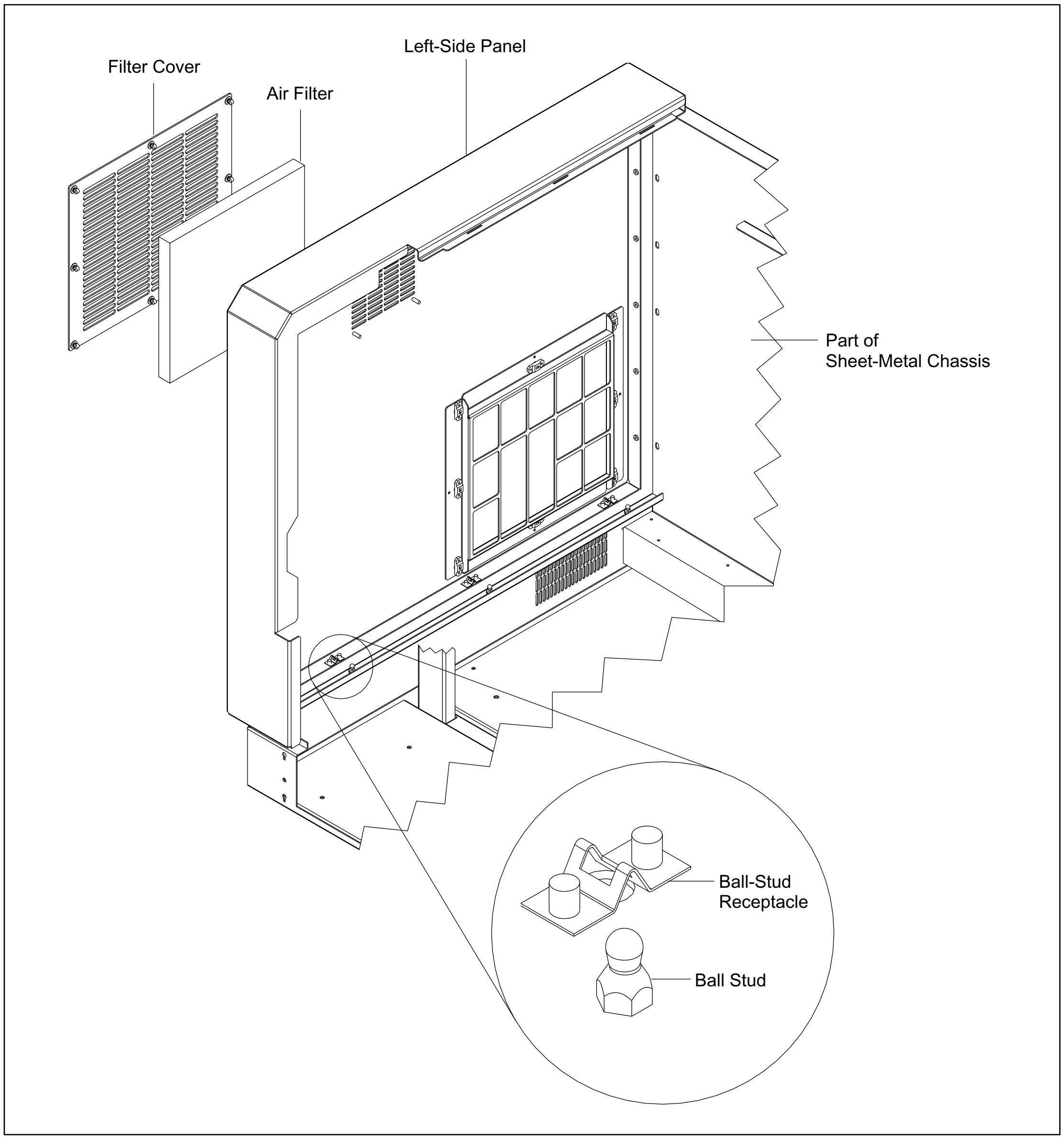



Figure 4-4. Left Panel Assembly.

### 4.2.4 Right Panel Assembly

The right panel assembly (figure 4-5) consists of the midcover support, filter cover assembly, hose support bracket, and lower-right cover. The midcover support is secured to the rear of the sheet-metal chassis with two screws, to the front bottom of the sheet-metal chassis with two screws, and to the electrophoresis chamber with one screw. The lower-right cover is secured |to the sheet-metal chassis with five ball studs and ball-stud receptacles and screws in the rear. The lower-right cover has a panel, secured with four screws, that provides access to the side panel of the internal PC. The hose support bracket is secured to the back panel with two screws. The filter cover assembly is secured to the lower-right cover with five ball studs and ball-stud receptacles and to the rear of the sheet-metal chassis with four screws. An LED board is mounted inside the front of the lower-right cover with four screws. This board has three LEDs (POWER, SCAN, and HIGH PRESSURE) that indicate the instrument is turned on, the instrument is scanning, and the anode assembly is pressurized to 1000 psi.

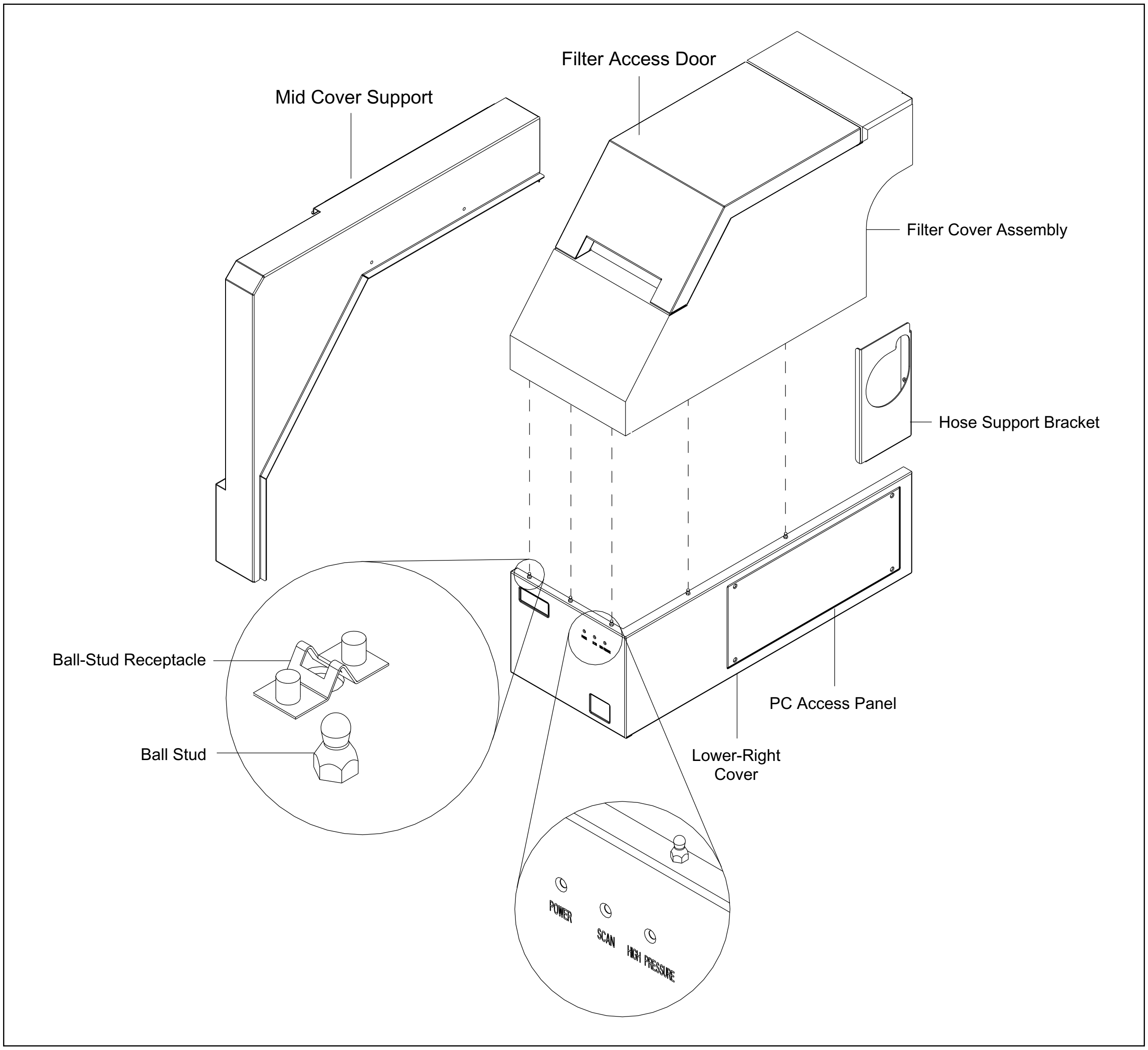



Figure 4-5.  Right Panel Assembly.

### 4.2.5 Filter Access Door

The filter access door (figure 4-5) provides access to the four PMT filters and the secondary beamsplitters. During a run operation, the filter access door remains closed to maintain a lightproof seal around the PMTs. The filter access door is hinged at the top and actuates an interlock switch when closed. The interlock switch routes +12 volts to two safety relays to keep them energized. When the filter door is opened, the +12 volts is removed from the safety relays. The relays de-energize and turn off the high voltage and remove power to the three-position shutter motor. The shutter motor returns to the home position and blocks both lasers.

### 4.2.6 Service Door Assembly

The service door (figure 4-6) provides access to the electrophoresis compartment for replacing the capillary arrays. The service door is secured with hinge mechanisms on the left and right sides of the electrophoresis chamber. Each hinge mechanism consists of two hinge arms and a spring, cable, and pulley system. The service door pivots where the hinge arms attach. A latch on the left side of the service door holds the service door shut during operation. The service door is spring-loaded in the closed position, and when the service door is released, the springs aid in lifting the service door. The service door latches can be released using the diagnostic software. A mechanical latch bypass exists for use by service personnel. The bypass is located at the left side of the instrument.

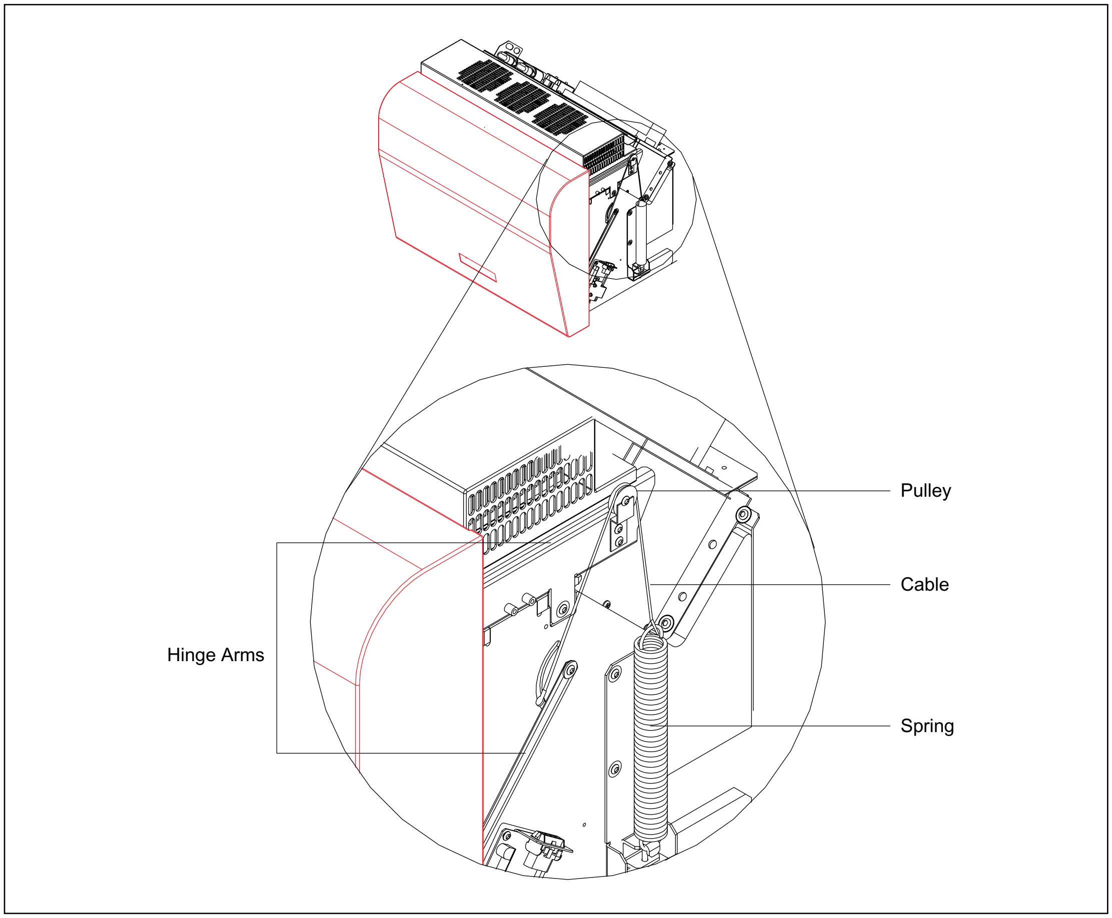



Figure 4-6. Service Door Assembly.

### 4.2.7 Front Panel Assembly

The front panel assembly (figure 4-7) provides openings for the anode and cathode access doors and mounting for the anode and cathode LCD boards. The front panel assembly is secured to the sheet-metal chassis with two screws and four ball studs and ball-stud receptacles. The anode and cathode LCD boards are each mounted to the rear of the front panel assembly with four screws.

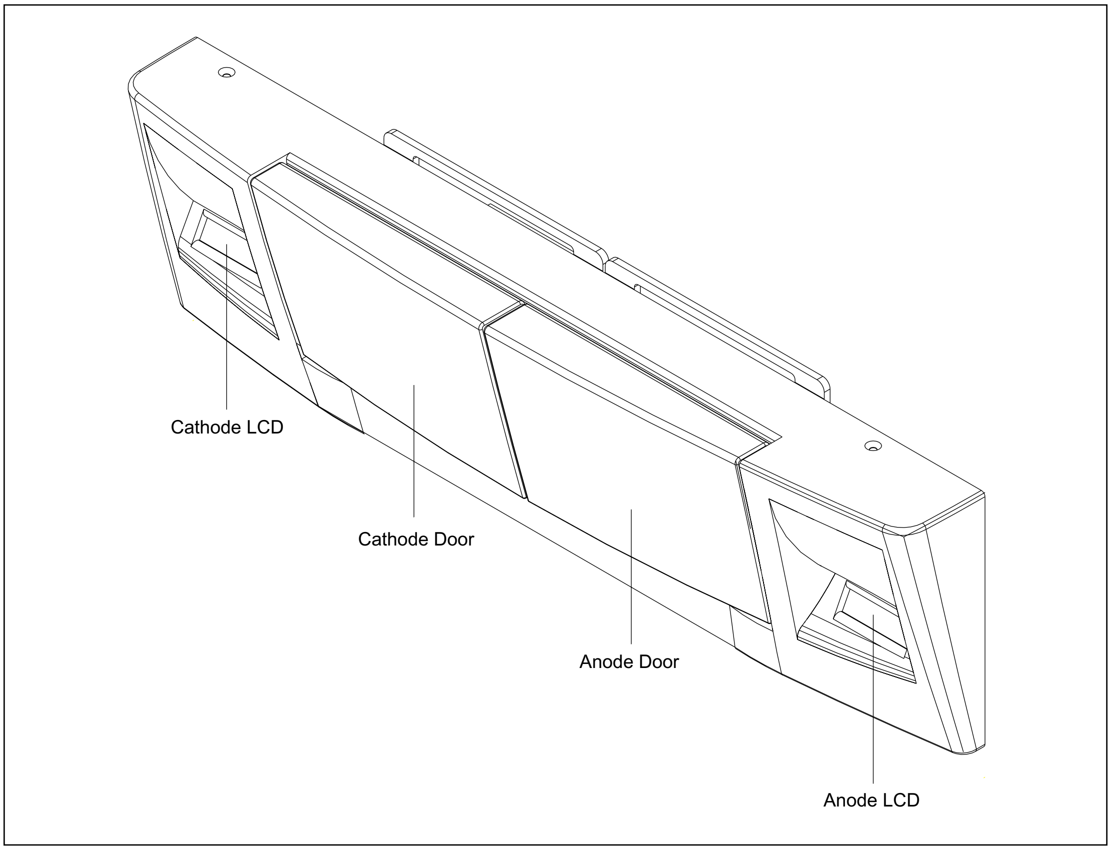



Figure 4-7. Front Panel Assembly.

### 4.2.8 Front Panel Assembly (MB 2000)

The front panel assembly for the MB 2000 is slightly different that the original front panel. The cathode door opening is slightly larger to accommodate the 384-well plate.

### 4.2.9 Cathode Access

The cathode door (figure 4-8) provides access to the cathode trays. The cathode door is connected to the cathode slide. Mechanical detents at both sides of the cathode tray signal the user that the cathode door has reached its stop position. The mechanical detents are spring-loaded setscrews with bullet-like plungers. The cathode release mechanism is under software control. After the cathode tray has been loaded, pushed in, and raised, the cathode door cannot be opened.

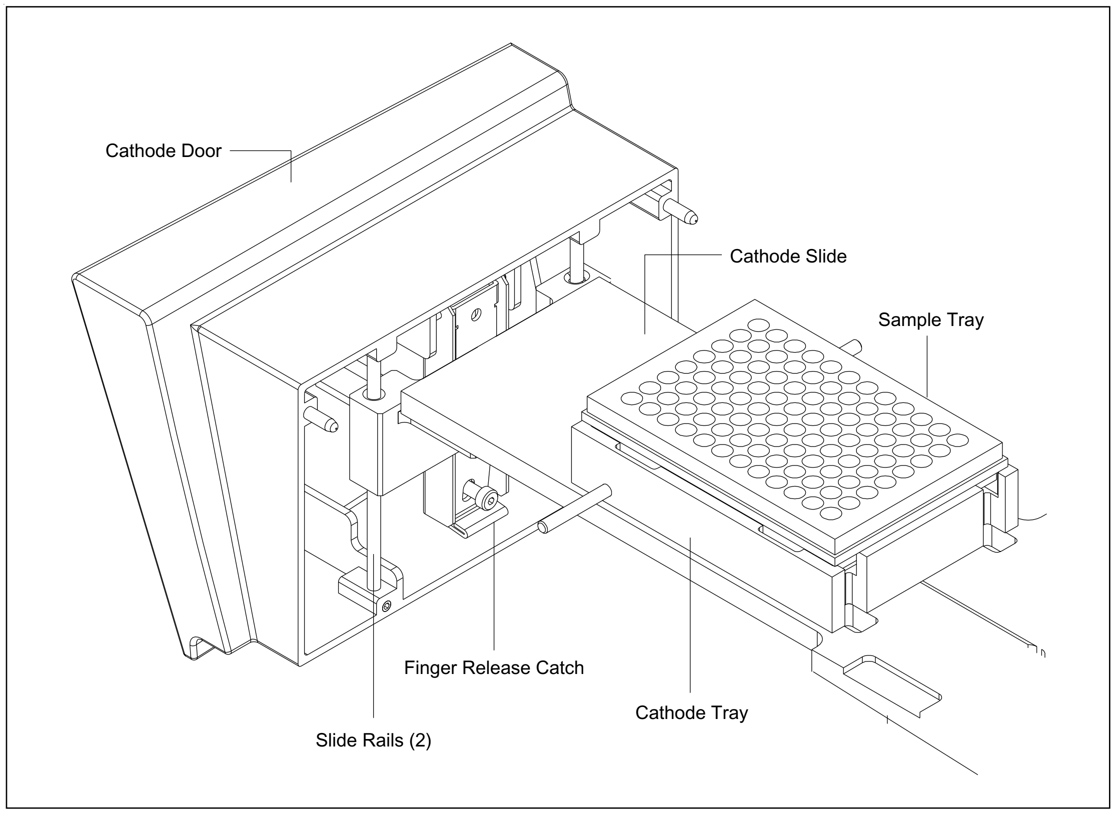



Figure 4-8. Cathode Door Assembly.

The cathode door is attached to the horizontal slide mechanism in the cathode assembly by two slide rails. The cathode door rides on the two slide rails, allowing the door to be raised and lowered. A finger-actuated door latch holds the cathode door in place until the door is lowered. The finger-actuated door release latch is a metal lever spring that holds the door in the raised position when the door is opened.

### 4.2.10 Anode Access

The anode door (not shown) provides access to the anode reservoir and is attached to the anode slide mechanism. The anode release mechanism is under software control. After the anode tray has been loaded, pushed in, and raised, the anode door cannot be opened. A mechanical detent is used to signal the user that the anode door/slide has reached its stop position.
The mechanical detent is provided at either side of the anode tray by two spring-loaded setscrews with a bullet-like plunger. The anode and cathode door are nearly identical and the mechanisms work essentially the same, but the anode slide mechanism cannot be removed from the anode assembly for cleaning.

## 4.3 Power Supply Box (Four-Supply Model)

Figure 4-9 is a top view of the power supply box with the covers removed and shows the locations of the four power supplies, power supply distribution board, INTC board, fans, AC input connector, and AC distribution terminal strip.

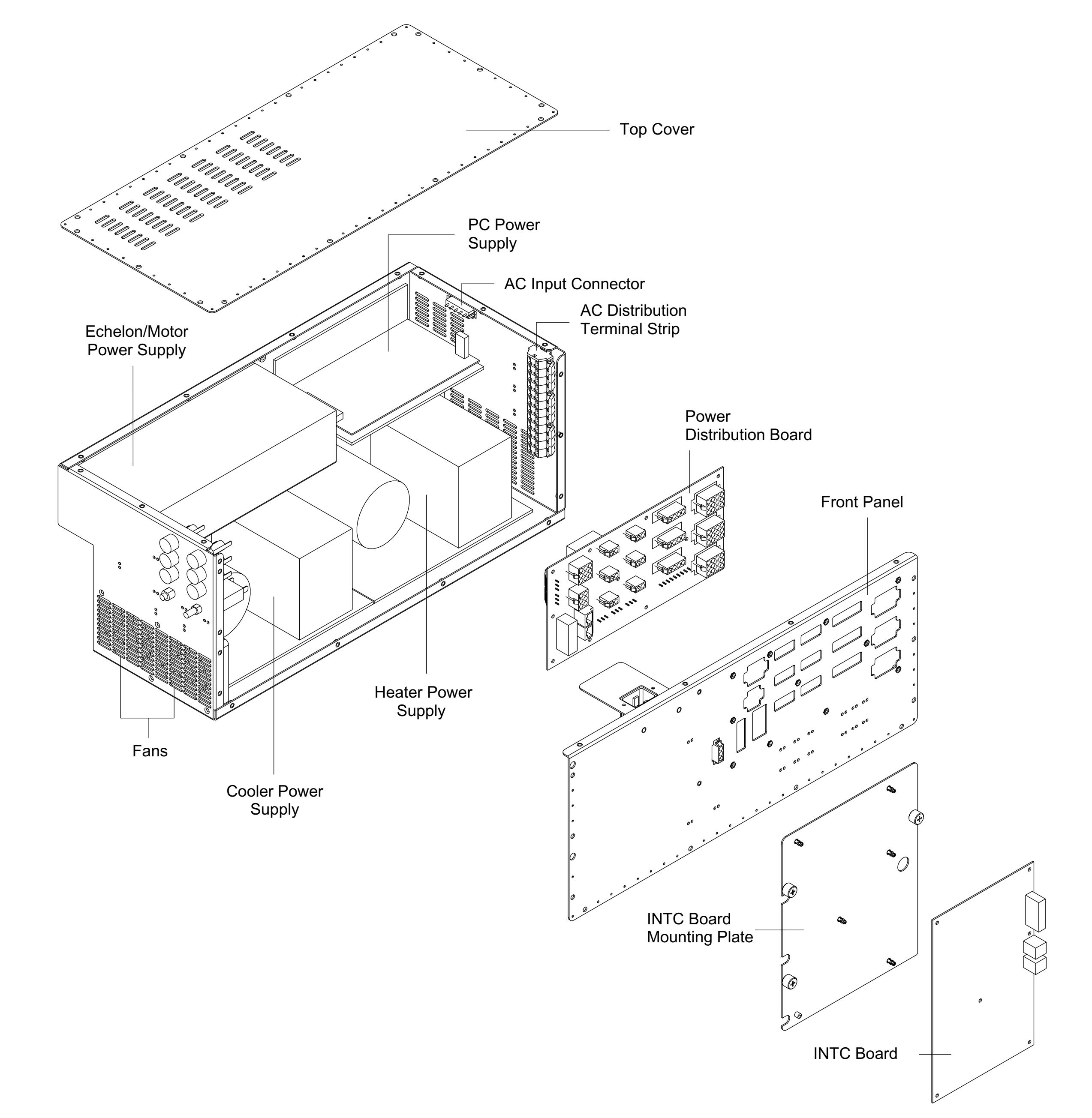



Figure 4-9. Power Supply Box Assembly.

The top cover is secured to the power supply box with 14 screws.

The cooler power supply and heater power supply are secured to the rear panel with two large Phillips-head screws, lock washers, and nuts. Each of these two power supplies are also secured to two studs on the bottom panel with two lock washers and nuts.

The Echelon/motor power supply is mounted to the rear panel of the power supply box with two screws. The internal computer power supply is a printed circuit board that is mounted to a bracket with four standoffs and four screws. The bracket is mounted to the rear panel of the power supply box with two screws and to the underside of the power supply box with two screws.

The power supply distribution board is secured to the front panel with 11 screws, and the front panel is secured to the power supply box with nine screws.

The DC outputs from the power supplies are routed from terminal strips in the power supplies to terminal strips on the back (input) side of the power supply distribution board. The power supply distribution board is mounted to the inside of the power supply box with the bulkhead connectors on the front (output) side of the power supply distribution board extending through holes in the power supply box. Six AC fuses and two DC circuit breakers are mounted on the left end of the power supply box.

The INTC board is secured to a mounting plate with five snap-on standoffs and one screw. The mounting plate is then secured to the front panel of the power supply box with four captive screws.

Each of the two fans are mounted to the left-side panel with two screws.

## 4.4 Power Supply Box (Two-Supply Model)

Figure 4-10 is a top view of the power supply box with the covers removed and shows the locations of the two power supplies, power supply distribution board, INTC board, fans, AC input connector, and AC distribution terminal strip.

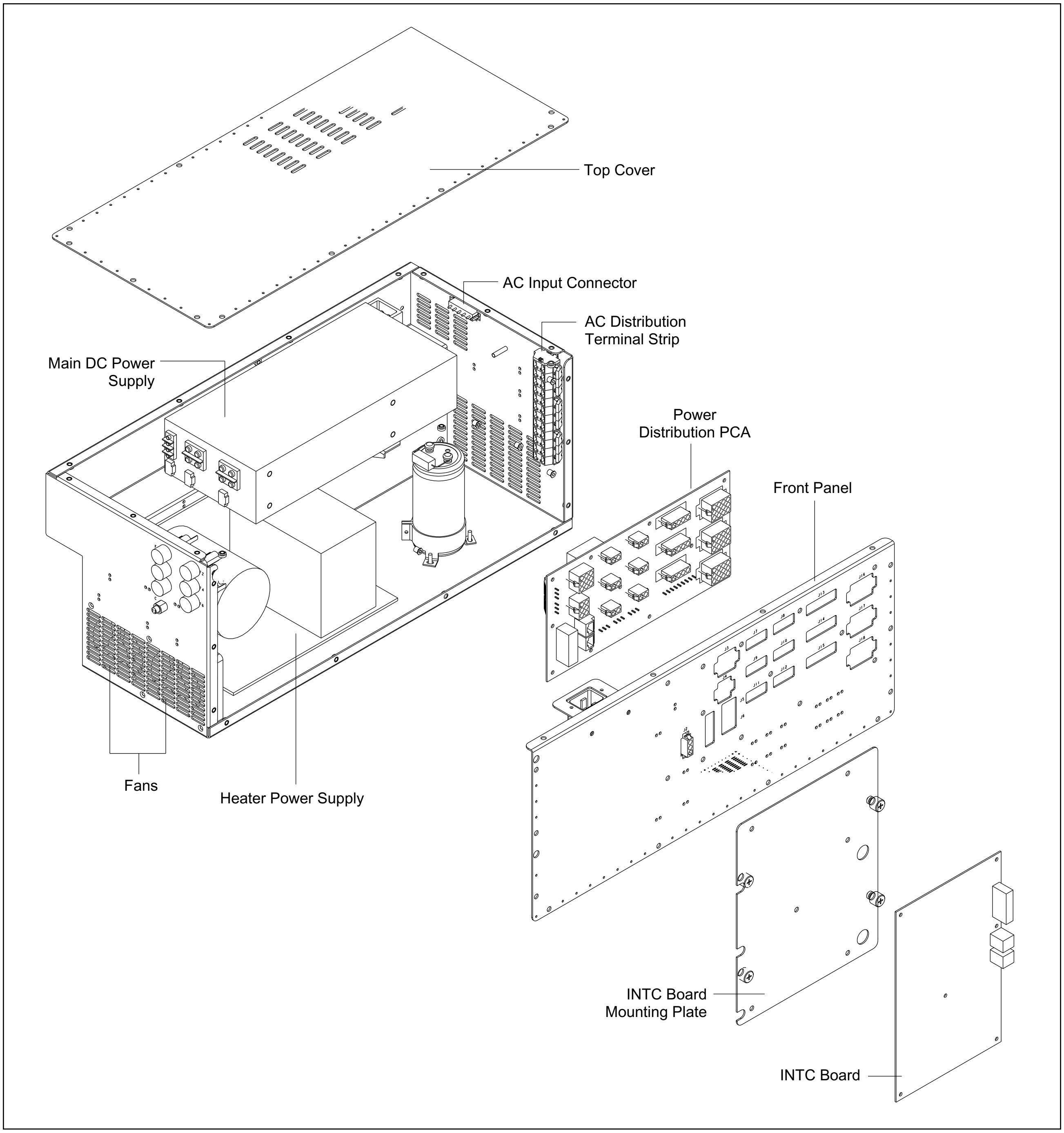



Figure 4-10. Power Supply Box Assembly.

The top cover is secured to the power supply box with 14 screws.

The heater power supply is secured to the rear panel with two large Phillips screws, lock washers, and nuts. The power supply is also secured to four studs on the bottom panel with four lock washers and nuts.

The main DC power supply is mounted to the bottom of the rear ledge with two screws and to a metal bracket with one screw. The bracket is mounted to two threaded studs on the rear panel of the power supply box.

The power supply distribution board is secured to the front panel with 11 screws, and the front panel is secured to the power supply box with nine screws.

The DC outputs from the power supplies are routed from terminal strips in the power supplies to terminal strips on the back (input) side of the power supply distribution board. The power supply distribution board is mounted to the inside of the power supply box with the bulkhead connectors on the front (output) side of the power supply distribution board extending through holes in the power supply box. Six AC fuses and one DC circuit breaker are mounted on the left end of the power supply box.

The INTC board is secured to a mounting plate with five snap-on standoffs and one screw. The mounting plate is then secured to the front panel of the power supply box with four captive screws.

Each of the two fans are mounted to the left-side panel with two screws.

## 4.5 Power Supply Box (CE 2001)

Figure 4-11 is a top view of the power supply box with the covers removed and shows the locations of the single power supply.

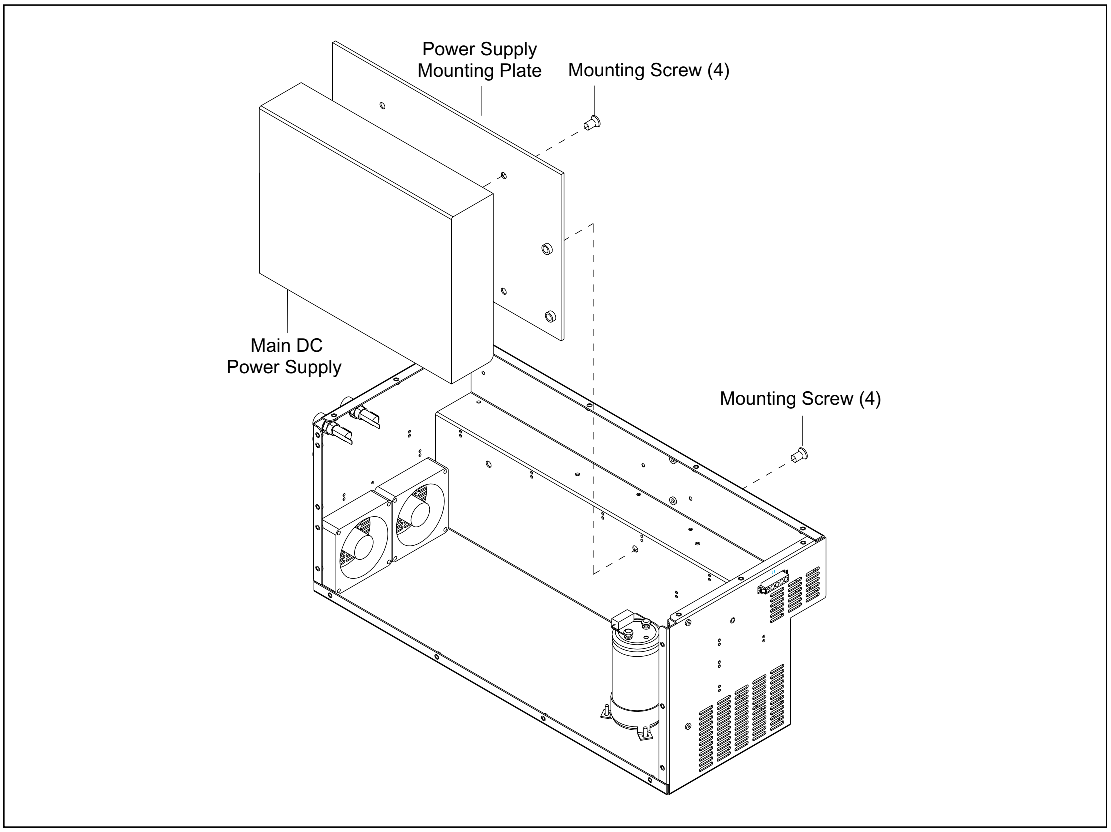



Figure 4-11. Power Supply Box Assembly.

The top cover is secured to the power supply box with 14 screws.

The main DC power supply is mounted to a mounting plate with four screws and the mounting plate is secured to the rear panel of the power supply box with four screws.

The power supply distribution board is secured to the front panel with 11 screws, and the front panel is secured to the power supply box with nine screws.

The DC outputs from the power supply are routed from terminal strips in the power supply to terminal strips on the back (input) side of the power supply distribution board. The power supply distribution board is mounted to the inside of the power supply box with the bulkhead connectors on the front (output) side of the power supply distribution board extending through holes in the power supply box. Two AC fuses are mounted on the left end of the power supply box.

The INTC board is secured to a mounting plate with five snap-on standoffs and one screw. The mounting plate is then secured to the front panel of the power supply box with four captive screws.

Each of the two fans are mounted to the left-side panel with two screws.

## 4.6 Internal Computer Assembly

The internal computer assembly consists of the internal computer, computer enclosure, EPHV board, ADAQ board, PDIO board, and high-voltage (HV) power supply. Figure 4-12 illustrates the internal computer assembly with the PDIO board, ADAQ board, and HV power supply in position. The PDIO board and ADAQ board are each mounted to the top cover assembly onto four plastic standoffs and secured with four nuts and washers. The plastic standoffs are press-fitted into holes in the top cover. The HV power supply is secured to a mounting plate with six screws. The mounting plate is then secured to the computer enclosure with six knurled captive screws.

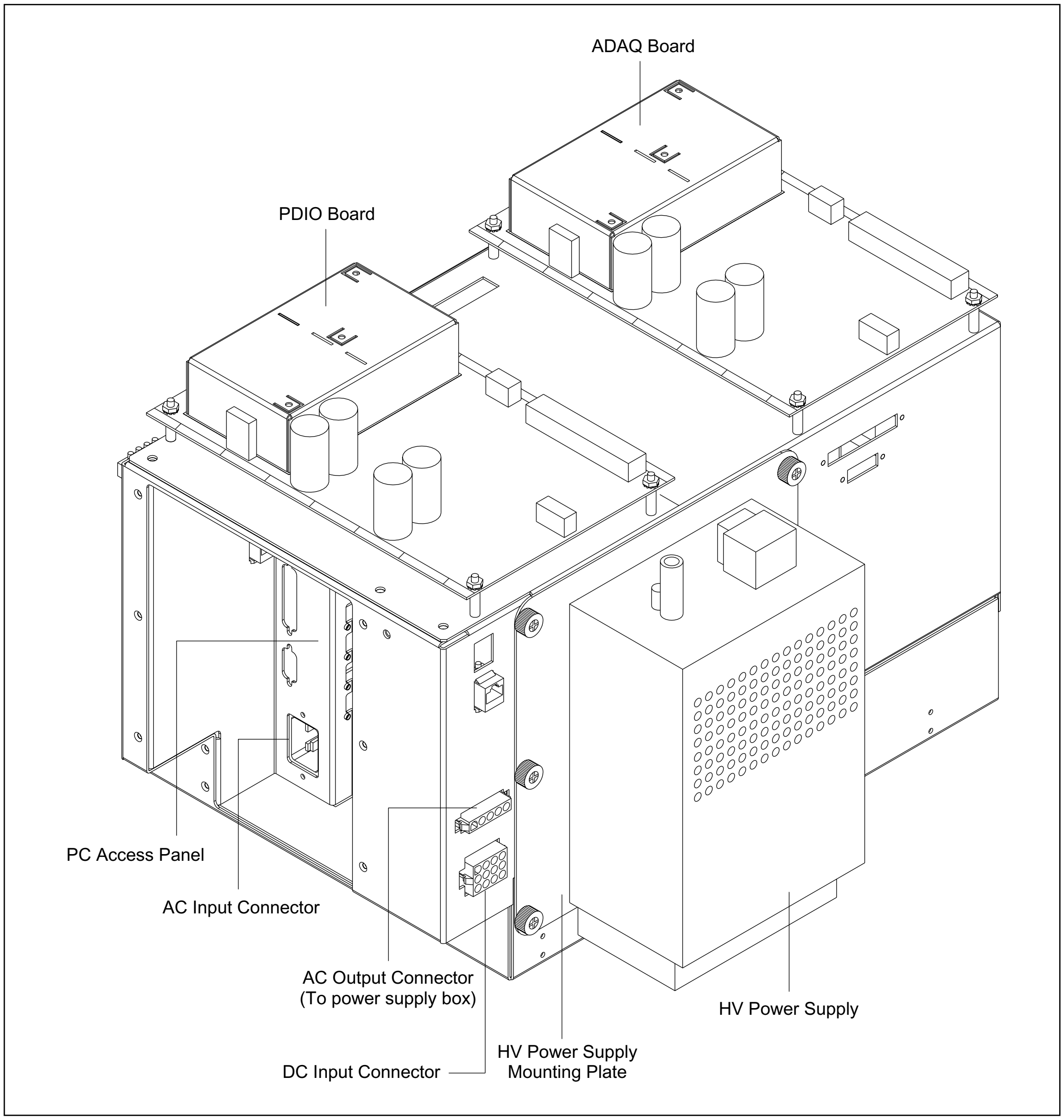



Figure 4-12. Internal Computer Assembly.

The internal computer enclosure is illustrated in figure 4-13. The enclosure consists of the sheet-metal chassis with internal partition and computer access panel, top cover assembly, HV power supply mounting plate, two fans, and front panel. The top cover is secured to the sheet-metal chassis with eight screws on the top and four screws along the side. The front cover is secured to the top cover assembly and sheet-metal chassis with six 1/4-turn studs. The EPHV board mounts to four standoffs inside the top cover's side panel.

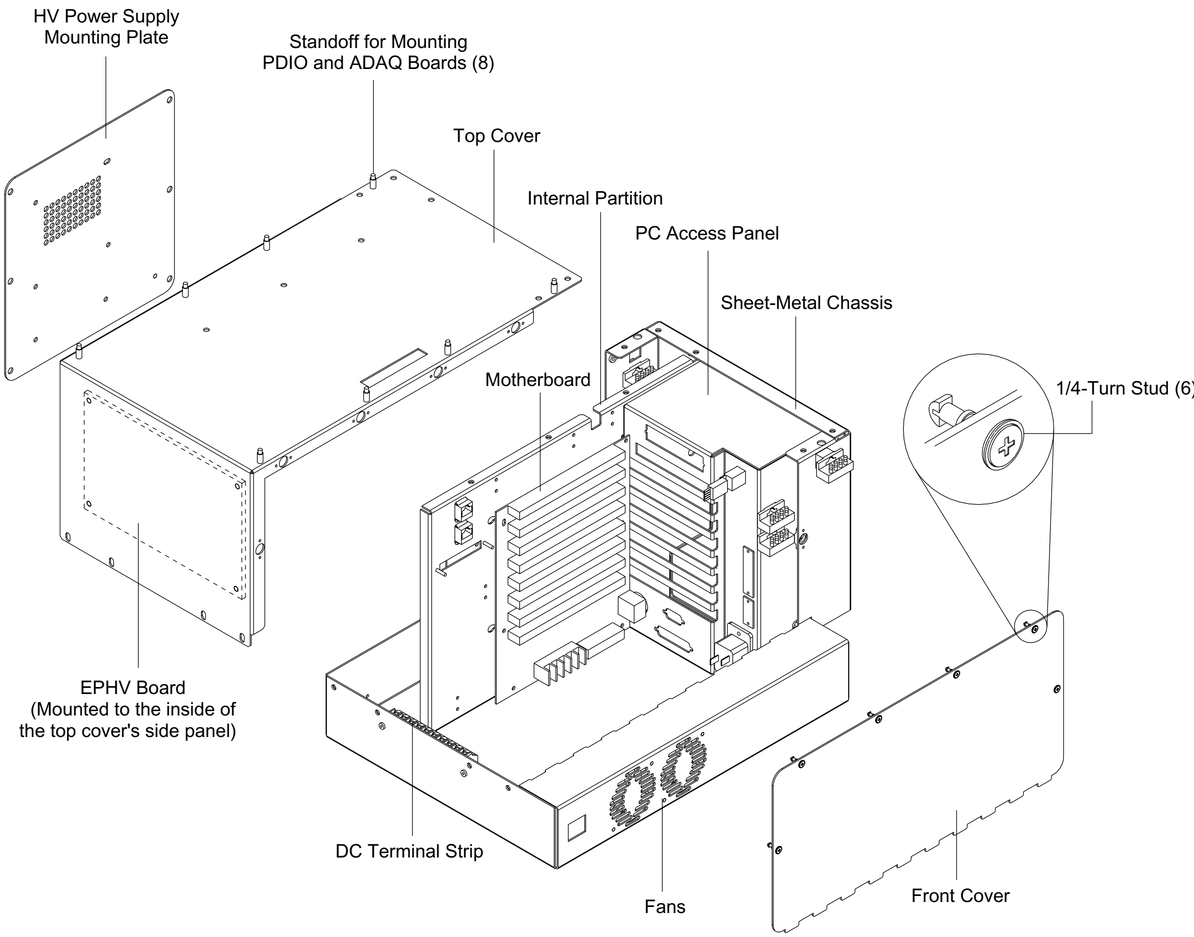



Figure 4-13. Internal Computer Enclosure.

## 4.7 Optics Plate Assembly

The optics plate assembly provides a mounting for all the instrument optical components. Figure 4-14 illustrates the optics plate assembly in position on the sheet-metal chassis. The optics plate assembly consists of a baseplate, optics enclosure assembly, and the optical components.

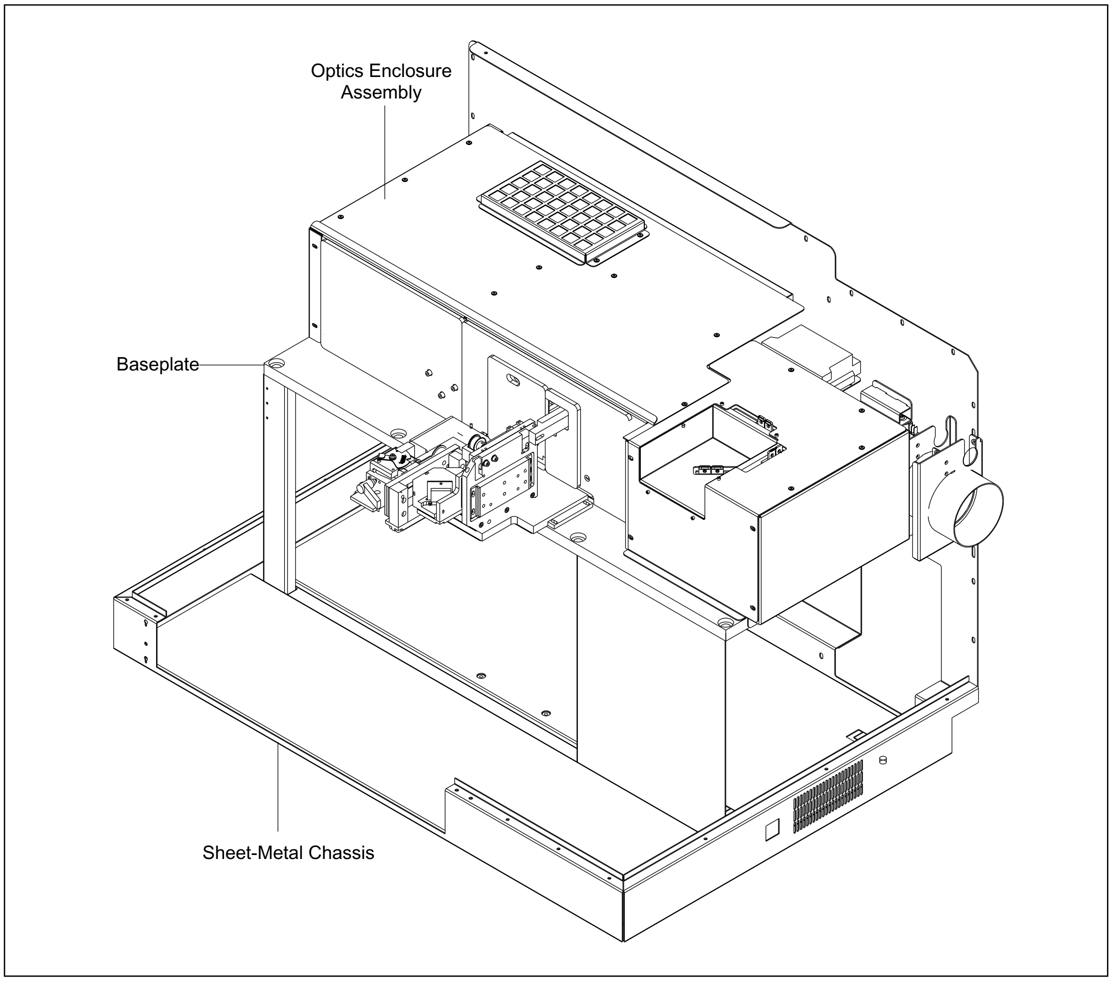



Figure 4-14. Optics Plate Assembly.

### 4.7.1 Baseplate

The baseplate is made of 3/4-inch thick aluminum and is mounted to the sheet-metal chassis with five screws. The baseplate has threaded screw holes for mounting the various optics components and their supports and the optics enclosure.

### 4.7.2 Optics Enclosure

The optics enclosure (figure 4-15) consists of a series of panels, partitions, and covers that divide the optics assembly into three lightproof compartments. These compartments prevent ambient light from entering and prevent scattered light from one compartment interfering with the optics in an adjacent compartment.

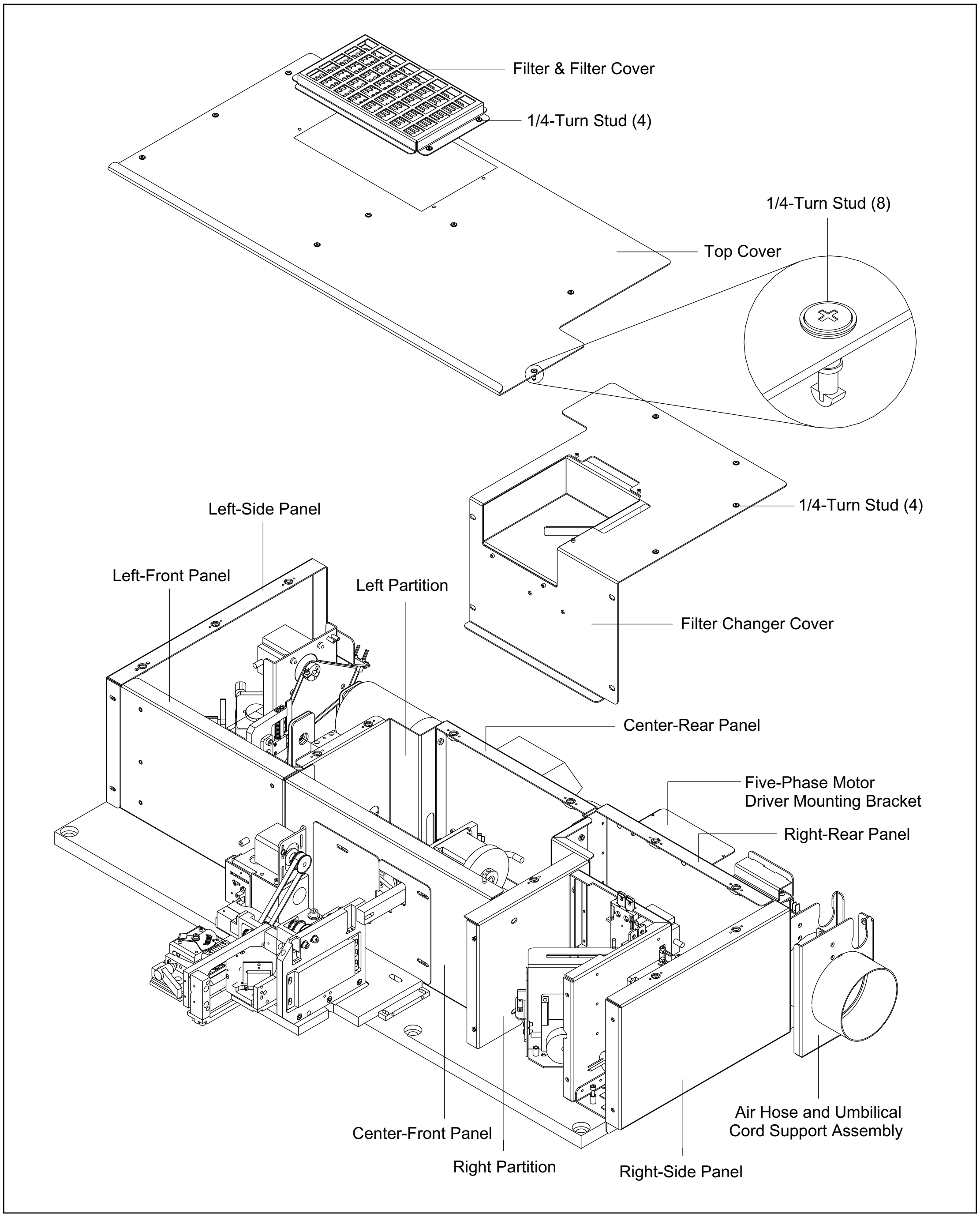



Figure 4-15.  Optics Enclosure Assembly.

The six panels and two partitions are secured to each other with screws. The right- and left-side panels are each secured to the edges of the optics baseplate with three screws. The front and rear panels are each secured to the top of the optics baseplate with two captive screws. The five-phase motor driver mounting bracket is secured to the right-rear panel with two screws. The air hose and umbilical cord support assembly are secured to the top of the optics baseplate with four screws. The right-rear, center-rear, and left-front panels also serve as mounting plates for the three motor driver boards. Each of the motor driver boards is mounted to standoffs on the inside of the panel with four screws. The filter changer cover is secured to front edges of the right-side panel and right partition with four screws and to the top edges of the right-side and right-rear panels with four 1/4-turn captive studs. The filter cover is secured to the top cover with four captive screws. The top cover is secured to the top edges of the left-side and center-rear panels and the two partitions with eight 1/4-turn captive studs.

### 4.7.3 Optical Components

Figures 4-16, 4-17, and 4-18 illustrate the positions of the optical components as they are installed on the optics baseplate. The optics enclosure assembly has been removed for clarity. For the sake of this explanation, the optical components are separated into three physical groups as shown in the three different illustrations. The first group of optical components (figure 4-16) consists of the blue laser with exhaust hose and umbilical cord, green laser, blue and green laser line filters, green neutral-density (ND) filter, shutter assembly, first and second turning mirrors, beam combiner, and capillary detection assembly.

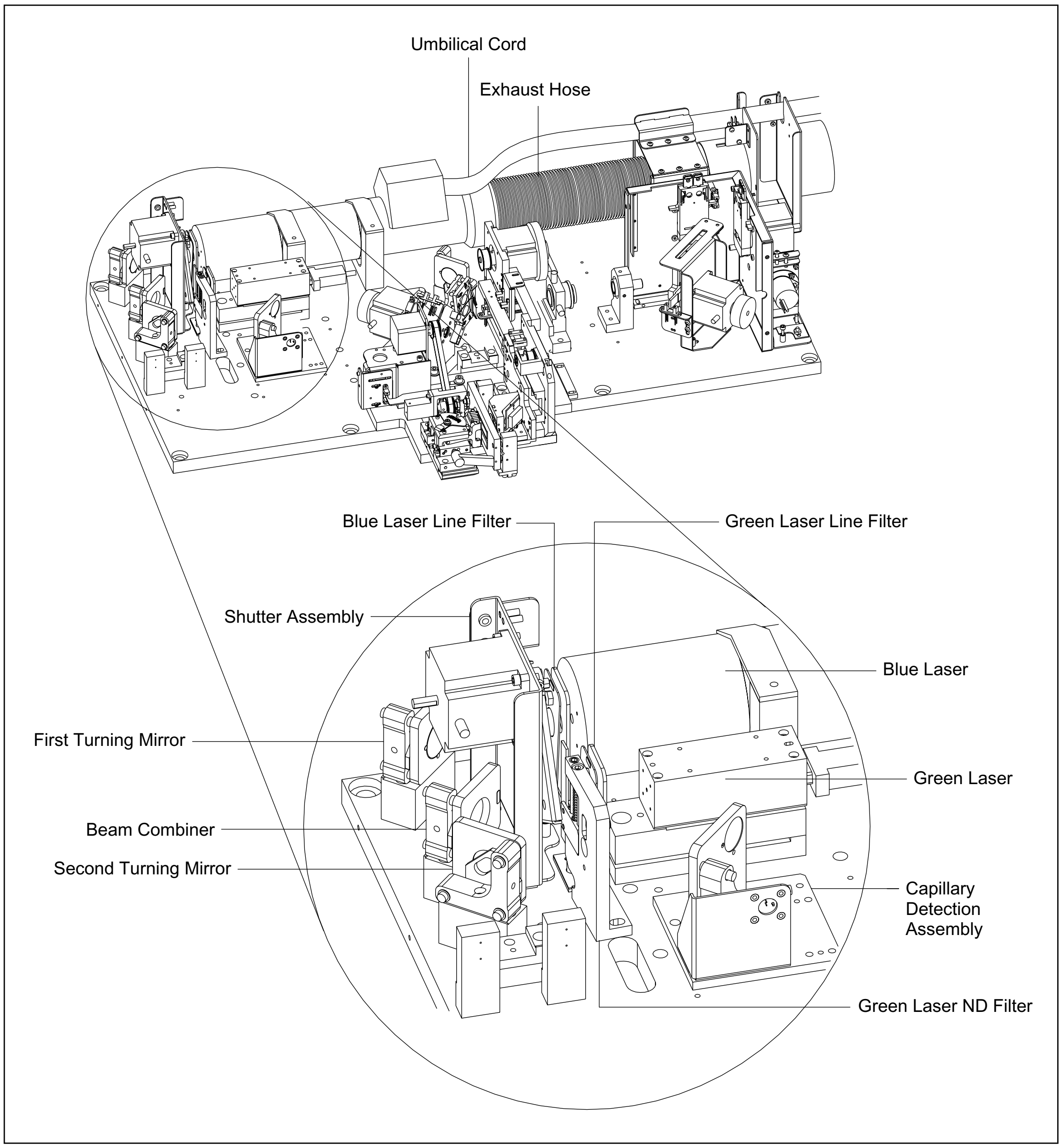



Figure 4-16. Optical Components Assembly (Sheet 1 of 3).

The second group of optical components (figure 4-17) consists of the third turning mirror, primary beamsplitter changer assembly, scanning stage assembly, capillary window platform, and first achromat.

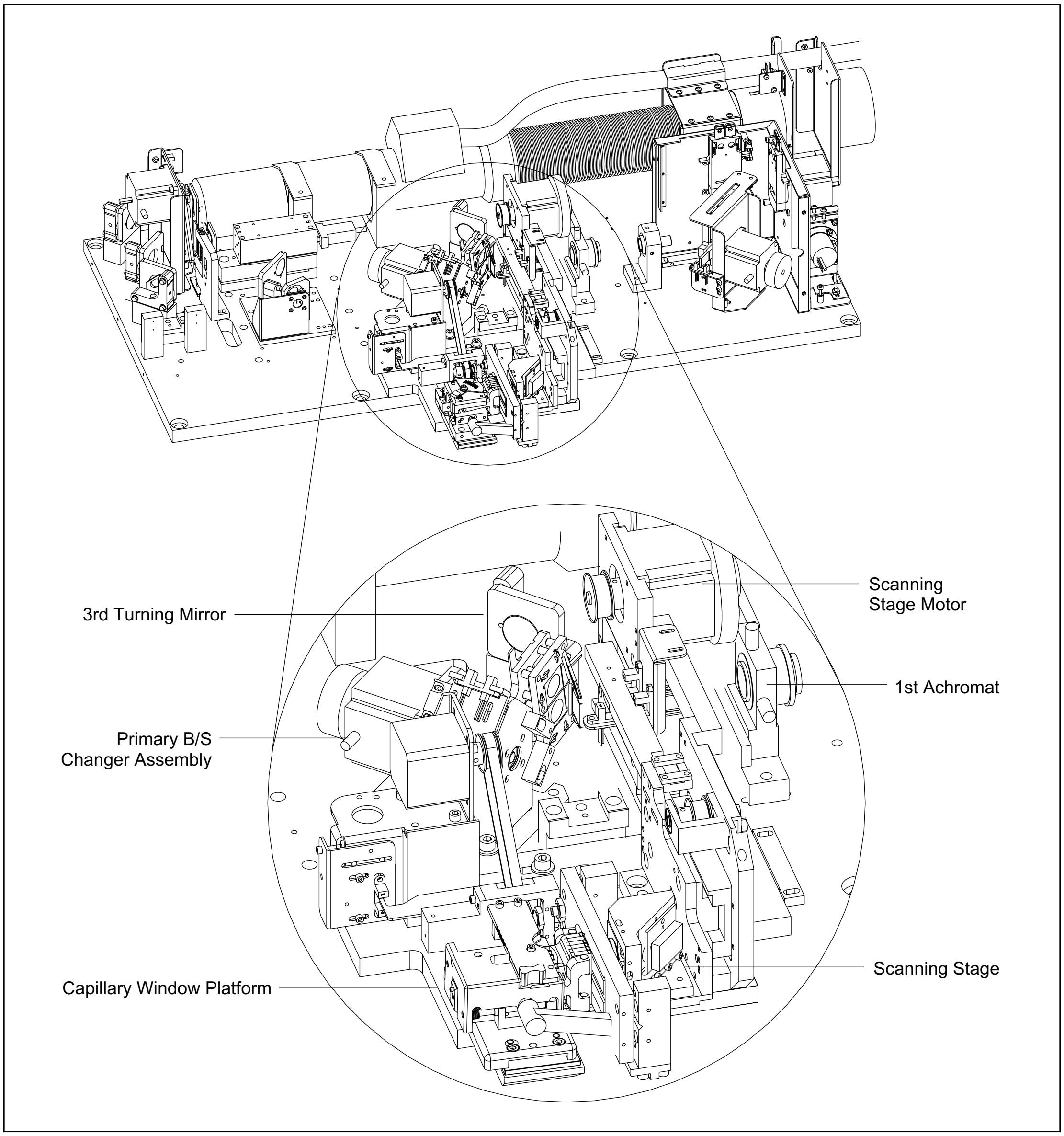



Figure 4-17. Optical Components Assembly (Sheet 2 of 3).

The third group of optical components (figure 4-18) consists of the second achromat, secondary beamsplitter changer assembly, two filter changer assemblies, and two PMTs.

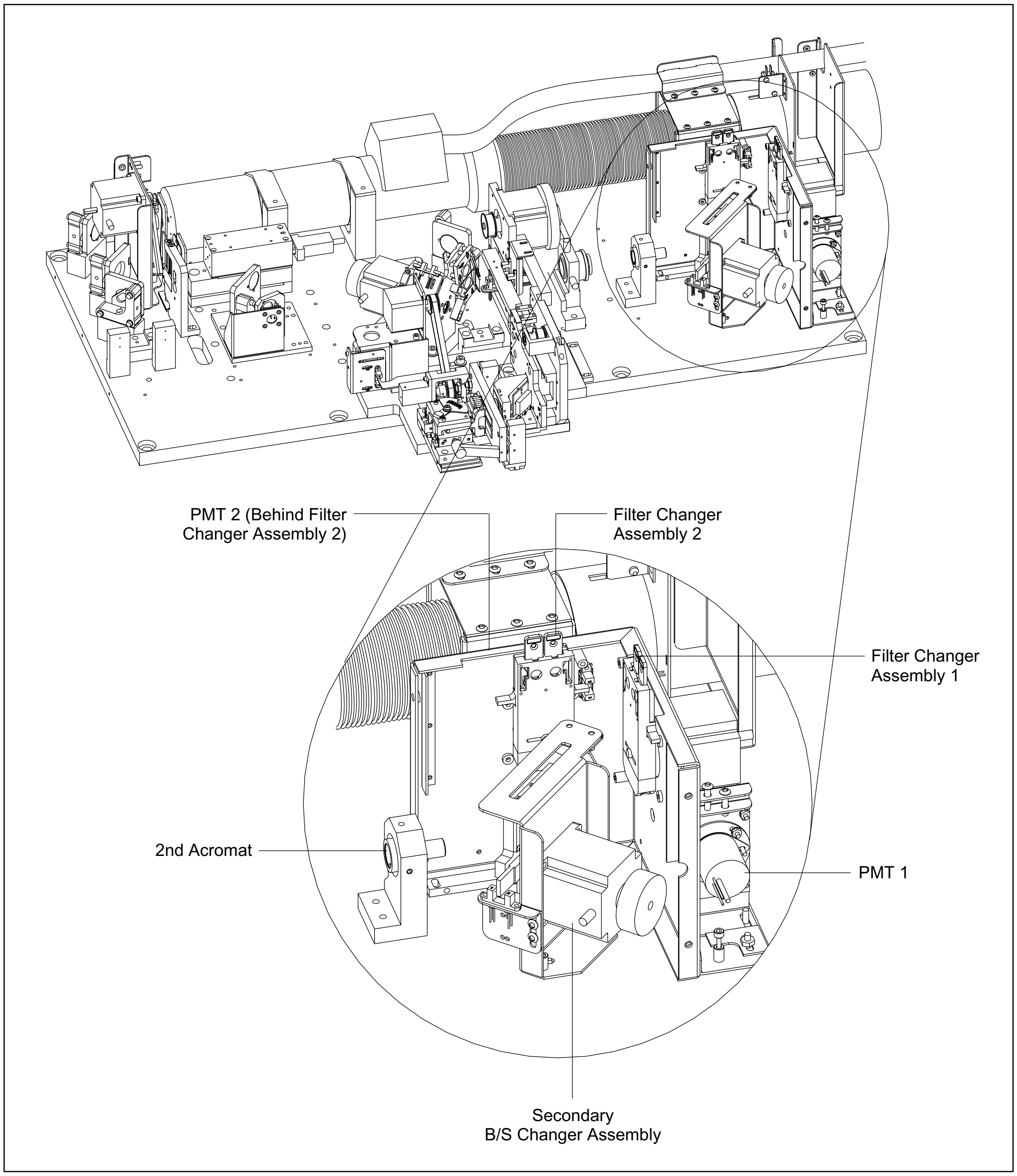



Figure 4-18. Optical Components Assembly (Sheet 3 of 3).

### 4.7.4 Blue Laser

The blue laser (figure 4-19) is an argon-ion laser operating at 488 nm with power up to 25 mW. The laser is mounted in a cradle on the optical plate at the rear of the instrument. The laser is secured to the cradle with two clamps. The laser is powered by the external power supply fan module. An umbilical cord connects the laser to the power supply fan module and enters the MegaBACE instrument near the exhaust vent. Exhaust for the laser is supplied by the fan located in the power supply fan module. A large air hose runs from the power supply fan module to the exhaust vent mounted on the right side of the instrument. Internally, another length of hose connects the laser to the exhaust vent. An air vane and microswitch provide a signal when the air flow stops. The microswitch is mounted to the cooling vent, and the vane extends into the air flow.

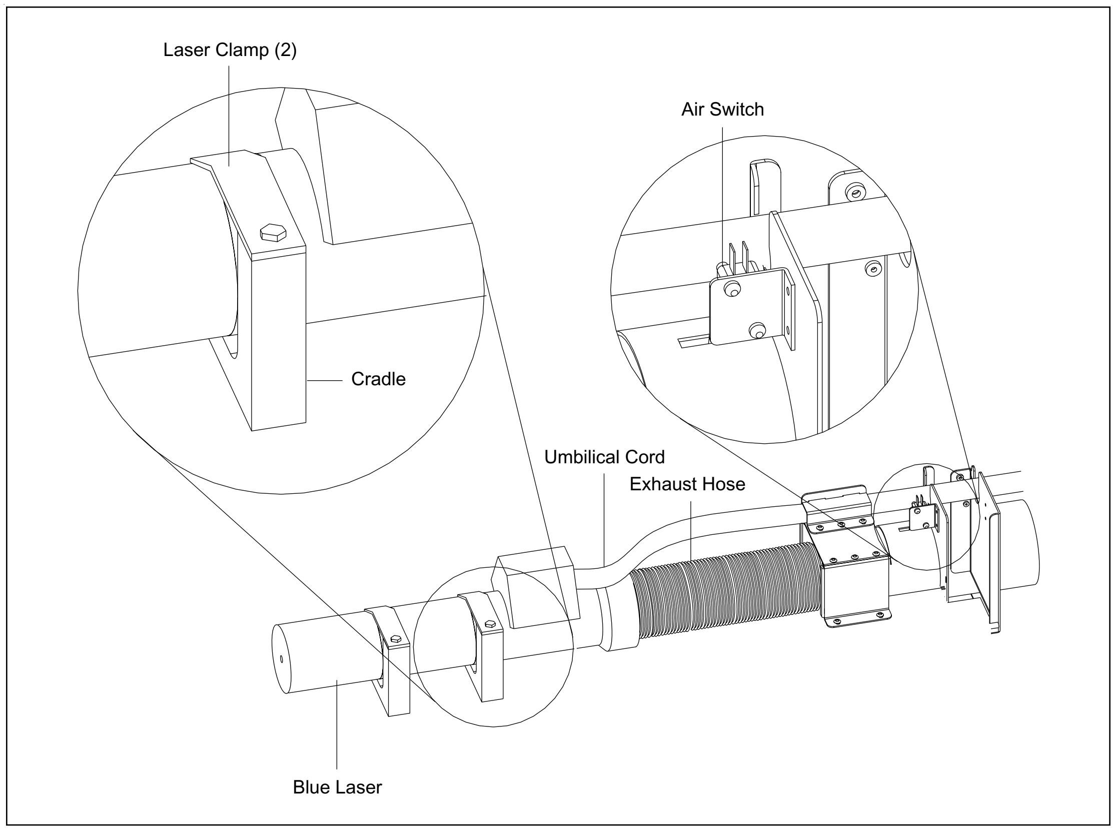



Figure 4-19. Blue Laser Assembly.

### 4.7.5 Green Laser

The green laser (figure 4-20) is a solid-state diode laser, operating at 532 nm with power up to 40 mW. The green laser mounts to an adjustable platform that is secured to the optics plate next to the blue laser. The adjustable platform allows the elevation of the green laser beam to be adjusted. The green laser has a separate power supply that is mounted to the underside of the optics plate. The green laser and its power supply have heat sinks with cooling fins to dissipate heat. The green laser and its power supply are connected by a power cable through a hole in the optics plate.

*CAUTION* **To prevent damage to the green laser caused by static electric discharge, *do not* disconnect the laser from its controller. The green laser is very susceptible to static electricity.**

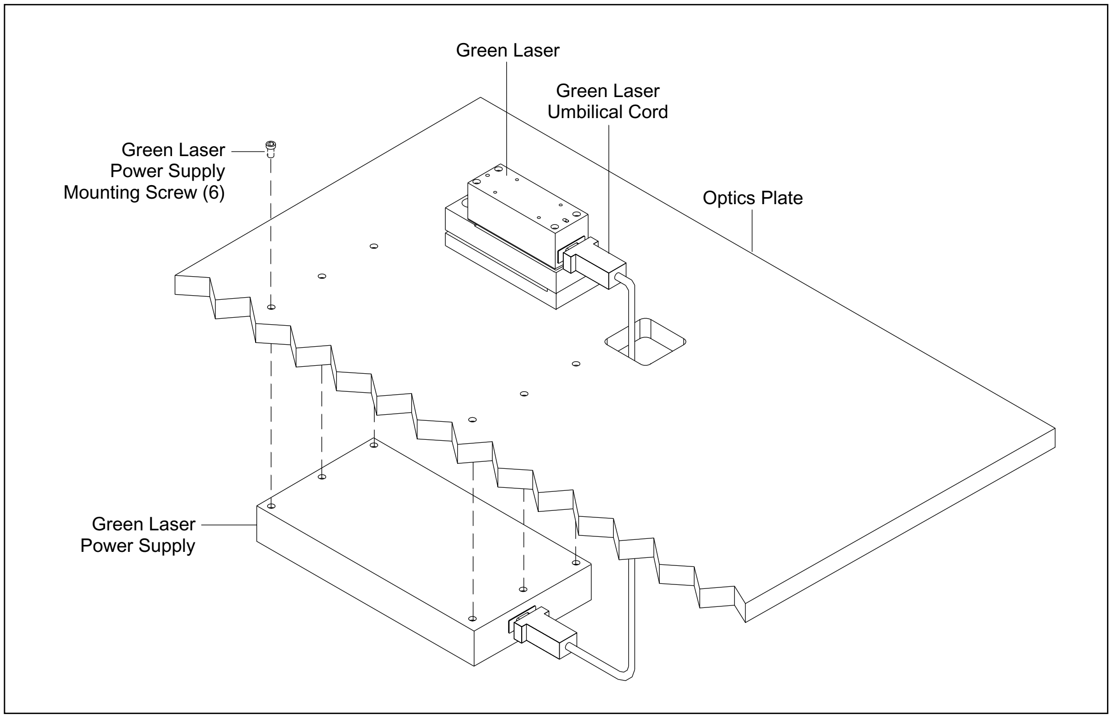



Figure 4-20. Green Laser Assembly.

### 4.7.6 Laser Line Filter Assembly

The blue and the green laser beams are initially filtered by a narrow-band filter (figure 4-21) to reject light that is not at the desired wavelength. These filters have a 10-nm band pass with greater than 80% transmission of the desired wavelength. The filter assemblies for the blue and the green filters are identical except for the actual filter lens. The filter is mounted to a flexible metal bracket that is riveted to the filter assembly bracket. The flexible metal bracket has a threaded screw hole that holds the filter adjustment screw. The filter is aligned in one plane by loosening the captive mounting screw and turning the filter assembly. The filter can be aligned in a second plane by loosening the locking nut and turning the filter adjustment screw, which pushes against the filter assembly bracket slightly and tilts the filter up or down. The laser line filters are secured to the baseplate by a captive mounting screw.

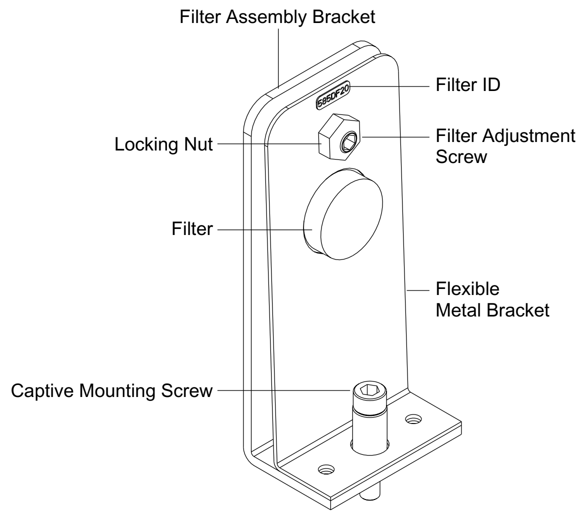



Figure 4-21. Laser Line Filter Assembly.

### 4.7.7 Green Laser ND Filter Assembly

The green laser neutral-density (ND) (figure 4-22) filter is located immediately after the green laser line filter assembly. The ND filter is a piece of glass with a coating that is graduated from top to bottom. This coating attenuates all light that passes through it. The filter can be raised or lowered by the filter adjustment screw to adjust the intensity of the laser beam. The ND filter assembly also has an adjustable aperture that is in line with the excitation light between the second turning mirror and the capillary detection assembly. The ND filter assembly is secured to the optical baseplate with two screws.

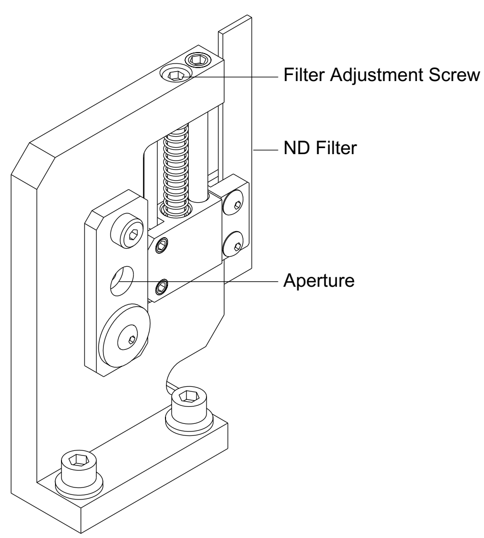



Figure 4-22. Green Laser ND Filter Assembly.

### 4.7.8 Three-Position Shutter Assembly

The three-position shutter assembly (figure 4-23) consists of the mounting bracket, stepper motor, shutter, shutter return spring, home sensor, and mounting hardware. The mounting bracket is secured to the optics plate with three captive screws. The stepper motor is mounted to the bracket with four screws, and the shutter is mounted to the stepper-motor shaft. The shutter return spring is connected between the bracket and the shutter. The shutter return spring ensures that the shutter returns to the home position, and blocks both lasers when power to the stepper motor is removed for any reason. The home sensor is an optical detector that signals when the shutter is in the home position. The home sensor is secured to the mounting bracket with two screws that allow the home sensor to be adjusted.

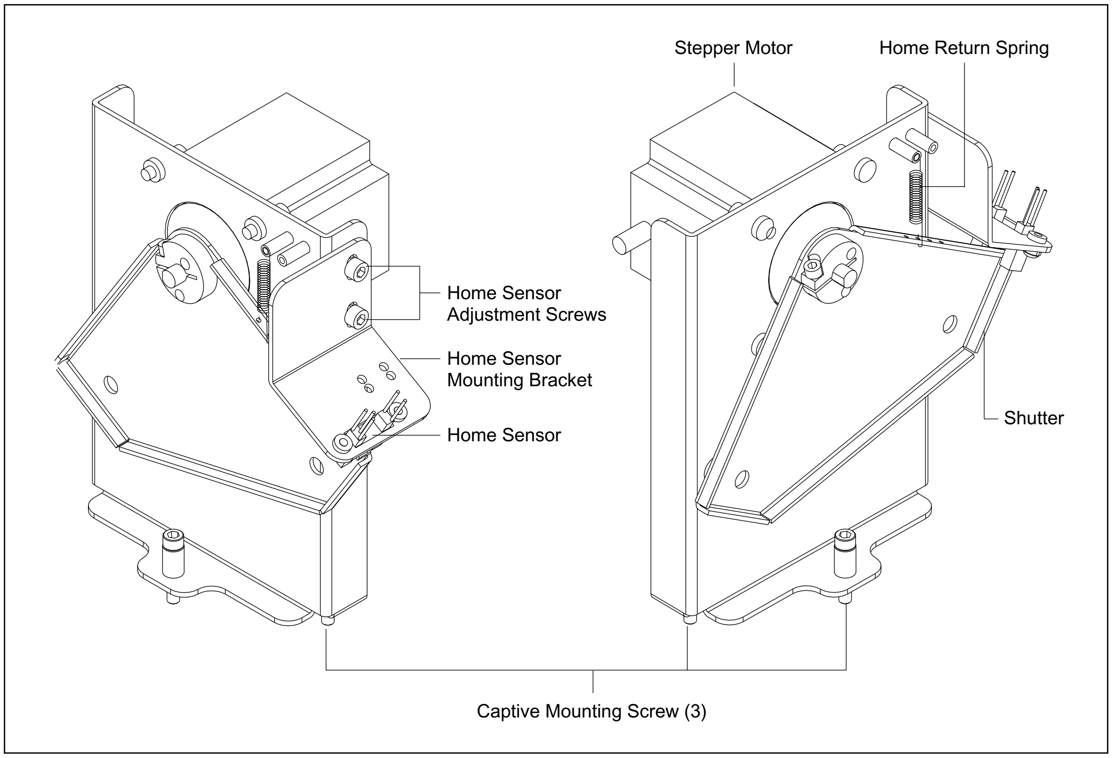



Figure 4-23. Three-Position Shutter Assembly (Sheet 1 of 2).

The laser openings in the shutter are moved to their respective positions by turning the stepper-motor shaft a predetermined number of degrees from the home position. It is important that the home sensor be accurately positioned. As shown in figure 4-24, if the shutter is rotated 7.2° clockwise, the green laser opening will be directly in line with the green laser beam. If the shutter is rotated 12.6° clockwise, the blue laser opening will be directly in line with the blue laser beam. The shutter selects between the two lasers or blocks both beams. The shutter is rotated to the home position and blocks both beams on power up, reset, or when a system interlock is opened.

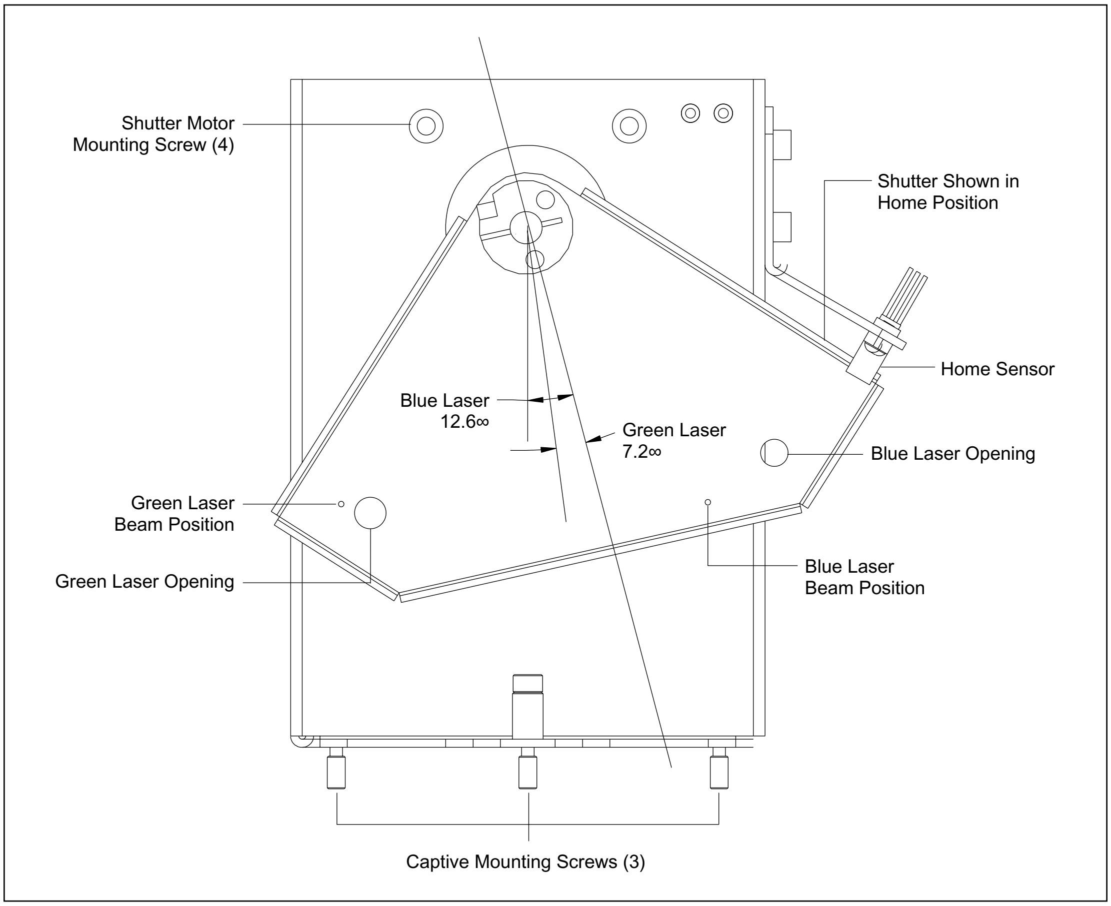



Figure 4-24.  Three-Position Shutter Assembly (Sheet 2 of 2).

### 4.7.9 Mirror Assemblies

The instrument uses three identical mirror assemblies (figure 4-25) to redirect the laser beams. The mirror is mounted in a frame that is secured to an adjustment mechanism. The adjustment mechanism has three screws that allow the mirror to be adjusted in the X, Y, and Z planes. Each mirror assembly is mounted by a single screw to a platform that is secured to the optics plate. The first mirror is positioned in front of the blue laser and turns the beam toward the beam combiner. The second mirror turns the blue and the green beams toward the third mirror. The third mirror turns both beams toward the primary beamsplitter.

### 4.7.10 Beam Combiner Assembly

With the exception of the type of optic mounted in the frame, the beam combiner assembly is identical to the mirror assemblies (figure 4-25). The beam combiner assembly is mounted in front of the green laser on a platform that is secured to the optics plate. The beam combiner passes the blue laser beam and redirects the green laser beam. The three adjustment screws allow for coaxial alignment of the blue and green laser beams. A label on the rear of the beam combiner assembly denotes the optical characteristics of the beam combiner.

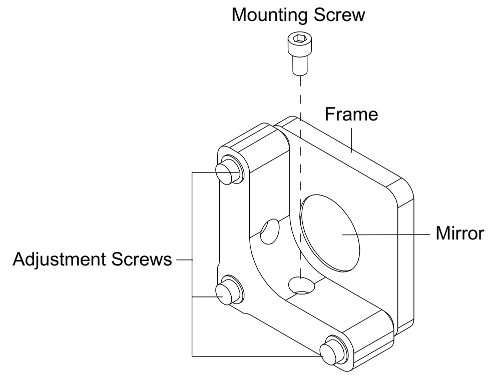



Figure 4-25. Mirror/Beam Combiner Assembly.

### 4.7.11 Capillary Detection Assembly

The capillary detection assembly (figure 4-26) consists of an adjustable beamsplitter, filter, and photodiode. The photodiode and a coaxial connector are mounted to a small circuit board. The circuit board is mounted to a bracket that is secured to a base plate. A coaxial cable carries the current from the photodiode to the PDIO board for processing. The beamsplitter is also mounted to the base plate, and the base plate is secured with two screws to the optics plate in the path of the laser beams. The beamsplitter is mounted in a frame that is secured to an adjustment mechanism. The adjustment mechanism has three screws that allow the beamsplitter to be adjusted in the X, Y, and Z planes.

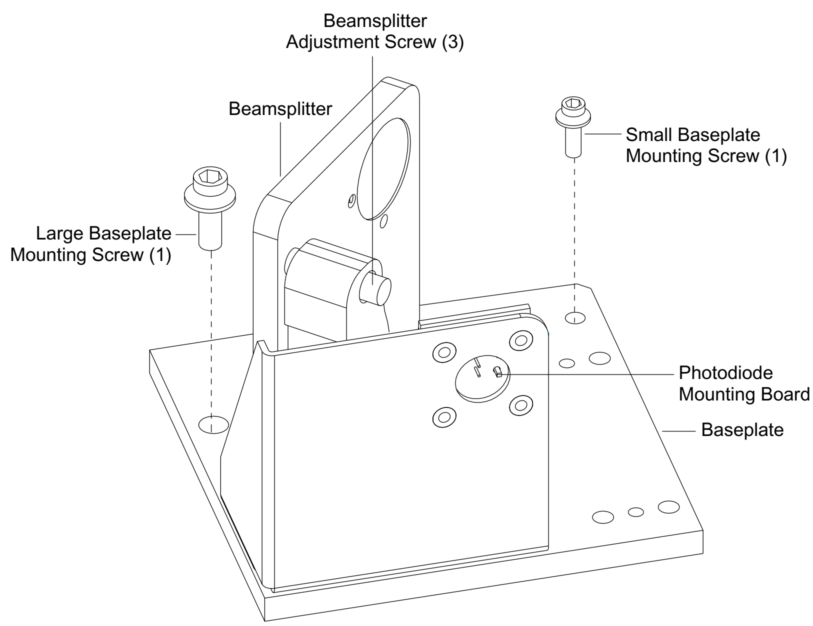



Figure 4-26. Capillary Detection Assembly.

### 4.7.12 Primary Beamsplitter Changer Assembly

The primary beamsplitter changer assembly (figure 4-27) consists of a beamsplitter arm assembly mounted to the shaft of a stepper motor. The primary beamsplitter changer assembly is secured to the optics plate with four screws. The changer assembly places either the blue or green beamsplitter in the laser beam path. The beamsplitter transmits greater than 95% of the associated laser beam and reflects greater than 95% of the emission spectra. The beamsplitters are laser-wavelength specific, and switching is synchronized with the three-position shutter. Each beamsplitter has a laser-blocking filter mounted to it. The filter blocks the laser light from the emission path.

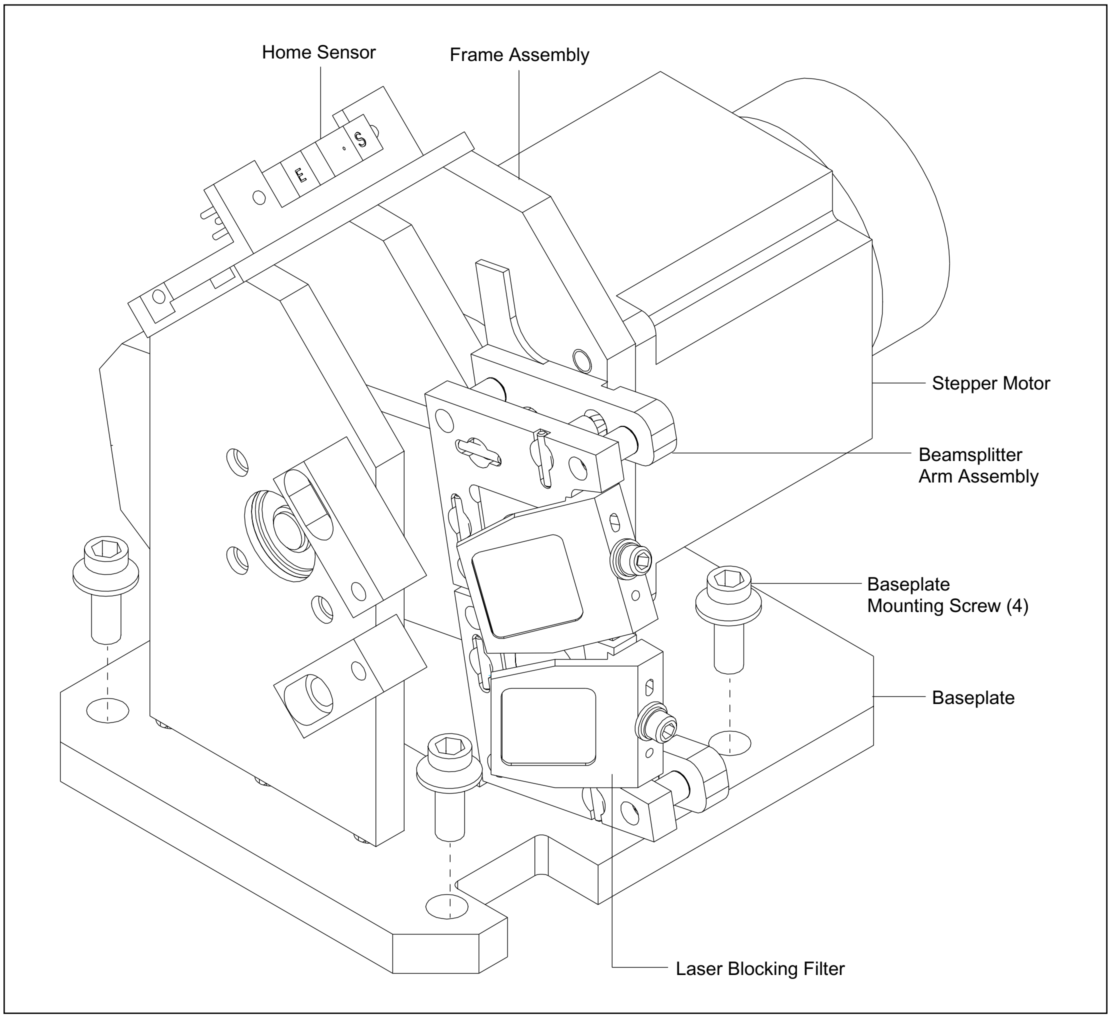



Figure 4-27. Primary Beamsplitter Changer Assembly.

Figure 4-28 illustrates the beamsplitter arm assembly. An optical home sensor signals when the beamsplitter arm is in the home position. At the home position, the home flag on the beamsplitter arm breaks the light path between the light emitter and the light sensor. The home sensor is mounted to an adjustable bracket. It is important that the home sensor be accurately adjusted because the blue and the green beamsplitters are moved to their respective positions by turning the stepper-motor shaft a predetermined number of degrees from the home position. At the home position, the centerline of the beamsplitter arm is at 45° from vertical. To place the blue beamsplitter in the path of the laser beam, the beamsplitter arm is rotated clockwise 34.2° from the home position. To place the green beamsplitter in the path of the laser beam, the beamsplitter arm is rotated clockwise 21.6° from the blue position.

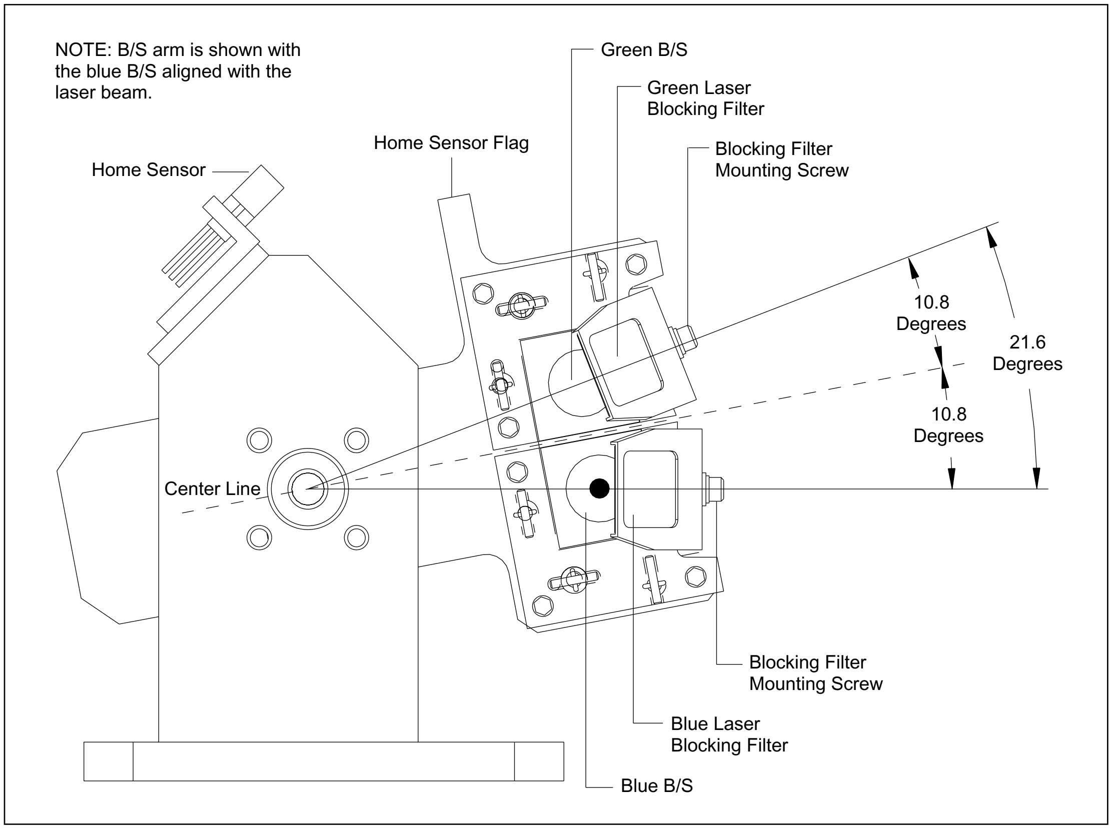



Figure 4-28. Primary Beamsplitter Arm Assembly.

### 4.7.13 Scanning Stage

The scanning stage (figure 4-29) consists of the scanhead assembly, scanhead drive assembly, and capillary window platform assembly.

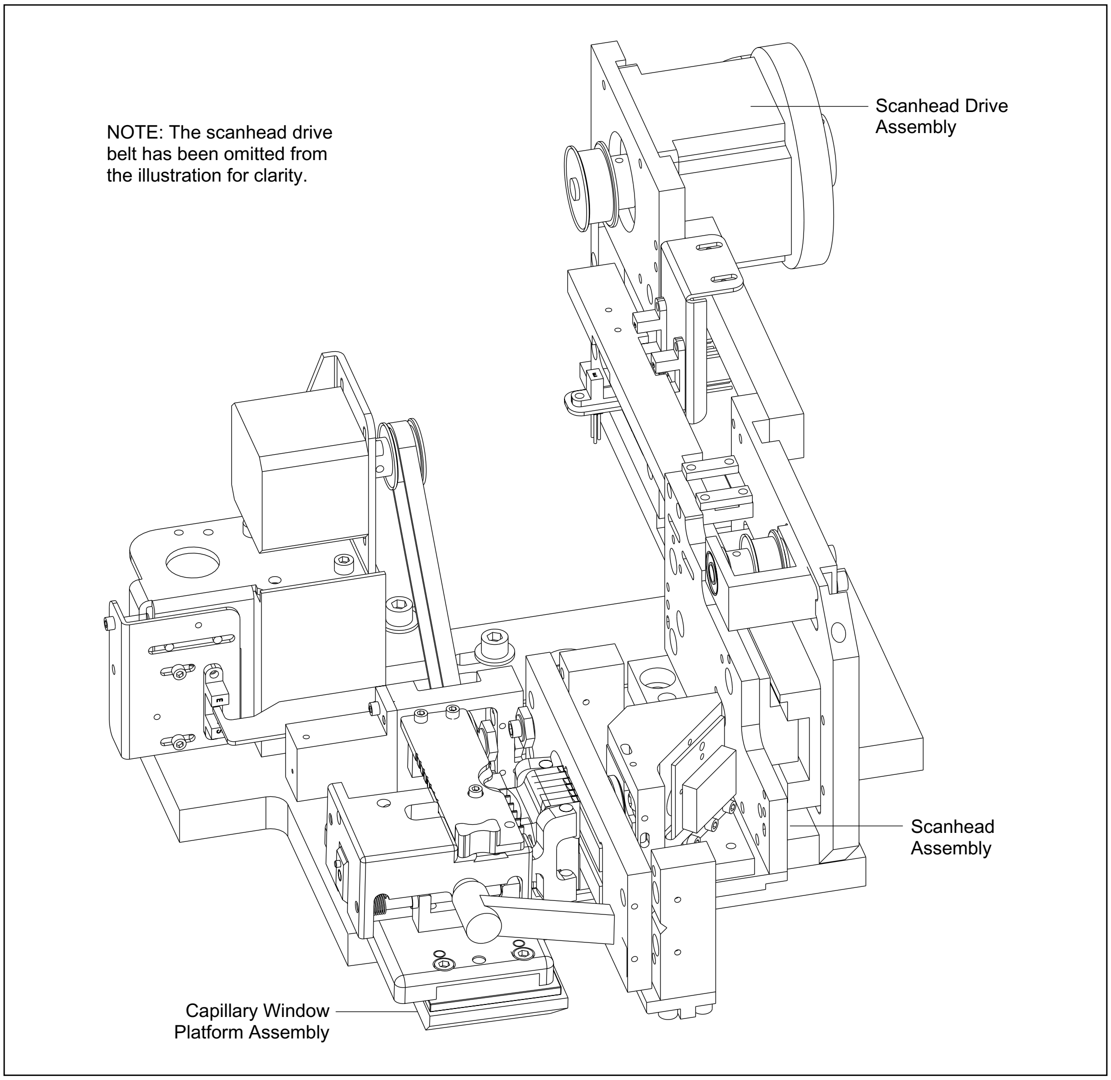



Figure 4-29. Scanning Stage Assembly.

#### 4.7.13.1 Scanhead Assembly

The scanhead assembly (figure 4-30) consists of an objective lens and a turning mirror secured to a mounting plate. The objective lens focuses the laser beam into the center of the capillary and collects the emission light. The objective lens is an aspheric acrylic lens with an NA of 0.5 and focal length of about 4.5 mm.

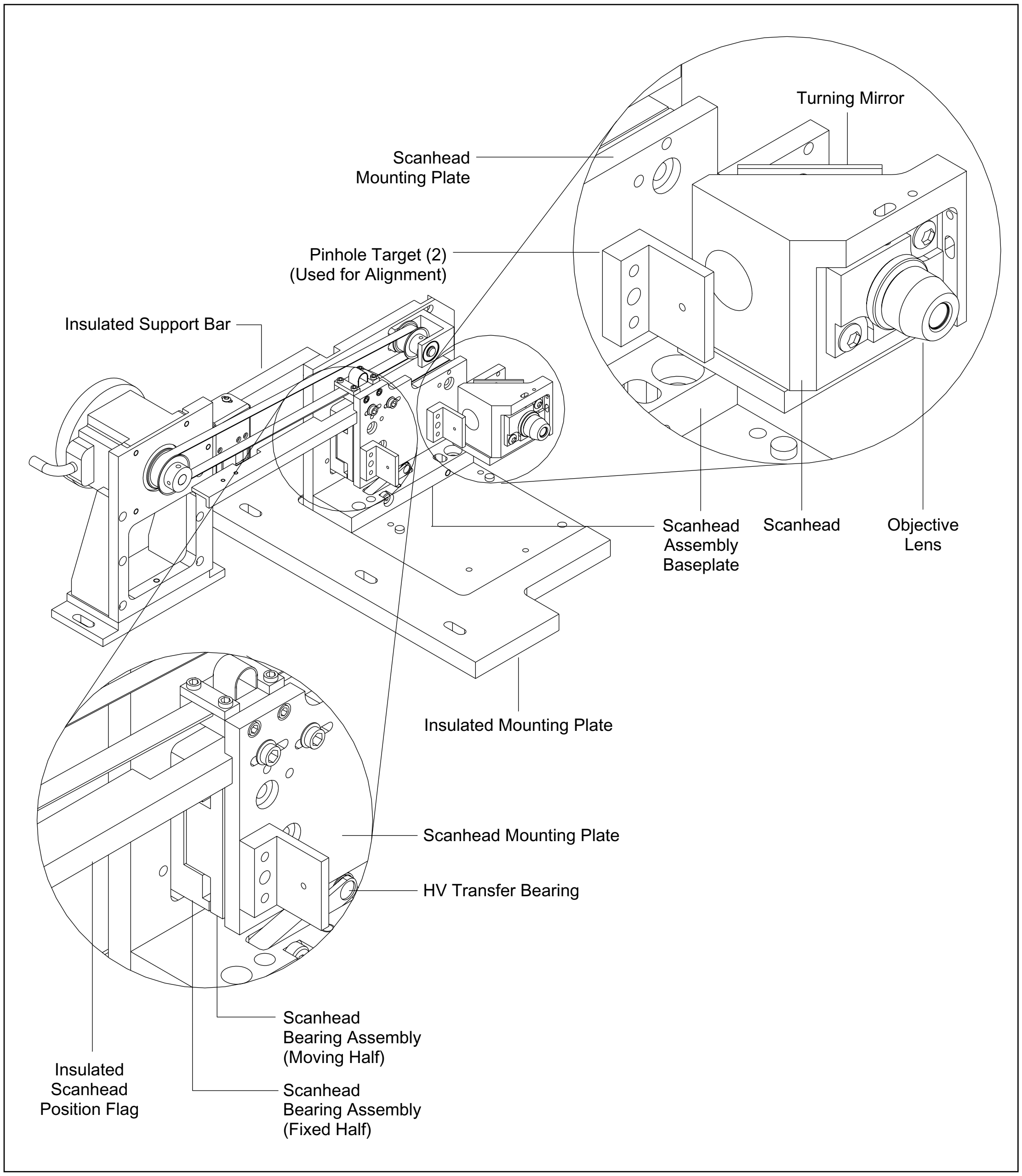



Figure 4-30. Scanhead Assembly.

The scanhead assembly mounting plate is secured to the moving half of the scanhead bearing assembly. The fixed half of the scanhead bearing assembly is secured to a bearing mounting bracket that is attached to the scanhead assembly baseplate. The bottom edge of the scanhead mounting plate rides on a spring-loaded HV transfer bearing. The scanhead assembly baseplate is wired to the output of the HV power supply, and the HV transfer bearing ensures that the scanhead is maintained at a high potential during scanning. The scanhead assembly baseplate is secured to an insulated baseplate to isolate the rest of the instrument from the high voltage. A support bar is attached between the bearing mounting bracket and the drive motor mounting bracket. This support bar is made of an insulating material and isolates the high voltage to the scanhead assembly.

The scanhead mounting plate has a position flag mounted to it that is made from the same insulating material as the support bar. The position flag has a slot cut into it that passes between optical sensors and provides a signal when the scanhead reaches the forward and reverse limits of its movement. The scanhead mounting plate also has a clamp assembly for securing the drive belt.

#### 4.7.13.2 Scanhead Drive Assembly

The scanhead drive assembly (figure 4-31) consists of the drive motor, mounting bracket, drive belt, and pulleys. The drive motor is secured to the mounting bracket with four screws, and the mounting bracket is secured to the optics plate with two screws. The drive pulley is mounted to the drive-motor shaft and the idler pulley is secured to the scanhead bearing mounting bracket. The drive belt is looped over both pulleys and secured at the scanhead assembly belt clamp.

*NOTE* **The drive-belt loop shown in the illustration is present only on a few of the earlier models. Its purpose was to adjust the belt length because the belts of the exact length needed were not available. On later instruments, this loop is not needed.**

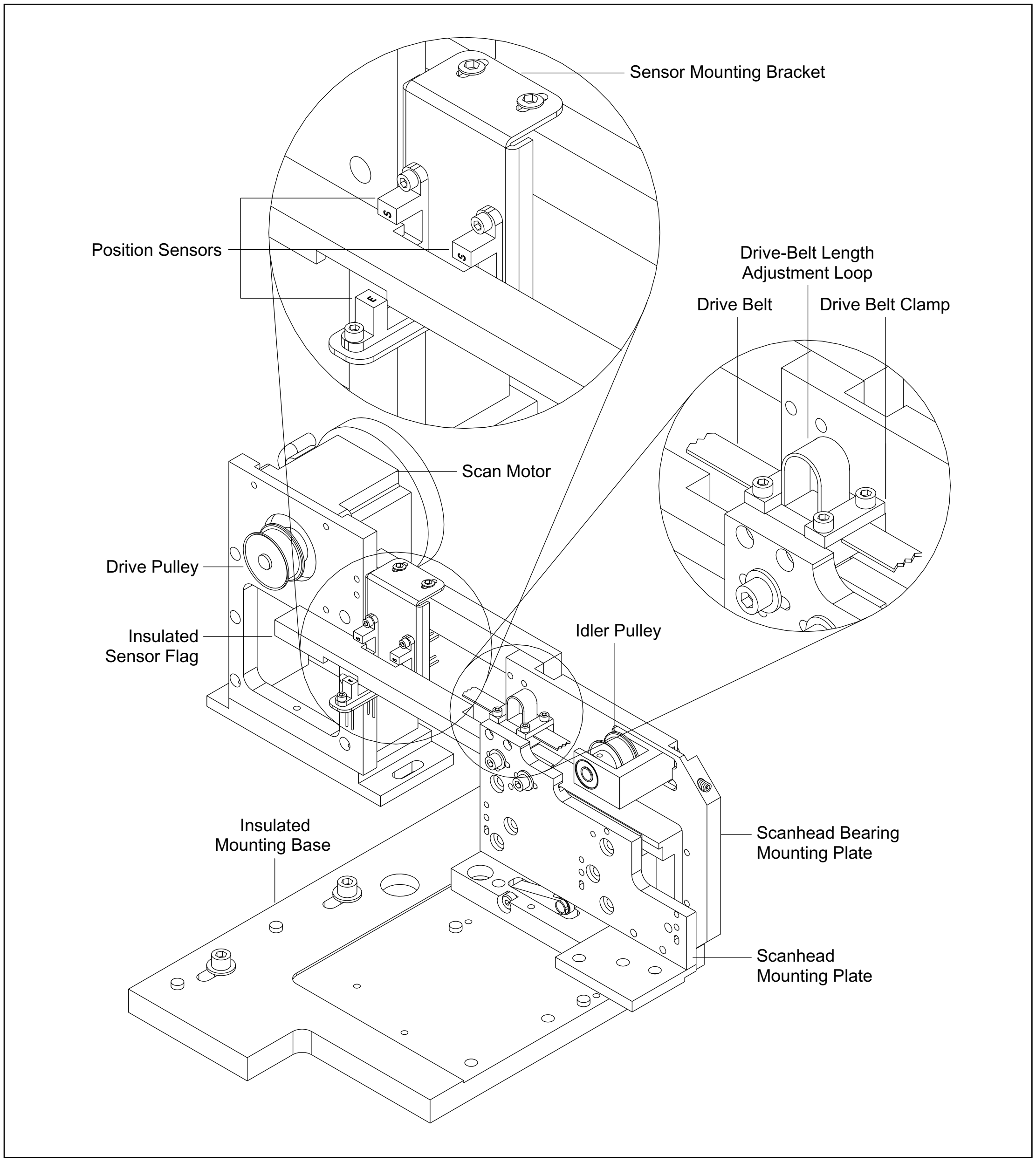



Figure 4-31. Scanhead Drive Assembly.

### 4.7.13.3 Capillary Window Platform Assembly

The capillary window platform assembly (figure 4-32) consists of the capillary window holder assembly and the power focus assembly. The capillary window holder assembly consists of the capillary window holder, registration plate, and sensor flag. The power focus assembly consists of a drive motor and mounting bracket, drive belt, screw assembly, and position sensor. As the drive motor turns, the drive belt turns the screw assembly. As the screw turns, it moves the focus stage closer to or farther from the objective lens.The sensor flag moves between the two elements of the position sensor, signaling the home position of the reference plate.

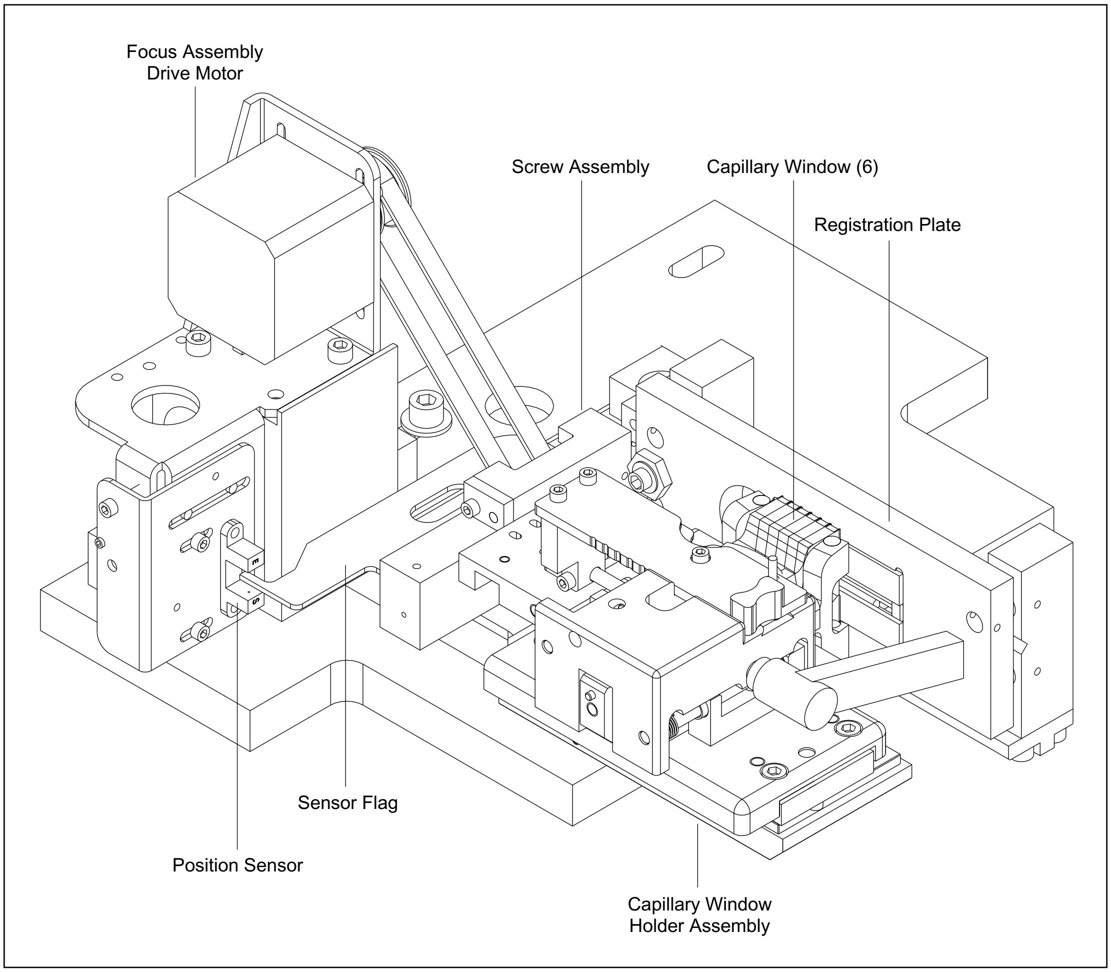



Figure 4-32. Capillary Window Platform Assembly.

### 4.7.14 First Achromatic Lens

The first achromatic lens (figure 4-33) focuses the emitted light into a 1000-micron-diameter confocal stop pinhole. Using the stop at a conjugate plane to the object reduces the background fluorescence from the capillary glass and eliminates most of the scattered light that is not initiated at the object space. The first achromatic lens has a focus control and adjustments for movement in the X and Y directions.

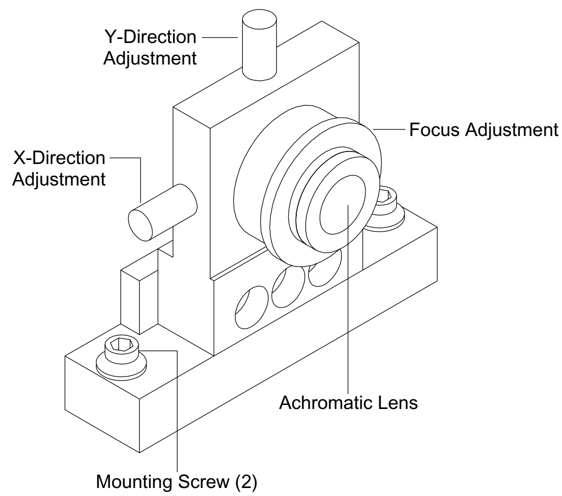



Figure 4-33. First Achromatic Lens.

### 4.7.15 Pinhole and Second Achromatic Lens

The pinhole is a 1000-micron aperture that directs collimated light to the secondary beamsplitter, as part of the confocal system (figure 4-34).

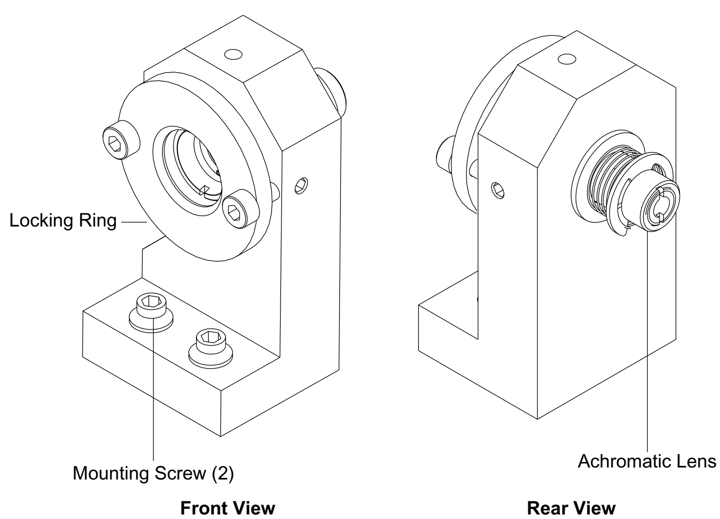



Figure 4-34. Pinhole and Second Achromatic Lens.

### 4.7.16 Secondary Beamsplitter Changer Assembly

The secondary beamsplitter changer assembly (figure 4-35) consists of a beamsplitter arm assembly mounted to the shaft of a stepper motor. The changer assembly places the appropriate beamsplitter in the emitted light path. The beamsplitters are laser-wavelength specific for the channels to be detected and switching is synchronized with the three-position shutter.

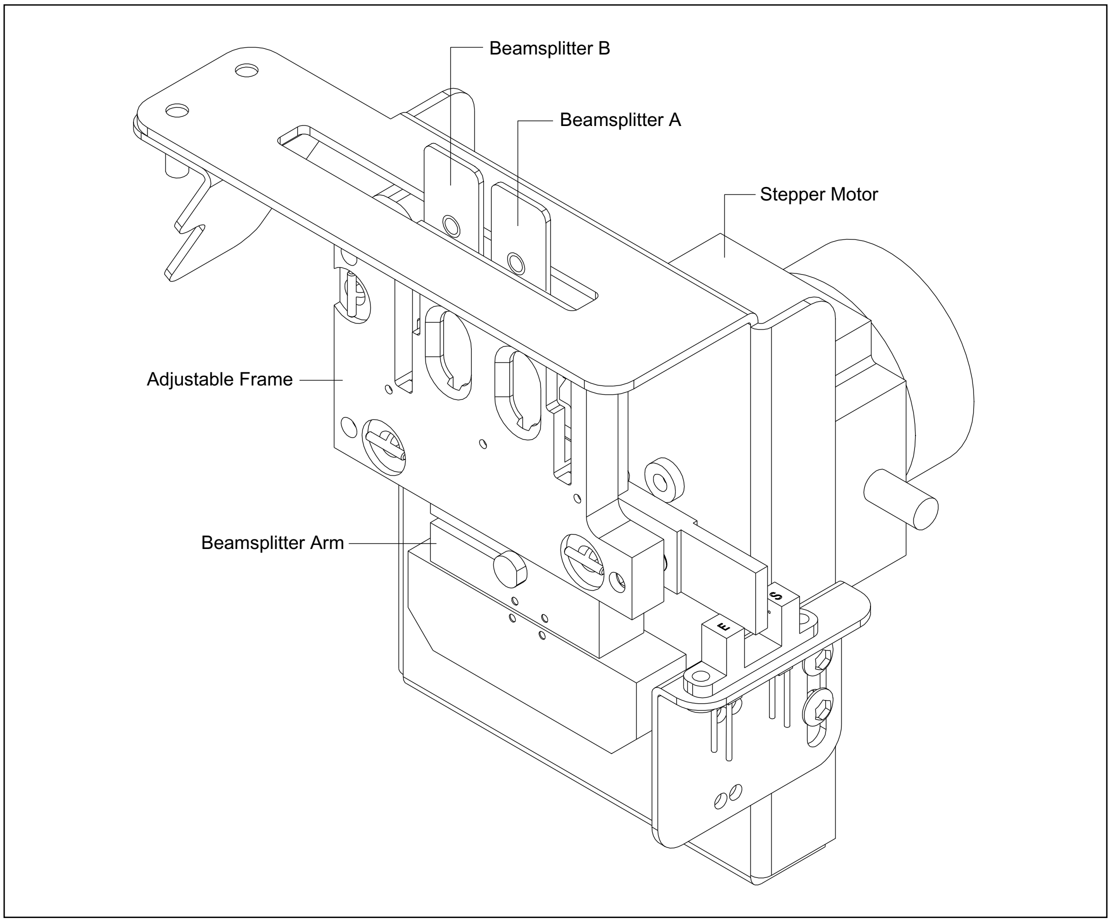



Figure 4-35. Secondary Beamsplitter Changer Assembly.

Figure 4-36 illustrates the beamsplitter arm assembly. An optical home sensor signals when the beamsplitter arm is in the home position. At the home position, the home flag on the beamsplitter arm breaks the light path between the two elements of the light sensor. The home sensor is mounted to an adjustable bracket. It is important that the home sensor be accurately adjusted, because the two beamsplitters are moved to their respective positions by turning the stepper-motor shaft a predetermined number of degrees from the home position. At the home position, the centerline of the beamsplitter arm is vertical. To place the A beamsplitter in the path of the laser beam, the beamsplitter arm is rotated counterclockwise 100.8° from the home position. To place the B beamsplitter in the path of the laser beam, the beamsplitter arm is rotated clockwise 21.6° from the A position. A sheet-metal filter stuffer is mounted perpendicular to the sheet-metal bracket. If the filters have not been fully inserted, as the arm rotates the filters will strike the filter stuffer, which will push the filters all the way in.

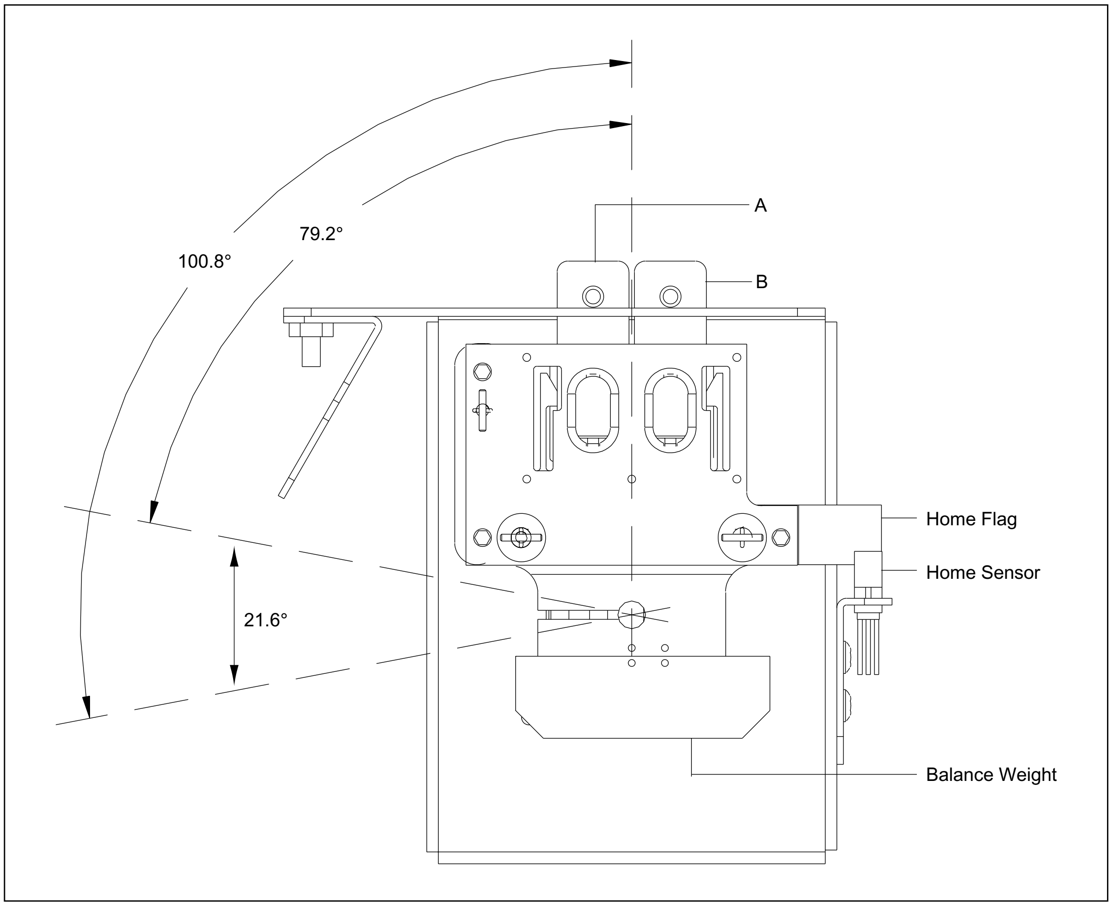



Figure 4-36. Secondary Beamsplitter Arm Assembly.

### 4.7.17 Filter Changer Assembly

The filter changer assembly (figure 4-37) consists of two filter changer arm assemblies, each mounted to the shaft of a stepper motor. The two filter changers are mounted on a single bracket at right angles to each other. The bracket is mounted to the optics plate with two captive screws. Each filter changer arm assembly places one of two filters (A or B) in the laser beam path. For each filter changer arm, a sheet-metal filter stuffer is mounted perpendicular to the sheet-metal bracket. If the filters have not been fully inserted, as the arm rotates, the filters will strike the filter stuffer, which will push the filters all the way in. The emitted light travels through the filter and then through an aperture in the sheet-metal bracket. The switching of the filters is synchronized with the three-position shutter.

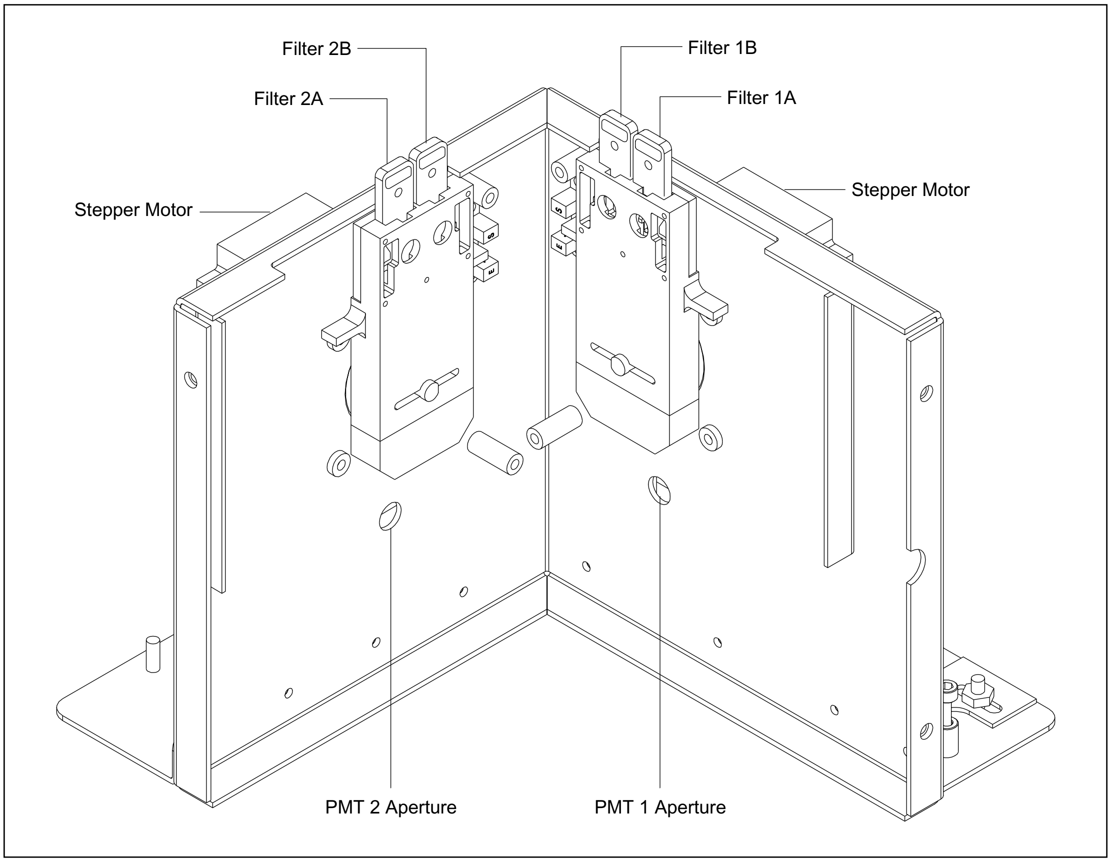



Figure 4-37. Filter Changer Assembly.

Figure 4-38 illustrates the filter changer arm assembly. An optical home sensor signals when the filter changer arm is in the home position. At the home position, the home flag on the filter changer arm breaks the light path between the light emitter and the light sensor. The position of the home sensor is adjustable. It is important that the home sensor be accurately adjusted, because the two filters are moved to their respective positions by turning the stepper-motor shaft a predetermined number of degrees from the home position. At the home position, the centerline of the filter changer arm is vertical. To place the A filter in the path of the emitted light, the filter changer arm is rotated 172.8° from the home position. To place the B filter in the path of the emitted light, the filter changer arm is rotated an additional 14.4° from the A position. Filter changer arm one rotates clockwise, and filter changer arm two rotates counterclockwise.

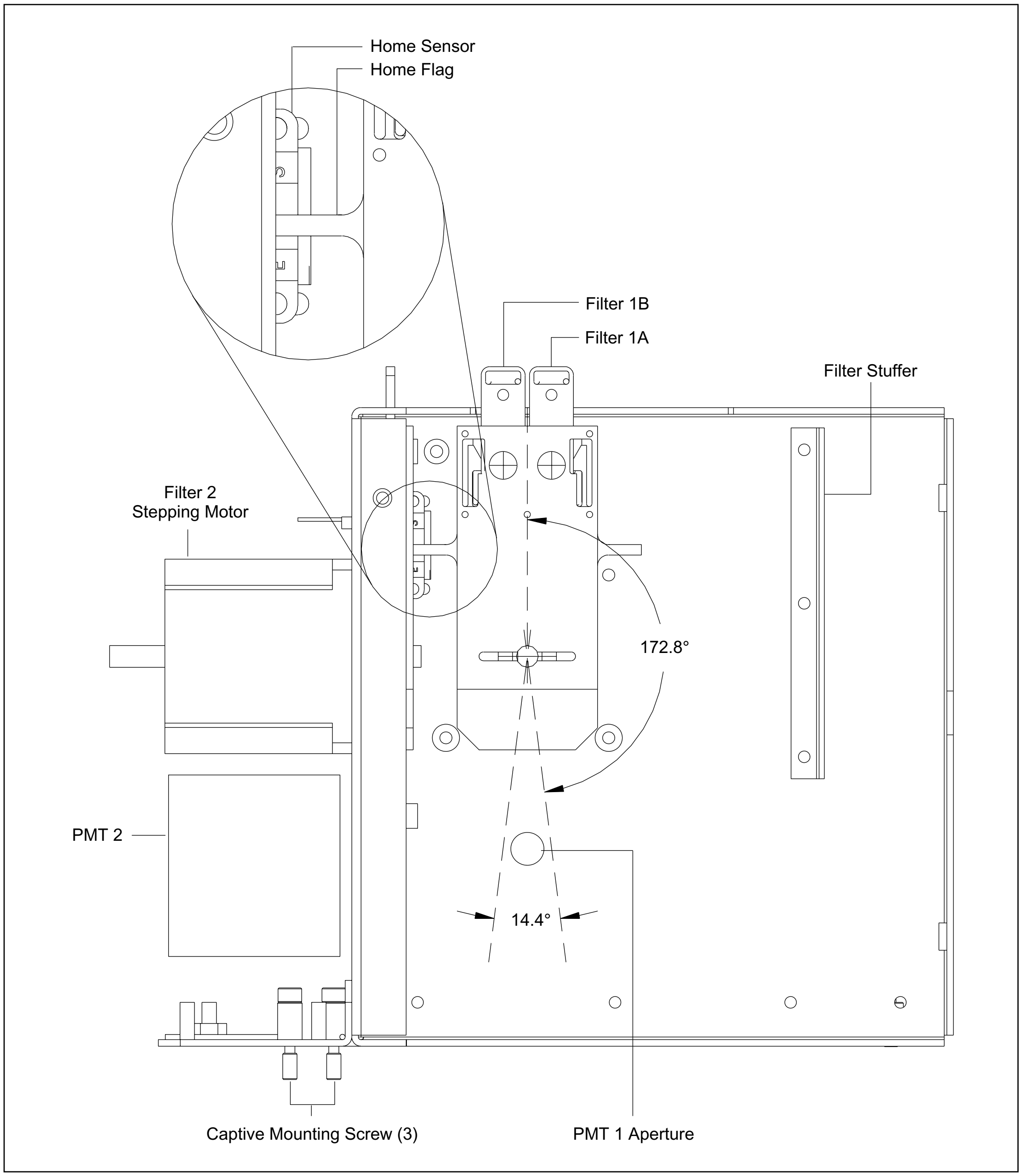



Figure 4-38. Filter Changer Arm Assembly.

### 4.7.18 PMT Assemblies

The two PMT assemblies (figure 4-39) are mirror images of each other and are each mounted to three threaded studs on the rear of the filter changer bracket. Each PMT assembly consists of a three-way adjustable housing assembly and the PMT socket assembly. The adjustments allow the PMT window to be aligned with the emitted light beam.

The PMT housing assembly consists of a sheet-metal enclosure with slotted brackets for mounting to the filter changer bracket. The slotted brackets allow the PMT housing to be moved in the X direction. The PMT housing assembly has a two-way adjustable faceplate that mounts to four threaded studs on the front of the PMT housing assembly. The four threaded studs fit through four vertical slots in the faceplate, allowing the faceplate to be adjusted in the Y direction. The PMT socket assembly has a built-in HV power supply, and the PMT plugs into the socket. The PMT socket assembly is mounted to two threaded studs on a circular sheet-metal bracket. The circular sheet-metal bracket with PMT socket assembly attached is mounted to four threaded studs on the front of the adjustable faceplate. The four threaded studs fit through four slots in the circular bracket, allowing the PMT socket assembly to be rotated.

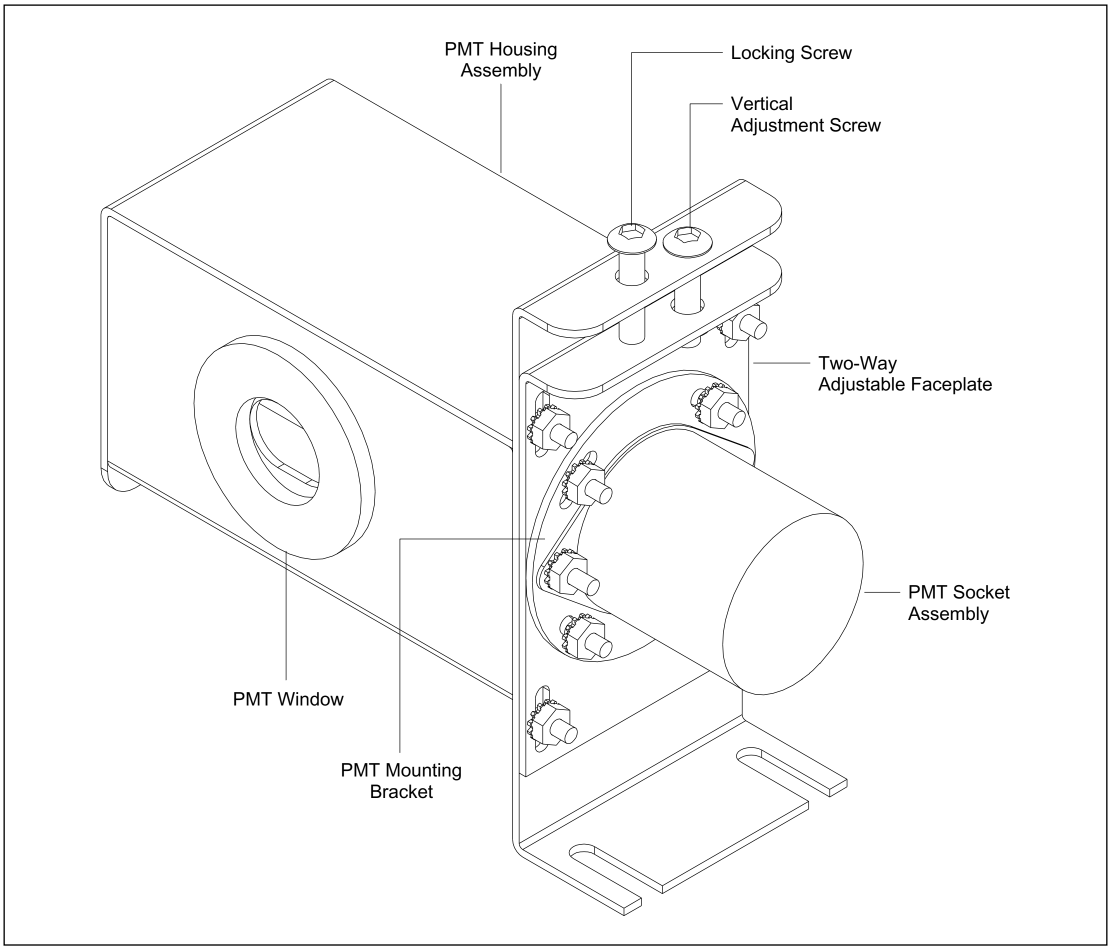



Figure 4-39. PMT Assembly.

## 4.8 Temperature Control System

The components of the temperature control system, consisting of the TE cooler assembly, heater assembly, temperature control assembly, and blower assembly, are all mounted on the electrophoresis chamber chassis (figure 4-40). The TMPR board is mounted on the temperature control assembly.

The thermoelectric (TE) cooler, in combination with the heater elements and blower motor, controls the air temperature in the electrophoresis compartment. The temperature sensor is positioned near the capillaries and in the direct air flow, and monitors the temperature in the electrophoresis compartment. The temperature sensor is connected to the TMPR board. The TMPR board provides the control for the TE cooler, heater, and blower motor.

The air is circulated from the blower through the TE cooler's lower heat sink, through the heater elements, to the opening in the service door. The air is directed around the inside of the service door and through a diffuser (filter) that distributes the air evenly into the electrophoresis compartment and then back to the blower intake.

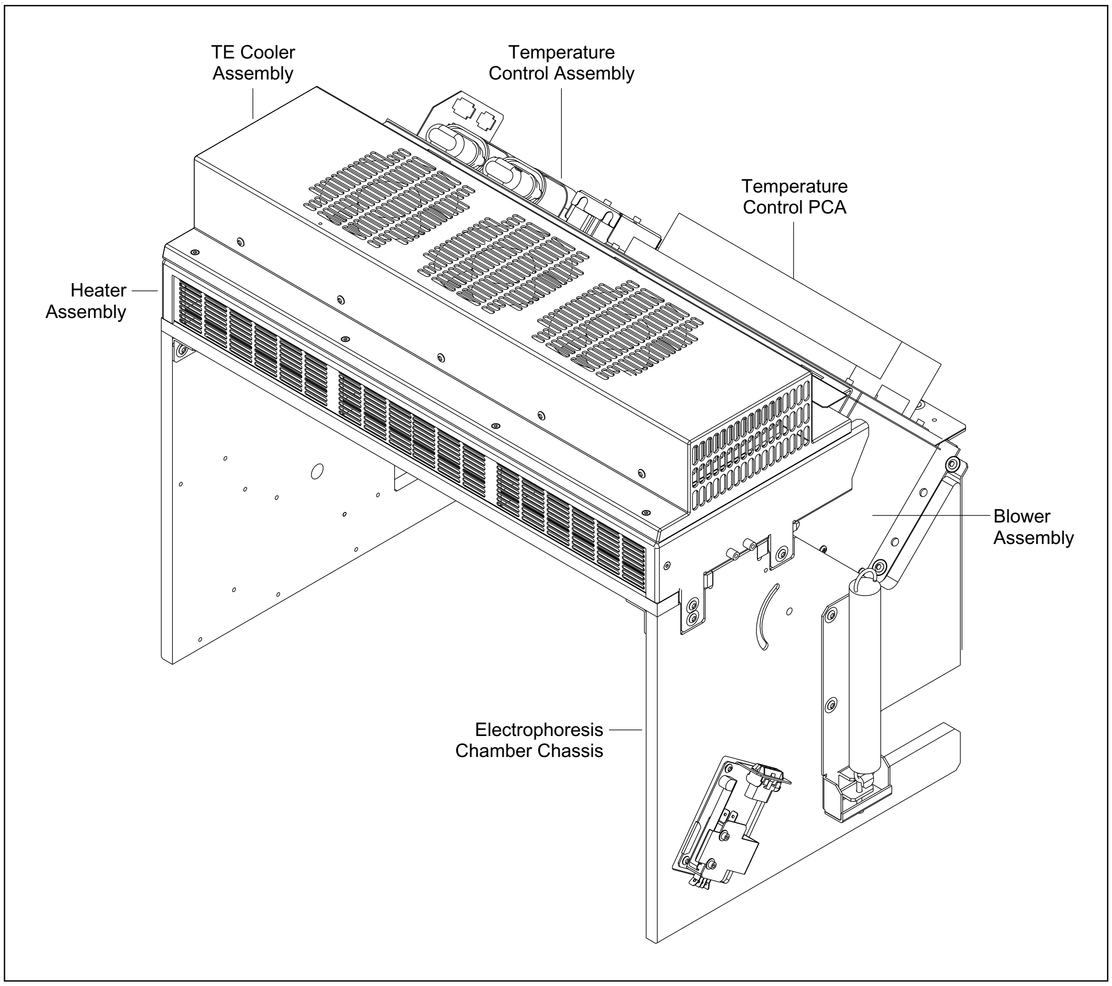



Figure 4-40. Temperature Control System.

### 4.8.1 Temperature Control Assembly

One side of the temperature control assembly is mounted on the electrophoresis chamber chassis with three screws. These screws also secure the cable clamps for the cables attached to the TMPR board. The other side of the temperature control assembly has three tabs that mesh with three slots on the electrophoresis chamber chassis. The TMPR board mounts on the temperature control assembly with four screws.

### 4.8.2 TE Cooler Assembly

The TE cooler assembly provides the cooling effect in the electrophoresis compartment. The TE cooler assembly is mounted between two large heat sinks. The hot side of the TE cooler is mounted to the upper heat sink, and the cool side is mounted to the lower heat sink. The TE cooler assembly is mounted to the heater assembly housing with eight screws. The TE cooler has three fans that exhaust the hot air out the top of the TE cooler assembly. The TE cooler assembly operating power and control signals come from cables connected to the TMPR board.

### 4.8.3 Heater Assembly

The heater elements are divided into three sections or compartments in the heater assembly housing. There are two individual heater elements in each compartment, and each heater element is a single thermoelectric wire wound on a flat sine-wave form and then attached to the mounting support. The heater assembly is mounted to its housing with a screw at each end. The heater assembly housing is mounted to the electrophoresis chamber chassis with three screws at each end. The heater assembly operating power and control signals come from cables connected to the TMPR board.

### 4.8.4 Blower Assembly

The blower assembly provides the circulating air used to heat or cool the electrophoresis compartment. The blower assembly consists of a (squirrel-cage) fan blade assembly, blower motor, and blower housing. The blower assembly housing and the fan blades run the full length of the capillary compartment. The fan assembly is enclosed in the blower assembly housing and mounted on roller bearings at both ends. The blower assembly housing is mounted to the electrophoresis chamber chassis with two screws on each end. The blower motor uses two start capacitors that are located on the temperature control assembly. The blower assembly operating power and control signals come from cables connected to the TMPR board.

## 4.9 Cathode Assembly (MB 1000)

The cathode assembly provides mounting for one end of the six capillary arrays, a means of loading and unloading either a 96-well sample plate or a water tank, and a system for accurately positioning the ends of the capillaries in the appropriate wells of the sample plate or water tank.

The cathode assembly (figure 4-41) consists of the housing assembly, base assembly, capillary array stand and CMON board, tray and slide assembly, cathode stage piston assembly, and mechanical position sensors. The housing assembly is secured to the main base with screws. The base assembly consists of the sheet-metal base and cathode connector board. The base assembly is secured to the instrument sheet-metal chassis with four screws and the cathode connector board is mounted to the rear of the base with four screws. Figure 4-42 shows a simplified view of the cathode assembly. The housing assembly with mechanical position sensors has been removed for clarity.

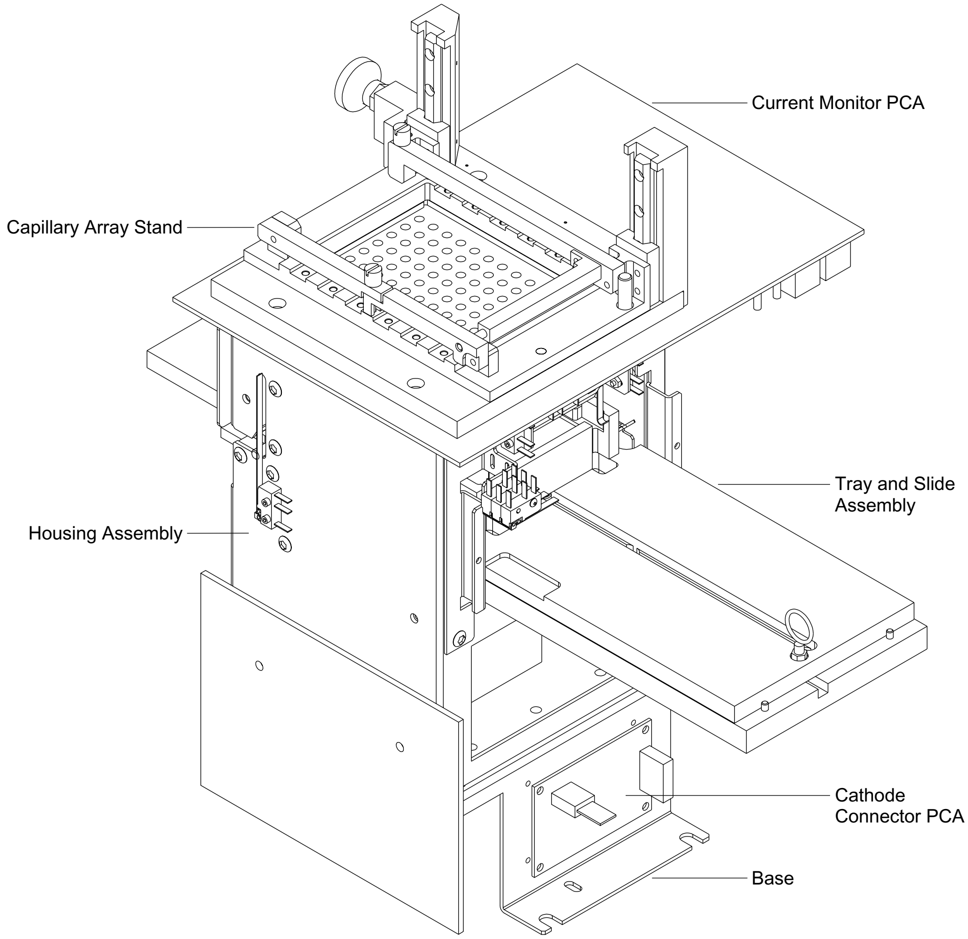



Figure 4-41. Cathode Assembly.

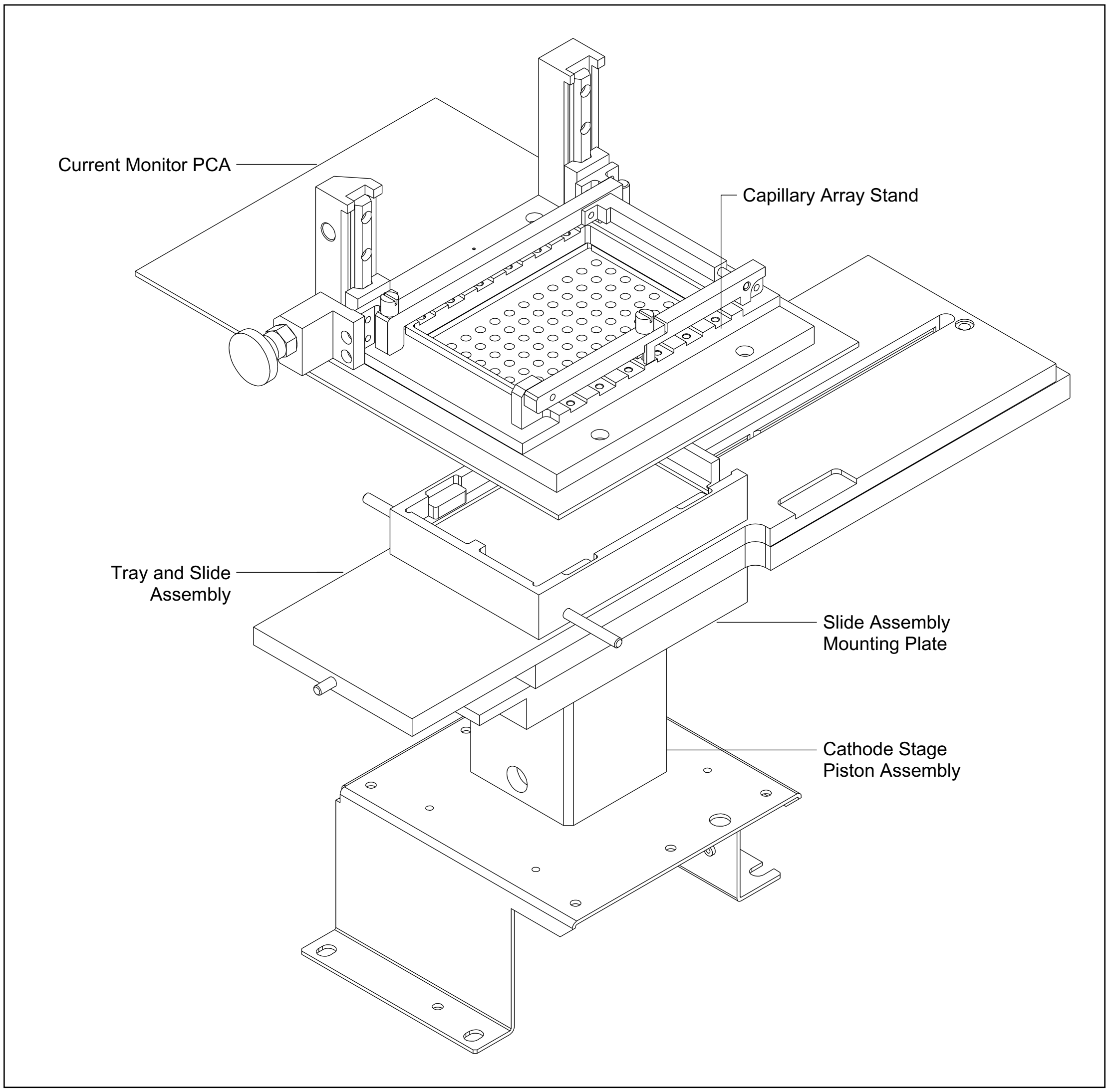



Figure 4-42. Cathode Assembly, Simplified View.

The capillary array stand assembly consists of the capillary array stand and the CMON board. The CMON board is secured to the underside of the capillary array stand with four screws (figure 4-43). The cathode array stand and CMON board are then secured to the cathode housing assembly with four screws.

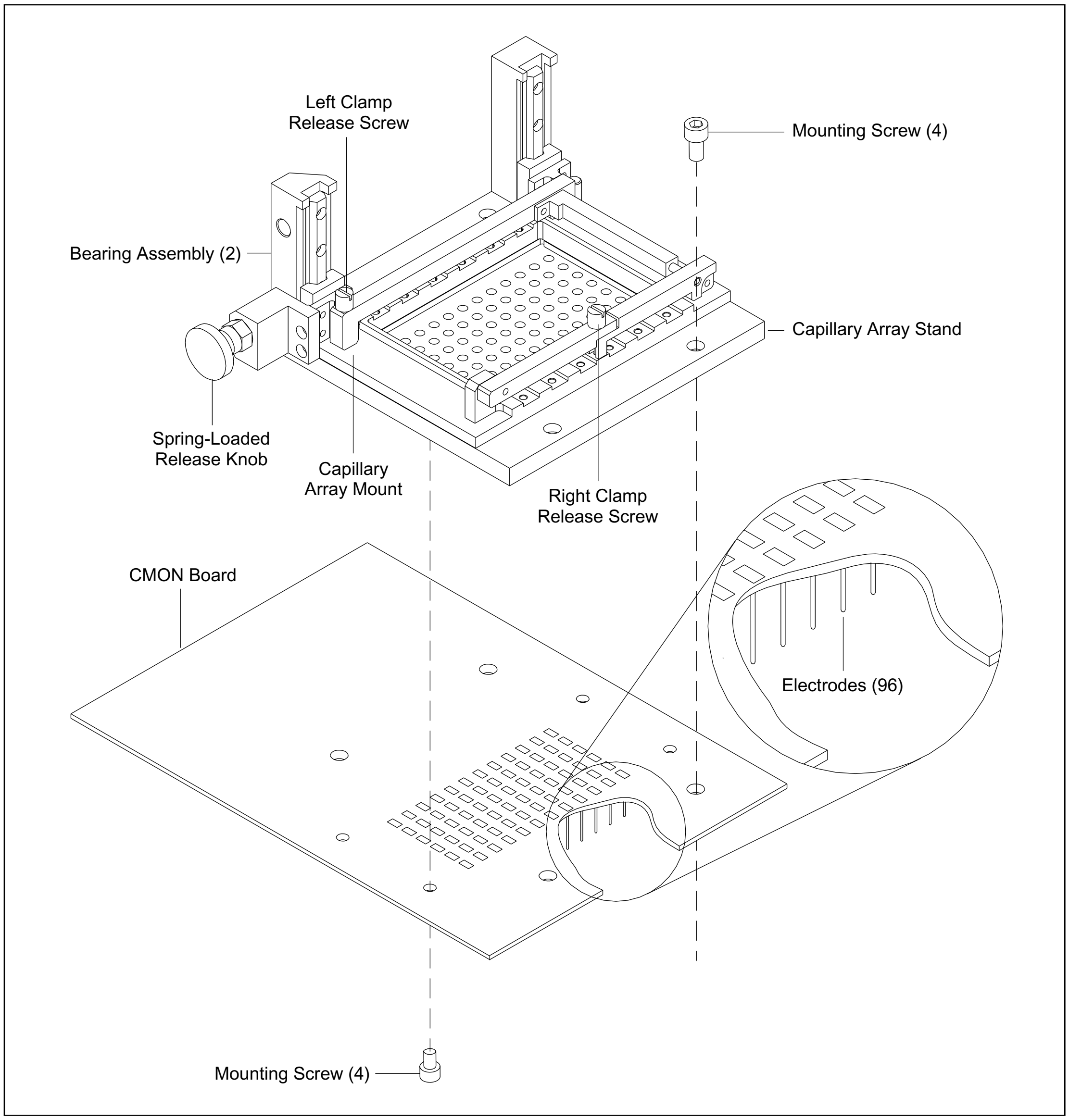



Figure 4-43. Cathode Array Stand Assembly.

The capillary stand consists of a base with two bearing assemblies and a capillary array mount. The capillary array mount has two clamps that secure the six capillary arrays. To install the capillary arrays, the spring-loaded release knob is pulled out, and the capillary array mount is raised manually on its two bearing assemblies until the release knob seats in the raised position. With the capillary array mount raised, two knurled screws are loosened and the two capillary clamps are raised. The right clamp must be raised before the left clamp can be raised. The capillary arrays are installed and then secured with the two clamps. The spring-loaded release knob is pulled out and the capillary array mount is lowered and secured with the release knob. As the stage is lowered, the capillary ends are directed through countersunk holes that match holes in the CMON board. Attached to each of the holes in the CMON board is a platinum electrode that extends down. Each capillary end is positioned alongside an electrode. To prevent damage to the capillary array clamp, the capillary array mount must be up to remove the capillary arrays. When the capillary array mount is down, an alignment pin at the rear of the capillary array stand prevents the left clamp from being opened.

Figure 4-44 shows a cross section of the capillary array stand with the capillaries inserted into a 96-well sample plate. Notice the close fit between the capillaries and the electrodes in the test well.

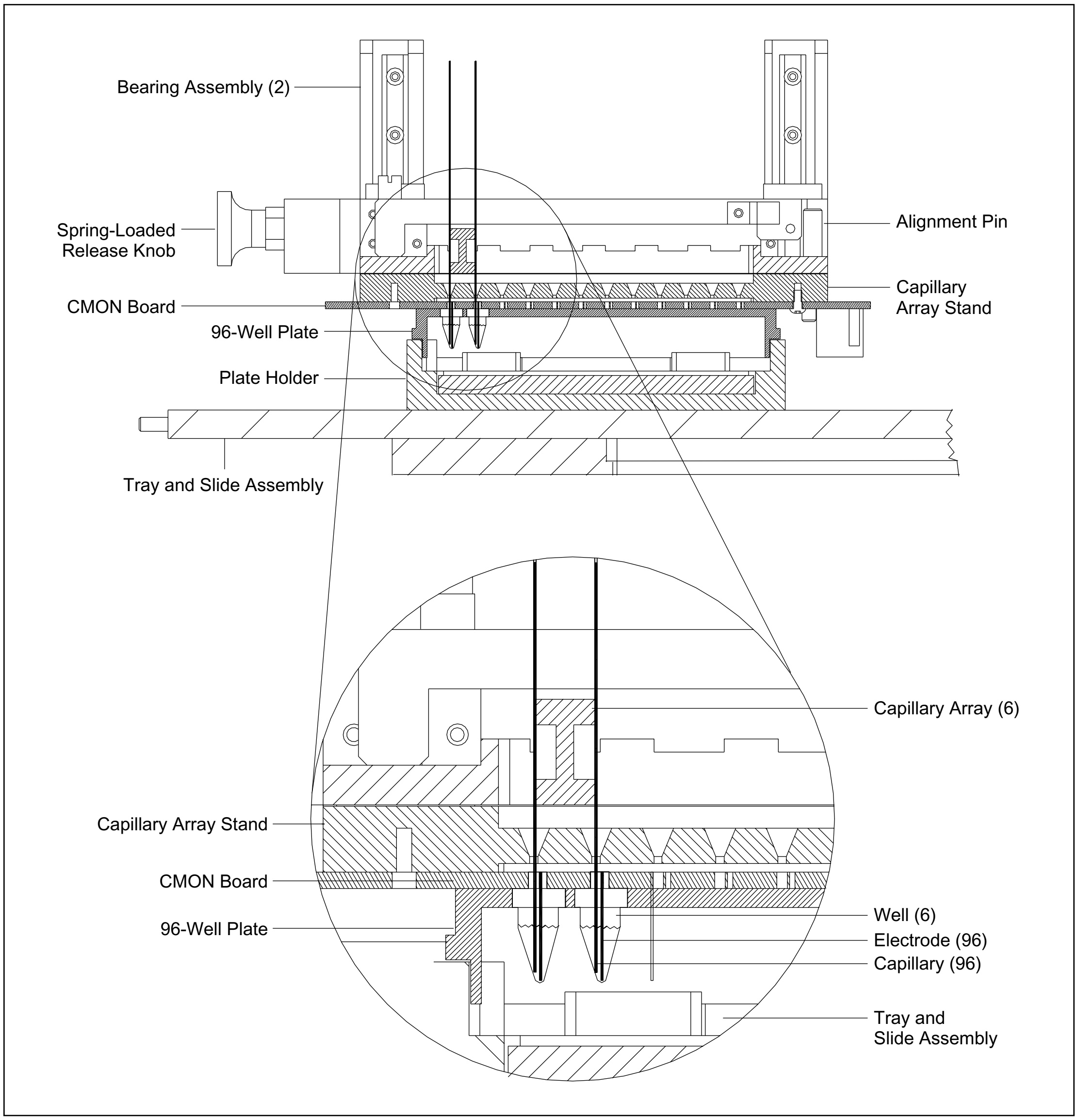



Figure 4-44. Cathode Assembly, Cross Section.

The tray and slide assembly is raised and lowered by the cathode piston assembly. The cathode piston assembly (figure 4-45) consists of a chamber, a piston with a slide mounting plate, and pneumatic fittings. The cathode piston assembly is attached to the base with four screws. The piston assembly has pneumatic fittings mounted to the chamber above and below the piston. The piston is raised and lowered by changing the gas pressure to both fittings.

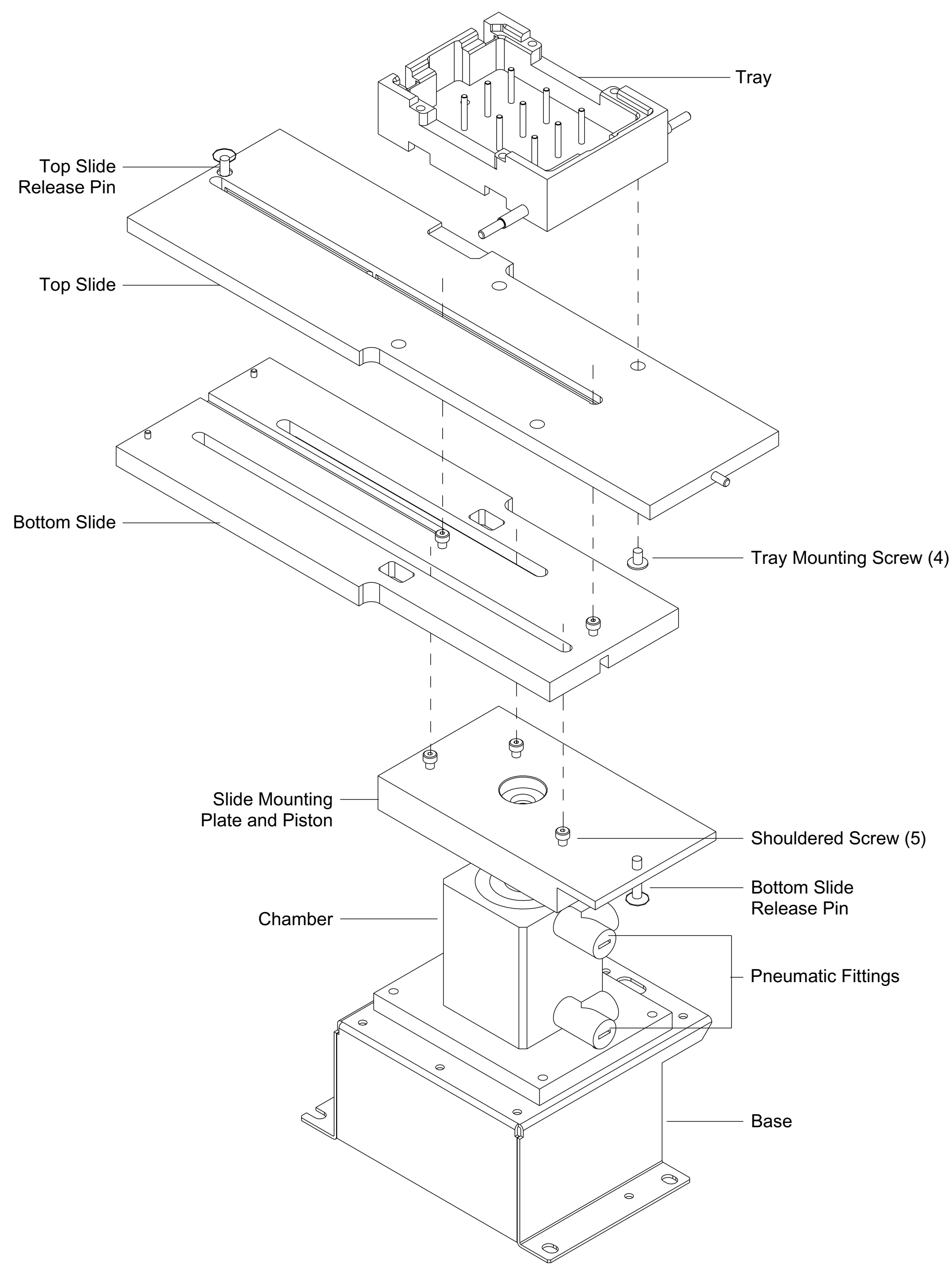



Figure 4-45. Cathode Piston Assembly.

The tray and slide assembly consists of a bottom slide, top slide, and a metal tray that holds the sample plate or water tank. The metal cathode tray is attached to the top slide with four screws and is keyed for both the 96-well sample plate and the water tank.

The key is toward the front of the cathode assembly so that both the sample plate and the water tank can be inserted in only one direction.

The top slide attaches to two shouldered screws mounted to the bottom slide. To remove the top slide, the top slide release pin is lifted and the top slide is moved until the shouldered screws are aligned with the access holes on the top slide. The top slide is slid forward until the shouldered screws are in the top slide slot, and then the release pin is allowed to lock the slide. The top slide can now move forward and back along the bottom slide. The bottom slide is attached to the slide mounting plate on three shouldered screws. The slide mounting plate also has a release pin that locks the bottom slide in place.

To protect the instrument, the cathode assembly has several mechanical switches (figure 4-46) that provide position data for the tray and slide assembly and the capillary array mount and interlocks.

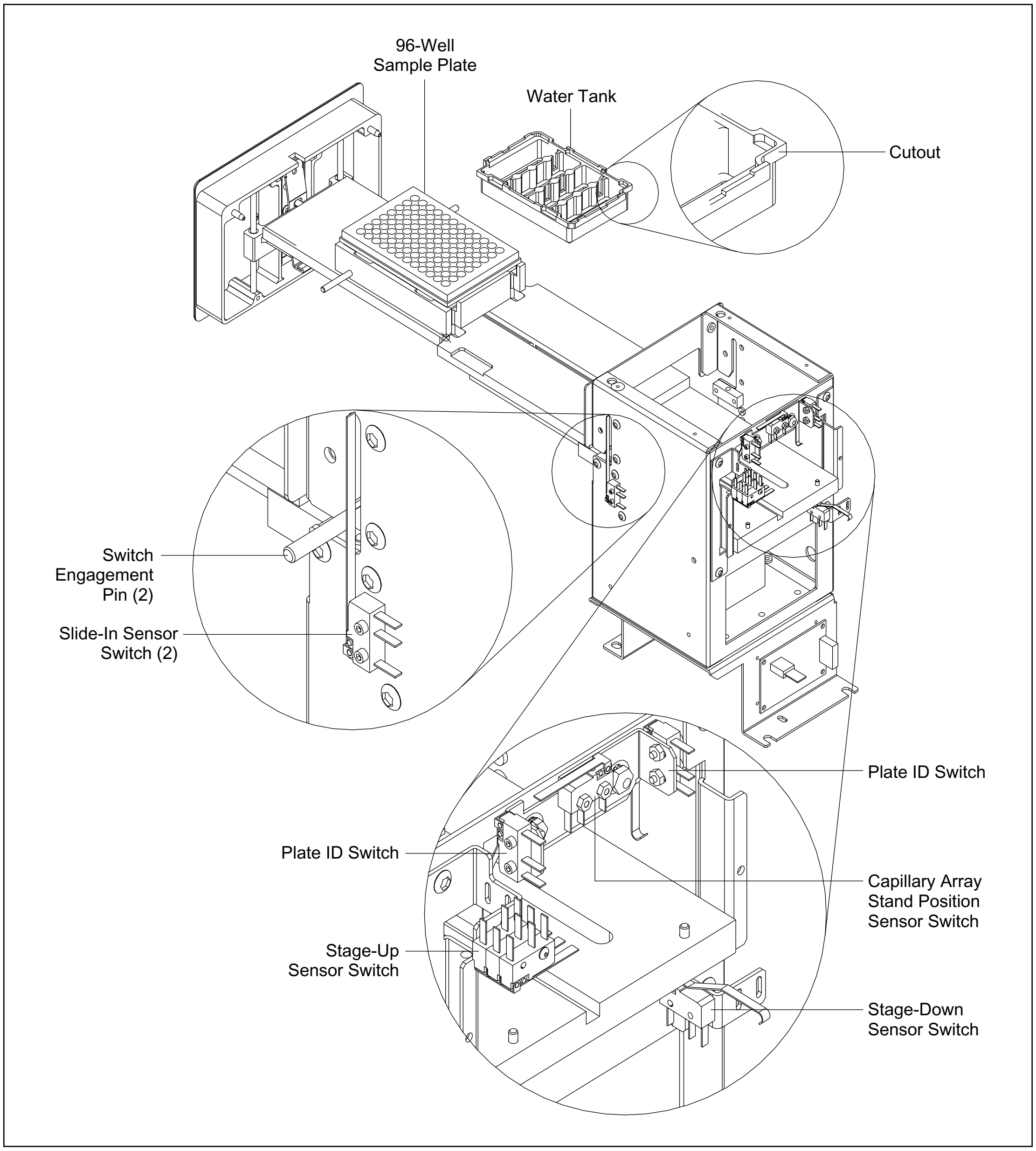



Figure 4-46. Cathode Assembly, Switch Locations.

The switches and their functions are as follows—

- **Slide-In Switches**—These two switches are located on either side of the cathode assembly. The switches are actuated by two metal pins that extend from the sides of the metal tray (plate holder). These switches are wired in a series and provide a hardware interlock that prevents the tray and slide assembly from being raised unless the slide is in all the way.
- **Stage-Up Switches**—These three switches are ganged together and mounted at the rear of the cathode stage. These switches are actuated by the slide when the slide is in all the way and the stage has been raised. Two of these switches are wired in a series with other interlock switches. This interlock circuit disables the high voltage and prevents the anode chamber from being pressurized or vented when either the cathode stage or anode stage is down or the service door is open. The third switch provides cathode stage position data to the CPU.
- **Stage-Down Switch—**This switch is mounted at the rear of the cathode stage and is actuated when the cathode stage is lowered and the slide is in. This switch provides cathode stage position data to the CPU.
- **Capillary Array Mount Switch**—This switch is mounted to the rear of the cathode stage and prevents the anode chamber from being pressurized or vented if the capillary array mount is raised.
- **Plate ID Switches**—These two switches are mounted to the rear of the cathode stage and identify which type of plate is in the tray. When the tray holds a 96-well sample plate, both switches are closed when the slide is pushed in all the way. The water tank has a cutout on the left-rear corner that prevents the plate from actuating the left switch.

## 4.10 Cathode Assembly (MB 2000)

The MB 2000 cathode assembly (figure 4-47) is based on the original version. It has the same capacity of 96 capillaries, but has been modified to accept a 384-well sample plate. The 4x96 cathode assembly uses pneumatic solenoids to move the sample plate in the Y direction (forward and back) and in the X direction (side to side) to select one of four sets of 96 wells. The position of the sample plate is monitored by two sets of optical sensors (figure 4-48). There is also a pneumatic solenoid that raises and lowers the capillary array stand. Another pneumatic solenoid is actuated to lock the sample-plate slide in position during repositioning of the sample plate. All the solenoid activations occur under software control.

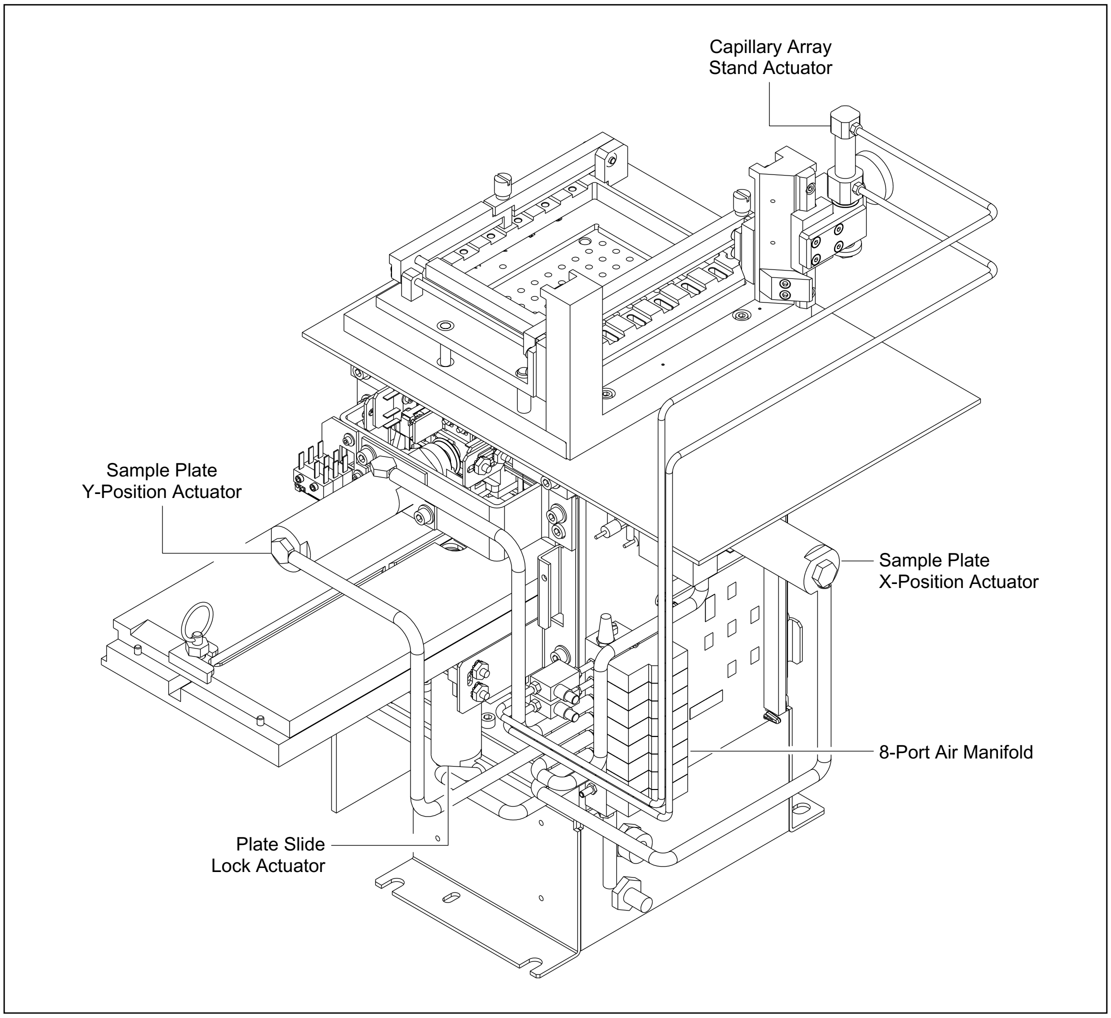



Figure 4-47. Cathode Assembly (MB 2000) (Right Rear).

The optical sensors and their functions are as follows—

- **Sample Plate Y-Position Sensors**—These two sensors are mounted to the left side of the cathode frame. The sensors monitor the two Y positions of the sample plate.
- **Sample Plate X-Position Sensors**—These two sensors are mounted to the left side of the cathode frame. The sensors monitor the two X position of the sample plate.
- **Sample Plate Y-Position Lock Sensor—**This sensor is mounted to a mounting bracket behind the Y-position actuator mounting bracket. This sensor cannot be seen in either of the two illustrations of the cathode assembly.

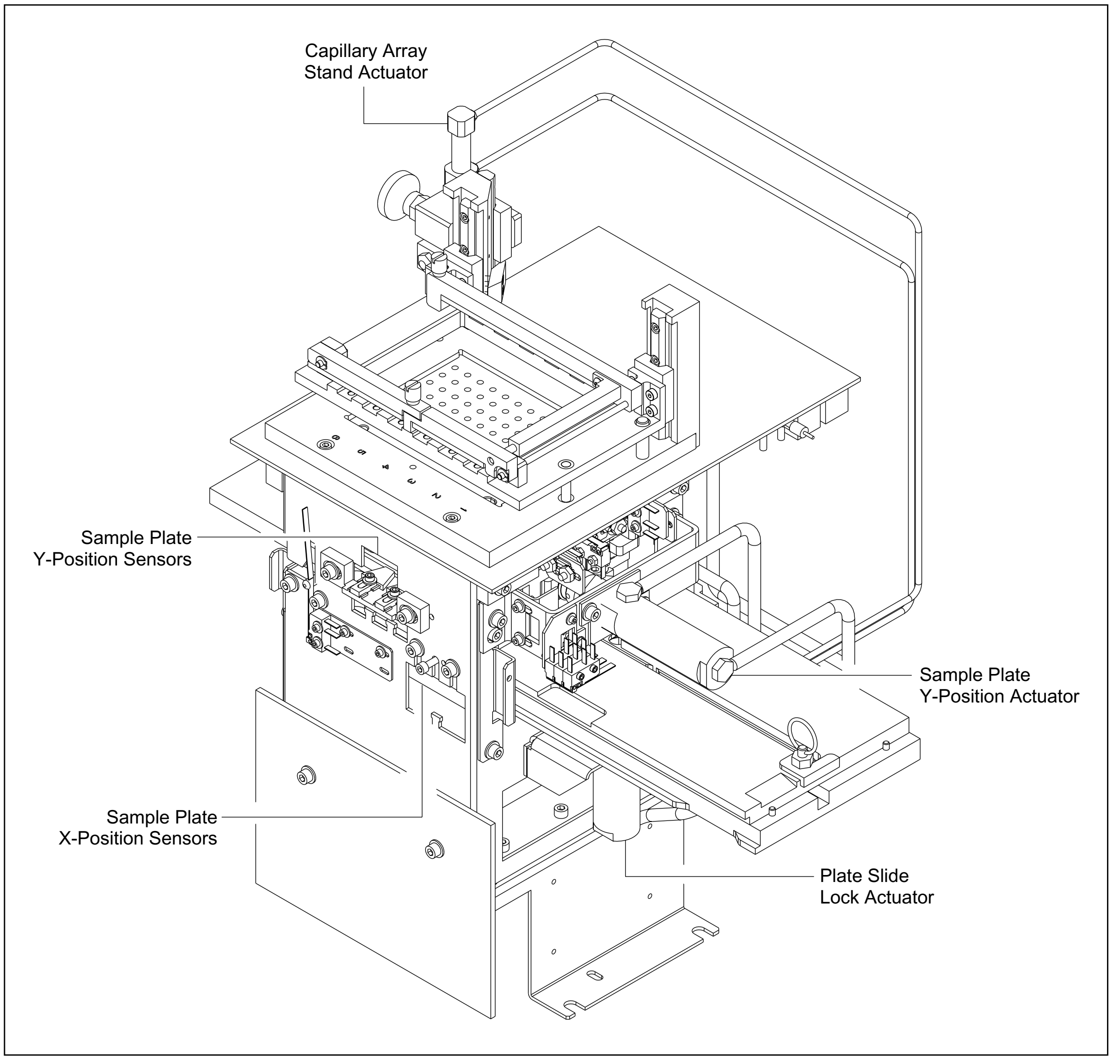



Figure 4-48.  Cathode Assembly (MB 2000) (Left Rear).

## 4.11 Anode Assembly

The anode assembly (figure 4-49) consists of the anode housing assembly, insulating base, piston assembly, vessel holder and slide assembly, anode cover assembly, high-pressure supply tube, and the motor and sensor mounting bracket. The motor and sensor mounting bracket consists of a sheet-metal bracket that holds the clamp motor, optical position sensors and mechanical interlock switches, and pneumatic fittings. The motor and sensor mounting bracket is electrically isolated from the anode assembly by the insulating base, two plastic insulating braces, and the plastic tubing and rubber drive belt.

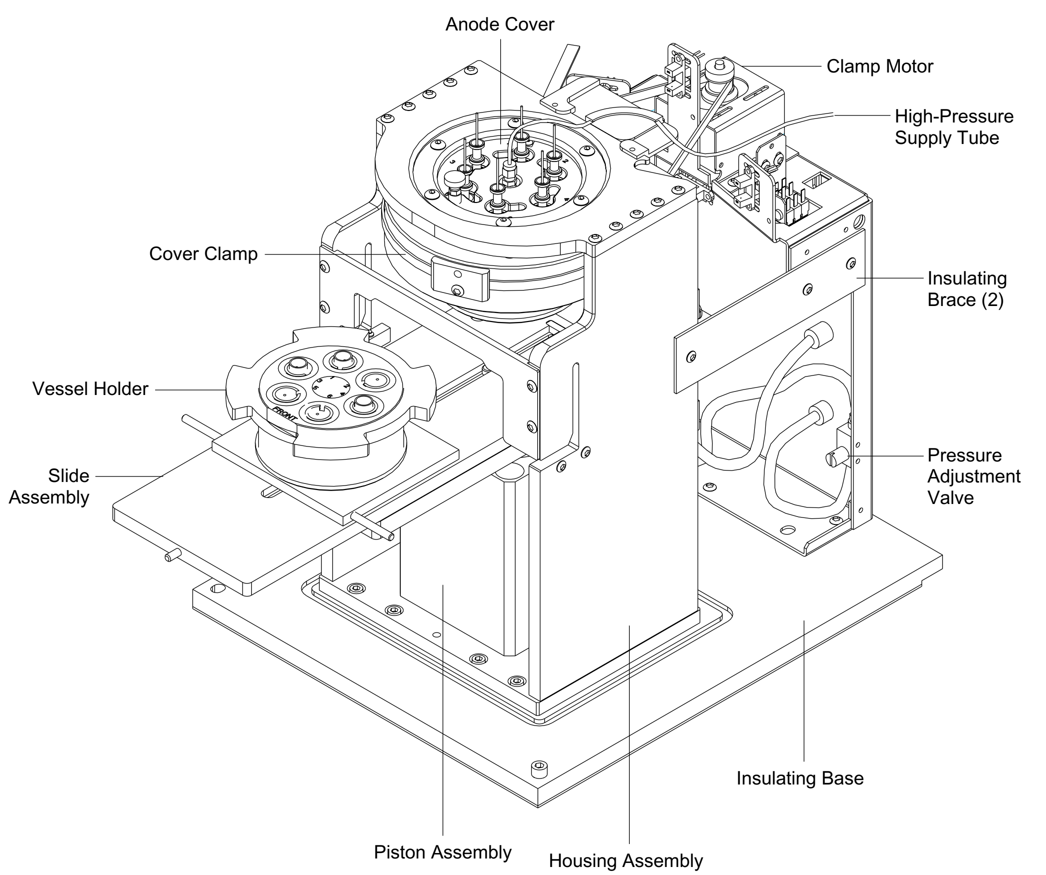



Figure 4-49. Anode Assembly.

The anode assembly provides a mechanically precise high-pressure reservoir capable of handling up to 1000 psi. The anode assembly also provides electrical isolation from the rest of the MegaBACE instrument. The material (stainless steel), weight, and precision of the pressure reservoir components ensure that the reservoir can handle the high pressure necessary to force matrix into the capillaries or to flush the capillaries for cleaning.

Figure 4-50 is a simplified drawing of the anode assembly with the housing assembly, base, slide, and motor and sensor mounting bracket removed for clarity. The anode cover is secured to the cover mounting plate with six screws. The cover mounting plate is secured to the left and right sides of the stainless steel housing assembly with ten screws.

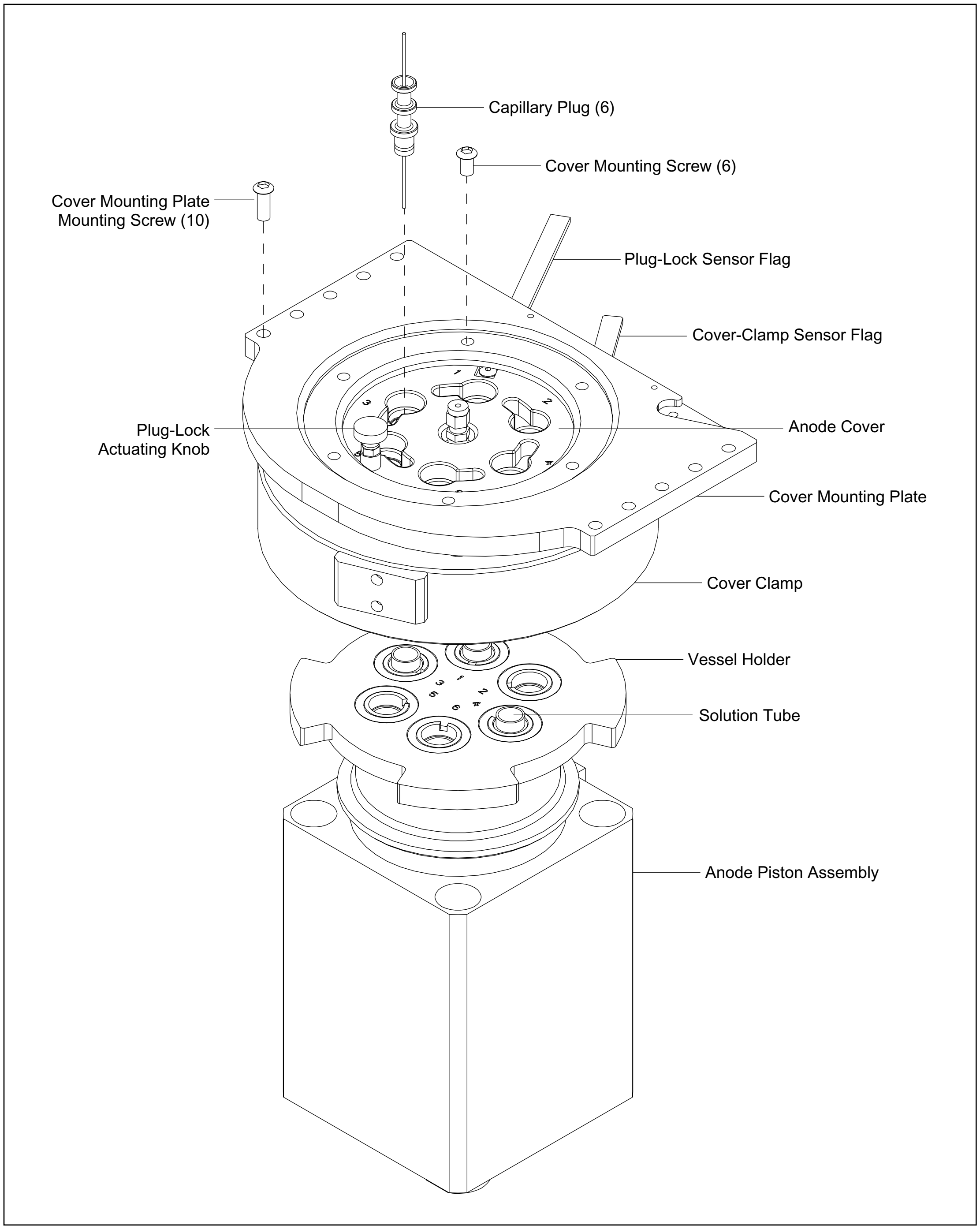



Figure 4-50. Anode Assembly, Simplified View.

The upper portion of the high-pressure reservoir is formed by seating the O-rings on the capillary plugs (or anode blockers) against the inside wall of the anode cover. The lower half of the high-pressure reservoir is formed by the compression of the anode reservoir O-rings against the bottom surface of the anode cover. The capillary plugs and/or anode blockers are inserted, and the plug-lock actuating knob is lifted and rotated clockwise to move the anode cover to the locked position. The knob is then released to drop into position. Solution tubes are inserted into the appropriate receptacles of the anode vessel and filled with the appropriate solution. The slide is pushed in all the way. The instrument software raises the anode vessel (and slide) and rotates the anode cover clamp clockwise to complete the seal. The vessel chambers are then pressurized to force the solution through the capillaries.

As the anode stage is raised, platinum electrodes attached to the anode cover extend into the solution tubes along with the ends of the capillary array (figure 4-51).

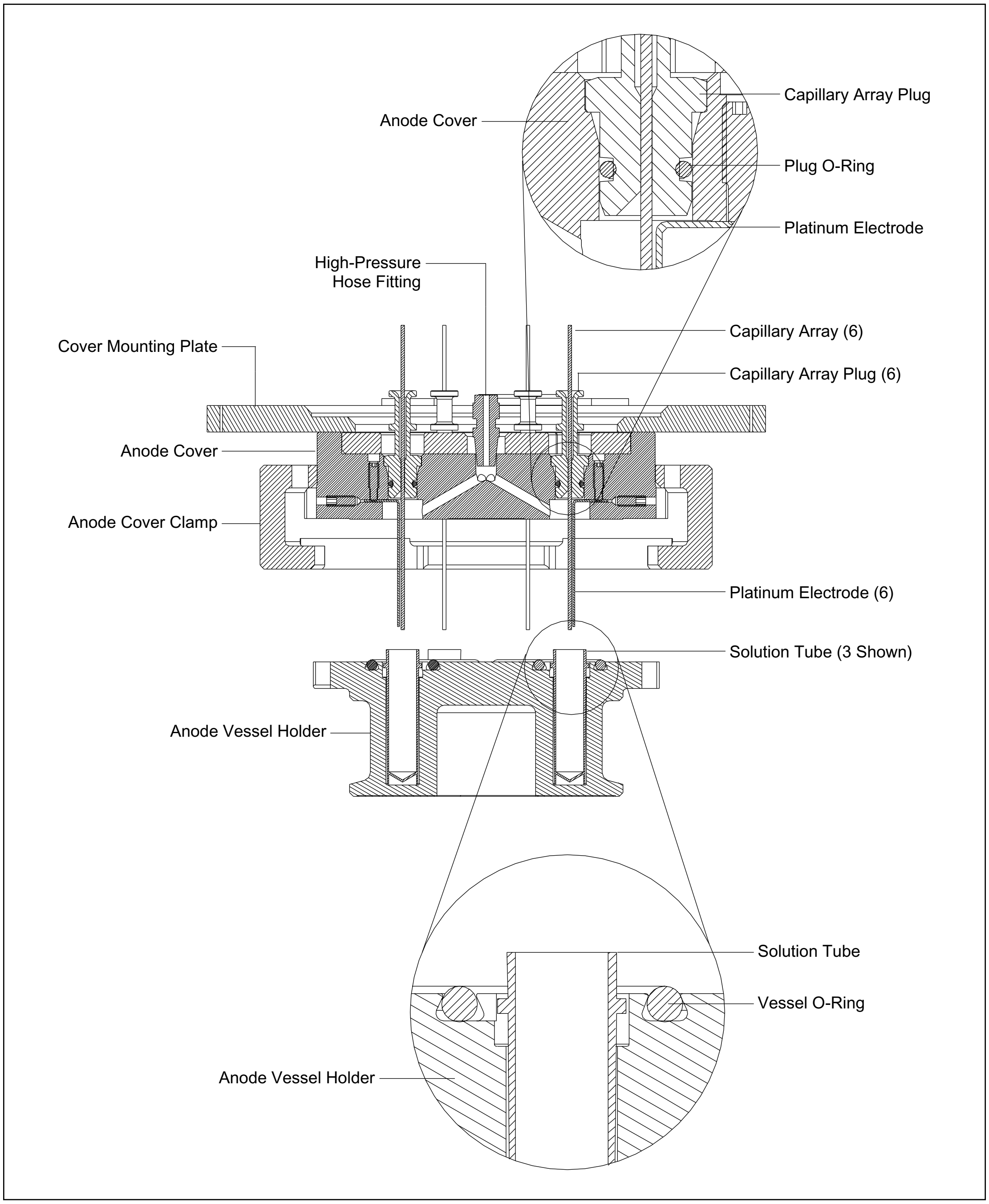



Figure 4-51. Anode Assembly, Cross Section.

A high voltage of 5 to 20 kV DC is applied to the stainless steel components of the anode assembly, placing a high voltage potential across the 96 capillaries connected between the cathode and the anode assemblies. The upper and lower slides supporting the anode vessel holder are made of a plastic insulating material. The high-pressure line (1000 psi) is made of a high-pressure insulating material. Figure 4-52 shows the anode vessel holder, slide assembly, and piston assembly.

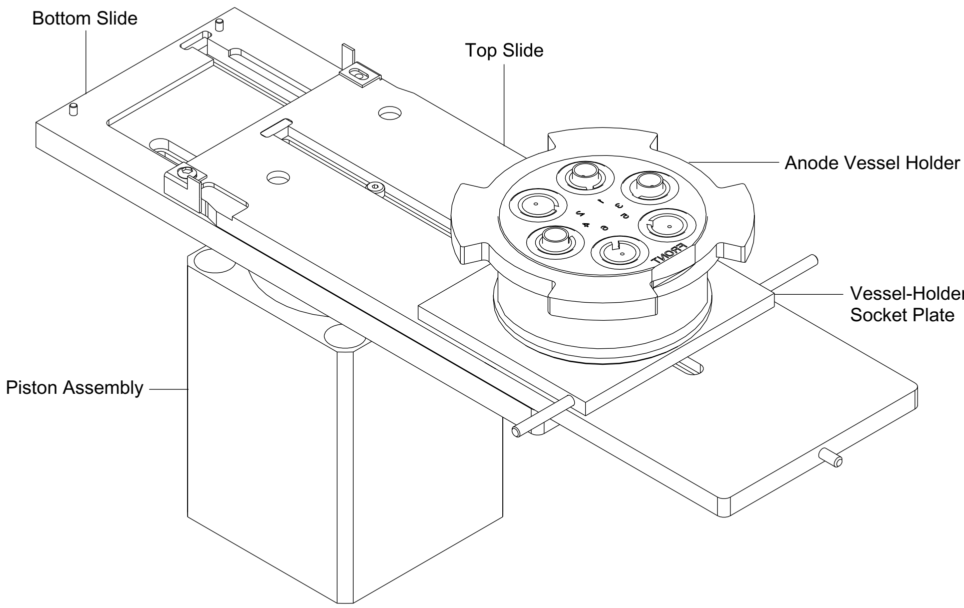



Figure 4-52. Anode Vessel and Slide Assembly.

The stainless steel anode vessel holder is keyed with two pinholes on its bottom surface that mate with two pins on the vessel holder socket plate. The anode vessel holder is symmetrical and could be reversed on the two pins with no mechanical consequences. The anode vessel holder is held in place on the vessel holder socket plate by two screws through the bottom of the socket plate.

The vessel holder socket plate is attached to the upper anode slide with four screws. The upper and lower anode slides do not have quick releases to separate the two slides for cleaning. In the unlikely event that the slide assembly must be disassembled, the two slides must be separated by removing the screws that hold the upper slide to the lower slide. The slides are secured to the cylinder slide plate with three shoulder screws.

The anode vessel holder and the slides are driven up or down by the nitrogen-driven piston. High pressure is required to compress the anode vessel holder O-rings when the anode vessel holder is driven up against the bottom of the anode cover. Sufficient O-ring compression is also required for the anode clamp clearance as it turns to clamp the anode vessel holder against the anode cover.

To protect the instrument, the anode assembly has a variety of interlock switches and optical position sensors mounted to the rear of the anode assembly (figure 4-53) that provide position data for the reservoir and slide assembly and interlocks.

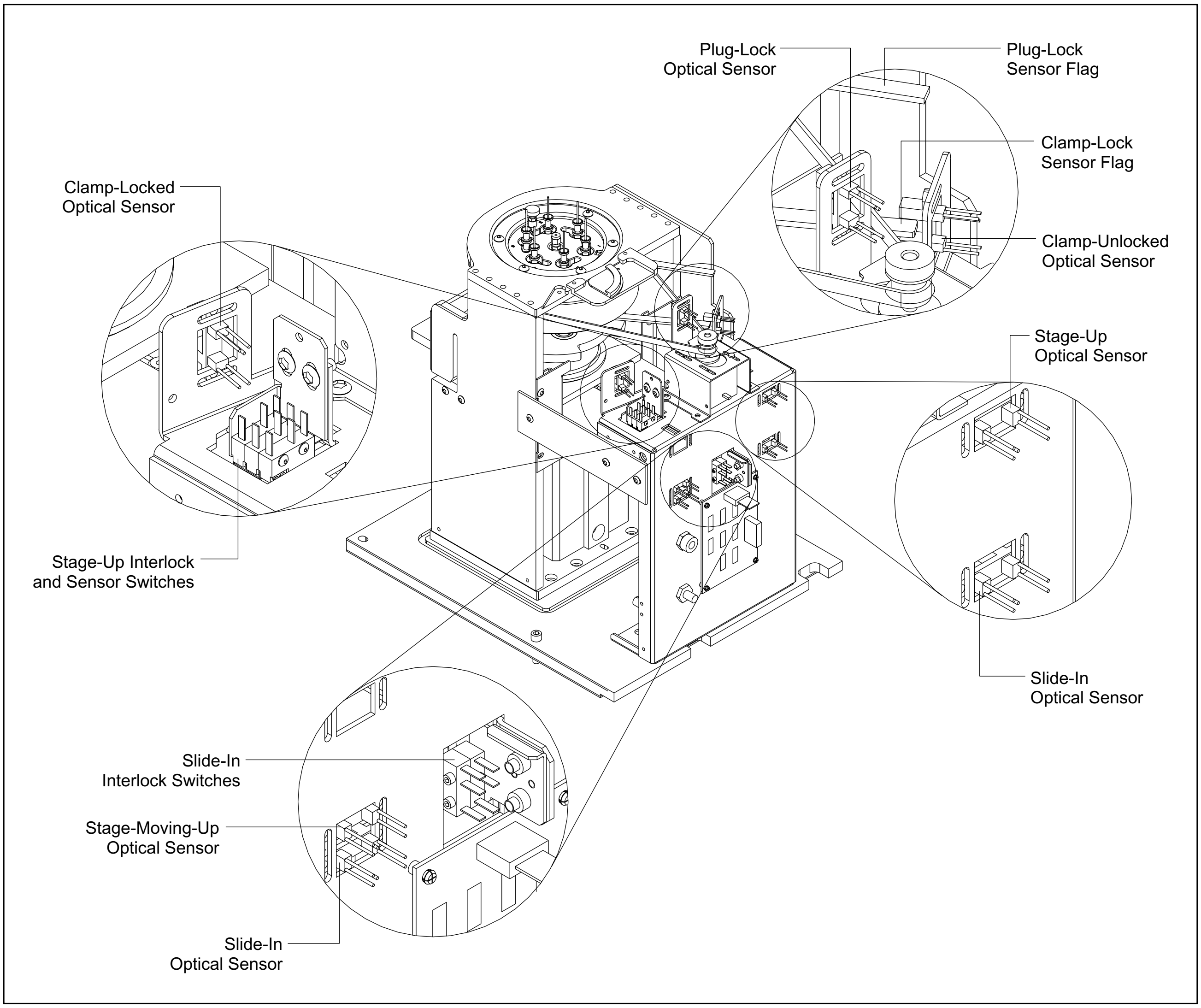



Figure 4-53. Anode Assembly, Switch and Sensor Locations.

The switches and their functions are as follows—

- **Plug-Lock Optical Sensor—**This sensor is mounted to the rear of the anode stage and is actuated by the plug-lock flag when the cover has been turned clockwise to lock the capillary plugs or anode plugs in position. The plug-lock flag is mounted to the anode cover assembly.
- **Clamp-Unlocked Optical Sensor—**This sensor is mounted to the rear of the anode stage and is actuated by the clamp-lock flag when the clamp lock has been turned counterclockwise to the unlocked position. The clamp-lock flag is mounted to the anode clamp assembly.
- **Stage-Up Optical Sensor—**This sensor is mounted to the rear of the anode stage and is actuated by a flag mounted to the slide assembly when the anode stage has been raised. This sensor provides anode stage position data to the CPU.

- **Slide-In Optical Sensor**—This sensor is mounted to the left-rear of the anode stage and is actuated by a flag mounted to the slide assembly when the slide has been pushed all the way in. This sensor provides anode slide position data to the CPU.
- **Slide-In Interlock Switches**—These two switches are located on the rear of the anode assembly. The switches are actuated by the slide when the slide is all the way in. These switches are wired in a series and provide a hardware interlock that prevents the reservoir and slide assembly from being raised unless the slide is in all the way.
- **Slide-In Optical Sensor—**This sensor is mounted to the right-rear of the anode stage and is actuated by a flag mounted to the slide assembly when the slide has been pushed in all the way. This sensor provides anode slide position data to the CPU.
- **Stage-Moving-Up Optical Sensor**—This sensor is mounted to the right-rear of the anode stage directly above the slide-in optical sensor and is actuated by the same flag as the slide-in optical sensor when the slide has been pushed in all the way and has started to move up. This sensor provides anode slide position data to the CPU.
- **Stage-Up Interlock and Sensor Switches**—These three switches are ganged together and mounted to the rear of the anode stage. These switches are actuated by the slide when the slide is in all the way and the stage has been raised. Two of these switches are wired in a series with other interlock switches. This interlock circuit disables the high voltage and prevents the anode chamber from being pressurized or vented when either the cathode stage or anode stage is down or the service door is open. The third switch provides anode stage position data to the CPU.
- **Clamp-Locked Optical Sensor**—This sensor is mounted to the rear of the anode stage and is actuated by the clamp-lock flag when the clamp lock has been turned clockwise to the locked position. The clamp-lock flag is mounted to the anode clamp assembly.

## 4.12 Anode Assembly (MB 500)

The anode assembly for the MB 500 (figure 4-54) has been modified to accept only three capillary arrays. Anode plugs are inserted into positions 1, 2, and 3 and a plastic cover fits over the anode and allows access to only positions 4, 5, and 6 for capillary arrays. In the anode reservoir holder, plastic vessel inserts are used in reservoirs 1, 2, and 3 to prevent solution tubes from being inserted into these reservoirs.

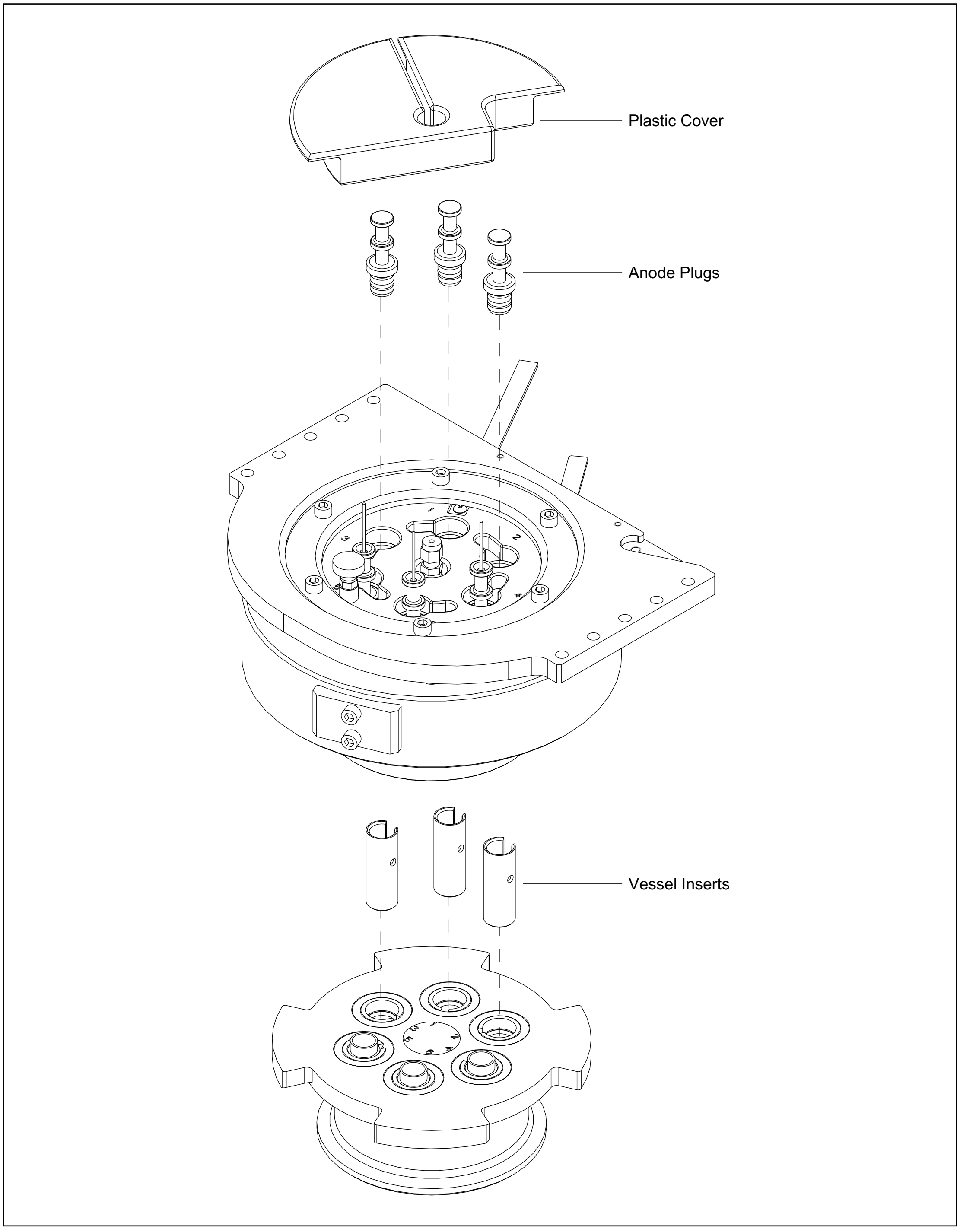



Figure 4-54.  Anode Assembly, Simplified View (MB 500).

## 4.13 Pneumatic Assembly (MB 1000)

The pneumatic assembly provides high- and low-pressure nitrogen to the anode and cathode assemblies under control of the INTC board. The pneumatic assembly is mounted to the instrument sheet-metal chassis with four screws. Figure 4-55 illustrates the various components mounted on the pneumatic assembly.

The pneumatic assembly has two pressure input lines, nitrogen at 1000 psi and at 100 psi. The two nitrogen input connections are located at the rear of the instrument and pressure lines are routed to the pneumatic assembly at the front of the instrument.

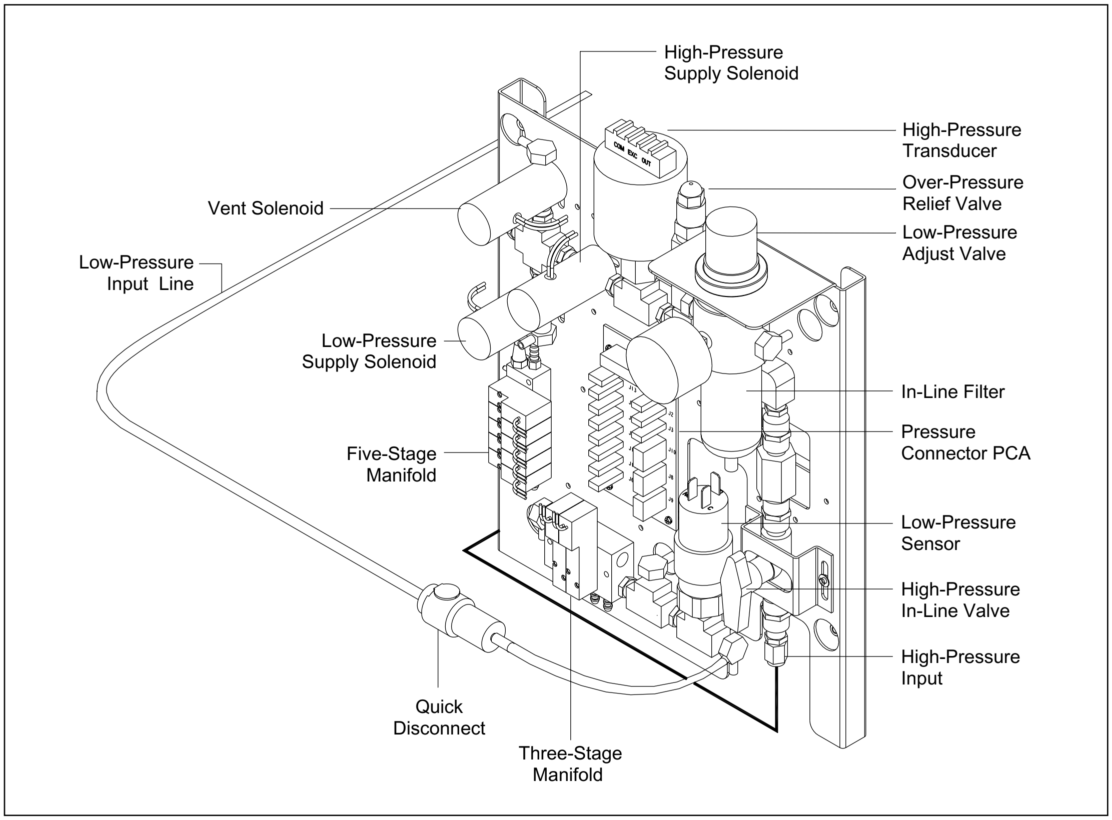



Figure 4-55. Pneumatic Assembly (MB 1000).

## 4.14 Pneumatic Assembly (MB 2000)

The pneumatic assembly for the MB 2000 is nearly identical to the original version. The new version provides an additional low-pressure connection to the cathode assembly to operate the pneumatic cylinders for indexing the 384-well plate. Figure 4-56 shows the additional low-pressure connection, which includes a pressure regulator and a pressure relief valve. The additional pressure regulator is mounted to the instrument sheet-metal framework adjacent to the pneumatic assembly.

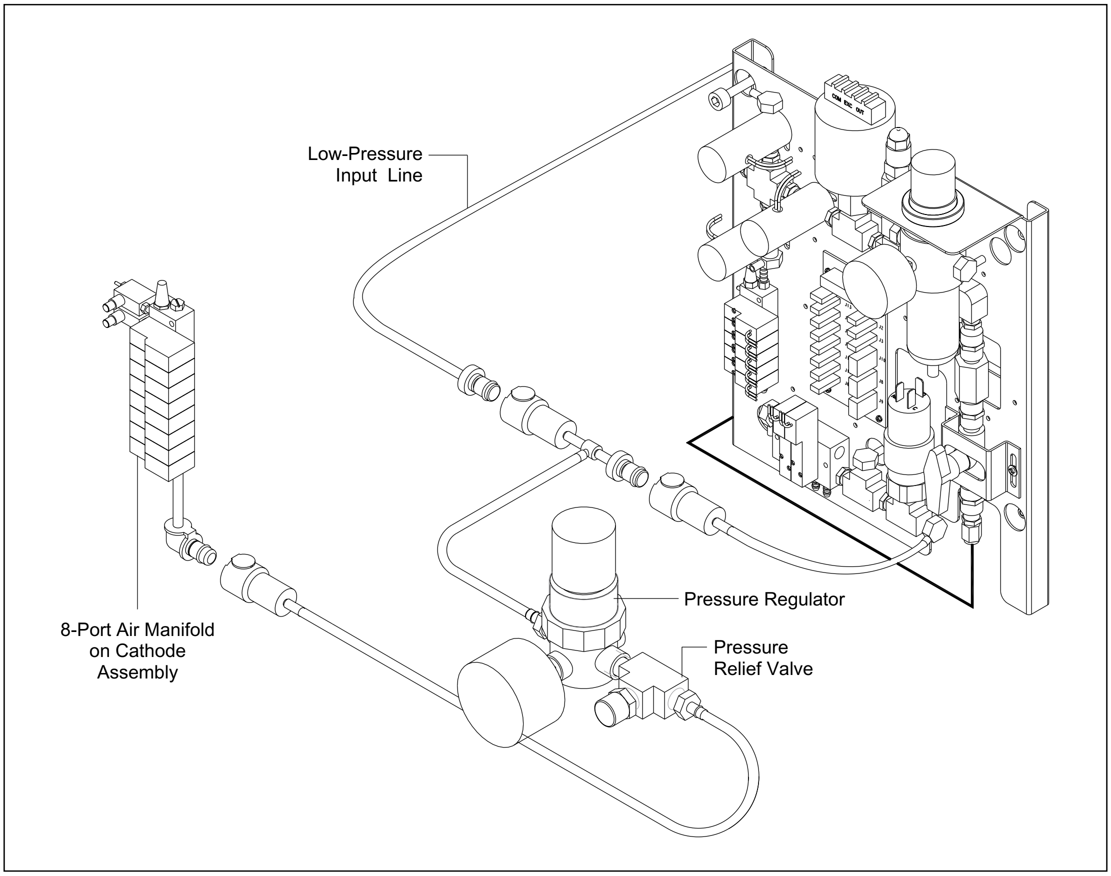



Figure 4-56. Pneumatic Assembly (MB 2000).

# Chapter 5 Electronics

## 5.1 Introduction

This chapter provides a functional description of the electronic components in the MegaBACE instrument. These components include:

- AC power distribution
- DC power generation and distribution
- Internal computer
- Neuron network boards
- Miscellaneous boards
- Interconnect Cabling

## 5.2 AC Power Distribution

The three-wire (line, neutral, and ground), 220-volt AC input enters at the rear of the internal computer enclosure, through an IEC320/C20 (20A) AC inlet, and is wired to an electromagnetic interference (EMI) filter (figure 5-1). The ground wire is tied to a ground lug and to pin three of a five-pin bulkhead connector mounted to the internal computer enclosure. The line and neutral wires are routed through the main power ON/OFF switch to the same five-pin bulkhead connector, to pins one and five, respectively. A three-wire cable routes the input AC to an identical five-pin bulkhead connector on the internal power supply box. The input AC is then sent to the main distribution terminal strip in the power supply box.

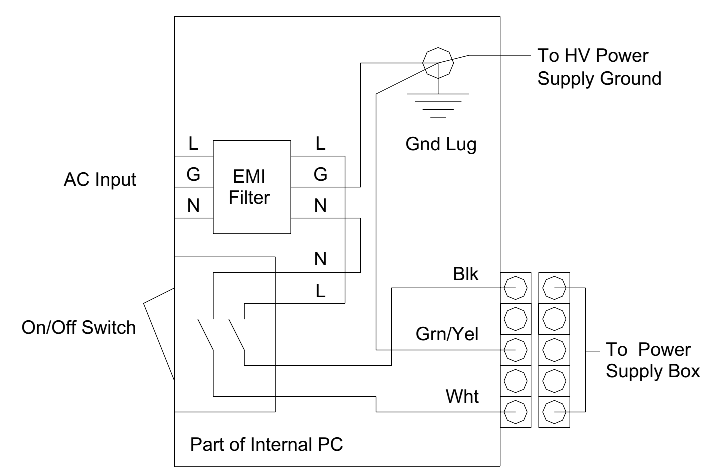



Figure 5-1. AC Power Input.

### 5.2.1 Power Supply Box (Four-Supply Model)

The original power supply box (figure 5-2) contains four DC power supplies and a power supply distribution board. The line and neutral circuits are routed from the main distribution terminal strip through 5-amp fuses (F3 and F4) to the cooler power supply and through 5-amp fuses (F5 and F6) to the heater power supply. These four AC fuses are mounted to the left end of the power supply box along with two 2-amp fuses (F1 and F2) for the main instrument blower and 20-amp and 15-amp DC circuit breakers for the heater and cooler DC power supply outputs. From the main distribution terminal strip, the three AC lines are connected to terminal strips on the PC/board power supply and the Echelon/motor power supply.

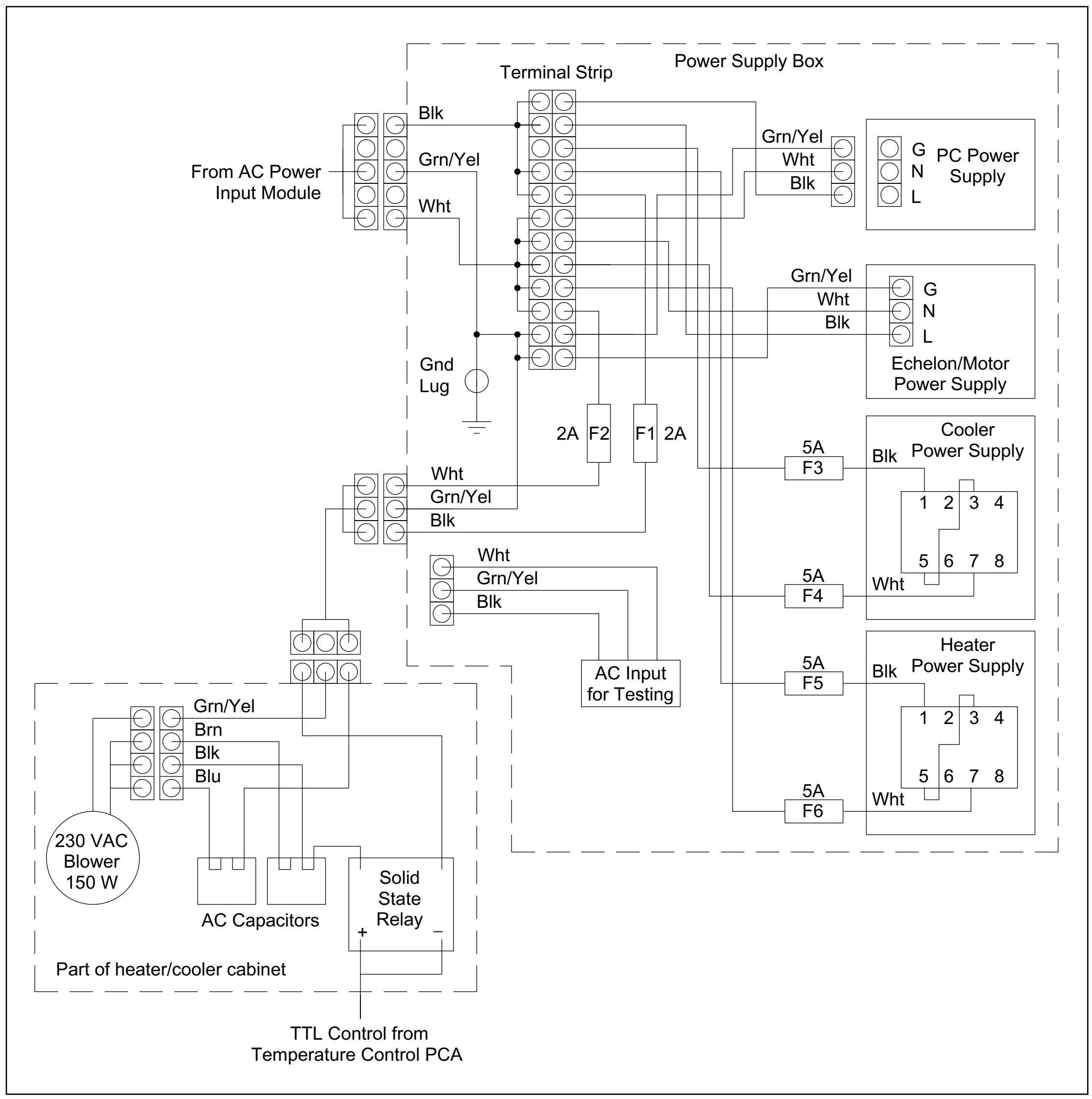



Figure 5-2. Main AC Distribution Block Diagram (Four-Supply Model).

### 5.2.2 Power Supply Box (Two-Supply Model)

The CE two-supply version of the power supply box (figure 5-3) contains the main DC power supply, heater power supply, and a power supply distribution board. The main DC power supply takes the place of the cooler power supply, PC/board power supply, and Echelon/motor power supply in the original version of the power supply box. The line and neutral circuits are routed from the main distribution terminal strip through 5-amp fuses (F3 and F4) to the heater power supply. These two AC fuses are mounted to the left end of the power supply box along two 2-amp fuses (F1 and F2) for the main instrument blower and a 20-amp DC circuit breaker (CB1) for the heater power supply output. Two spare 5-amp fuses are also mounted to the left end of the power supply box. From the main distribution terminal strip, the three AC lines are connected to terminal strips on the main DC power supply.

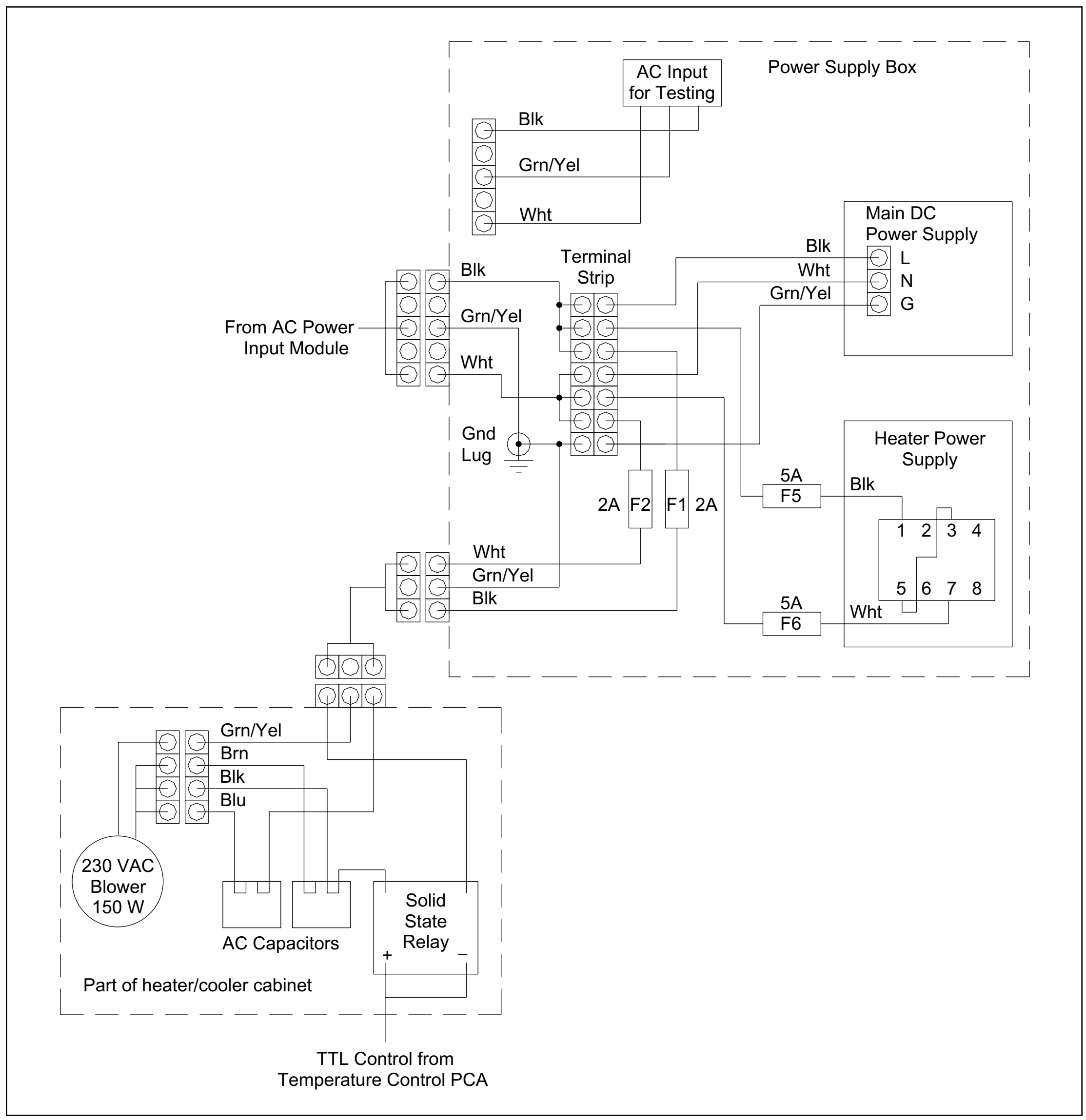



Figure 5-3. Main AC Distribution Block Diagram (Two-Supply Model).

### 5.2.3 Power Supply Box (CE 2001)

The CE 2001 version of the power supply box (figure 5-4) contains a single DC power supply that takes the place of the cooler power supply, heater power supply, PC/board power supply, and Echelon/motor power supply in the original version of the power supply box.

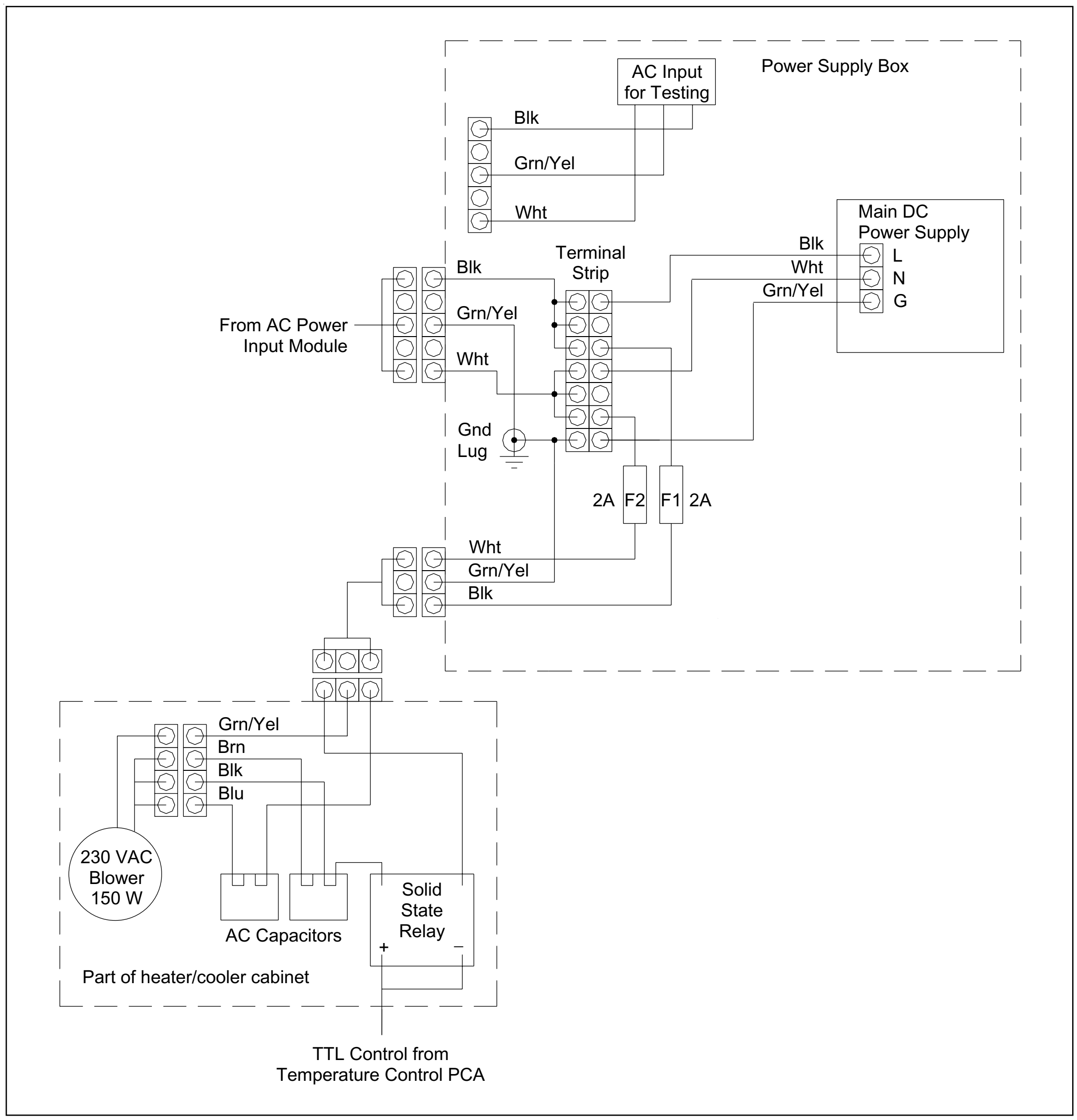



Figure 5-4. Main AC Distribution Block Diagram (CE 2001).

### 5.2.4 AC Input for Testing

In each version of the power supply box there is an auxiliary AC jumper cable that allows testing of the power supply box outside the instrument. This cable consists of a three-pole, 220-volt AC receptacle, a two-foot section of three-conductor cable, and a five-pin Mat-N-Lok connector. The AC receptacle is mounted to a flange on the top of the front panel of the power supply box, under the top cover, and the cable with the Mat-N-Lok connector is coiled and stored inside the power supply box. To use the cable, remove the top cover, plug the five-pin Mat-N-Lok connector into the matching bulkhead connector on the right side panel, and plug a three-conductor 220-volt AC power cord into the AC receptacle.

### 5.2.5 Main Instrument Blower

Three-wire AC is also supplied to the main instrument blower motor via a three-pin Mat-N-Lok bulkhead connector and a three-wire cable to an identical connector located on the heater/cooler board. The neutral and line circuits are protected by 2-amp fuses (F1 and F2, respectively). These fuses are located on the left end of the power supply box. A solid-state relay controls the application of the AC to the blower through AC starting capacitors. A four-pin Mat-N-Lok connector is mounted to the heater/cooler board, and a cable routes the AC to the blower. The solid-state relay is controlled by a DC voltage from the TMPR board.

### 5.2.6 Power Supply Fan Module

The power supply fan module supplies power to the blue laser and air flow to the blue laser for cooling. The power supply fan module is a sheet-metal enclosure that houses a blower, a blue laser power supply, and an internal sheet-metal chassis that contains three solid-state relays, two circuit breakers for the blower, and a blower service switch. The blue power supply fan module AC distribution (figure 5-5) is separate from the instrument AC distribution.

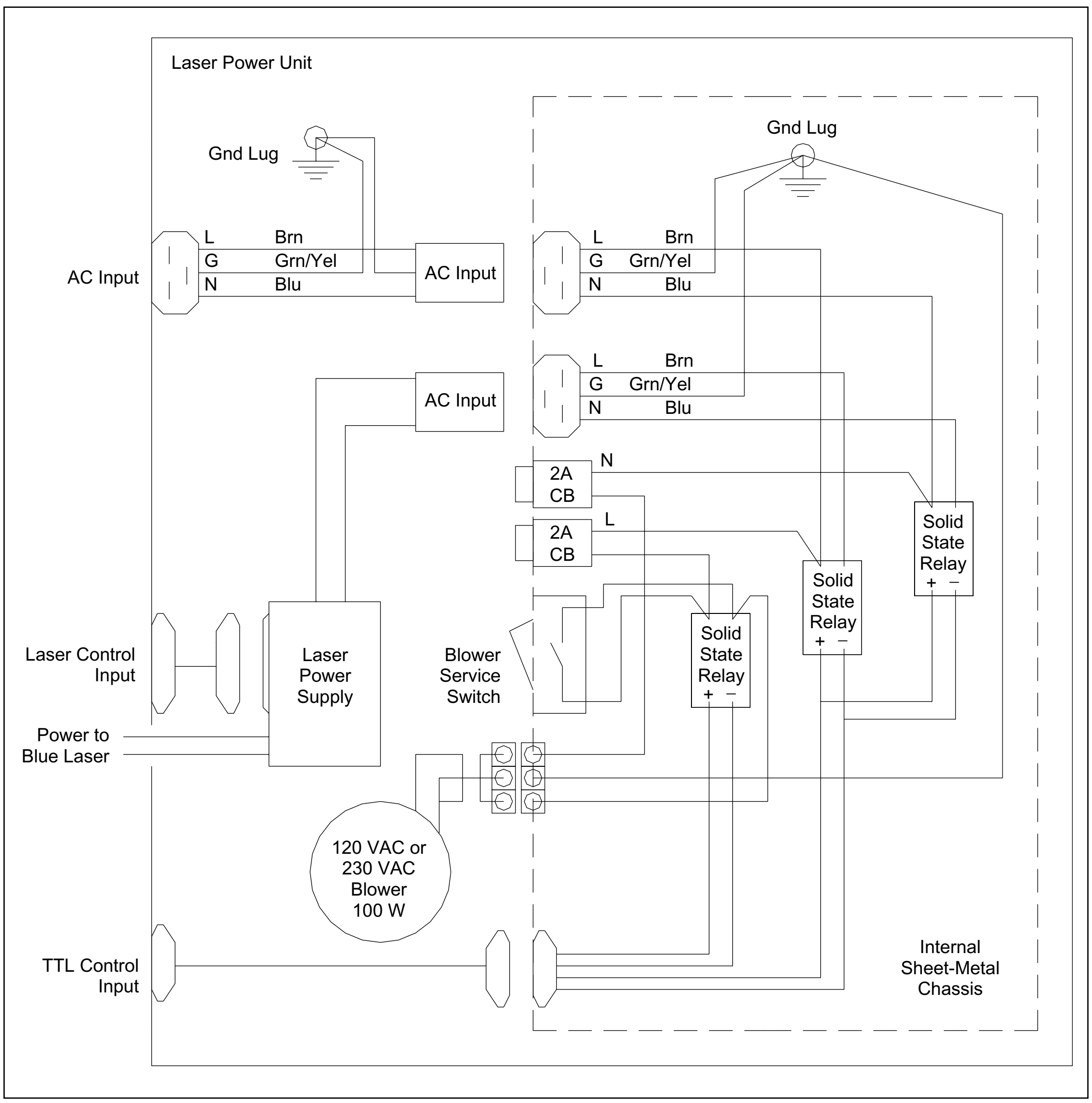



Figure 5-5. Power Supply Fan Module AC Distribution Block Diagram.

The input AC cord plugs into the AC input receptacle mounted to the exterior sheet-metal enclosure. From here the AC is routed through another plug to an AC receptacle mounted to the internal sheet-metal chassis. The line and neutral sides of the AC input are routed to two solid-state relays. The outputs of these two relays are sent to the laser power supply via another AC receptacle and plug combination and to two circuit breakers mounted to the internal sheet-metal chassis. These circuit breakers route the AC to the blower, which supplies cooling air to the laser power supply. The line side of the AC is sent to the blower via a third solid-state relay. These three relays are controlled by transistor-to-transistor logic (TTL) control signals from the instrument through a nine-pin connector. The laser power supply is controlled from the instrument through a 25-pin connector. A blower service switch, mounted to the internal sheet-metal chassis, allows control of the blower when the TTL control input is disconnected. The laser power supply has its own internal fusing.

## 5.3 DC Power Generation and Distribution

### 5.3.1 Power Supply Box (Four-Supply Model)

The power supply box (figure 5-6) contains the four DC power supplies and the power supply distribution board. The INTC board is mounted to the outside of the power supply box. Six AC fuses and two DC circuit breakers are mounted to the left end of the power supply box.

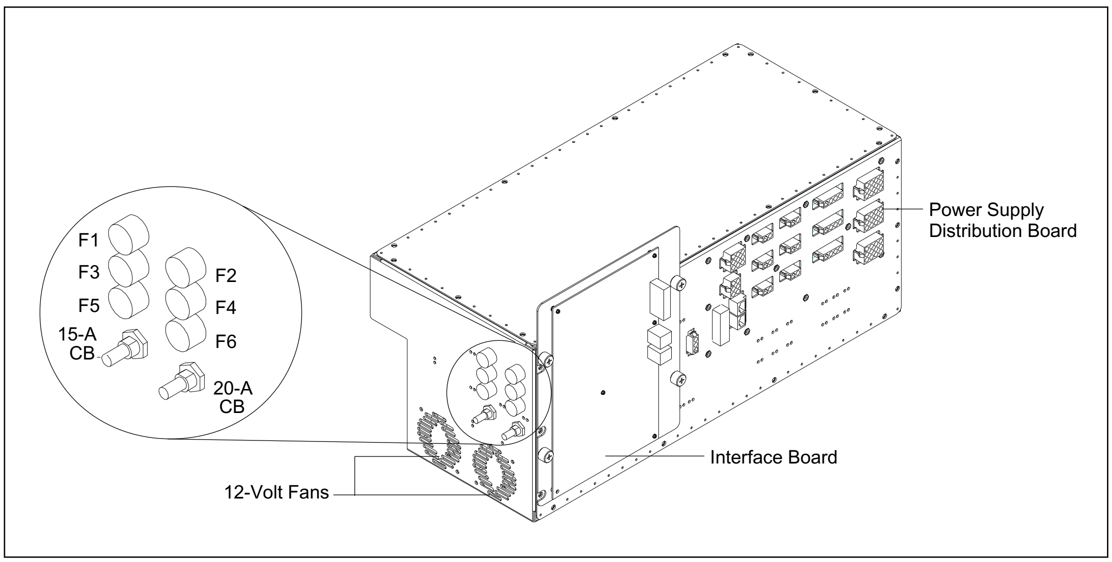



Figure 5-6. Power Supply Box (Four-Supply Model).

Figure 5-7 is a simplified wiring diagram of the original version of the DC power generation system and initial routing of the DC to the power supply distribution board. The DC output grounds of all the power supplies are tied together on the ground plane of the power supply distribution board.

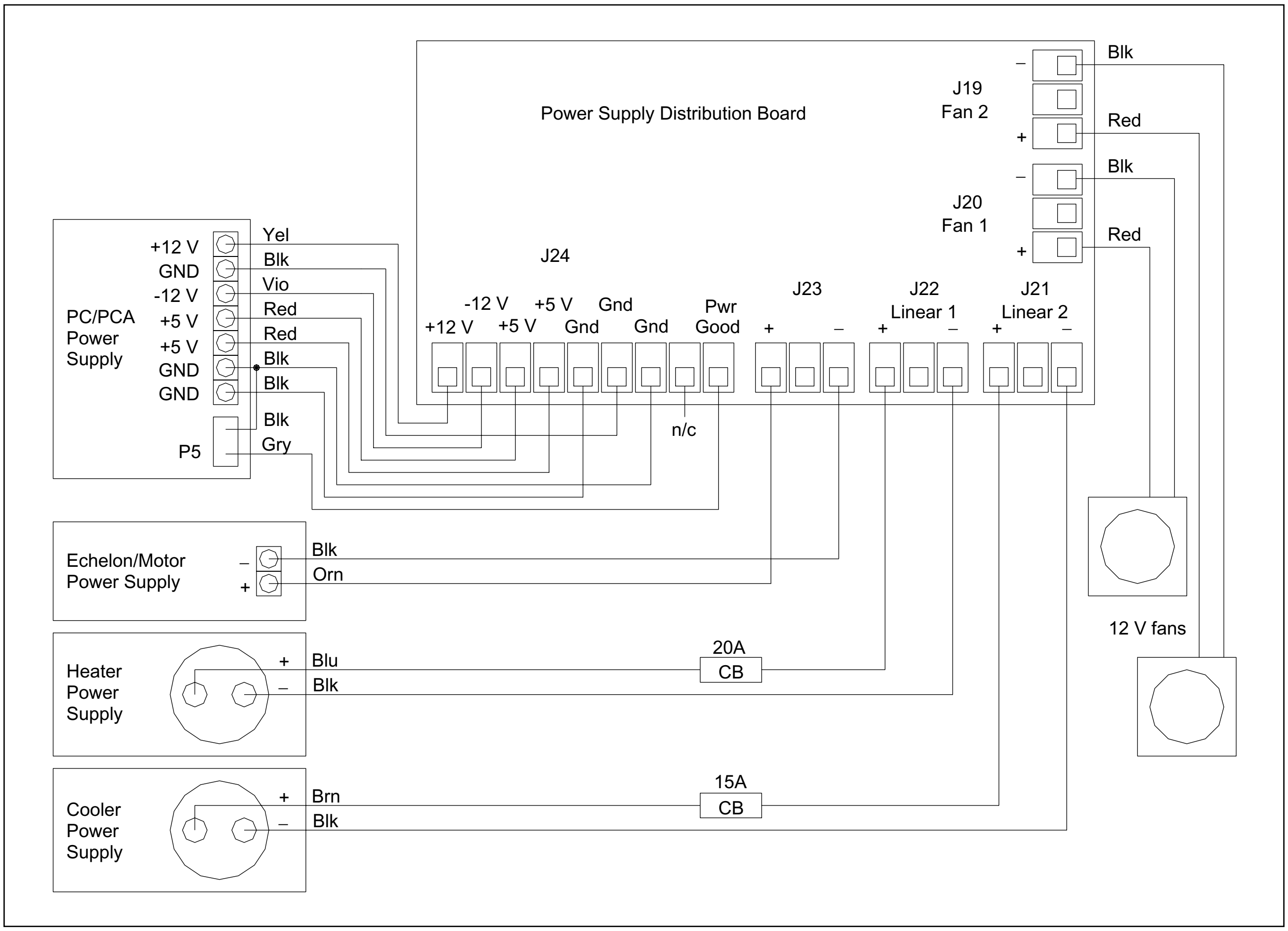



Figure 5-7. Power Supply Box DC Distribution Block Diagram (Four-Supply Model).

### 5.3.1.1 Cooler Power Supply

The cooler power supply provides unregulated +24 volts for the thermoelectric (TE) cooler assembly located on the heater/cooler assembly. The output of the cooler power supply is protected by a 15-amp circuit breaker. This circuit breaker is located below the AC fuses on the left end of the power supply box. The 24-volt output is routed to terminal strip J21 on the input side of the power supply distribution board.

### 5.3.1.2 Heater Power Supply

The heater power supply provides unregulated +36 volts for the heater elements located on the heater/cooler assembly. The output of the heater power supply is protected by a 20-amp circuit breaker. This circuit breaker is located below the AC fuses on the left end of the power supply box. The 36-volt output is routed to terminal strip J22 on the input side of the power supply distribution board.

### 5.3.1.3 Echelon/Motor Power Supply

The Echelon/motor power supply provides regulated +24 volts DC to the Echelon Neuron network, the solenoids in the pneumatic assembly, relays on various boards, and specific motors. The 24-volt output is routed to terminal strip J23 on the input side of the power supply distribution board.

#### 5.3.1.4 Internal Computer/Board Power Supply

The internal computer/board power supply supplies regulated +5-volt, –12-volt, and +12-volt DC for the internal computer, the INTC board, and to the two 12-volt fans in the power supply box. These voltages and grounds are routed from a terminal strip in the power supply to terminal strip J24 on the back (input) side of the power supply distribution board. A signal called PWR GOOD is routed from plug P5 on the power supply to J24 on the power supply distribution board. This signal indicates that the power supply is working. The two 12-volt fans are connected to terminal strips J19 and J20.

### 5.3.2 Power Supply Box (Two-Supply Model)

The power supply box (figure 5-8) contains the two DC power supplies and the power supply distribution board. The INTC board is mounted to the outside of the power supply box. Six AC fuses and one DC circuit breaker are mounted to the left end of the power supply box. The bottom two fuses are spares.

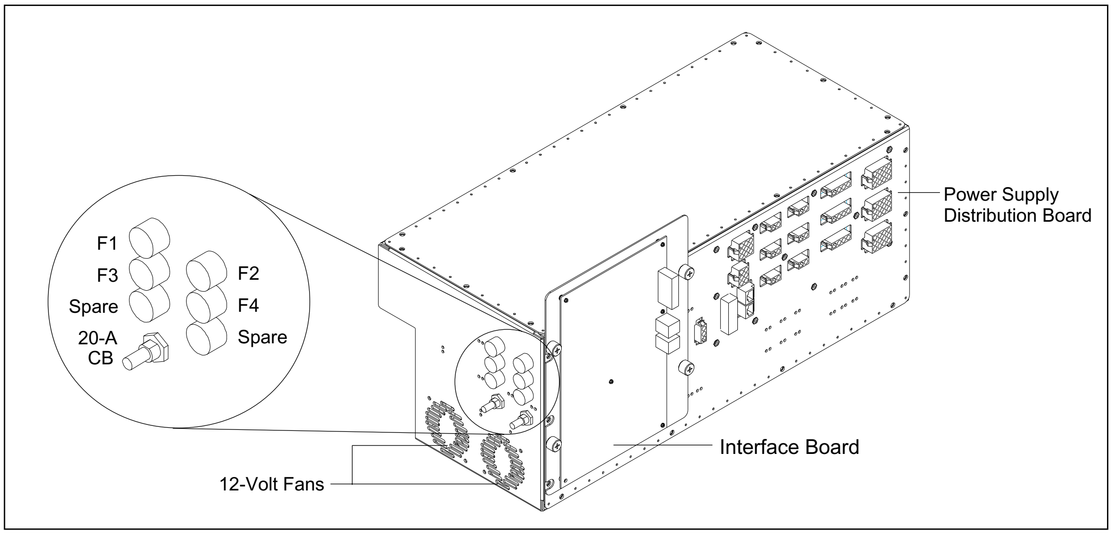



Figure 5-8. Power Supply Box (Two-Supply Model).

#### 5.3.2.1 Heater Power Supply

The heater power supply provides unregulated +36 volts for the heater elements located on the heater/cooler assembly. The output of the heater power supply is protected by a 20-amp circuit breaker. This circuit breaker is located below the AC fuses on the left end of the power supply box. The 36-volt output is routed to terminal strip J21 on the input side of the power supply distribution board.

#### 5.3.2.2 Main DC Power Supply

The main DC power supply supplies regulated +5-volt, –12-volt, and +12-volt DC for the internal computer, the INTC board, and to the two 12-volt fans in the power supply box. These voltages and grounds are routed from a terminal strip in the power supply to terminal strip J24 on the back (input) side of the power supply distribution board. The two 12-volt fans are connected to terminal strips J19 and J20. This power supply also provides unregulated +24 volts for the thermoelectric (TE) cooler assembly located on the heater/cooler assembly.
The 24-volt output is routed to terminal strip J23 on the input side of the power supply distribution board.

Figure 5-9 is a simplified wiring diagram of the two-supply model of the DC power generation system and initial routing of the DC to the power supply distribution board. The DC output grounds of all the power supplies are tied together on the ground plane of the power supply distribution board.

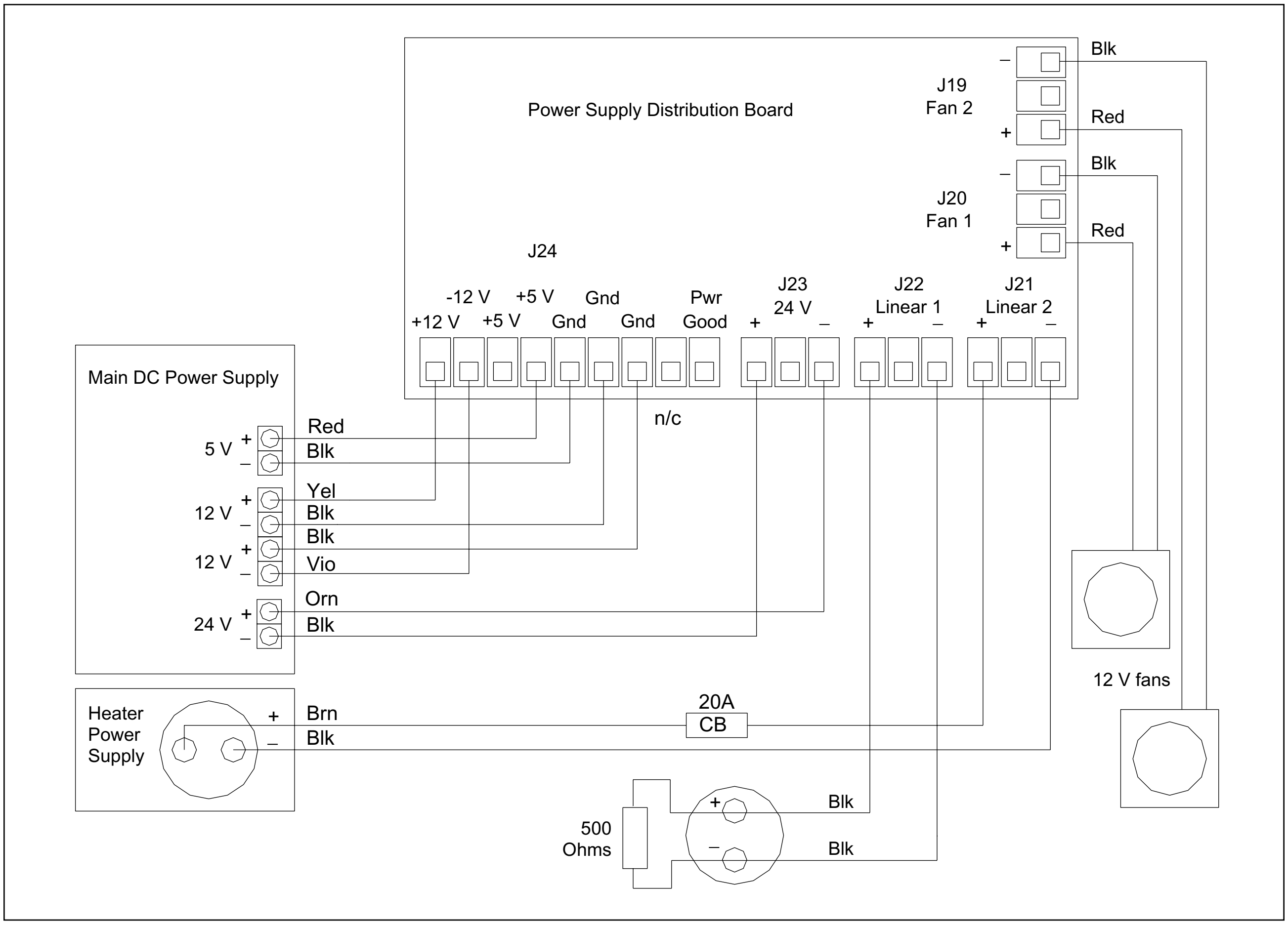



Figure 5-9. Power Supply Box DC Distribution Block Diagram (Two-Supply Model).

### 5.3.3 Power Supply Box (CE 2001)

The power supply box (figure 5-10) contains a single DC power supply and the power supply distribution board. The INTC board is mounted to the outside of the power supply box. Two AC fuses are mounted to the left end of the power supply box.

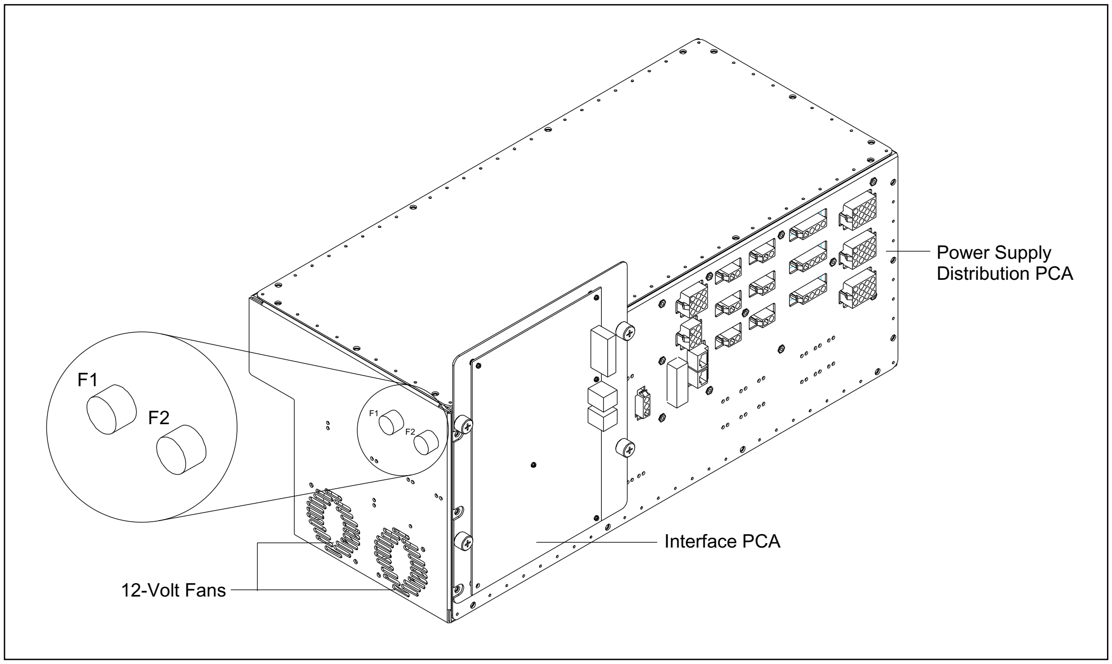



Figure 5-10. Power Supply Box (CE 2001).

### 5.3.3.1 Main DC Power Supply

The main DC power supply supplies regulated +5-volt, –12-volt, and +12-volt DC for the internal computer, the INTC board, and two 12-volt fans in the power supply box. This power supply also provides +24 volts for the cooler, and +36 volts for the heater.

Figure 5-11 is a simplified wiring diagram of the CE 2001 version of the DC power generation system and initial routing of the DC to the power supply distribution board. The DC output grounds of all the power supplies are tied together on the ground plane of the power supply distribution board.

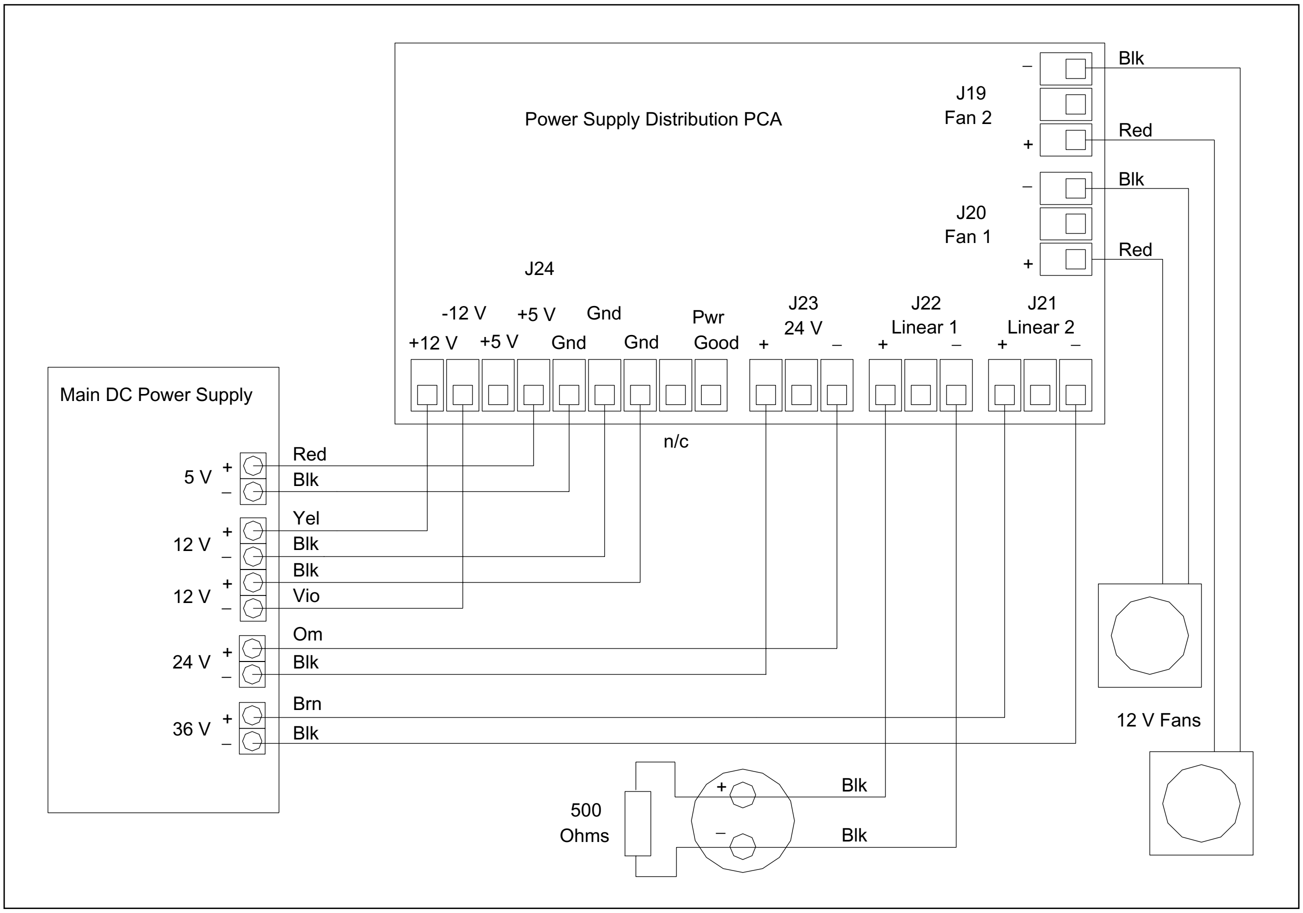



Figure 5-11. Power Supply Box DC Distribution Block Diagram (CE 2001).

### 5.3.4 Power Supply Distribution board

The power supply distribution board is located inside the power supply box and provides output connections for the DC power supplies. Figure 5-12 illustrates the output side of the power supply distribution board.

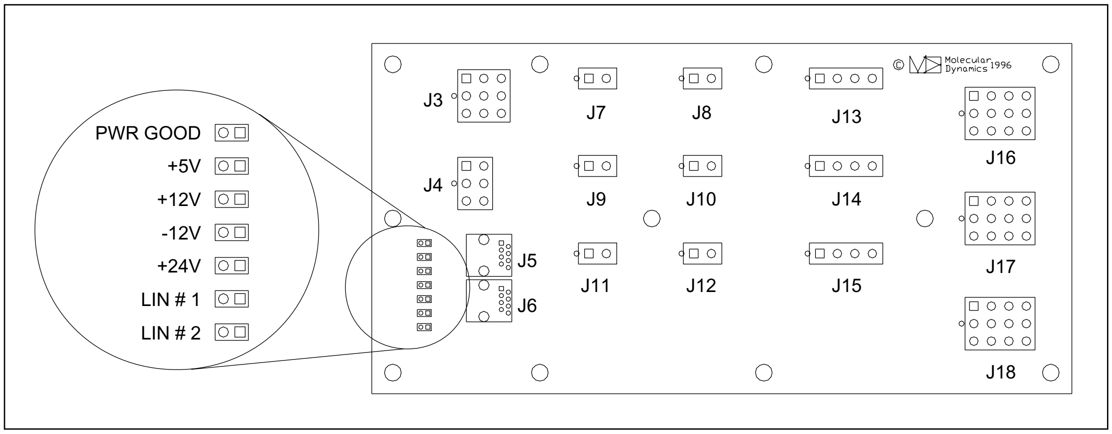



Figure 5-12. Power Supply Distribution Board Output Connections.

The power supply distribution board has eight LEDs that indicate the presence of the power supply output voltages. The PWR GOOD voltage is required to complete the instrument software booting process.

All but two of the outputs are Mat-N-Lok bulkhead connectors that extend through holes in the power supply box. Figure 5-13 is a simplified block diagram of the instrument DC power distribution. Of the six two-pin connectors (J7 through J12), three are used to supply 24-volt power to the three motor control boards. There are three four-pin connectors (J13 through J15); one supplies 12-volt power to the green laser, another supplies 12-volt power to three fans located on the TE cooler, and the third is a spare. There are three 12-pin connectors (J16 through J18); one supplies 5-volt, 12-volt, and 24-volt power to the internal PC, one supplies 5-volt, 12-volt, and 24-volt power to the INTC board, and the third is a spare. All multiple connectors of the same type (2-pin, 4-pin, and 12-pin) are wired identically and provide the same voltage outputs. They can be used interchangeably. There is a single nine-pin connector (J3) that supplies 24-volt power through the TMPR board for the TE cooler assembly and a single six-pin connector (J4) that supplies 36-volt power through the TMPR board for the heaters.

The last two jacks (J5 and J6) are the RJ45 jacks that supply 24-volt DC power to the TMPR board, PDIO board, ADAQ board, and CMON board and provide terminations for the Neuron network. These four boards have DC-to-DC converters that convert the 24 volts to the individual operating potentials required by the boards.

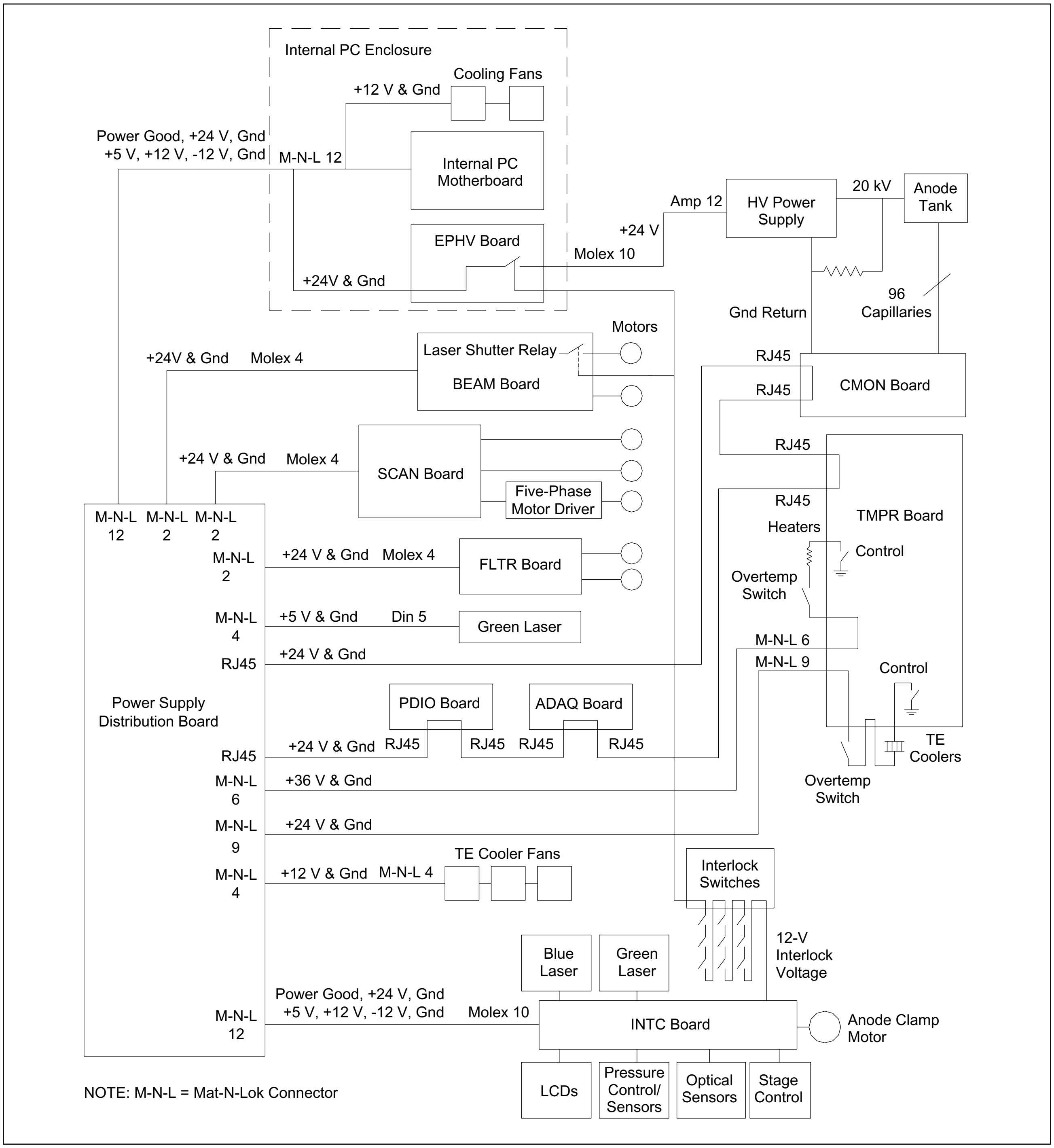



Figure 5-13. Instrument DC Distribution Block Diagram.

### 5.3.5 Neuron Network Signal and DC Distribution

Figure 5-14 is a simplified block diagram of the Neuron network signal and power distribution. With the exception of the Neuron network board, all the network connections to the boards are RJ45. Figure 5-15 details the RJ45 connections for the different boards and the special connection to the Neuron network board. Because the TMPR board, PDIO board, ADAQ board, and CMON board draw very little current, they receive 24-volt power from the power supply distribution board via the Neuron network cables. These four boards then use DC-to-DC converters to develop the required operating potentials. To decrease the possibility of a ground loop, the four boards that receive their power via the Neuron network are located as close as possible to the power supply distribution board. The +24-volt power is available on the connections to the INTC board and the three motor control boards, but is not used. Each of these boards has dedicated power connections from the power supply distribution board. The power supply distribution board also provides terminations for the Neuron network data lines.

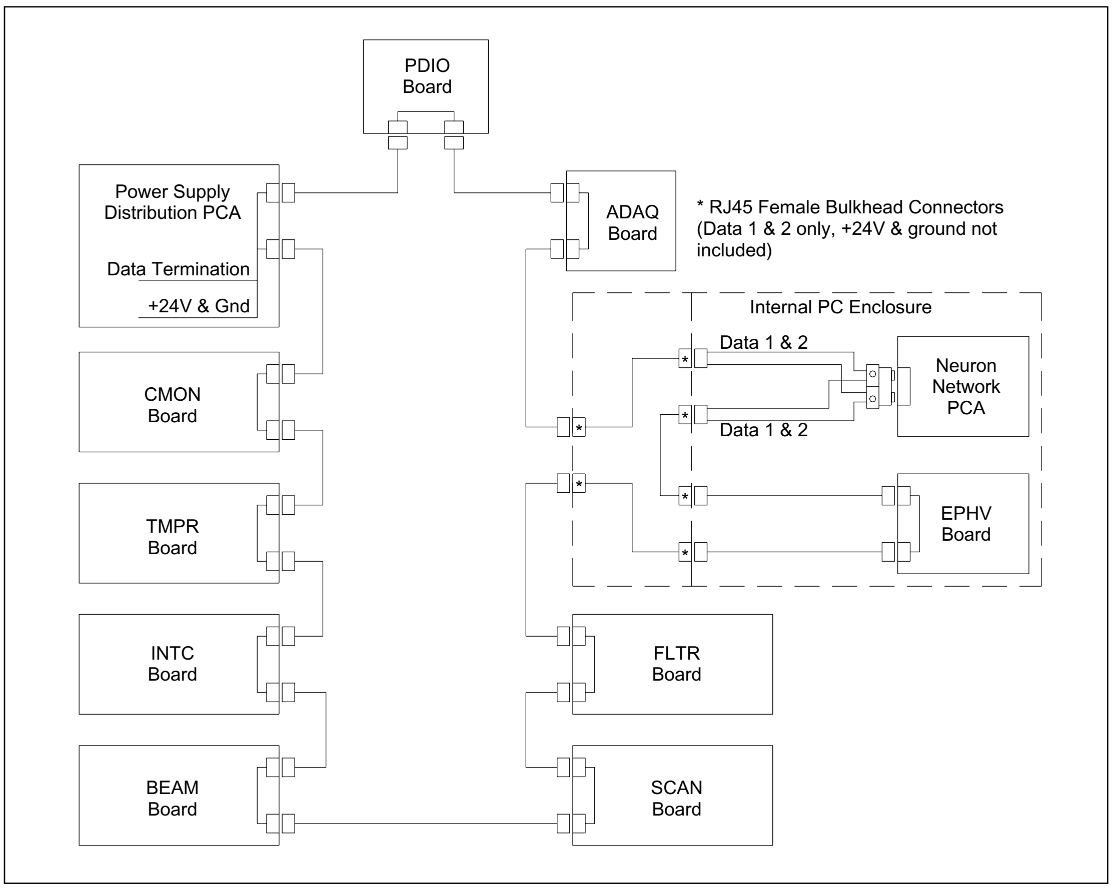



Figure 5-14. Neuron Network Signal and DC Distribution Block Diagram.

The Neuron network connections within the enclosure consist of three sets of RJ45 female bulkhead connectors. These connections use only the two data lines. The +24-volt power and ground are not used anywhere inside the enclosure.

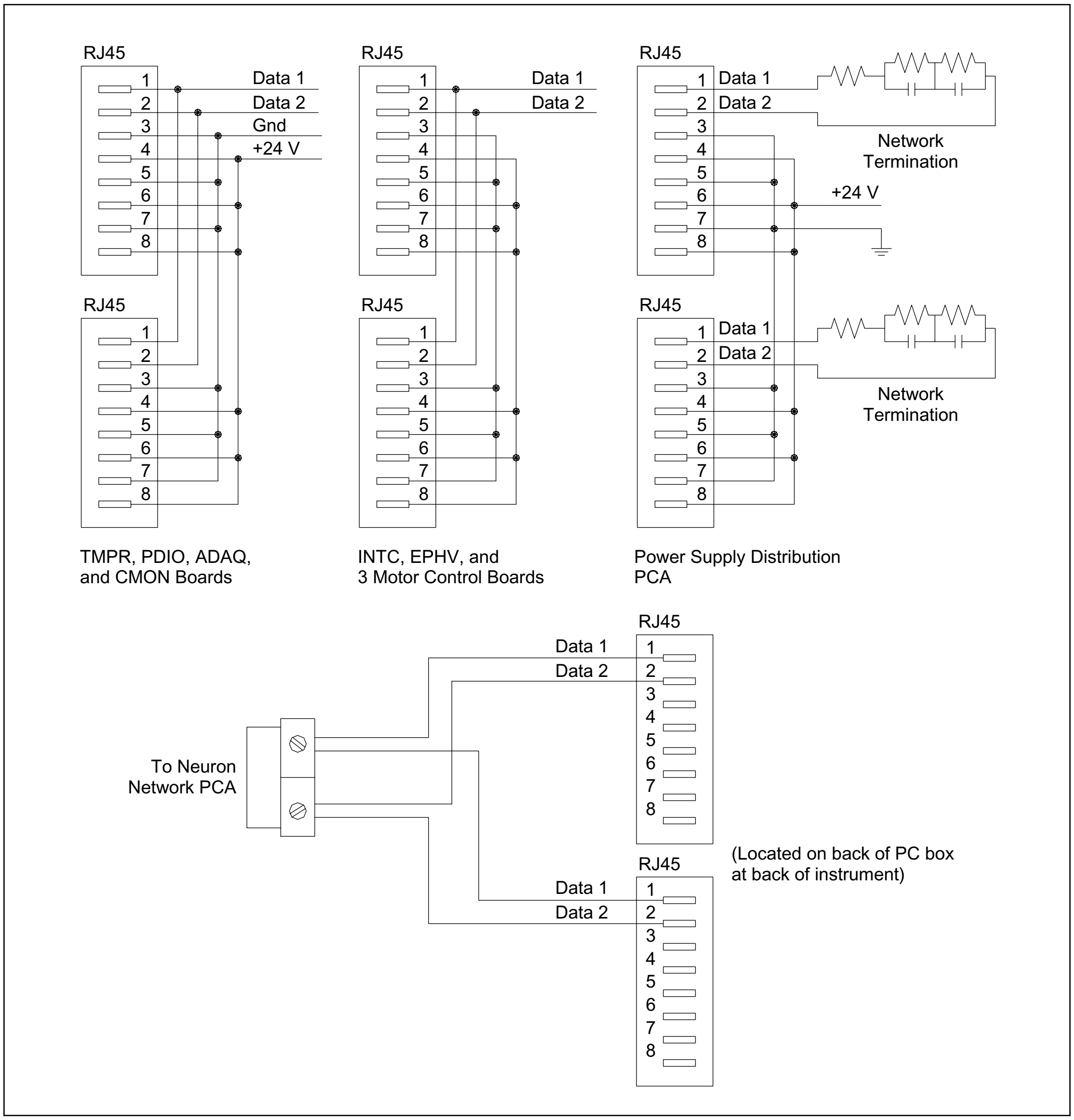



Figure 5-15. Neuron Network Connector Detail Diagram.

### 5.3.6 High-Voltage (HV) Power Supply

The HV power supply provides a high-voltage DC output of up to 20 kV to the anode assembly. The EPHV board provides a control voltage and +24 volts to drive the high-voltage output circuitry. Figure 5-16 is a simplified diagram of the HV power distribution. There is a direct correlation between the control voltage input and the output voltage of the HV power supply:

$$\text{output voltage} = \text{control voltage} \times 2000$$

Because there is no repair of the HV power supply in the field, it must be replaced as a module.

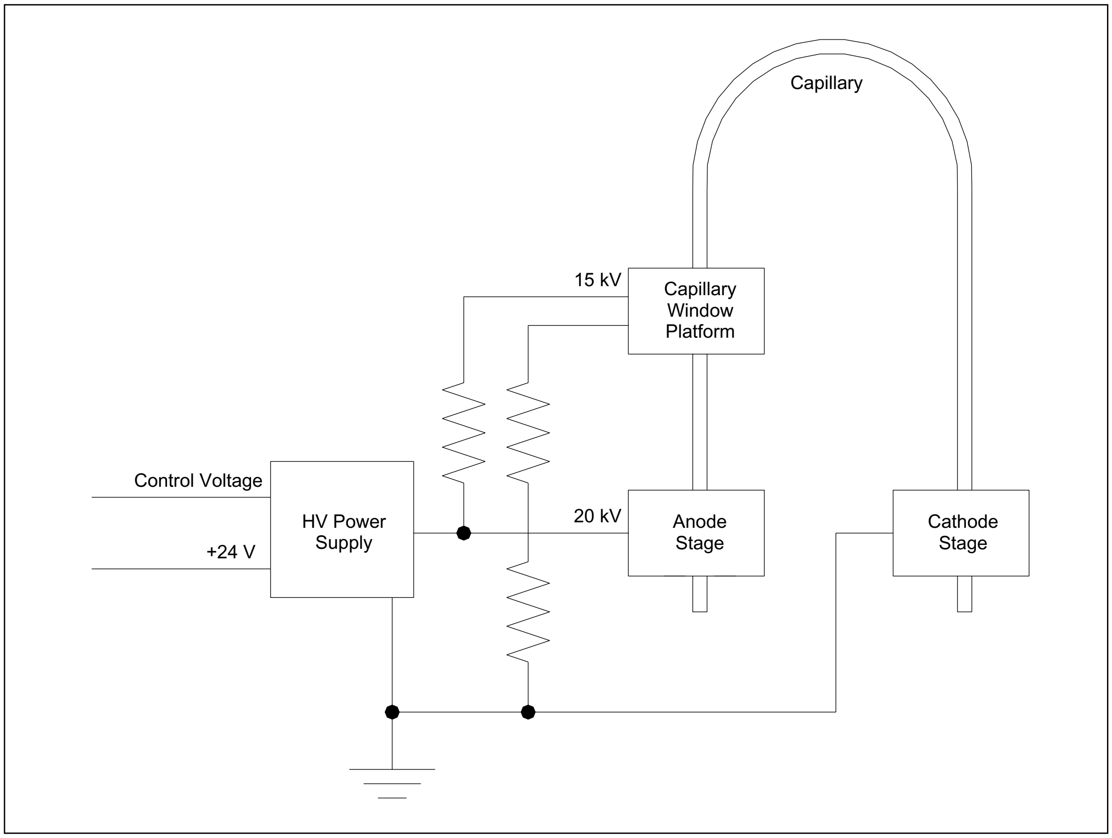



Figure 5-16. HV Power Distribution Block Diagram.

There are three high-voltage leads out of the HV power supply, one lead to the anode stage (+20 kV) and two leads to the base of the scanning assembly. The two leads to the base of the scanning assembly have resistors in series that drop the voltage to approximately one-third of the anode voltage and put the scanning assembly at the same voltage as the capillary windows. This prevents arcing from the capillary windows to the scanning assembly.

### 5.3.7 PMT High-Voltage Power Supply

The PMT high-voltage power supply (figure 5-17) is contained in the PMT tube socket and provides up to 1100 volts DC to the PMT. The tube socket base contains a voltage divider network that distributes the high voltage to the PMT dynodes. The PMT tube socket also has a current limiting circuit that protects the circuitry in the PDIO board in the event that the filters have been removed from the filter changer. If the filters have been removed, the full power of the emission beam would hit the PMTs, causing a large current surge to the preamps. The current limiting circuit prevents this current surge.

The input power to the PMT high-voltage power supply is +15 volts with an isolated ground. The +15 volts, isolated ground, and control voltage are routed to the tube socket base through a six-connector plug, J10Q or J16Q on the ADAQ board. Pins 1 and 6 are used to key the plugs differently for the two PMTs. On the plug for one PMT, pin 1 is blocked and on the plug for the other PMT, pin 6 is blocked. The PMT output current is fed through a shielded center conductor cable to the jack J3W or J14W of the ADAQ board.

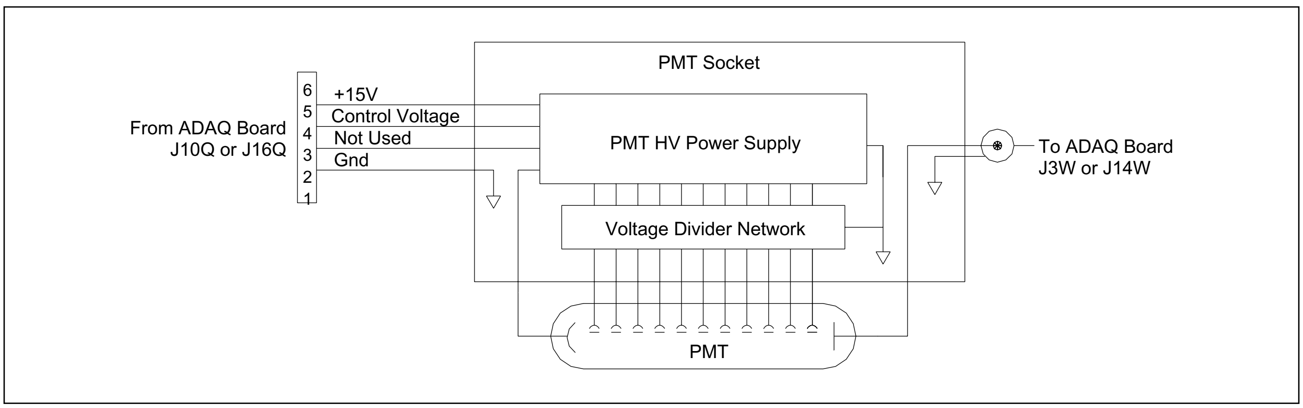



Figure 5-17. PMT High-Voltage Power Supply Block Diagram.

## 5.4 Internal Computer

The internal computer and the EPHV board are mounted in a sheet-metal electronics enclosure. The internal computer provides control of the instrument over the Echelon Neuron network, accepts control signals from the host computer, and sends the stored data out to the host computer. The electronics enclosure provides an input/output panel that is the central location for all external connections to the instrument.

The internal computer has a passive-backplane board that provides the ISA bus for the other boards. The internal computer uses a single-board Pentium computer, hereafter called the CPU, that plugs into the ISA bus. The CPU contains connections for a serial port keyboard and monitor. The internal computer also has a SCSI interface board, Echelon Neuron network controller board, and two PC interface boards that all plug into the ISA bus. Figure 5-18 is a simplified block and wiring diagram of the electronics enclosure.

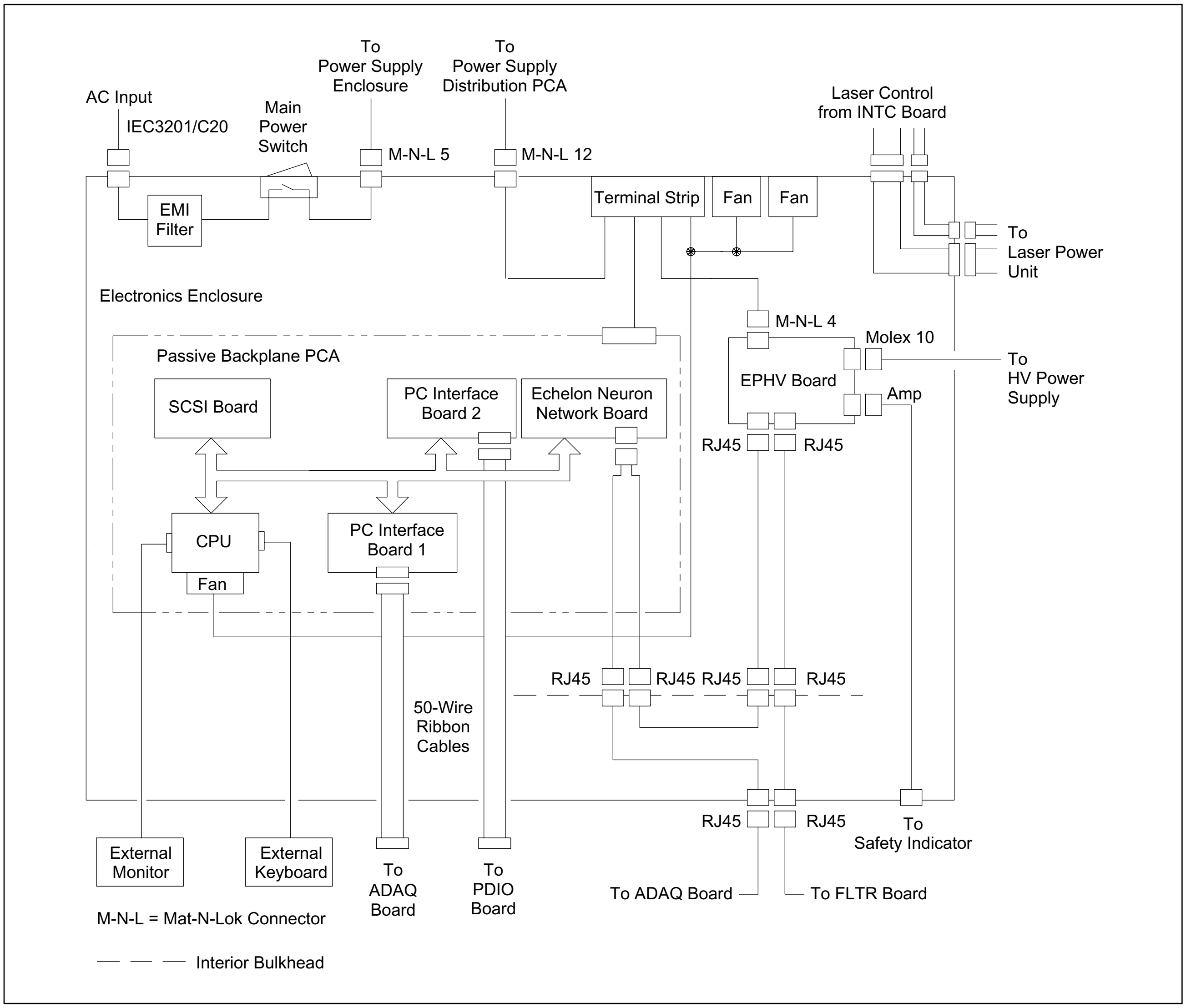



Figure 5-18. Internal Computer Block Diagram.

The input AC is routed through an EMI filter and the main power switch to the power supply enclosure. DC power from the power supply distribution board enters the electronics enclosure through a 12-pin Mat-N-Lok connector to a DC terminal strip. From the DC terminal strip, power is supplied to a five-connector terminal strip on the passive backplane, EPHV board, and two cooling fans.

The EPHV board sends +24 volts and control signals to the HV power supply from a 10-pin Molex™ connector through an opening in the electronics enclosure. The HV control board also sends a 24-volt level to a 1/4-inch phone jack mounted on the input/output panel. This voltage is available when the HV power supply is on and can be used to provide safety indications of high voltage when the interlocks have been defeated for instrument servicing.

Two ribbon cables route laser control signals from the INTC board through the electronics enclosure to the input/output panel. These signals are then routed through a DB-9 cable and a DB-25 cable to the power supply fan module.

The two PC interface boards are connected to the PDIO and ADAQ boards through 50-wire ribbon cables. The PDIO and ADAQ boards also connect to the Neuron network through RJ45 connectors.

The EPHV board and the Neuron network controller are interfaced through a series of two-wire cables and RJ45 connectors. These cables connect via three sets of female RJ45 bulkhead connectors.

### 5.4.1 Passive Backplane Board

The passive backplane board provides the 16-bit ISA interconnect bus for the active circuit boards in the internal computer. This board is a standard off-the-shelf item and has no jumpers or switches to configure.

### 5.4.2 SCSI Interface Board

The SCSI interface board communicates with the host computer and sends the data out to the host computer when requested. On newer SCSI boards, the jumpers shown in figure 5-19 are not present.

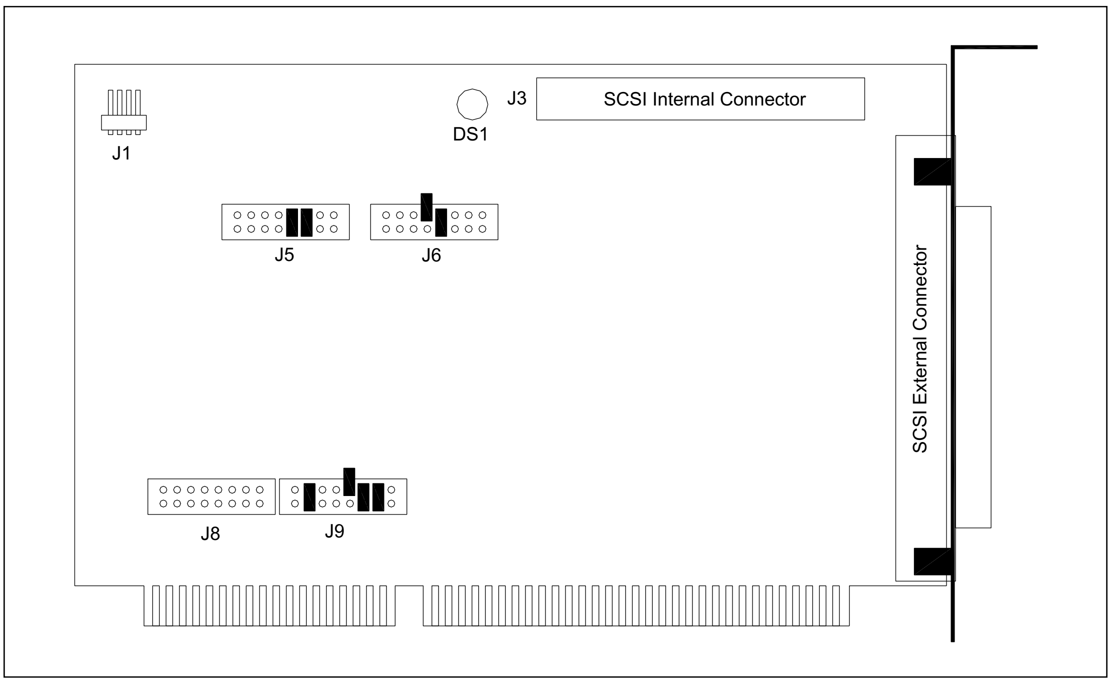



Figure 5-19.  SCSI Interface Board Component Layout Diagram.

### 5.4.3 CPU

The CPU (figure 5-20) provides control for the internal computer, which controls the instrument functions. The CPU uses a Pentium processor operating at 133 MHz, with 8 MB of RAM on board. Since the internal computer does not have a hard drive or floppy drive, the CPU uses the flash memory on the interface/flash memory board to store its programs and operational instructions. The BIOS is loaded on the processor board and operates in the ROM DOS environment. After 1998, the CPU board incorporates a video driver on board and a separate video driver board is no longer needed.

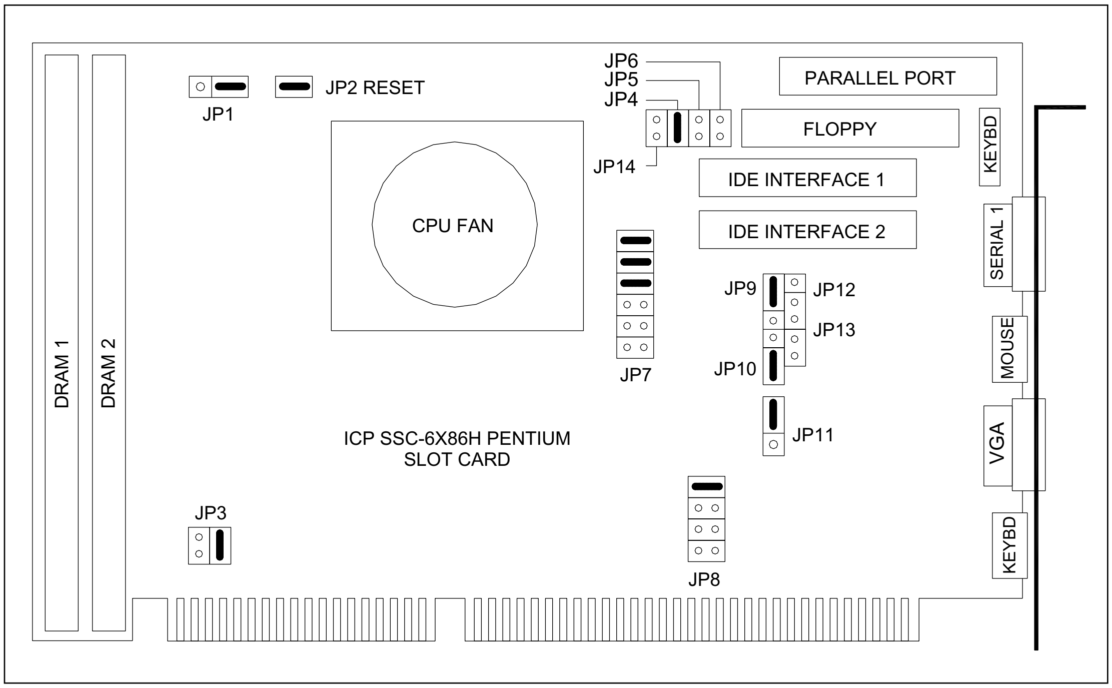



Figure 5-20. CPU Component Layout Diagram.

### 5.4.4 Neuron Network Control board

The Neuron network control board (figure 5-21) communicates with the Neuron network and moves information between the Neuron network and the internal computer.

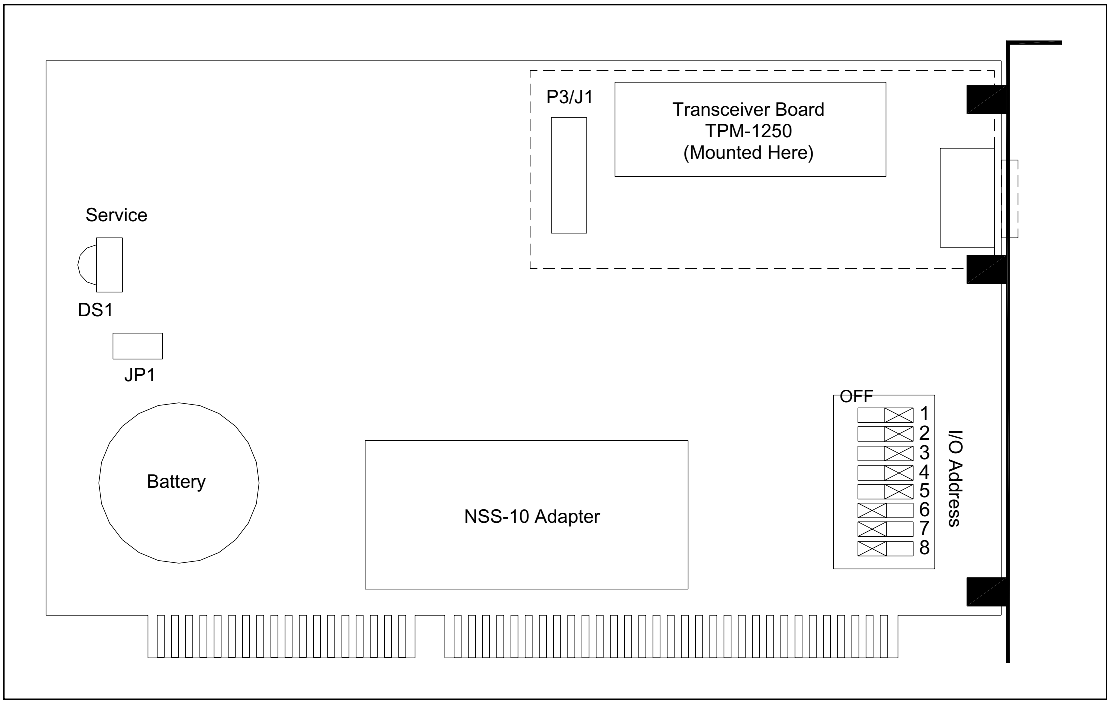



Figure 5-21. Neuron Network Control Board Component Layout Diagram.

Each board in the Neuron network has a unique I/O address that is programmed by an eight-segment DIP switch.

### 5.4.5 PC Interface Board

There are two PC interface boards. One provides an interface for the ADAQ board, and the other provides an interface for the PDIO board. The two PC interface boards are identical, except for the addresses programmed by their eight-segment DIP switches and the configurations of jumper JM6B. This jumper is in place on the PC interface board for the PDIO board to disable the flash RAM. The flash RAM on this board is not needed because the instrument model/serial number information is stored on the flash RAM on the PC interface board for the ADAQ board. The PC interface boards (figure 5-22) accept the digitized signals from the ADAQ board and the PDIO board and store the data until the CPU reads the data for processing. The data comes in through J1F and leaves the board through the ISA interface bus.

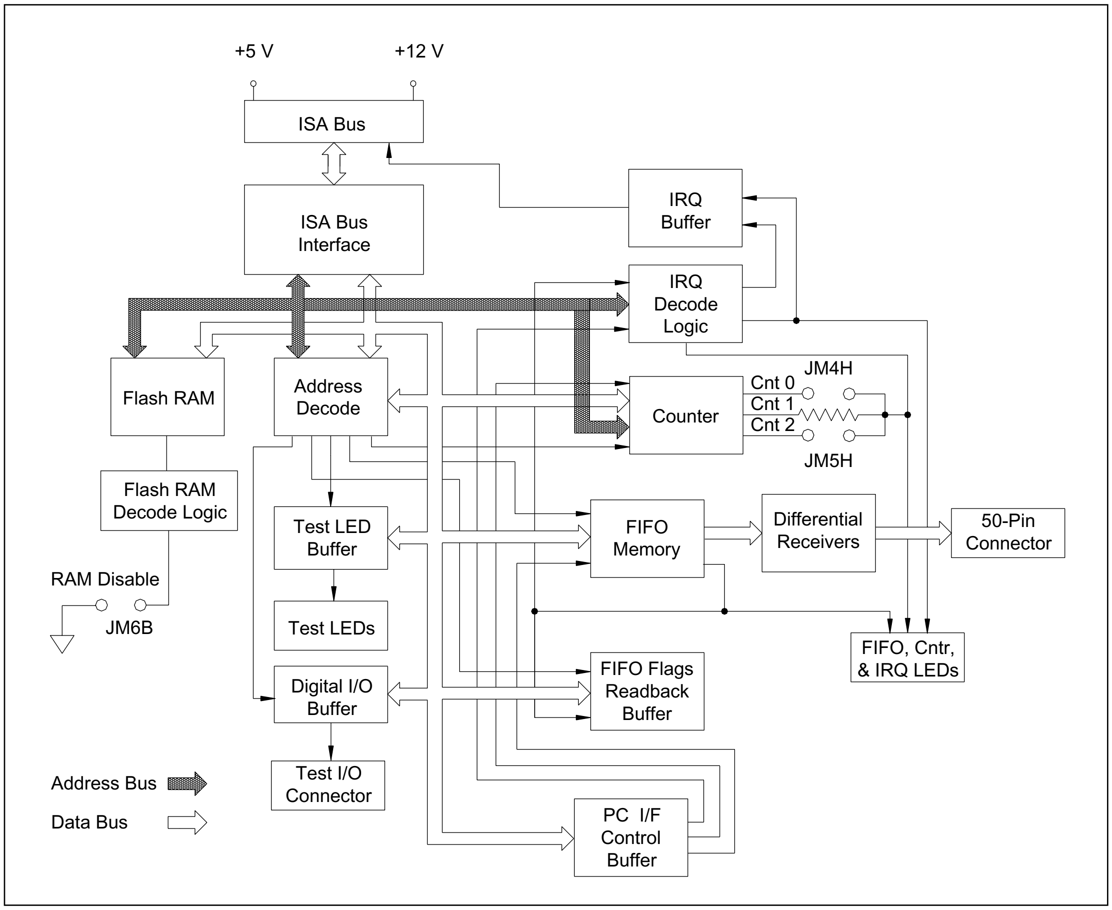



Figure 5-22. PC Interface Board Block Diagram.

#### 5.4.5.1 Component Layout

The component layout of the PC interface board is shown in figure 5-23. The illustration has been simplified to show only the test point, jumper, switch, and connector locations that are relevant to the board functions.

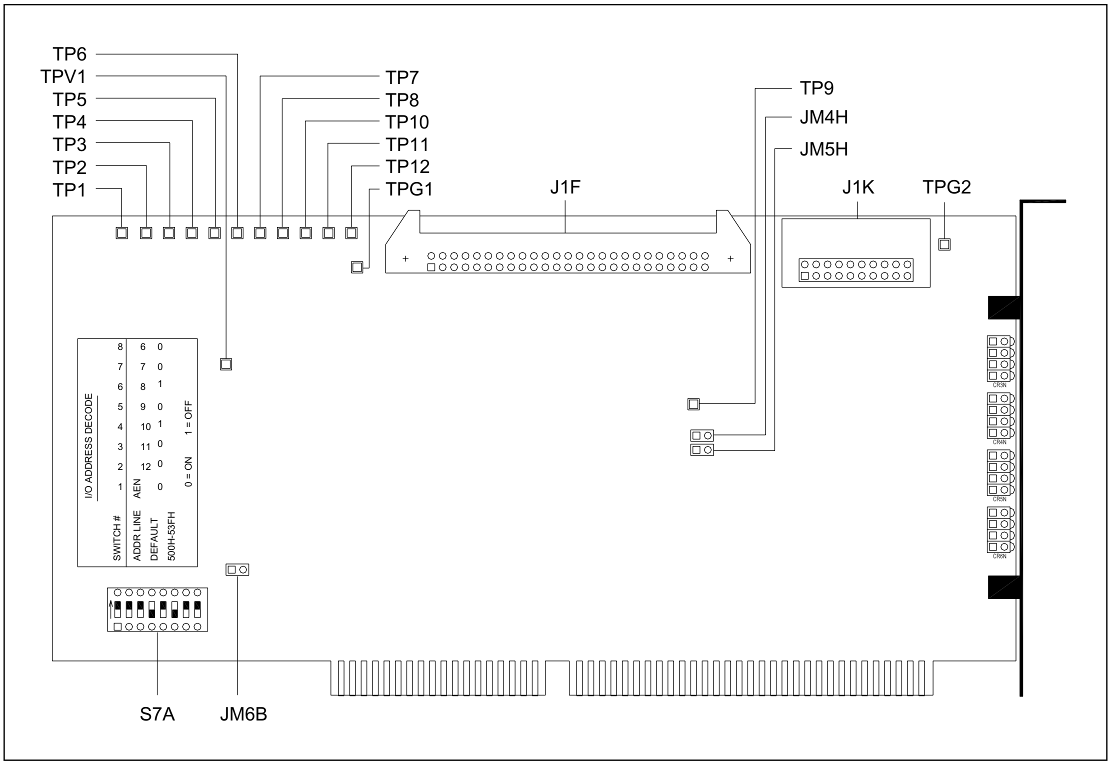



Figure 5-23. PC Interface Board Component Layout Diagram.

Test point, jumper, and switch details are provided below:

- **Test Point TP1**—FIFO empty flag for FIFO U3G.
- **Test Point TP2**—FIFO half-full flag for FIFO U3G.
- **Test Point TP3**—FIFO full flag for FIFO U3G.
- **Test Point TP4**—FIFO empty flag for FIFO U3D and U3C (sample data).
- **Test Point TP5**—FIFO half-full flag for FIFO U3D and U3C (sample data).
- **Test Point TP6**—FIFO full flag for FIFO U3D and U3C (sample data).
- **Test Point TP7**—Interrupt signal (IRQ).
- **Test Point TP8**—Counter output.
- **Test Point TP9**—PDIO board A/D converter BUSY signal. This signal is used to generate the write signal to the FIFO memory.
- **Test Point TP10**—Channel select signal from PDIO board. Signal is low if PMT channel 1 data is being written to the FIFO and high if PMT channel 2 data is being written to the FIFO.

- **Test Point TP11**—Hardware SOS sensor signal from PDIO board. Signal is low during stage scan time and high during stage turnaround time.
- **Test Point TP12**—Software scan state signal from PDIO board. Signal is high during data acquisition and low during stage turnaround time.
- **Test Point TPG1 and TPG2**—Ground test points.
- **Test Point TPV1**— +5-volt test point.
- **Jumper JM6B**—This jumper disables access to the flash memory and is installed on the PC interface board connected to the PDIO board.
- **Jumper JM4H**—If this jumper is installed and the zero-ohm resistor R4H is removed, the counter output is generated by counter number 0.
- **Jumper JM5H**—If this jumper is installed and the zero-ohm resistor R4H is removed, the counter output is generated by counter number 2.
- **Switch S7A**—Address DIP switch. Sets the individual I/O address for the board.
    - ADAQ PC interface board—positions 1, 2, 3, 5, 7, and 8 are on.
    - PDIO PC interface board—positions 1, 2, 3, 5, and 7 are on.

### 5.4.5.2 Connector Details

The connector details of the PC interface board are shown in figure 5-24.

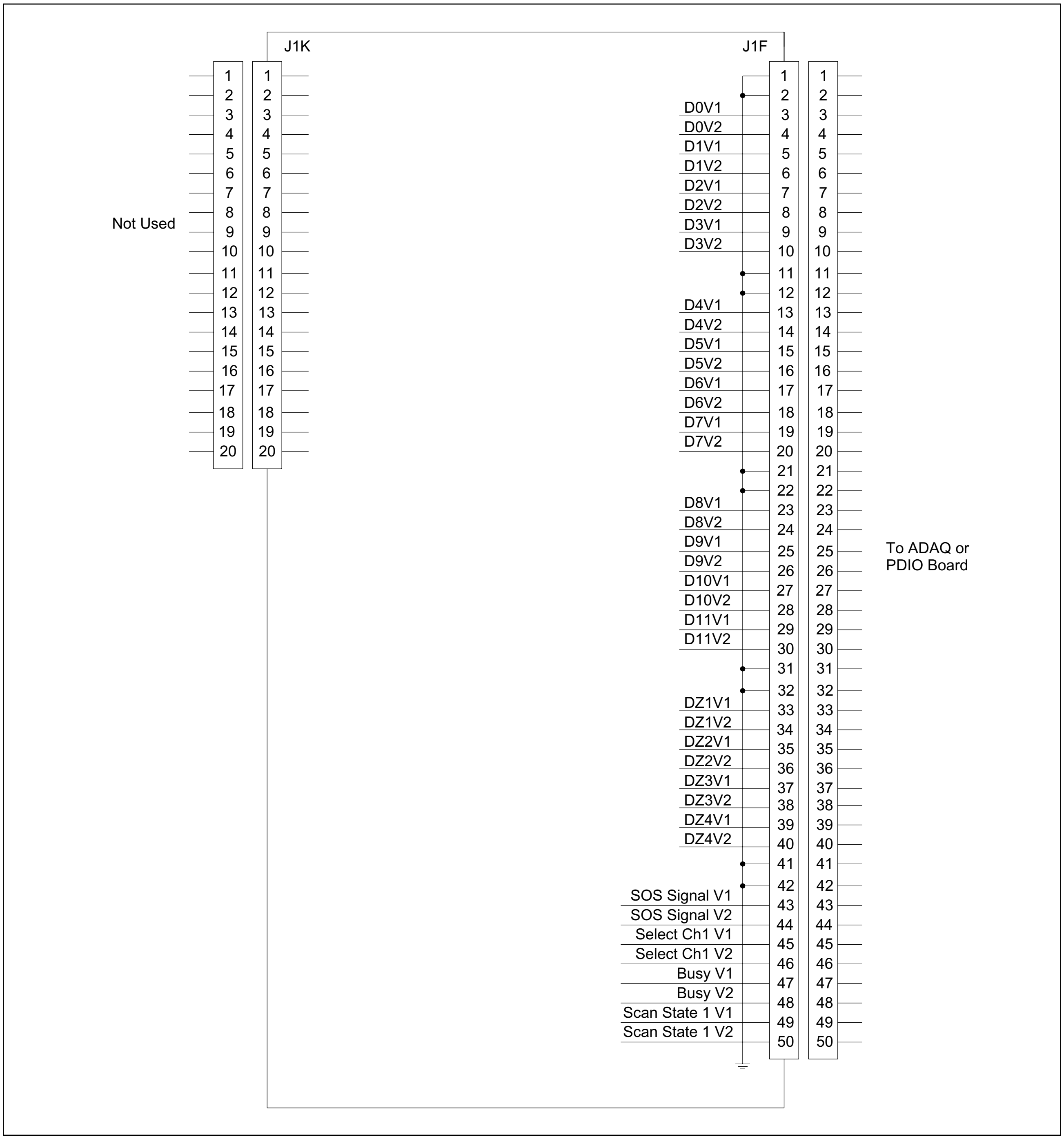



Figure 5-24. PC Interface Board Connector Detail Diagram.

- **Jack J1F**—Is a 50-pin ribbon connector. It connects to a 50-wire ribbon cable that routes digital data and control signals from the ADAQ or PDIO board.
- **Jack J1K**—Digital I/O used for testing and board diagnostics.

## 5.5 Neuron Network

The Neuron network consists of a control board that is located in the internal computer and the following network boards:

- EPHV board
- FLTR board
- SCAN board
- BEAM board
- INTC board
- TMPR board
- CMON board
- ADAQ board
- PDIO board
- Power supply distribution board (**Note:** This board is not an integral part of the Neuron network. It has connections to the Neuron network that are used only to supply 24-volt power to several of the network boards and for network termination.)

All the Neuron network boards, except the power supply distribution board, have an Echelon microcontroller, a peripheral I/O-memory chip that holds the Echelon instruction set, a flash memory chip for downloading application software to the board, and an eight-segment DIP address switch that programs the unique address of the board.

### 5.5.1 EPHV Board

The EPHV board (figure 5-25) controls the high voltage to the anode assembly by enabling and then setting the level of the voltage out of the HV power supply. The EPHV board monitors the HV power supply output voltage and current to maintain the set point voltage. The EPHV board supplies the +24 volts to the HV power supply that is used to generate a high voltage of up to 20 kilovolts.

#### 5.5.1.1 Block Diagram Analysis

The control messages for turning on the high voltage or changing the high-voltage output come over the Neuron network to jacks J2 and J3. The messages are handled by the Neuron transceiver and passed to the Echelon microcontroller. The Echelon microcontroller controls the operation of the board and communicates the high-voltage status to the rest of the system. The Echelon microcontroller sends the commands to voltage and current setpoint DACs.

The analog-to-digital multiplexer and HV control circuit provide the HV enable signal to the HV power supply and complete the path to energize the HV relay. All control and monitoring voltages to and from the HV power supply enter and leave at jack J5.

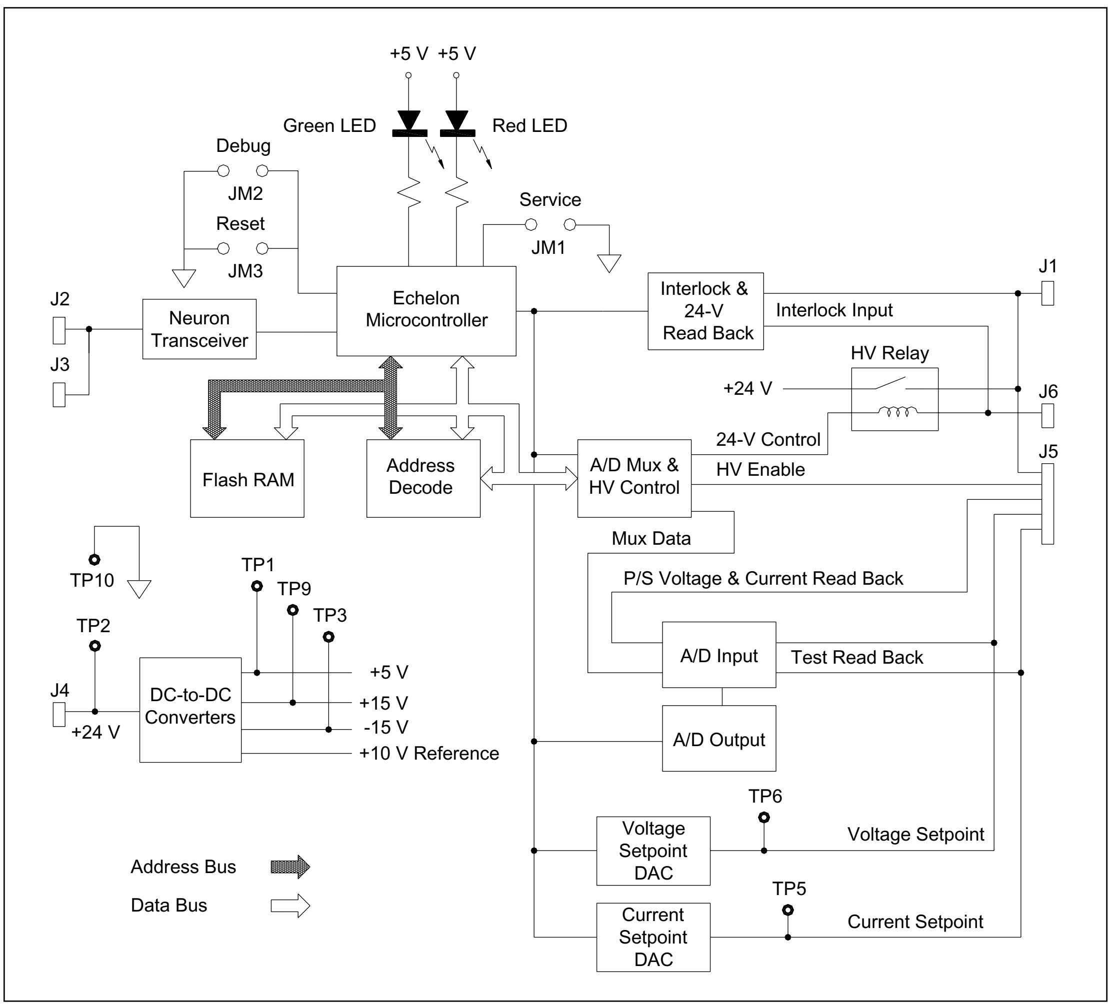



Figure 5-25. EPHV Board Block Diagram.

The HV relay disconnects the +24 volts to the HV power supply, stopping the high voltage to the anode assembly. The +12 volts and ground level that keep the safety relay closed come from the system interlock circuit (jack J6), which is connected in series with the HV relay. A safety indicator connection at jack J1 is connected to a phone jack at the rear of the instrument, near the internal computer connections. The safety indicator circuit provides a 24-volt output until the safety relay opens and disables the high voltage. This 24-volt indication only comes on when the HV power supply is on.

The interlock and 24-volt read-back circuit provides the Echelon microcontroller with the status of the interlock circuit and the 24-volt power to the HV power supply.

The voltage and current setpoint DACs send voltage and current setpoints to the HV power supply via jack J5. The HV power supply responds to the change in voltage and current and reads back the change to the ADC input along with the test readback of the voltage and current setpoint. The ADC output then sends a signal to the Echelon microcontroller acknowledging the setpoint change.

The +24 volts at jack J4 supply the power to the EPHV board. Two DC-to-DC converters provide the +5 and +/–15 volts. A 10-volt reference voltage is provided to jack J5 for use in a particular type of HV power supply from Spellman.

#### 5.5.1.2 Component Layout

The component layout of the EPHV board is shown in figure 5-26. The illustration has been simplified to show only the test point, jumper, switch, and connector locations. Test point, jumper, and switch details are provided below.

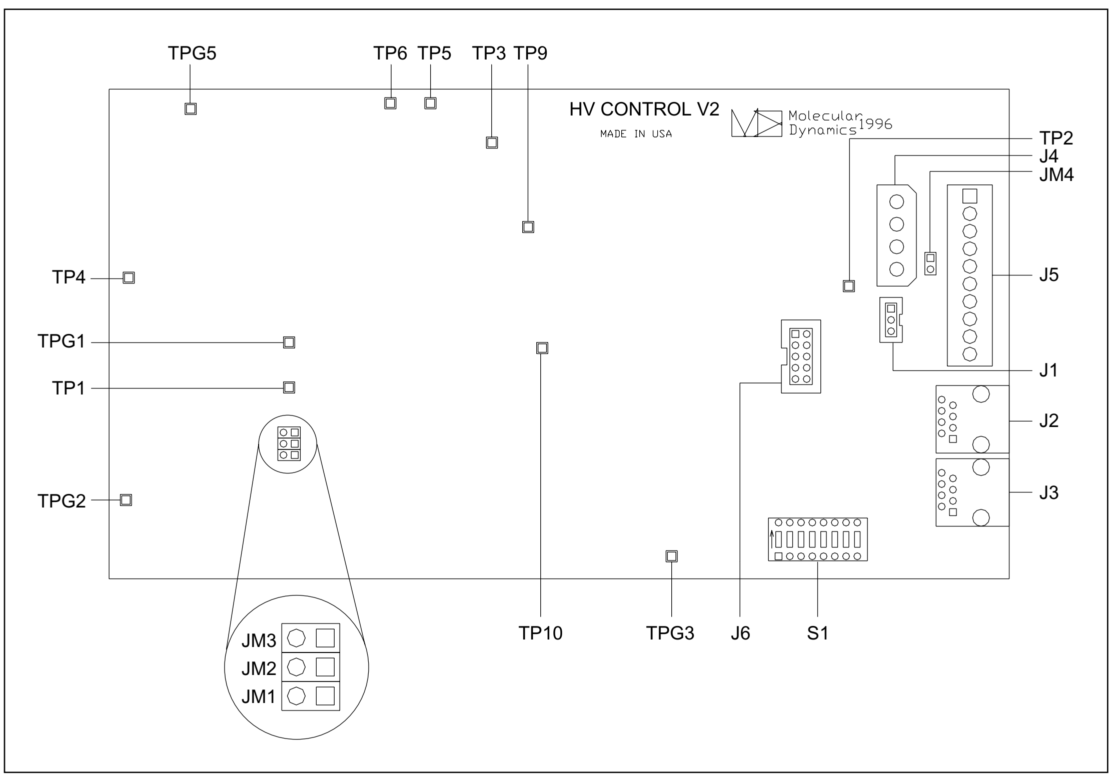



Figure 5-26. EPHV Board Component Layout Diagram.

- **Test Point TP1**—Output of the +5-volt DC-to-DC converter.
- **Test Point TP2**— +24-volt input power to the board.
- **Test Point TP3**—Negative output of the 15-volt DC-to-DC converter.
- **Test Point TP4**—Input to ADC.
- **Test Point TP5**—Current setpoint output. Should measure from 0–10 volts for a current limit setpoint of 0–3 ma (1 volt = 0.3 ma).
- **Test Point TP6**—Voltage setpoint output. Should measure from 0–10 volts for a HV power supply output of 0–20 kilovolts (1 volt setpoint = 2000 volts HV output).
- **Test Point TP9**— +15-volt output of 15-volt DC-to-DC converter.
- **Test Point TP10**—System ground.
- **Test Points TPG1, TPG2, and TPG3**—Ground test points.
- **Test Point TPG5—**Ground for the 15-volt DC-to-DC converter.
- **Jumper JM1—**Service jumper. This jumper is programming the Echelon microcontroller.
- **Jumper JM2—**Debug jumper. Each time this jumper is shorted, the Echelon lights the green LED.
- **Jumper JM3**—Manual reset jumper. When this jumper is shorted, the Echelon microcontroller is reset.
- **Jumper JM4**—Ties system ground to digital ground.
- **Switch S1**—Address DIP switch. Sets the network address for the EPHV board (positions 1, 3, 4, and 6).

### 5.5.1.3 Connector Details

The connector details of the EPHV board are shown in figure 5-27.

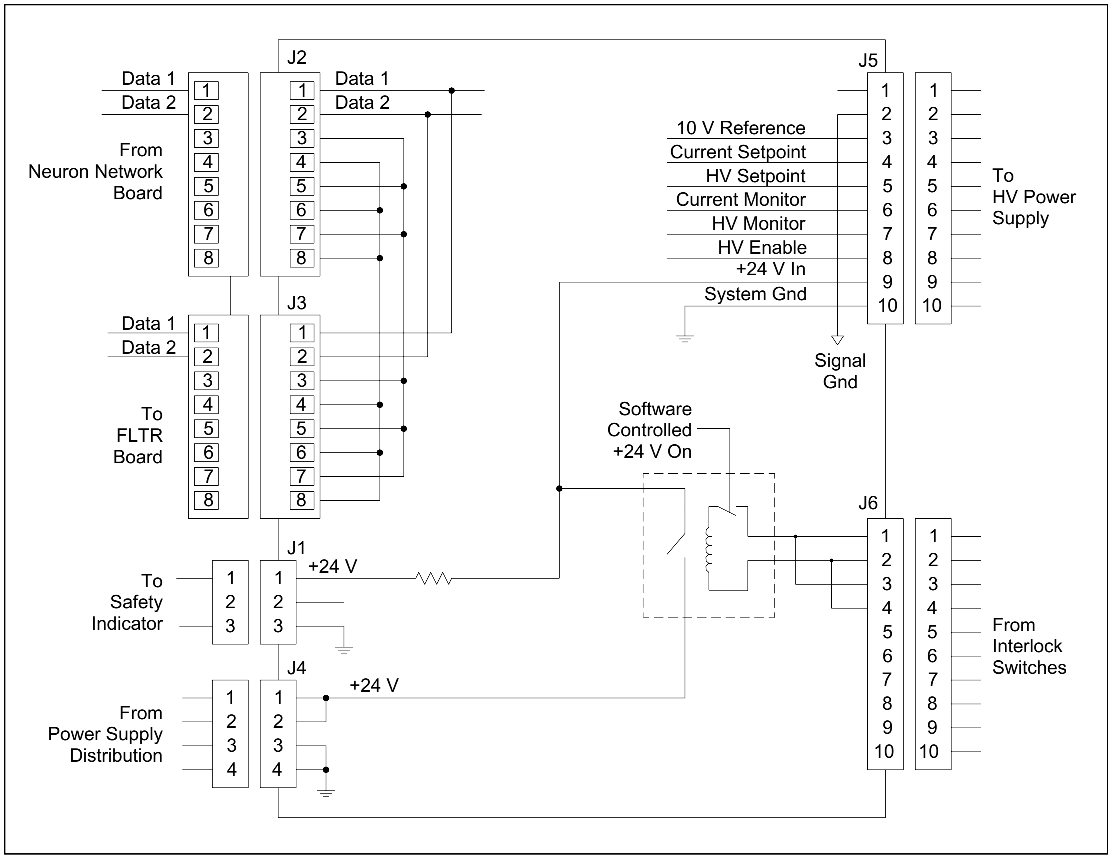



Figure 5-27. EPHV Board Connector Detail Diagram.

- **Jack J1**—Is a three-pin connector. It connects to a two-wire cable that routes +24 volts to a phone jack mounted to the input panel of the internal computer. This phone jack is used during manufacturing and testing to power an external safety indicator light that indicates the presence of high voltage in the instrument. There is a current limiting resistor in series with this output to protect against inadvertent shorting at this connector.
- **Jack J2**—Is an eight-pin RJ45 female connector. It connects to a two-wire RJ45 cable that routes communications signals from the Neuron network board in the internal computer.
- **Jack J3**—Is an eight-pin RJ45 female connector. It connects to a two-wire RJ45 cable that routes communications signals to the FLTR board.
- **Jack J4**—Is a four-pin connector. It connects to a two-wire cable that routes +24 volts and ground from the power supply distribution board.
- **Jack J5**—Is a 10-pin connector. It connects to a nine-wire cable that routes DC power and control signal to the HV power supply and voltage and current monitoring signals from the HV power supply.

- **Jack J6**—Is a 10-pin connector. It is part of a series circuit of interlock switches and relays that, when complete, enables the +24-volt power to the HV power supply. The relay is also under software control. The interlocks must be engaged, and the software must acknowledge before this relay will energize. The software approves only if it has found no errors, the setpoint is above 0 volts, and the user has requested the HV to come on.

### 5.5.2 FLTR Board

The FLTR board (figure 5-28) drives the two filter changers for the two PMTs. The two filter changer motors are driven to the home position on power up or reset. The only reference position for either motor is the home position. To move either motor from the home position to one of the other two positions, the motor is commanded to move a set number of steps. The precise number of steps for home, first position, and second position is held in the firmware, and the only adjustment is to move the home sensor, which changes all three positions an equal amount.

When the FLTR board receives a start-of-scan signal, both filter changer motors are driven to the home position and then to the first position. When the scanning head has completed its first pass, the scanning head starts a scan in the reverse direction. At this point, both filter changer motors are moved to the second position.

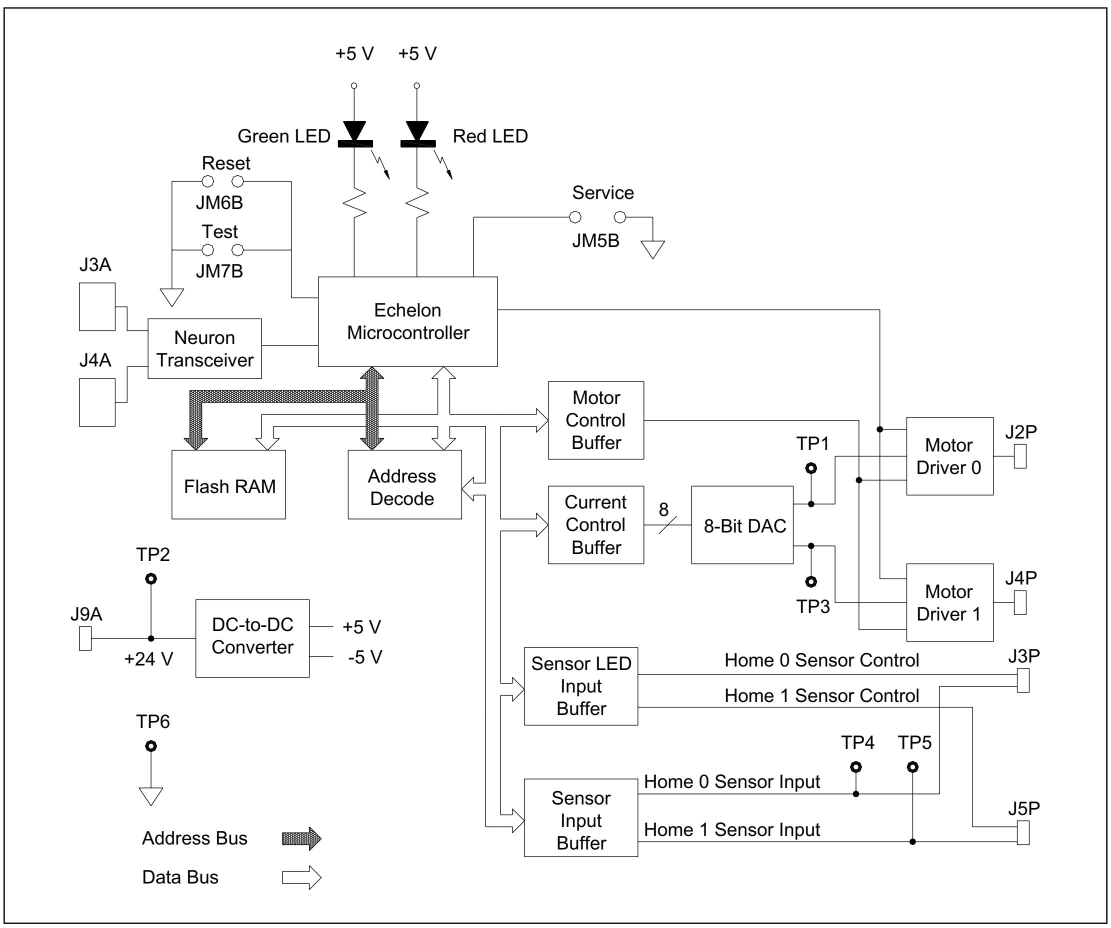



Figure 5-28. FLTR Board Block Diagram.

#### 5.5.2.1 Block Diagram Analysis

The control messages enter the FLTR board through the Neuron network connectors (J3 and J4) and are processed by the communications transceiver. The transceiver passes the messages to the Echelon microcontroller, which interprets the messages and sends the appropriate control signals to the eight-bit DAC to be translated into an analog output voltage. The analog output voltage from the DAC is amplified and sent as the motor-current control voltages to the two two-phase motor drivers.

Control signals for the home sensors are sent over the data bus to the sensor control buffer and then to the two home sensors. The sensor position data comes into the board and is made available to the data bus.

#### 5.5.2.2 Component Layout

The component layout of the FLTR board is shown in figure 5-29. The illustration has been simplified to show only the test point, jumper, switch, and connector locations that are relevant to the board functions. Test point, jumper, and switch details are provided below.

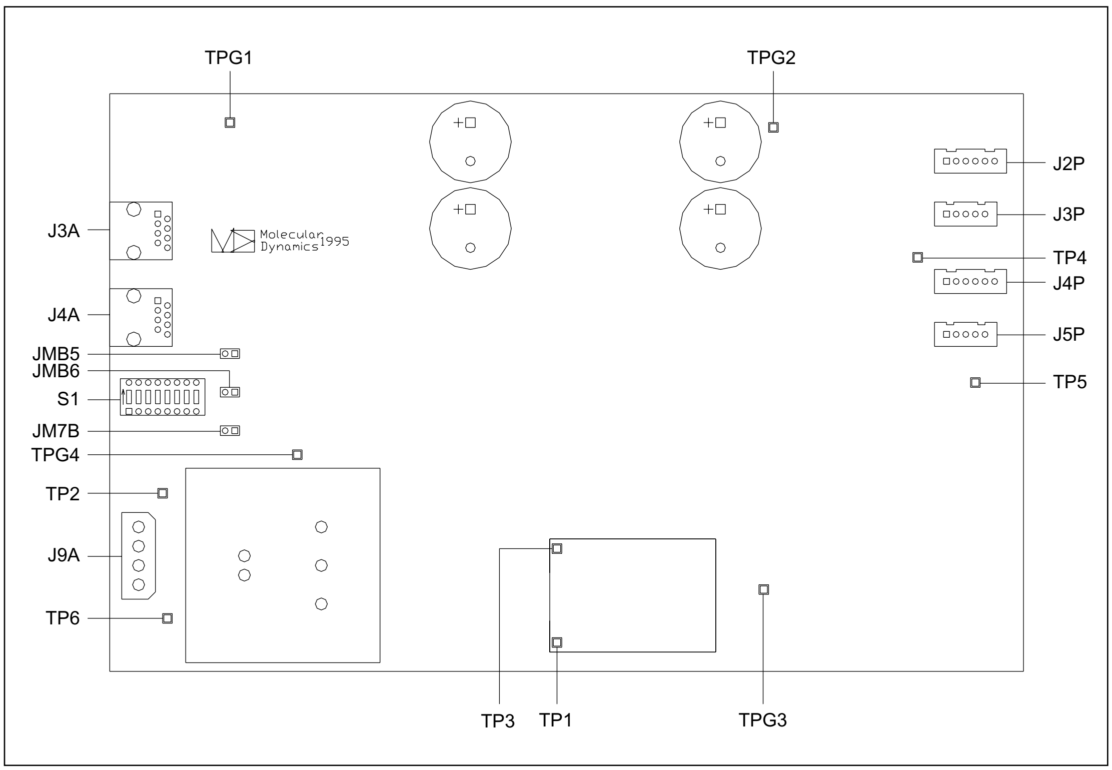



Figure 5-29. FLTR Board Component Layout Diagram.

- **Test Point TP1**—Motor-current control voltage for motor 0. The voltage should read approximately 0.625 volts at the home position and approximately 2.5 volts when the motor is turning.
- **Test Point TP2**—+24-volt input power to the board.
- **Test Point TP3**—Motor-current control voltage for motor 1. The voltage should read approximately 0.625 volts at the home position and approximately 2.5 volts when the motor is turning.
- **Test Point TP4**—Home sensor input data for motor 0.
- **Test Point TP5**—Home sensor input data for motor 1.
- **Test Point TP6**—System ground.
- **Jumper JM5B**—Service jumper. This jumper is programming the Echelon microcontroller.
- **Jumper JM6B**—Manual reset jumper. When this jumper is shorted, the Echelon microcontroller is reset.
- **Jumper JM7B**—A test jumper provides onboard testing of the motor operation while the scanning system is in idle mode. The test sequence relies on the home sensors, and the sensors must be operating correctly for the test to work. The test also requires segment 8 of the address DIP switch to be set to OFF. The test points are momentarily shorted to initiate the test. The test sequence is:
  - The first time the test points are shorted, the filter changer motors move to the home position and then back to the first position.
  - The second time the test points are shorted, the filter changer motors move back and forth between the first and second positions at the normal scanning rate (1.75 Hz).
  - The third time the test points are shorted, the motors stop, move to the home position, and then back to the first position.
- **Switch S1**—Address DIP switch. Sets the network address for the board (positions 1, 4, and 6 are on).

### 5.5.2.3 Connector Details

The connector details of the FLTR board are shown in figure 5-30.

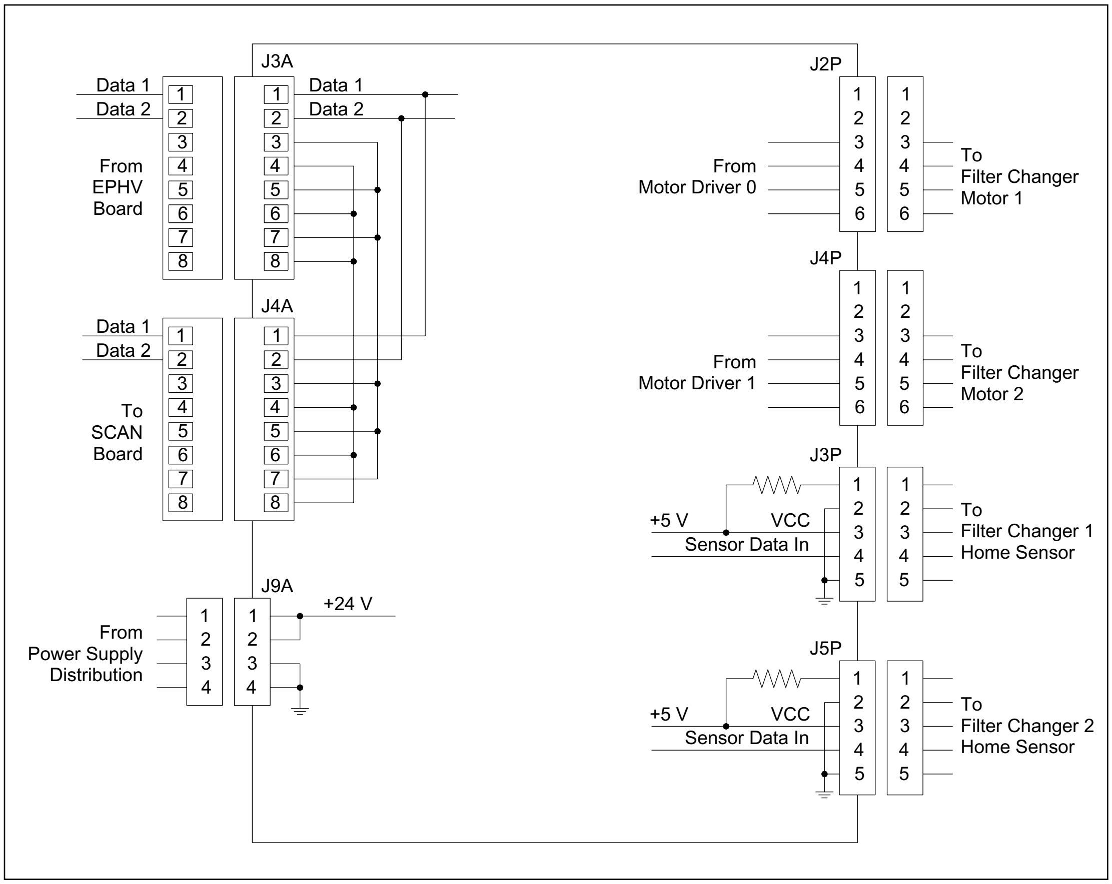



Figure 5-30. FLTR Board Connector Detail Diagram.

- **Jack J3A**—Is an eight-pin RJ45 female connector. It connects to a two-wire RJ45 cable that routes communications signals from the EPHV board.
- **Jack J4A—**Is an eight-pin RJ45 female connector. It connects to a two-wire RJ45 cable that routes communications signals to the SCAN board.
- **Jack J9A**—Is a four-pin connector. It connects to a two-wire cable that routes +24 volts and ground from the power supply distribution board.
- **Jack J2P—**Is a six-pin connector. It connects to a four-wire cable that routes power and control signals to filter changer motor number 1.
- **Jack J3P**—Is a five-pin connector. It connects to a five-wire cable that routes power and control signals to filter changer motor number 1 home sensor circuit.
- **Jack J4P**—Is a six-pin connector. It connects to a four-wire cable that routes power and control signals to filter changer motor number 2.
- **Jack J5P—**Is a five-pin connector. It connects to a five-wire cable that routes power and control signals to filter changer motor number 2 home sensor circuit.
- **Jacks J1, J7M, J7N, J8Q, J9M, and J9N**—Are not used.

### 5.5.3 SCAN Board

The SCAN board (figure 5-31) drives the secondary beamsplitter changer motor and the focus motor from two-phase motor drivers located on the board and provides control signals to an external five-phase motor driver for the scan motor.

The secondary beamsplitter changer motor is driven to the home position on power up or reset. The only reference position for this motor is the home position. To move this motor from the home position to either of the other two positions, the motor is commanded to move a set number of steps. The precise number of steps for home, first position, and second position is held in the firmware, and the only adjustment is to move the home sensor, which changes all three positions an equal amount.

When the SCAN board receives a start of scan message, the motor is driven to the home position and then to the first scan position. When the scanning head has completed its first pass, the scanning head starts a scan in the reverse direction. At this point, the filter changer motor is moved to the second position.

The scan motor controls the scan head and, when driven to the home position, moves the scanning head away from the capillaries, preventing any direct laser light from striking the capillaries.

When this board receives a start-of-scan message, the secondary beamsplitter changer is driven to the home position and then to the first scan position. The scan motor is driven to the start-of-line position. The scan motor does not start the scan until the board receives the proper commands. The proper commands to start the scan come from the BEAM board and the FLTR board, indicating the shutter, primary beamsplitter, and both filter changers are in the first scan position. The command messages can be received in any order, but both control boards have to report that all stages are ready. The scan motor starts and moves the scan head in the forward direction and then in the reverse direction at a 1.75-Hz rate. The length of the scan is limited to the combined width of the six capillary windows. After the scanning starts, it runs until it receives a signal to stop.

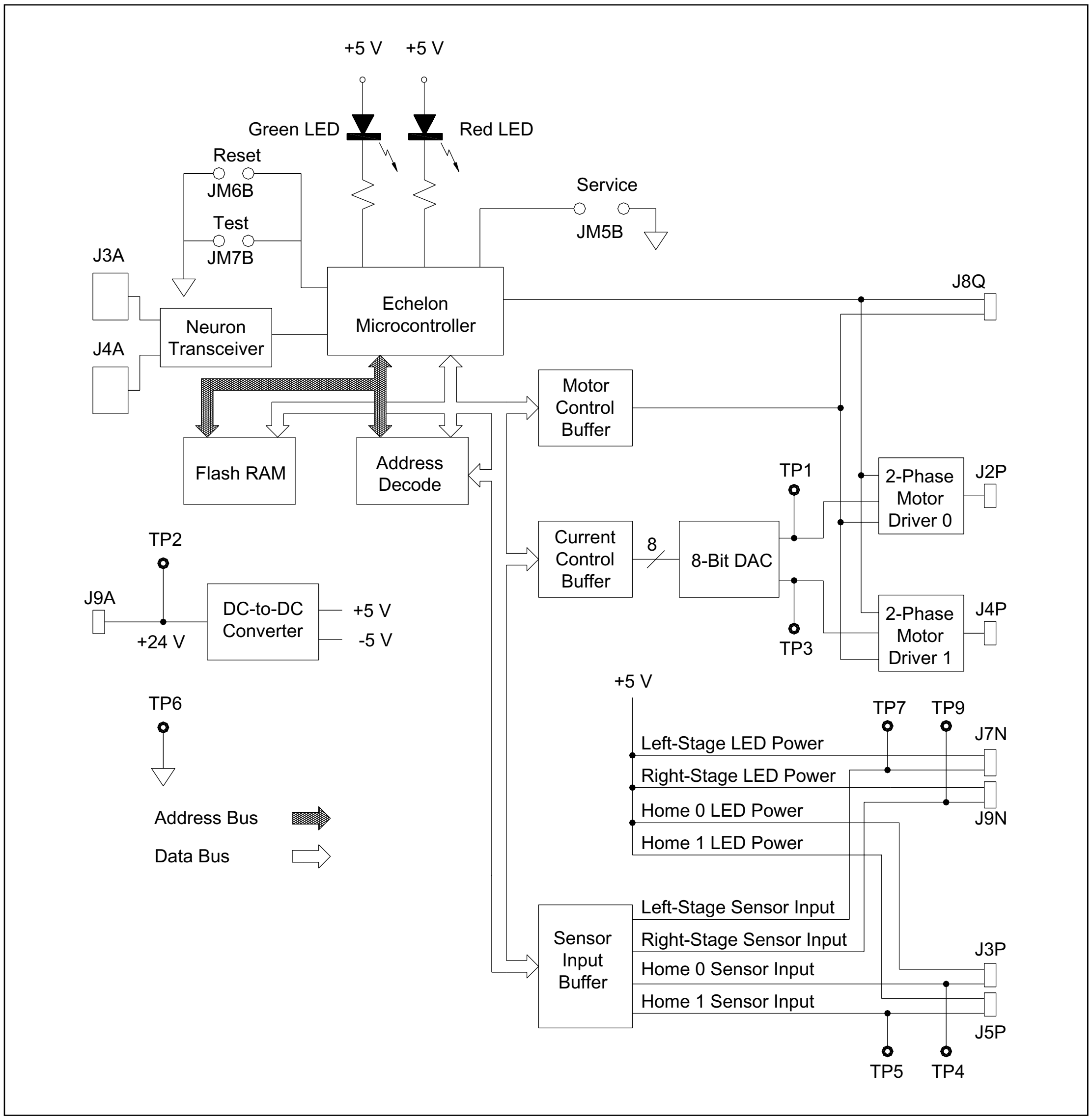



Figure 5-31.  SCAN Board Block Diagram.

When the scan motor has completed its first pass and is at its turning point to start a second pass in the reverse direction, the board sends out a message over the network indicating an end-of-line. At this turnaround point, the primary and the secondary beamsplitters and the filter changers move to the second scan position.

The focus motor operates independently of the scan motor. This motor is controlled by software commands and causes the capillary window platform to move closer to or farther from the objective lens. A sensor mounted to the focus motor assembly and a sensor flag mounted to the capillary window platform determine the home position of the capillary window platform.

#### 5.5.3.1 Block Diagram Analysis

The control messages enter the SCAN board through the Neuron network connectors (J3A and J4A) and are processed by the communications transceiver. The transceiver passes the messages to the Echelon microcontroller, which interprets the messages and sends the appropriate control signals to the eight-bit DAC to be translated into an analog output voltage. The analog output voltage from the DAC sets the amount of current sent to the motor by the motor drivers. The outputs from the two-phase motor drivers are sent to the motors via jacks J2P and J4P. The motor current control voltages, which control the output current from the two-phase motor drivers, can be measured at TP1 and TP3. These voltages should read approximately 0.625 volts at the home position and approximately 2.5 volts when the motor is turning.

Control signals for the home sensors are sent over the data bus to the sensor LED control buffer and then to the home sensor. The sensor position data comes into the board and is made available to the data bus by the sensor input buffer.

The signal for the five-phase scan motor come directly from the Echelon microcontroller through the J8Q connector to a five-phase motor driver module. The driver module converts the signals to an analog voltage and provides a current output to drive the scan motor.

### 5.5.3.2 Component Layout

The component layout of the SCAN board is shown in figure 5-32. The illustration has been simplified to show only the test point, jumper, switch, and connector locations. Test point, jumper, and switch details are provided below.

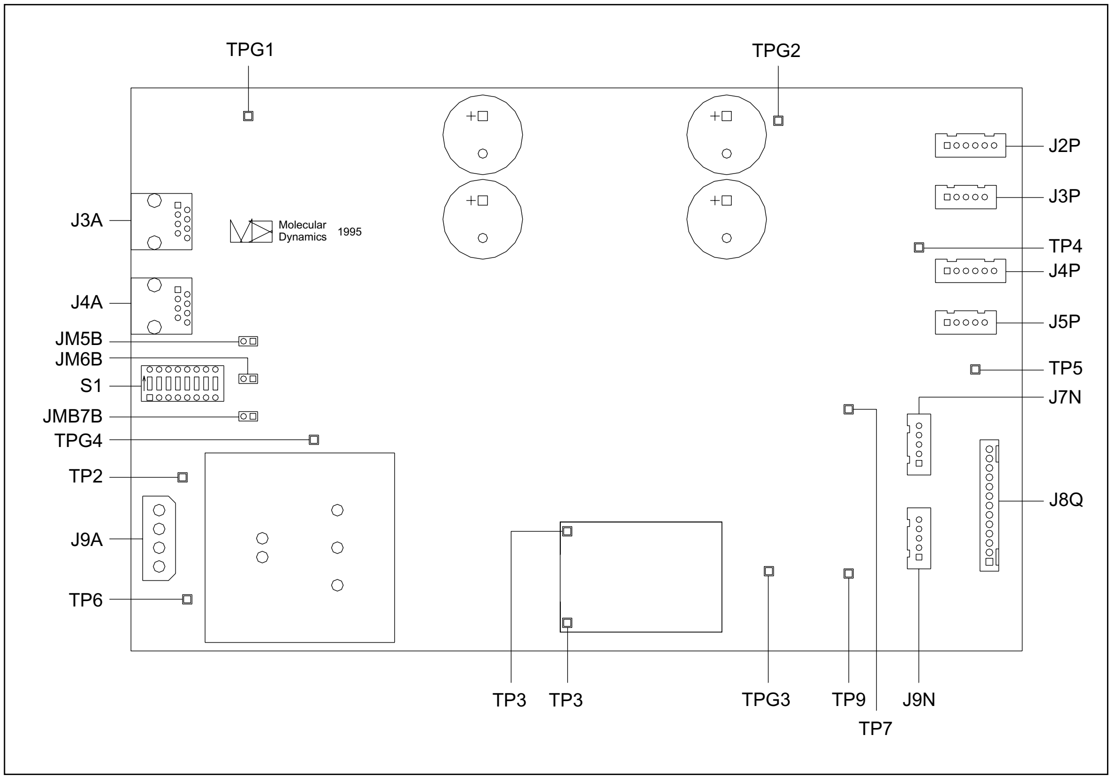



Figure 5-32. SCAN Board Component Layout Diagram.

- **Test Point TP1**—Motor-current control voltage for motor 0. The voltage should read approximately 0.625 volts at the home position and approximately 2.5 volts when the motor is turning.
- **Test Point TP2**— +24-volt input power to the board.
- **Test Point TP3**—Motor-current control voltage for motor 1. The voltage should read approximately 0.625 volts at the home position and approximately 2.5 volts when the motor is turning.
- **Test Point TP4**—Home sensor input data for focus motor.
- **Test Point TP5**—Home sensor input data for the secondary beamsplitter changer motor.
- **Test Point TP6**—System ground.
- **Test Point TP7**—Left-stage sensor input data.
- **Test Point TP9**—Right-stage sensor input data.
- **Test Points TPG1, TPG2, TPG3, and TPG4**—Ground test points.
- **Jumper JM5B**—Service jumper. This jumper is used when programming the Echelon microcontroller.
- **Jumper JM6B**—Manual reset jumper. When this jumper is shorted, the Echelon microcontroller is reset.
- **Jumper JM7B**—A test switch jumper provides onboard testing of the motor operation while the scanning system is in idle mode. To use, you momentarily short the two pins of the jumper. The test switch sequence is:
  - The first time the test points are shorted, the secondary beamsplitter changer motor moves to the home position and then back to the first position. The scan motor moves to its home position and then to its start-of-scan position.
  - The second time the switch is pressed, the secondary beamsplitter changer motor and the scan motor move back and forth at the normal scanning rate (1.75 Hz).
  - The third time the switch is closed, the motor stops, the secondary beamsplitter changer motor moves to the home position and then back to the first position, and the scan motor moves to the home position and then back to its start-of-scan position.
- **Switch S1**—Address DIP switch. Sets the network address for the board (positions 4 and 6 are on).

### 5.5.3.3 Connector Details

The connector details of the SCAN board are shown in figure 5-33.

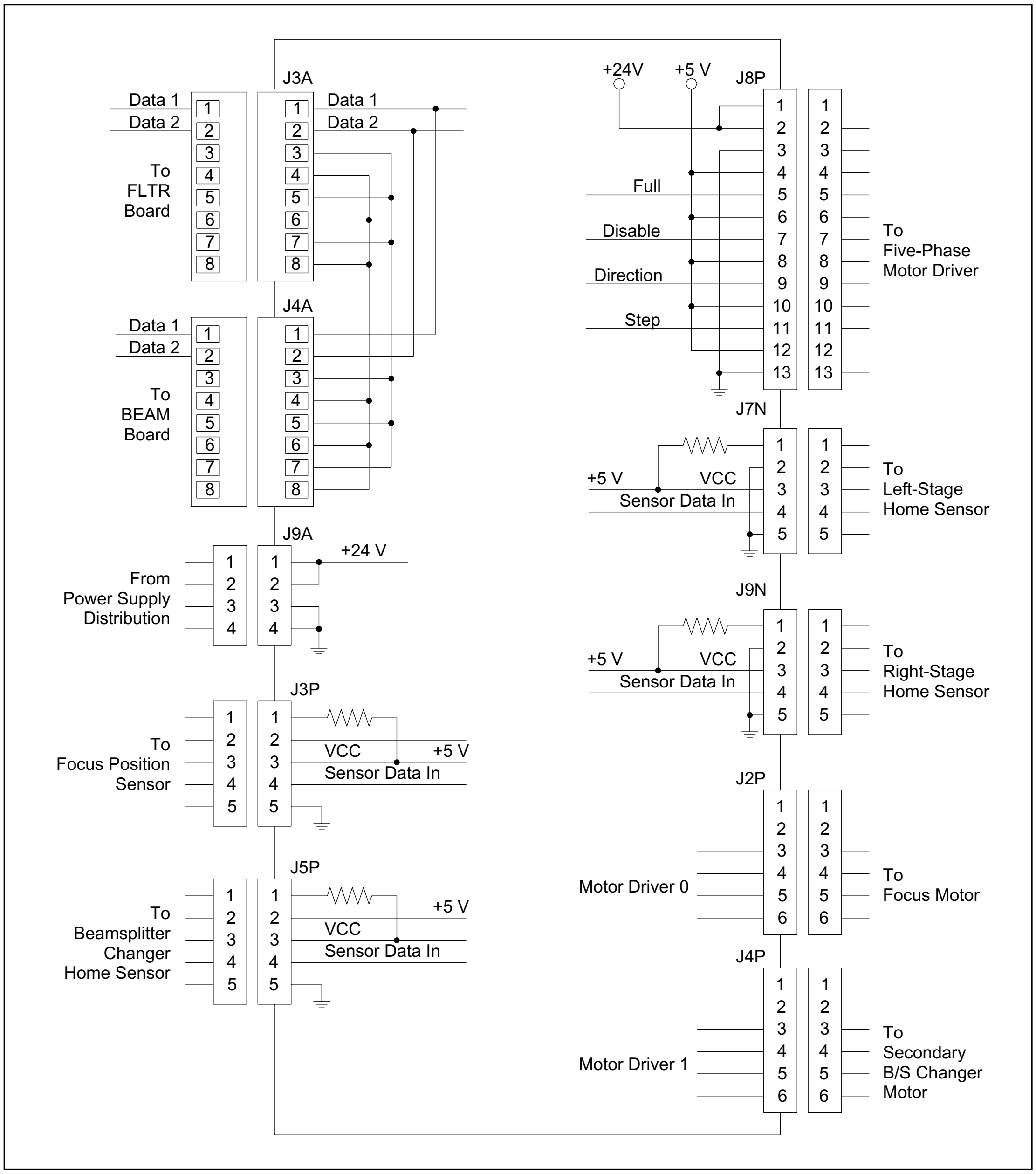



Figure 5-33. SCAN Board Connector Detail Diagram.

- **Jack J3A**—Is an eight-pin RJ45 female connector. It connects to a two-wire RJ45 cable that routes communications signals from the FLTR board.
- **Jack J4A**—Is an eight-pin RJ45 female connector. It connects to a two-wire RJ45 cable that routes communications signals to the BEAM board.
- **Jack J2P**—Is a six-pin connector. It connects to a four-wire cable that routes power and control signals to the focus motor.
- **Jack J3P**—is a five-pin connector. It connects to a five-wire cable that routes power and control signals to the focus motor position sensor circuit.
- **Jack J9A**—Is a four-pin connector. It connects to a two-wire cable that routes +24 volts and ground from the power supply distribution board.
- **Jack J4P**—Is a six-pin connector. It connects to a four-wire cable that routes power and control signals to the secondary beamsplitter changer motor.
- **Jack J5P**—Is a five-pin connector. It connects to a five-wire cable that routes power and control signals to the secondary beamsplitter changer motor position sensor circuit.
- **Jack J8P—**Is a 13-pin connector. It connects to a 13-wire cable that routes control signals to the five-phase driver for the scan motor.
- **Jack J7N**—Is a five-pin connector. It connects to a five-wire cable that routes power and control signals to the left-stage home sensor circuit.
- **Jack J9N**—Is a five-pin connector. It connects to a five-wire cable that routes power and control signals to the right-stage home sensor circuit.

### 5.5.4 BEAM Board

The BEAM board (figure 5-34) drives the primary beamsplitter changer and shutter motors from two 2-phase motor drivers. The two motors are driven to the home position on power up or reset. The only reference position for either motor is the home position. To move either motor from the home position to one of the other two positions, the motor is commanded to move a set number of steps. The precise number of steps for home, first position, and second position is held in firmware, and the only adjustment is to move the home sensor, which changes all three positions an equal amount.

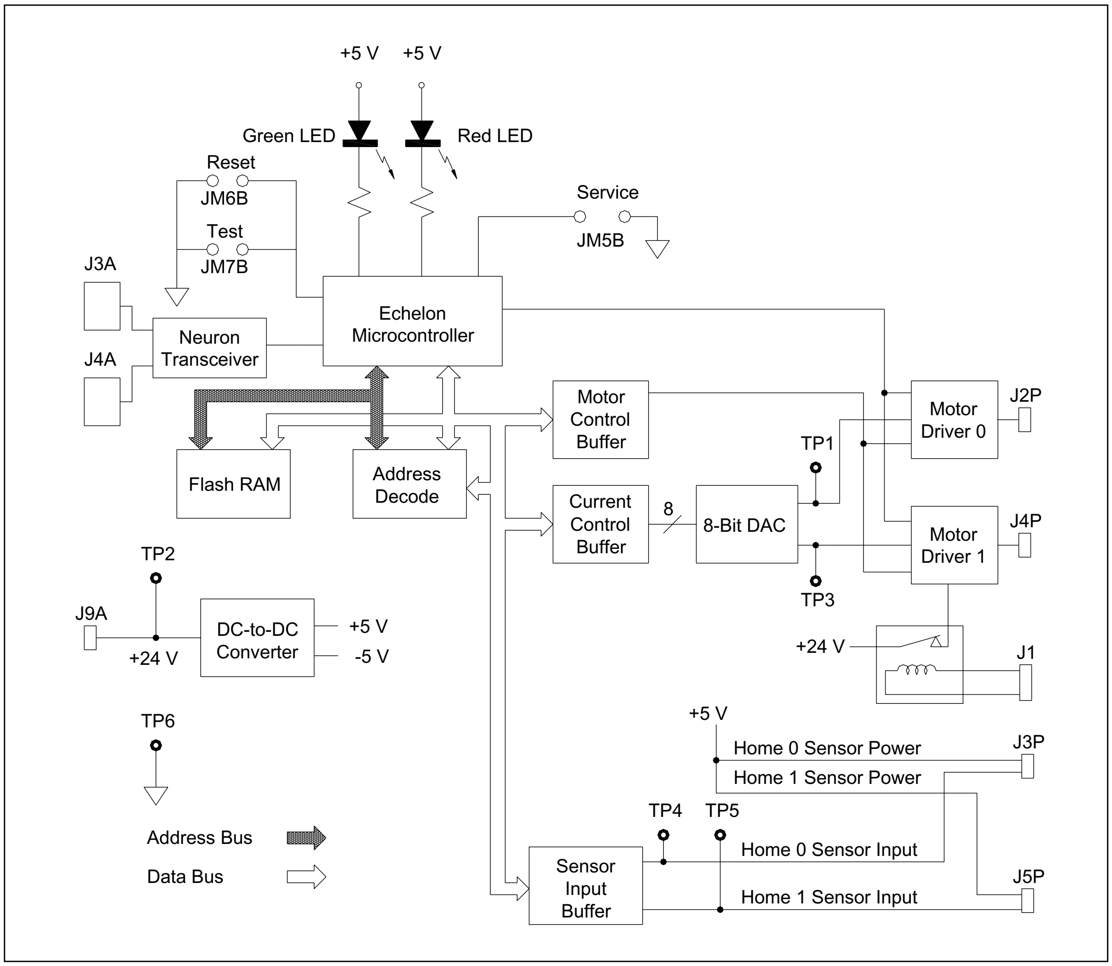



Figure 5-34. BEAM Board Block Diagram.

When the BEAM board receives a start-of-scan signal, both motors are driven to the home position and then to the first position. When the scanning head has completed its first pass, the scanning head starts a scan in the reverse direction.

#### 5.5.4.1 Block Diagram Analysis

The control messages enter the board through the Neuron network connectors (J3A and J4A) and are processed by the communications transceiver. The transceiver passes the messages to the Echelon microcontroller, which interprets the messages and sends the appropriate control signals to the 8-bit DAC to be translated into an analog output voltage. The analog output voltage from the DAC controls the output current of the two-phase motor drivers.

The 24-volt power for the shutter motor driver is routed through the contacts of a relay. This relay is kept energized through a series circuit of two interlock switches located on either side of the service door. If either of these interlocks opens, the relay de-energizes and removes power to the shutter motor. A spring on the shutter arm then pulls the shutter arm to the home position to block the laser beams.

Control signals for the home sensors are sent over the data bus to the sensor control buffer and then to the two home sensors via jacks J3P and J5P. The sensor position data comes into the board on these two jacks and is made available to the data bus by the sensor input buffer.

### 5.5.4.2 Component Layout

The component layout of the BEAM board is shown in figure 5-35. The illustration has been simplified to show only the test point, jumper, switch, and connector locations that are relevant to the board functions. Test point, jumper, and switch details are provided below.

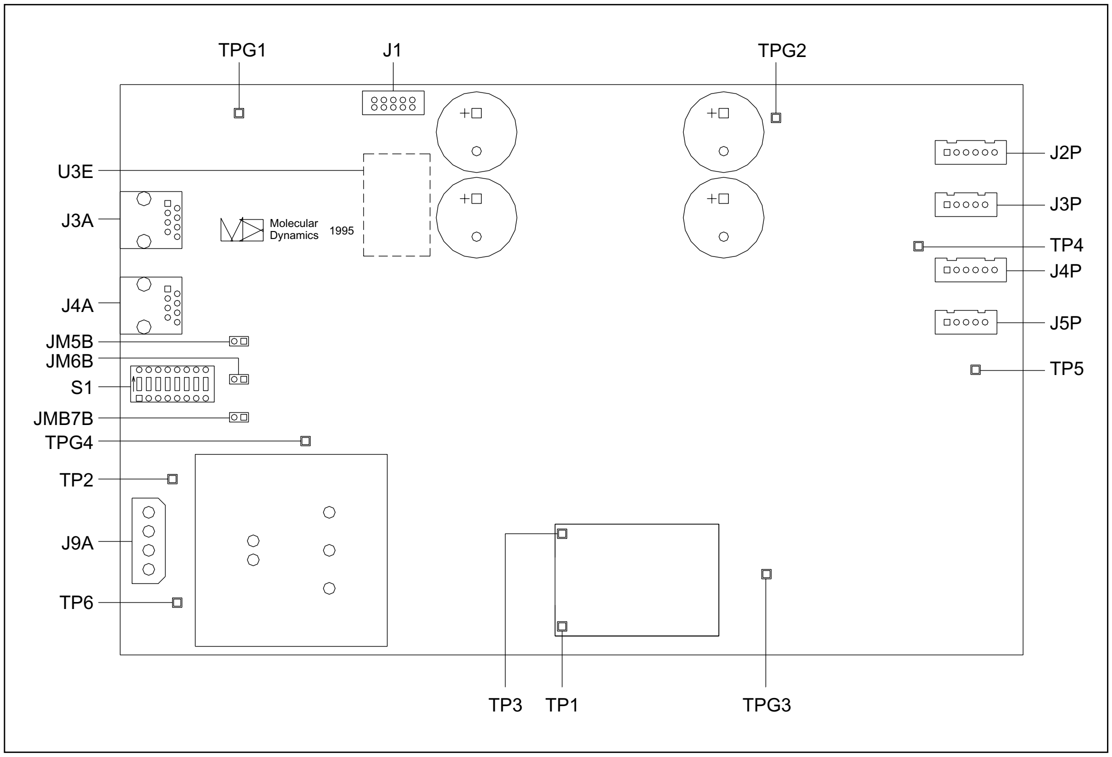



Figure 5-35. BEAM Board Component Layout Diagram.

- **Test Point TP1**—Motor-current control voltage for motor 0. The voltage should read approximately 0.625 volts at the home position and approximately 2.5 volts when the motor is turning.
- **Test Point TP2**— +24-volt input power to the board.
- **Test Point TP3**—Motor-current control voltage for motor 1. The voltage should read approximately 0.625 volts at the home position and approximately 2.5 volts when the motor is turning.
- **Test Point TP4**—Home sensor input data for motor 0.
- **Test Point TP5**—Home sensor input data for motor 1.
- **Test Point TP6**—System ground.
- **Test Points TPG1, TPG2, TPG3, and TPG4—**Ground test points.
- **Jumper JM5B**—Service jumper. This jumper is programming the Echelon microcontroller.
- **Jumper JM6B**—Manual reset jumper. When this jumper is shorted, the Echelon microcontroller is reset.
- **Jumper JM7B**—This jumper provides onboard testing of the operation of the primary beamsplitter changer motor. The shutter motor cannot be tested with the test jumpers unless the interlock switches on either side of the service door have been defeated.
- **Switch S1**—Address DIP switch. Sets the network address for the board.

### 5.5.4.3 Connector Details

The connector details of the BEAM board are shown in figure 5-36.

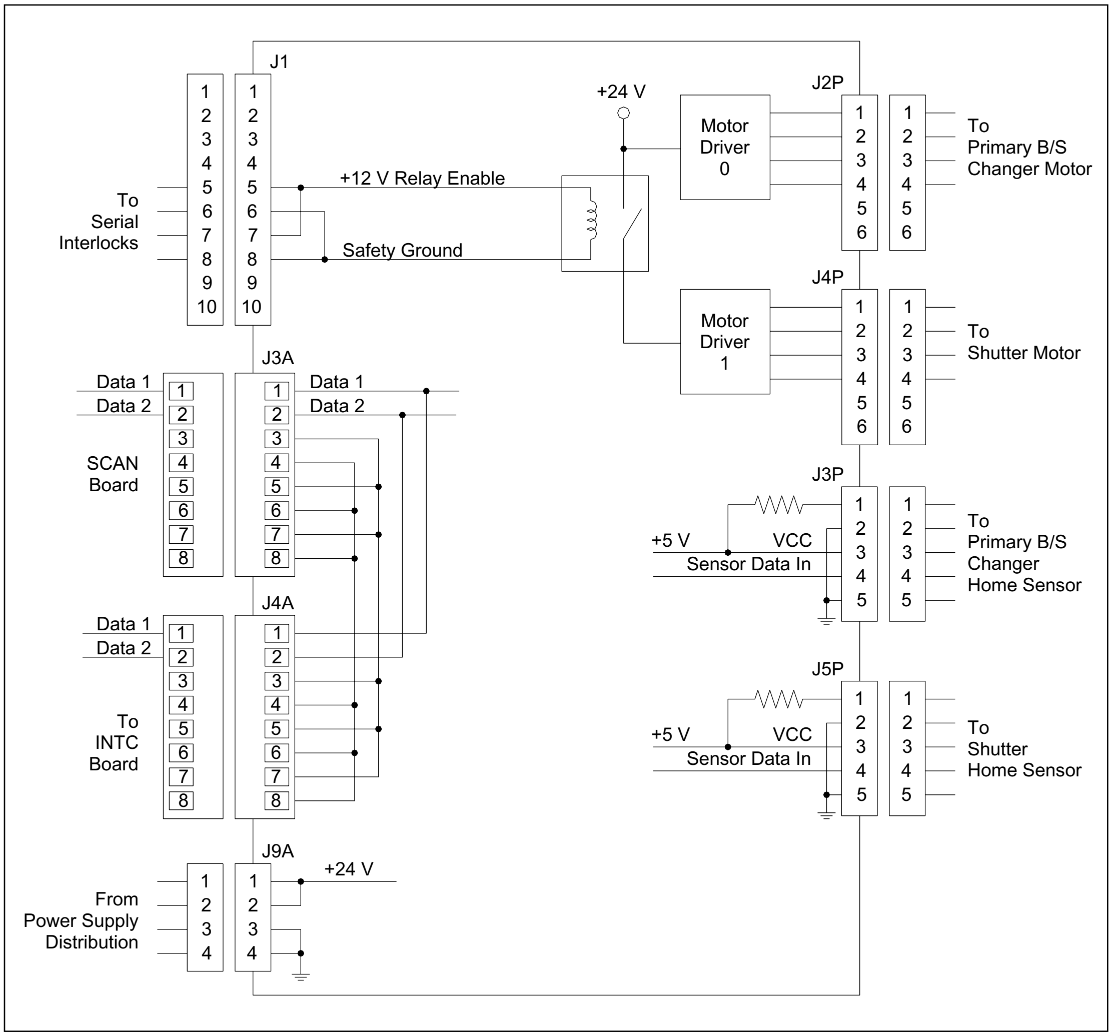



Figure 5-36. BEAM Board Connector Detail Diagram.

- **Jack J1**—Is a 10-pin connector. It connects to a four-wire cable that routes +12 volts and ground from the serial interlocks.
- **Jack J3A**—Is an eight-pin RJ45 female connector. It connects to a two-wire RJ45 cable that routes communications signals from the SCAN board.
- **Jack J4A**—Is an eight-pin RJ45 female connector. It connects to a four-wire RJ45 cable that routes communications signals to the INTC board.
- **Jack J9A**—Is a four-pin connector. It connects to a four-wire cable that routes +24 volts and ground from the power supply distribution board.
- **Jack J2P**—Is a six-pin connector. It connects to a four-wire cable that routes power and control signals to the primary beamsplitter changer motor.
- **Jack J3P**—Is a five-pin connector. It connects to a five-wire cable that routes power and control signals to the primary beamsplitter changer motor home sensor circuit.
- **Jack J4P**—Is a six-pin connector. It connects to a four-wire cable that routes power and control signals to the shutter motor.
- **Jack J5P**—Is a five-pin connector. It connects to a five-wire cable that routes power and control signals to the shutter motor home sensor circuit.

### 5.5.5 INTC Board

The INTC board (figure 5-37) monitors most of the instrument sensors, reports the status of the sensors to the rest of the system, and provides control drive to various assemblies. The INTC board receives commands over the network and controls the pneumatic pressure system solenoid valves that raise or lower the cathode and anode stages and pressurize the anode assembly. The INTC board also turns both lasers on or off, drives the LED board and the two LCD boards, and drives the motor for the clamp lock on the anode assembly.

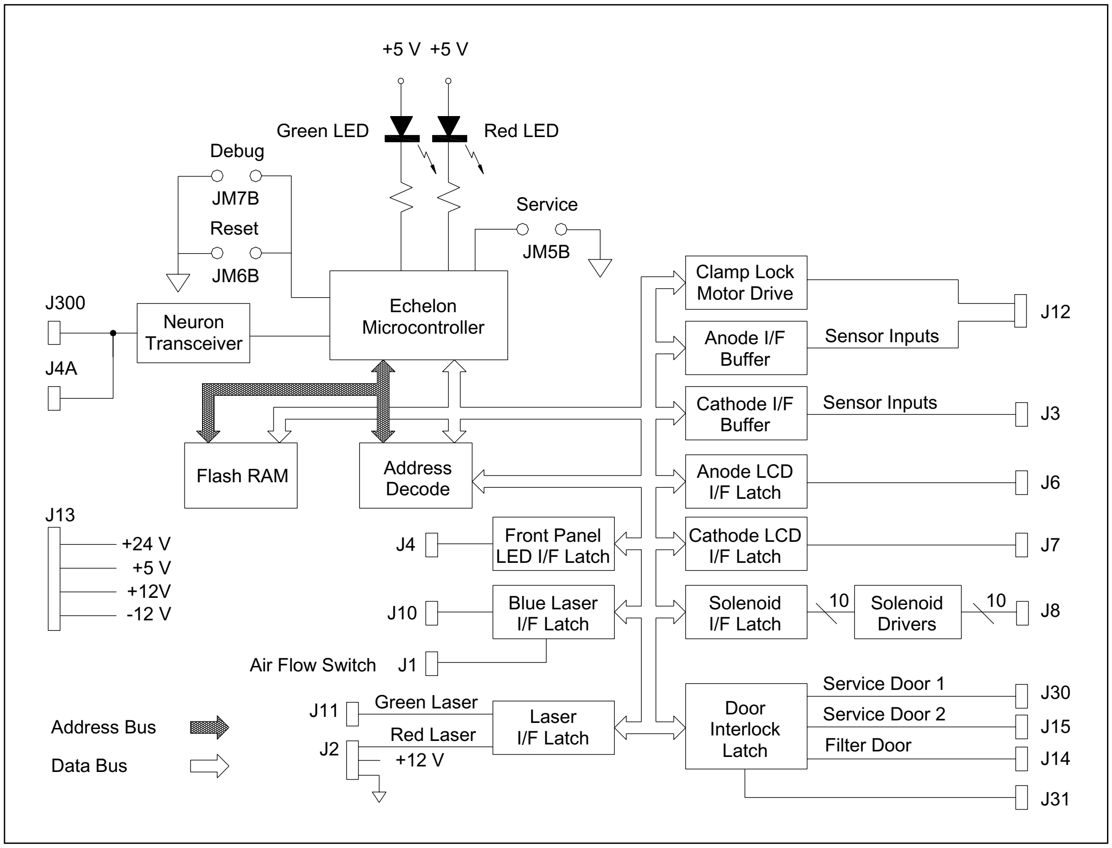



Figure 5-37. INTC Board Block Diagram.

The +12 volts supplied to the system interlock switches come from the INTC board and power the safety relays on the EPHV board and the primary beamsplitter changer and shutter motor control board.

The control circuits for both lasers are on the INTC board. The blue laser's power supply and blower are located in the fan module but controlled from the INTC board.

The INTC board draws its power (+5, +/–12, and +24 volts) from the power supply box connectors on the power distribution board. The INTC board is mounted to the power supply box on a removable plate and secured by four thumbscrews.

#### 5.5.5.1 Block Diagram Analysis

The control messages enter the board through the Neuron network connectors (J300 and J4A) and are processed by the communications transceiver. The transceiver passes the messages to the Echelon microcontroller, which interprets the messages and sends the appropriate control signals over the data bus to the interface buffers and latches.

The sensing signals for the anode and cathode stages come into the INTC board through jacks J12 for the anode stage and J3 for the cathode stage. Power to the anode stage clamping motor is provided by a motor driver and sent to the anode stage via jack J12.

Sensor data for the safety interlock circuit come into the board on jacks J15 and J30 for the two sides of the main service door and J14 for the filter door.

The incoming signals are digitized and sent to the Echelon microcontroller. From the software instructions in the INTC board and command signals from the Neuron network, the Echelon microcontroller provides the control signals through the solenoid interface latch to the solenoid drivers. These drive signals are routed through jack J8 to the pressure control board. The drive signals control the solenoids that raise and lower the anode and cathode stages and pressurize the anode stage.

The blue laser air flow switch provides a signal to the INTC board through J1. The blue laser I/O signals and control signals are routed through J10. The green laser enable signal is routed through J11 and the red laser enable signal (when implemented) will be routed through jack J2.

The output to the LCDs are routed through J6 and J7 and the LED display board signals are routed through J4.

### 5.5.5.2 Component Layout

The component layout of the INTC board is shown in figure 5-38. The illustration has been simplified to show only the test point, jumper, switch, and connector locations that are relevant to the board functions. Test point, jumper, and switch details are provided below.

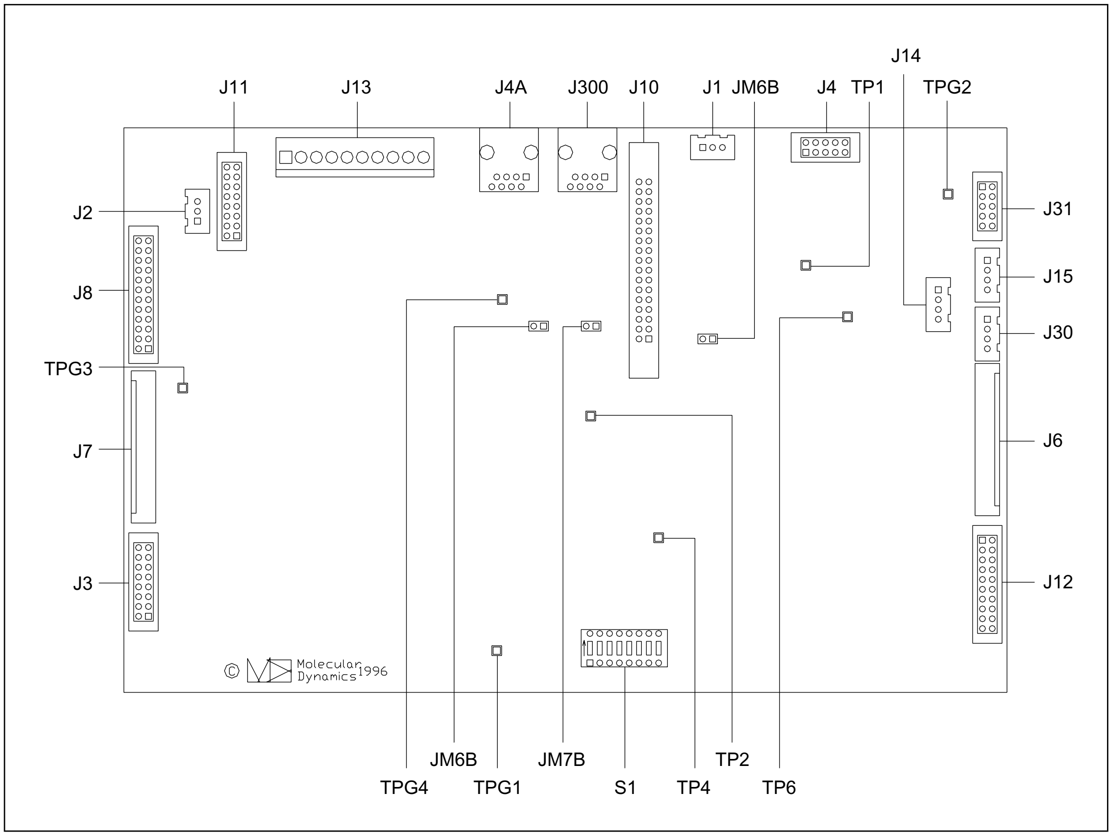



Figure 5-38. INTC Board Component Layout Diagram.

- **Test Point TP1**—Laser Power Monitor.
- **Test Point TP2**—Laser Power Out.
- **Test Point TP4**—Reset.
- **Test Point TP6 —**Current control for the clamp motor.
- **Test Points TPG1, TPG2, TPG3, and TPG4**—Ground test points.
- **Jumper JM5B**—Service jumper. This jumper is programming the Echelon microcontroller.
- **Jumper JM6B**—Manual reset jumper. When this jumper is shorted, the Echelon microcontroller is reset.
- **Jumper JM7B**—Not used.
- **Switch S1**—Address DIP switch. Sets the network address for the board.

### 5.5.5.3 Connector Details

The connector details for jacks J1, J2, J3, J4, J6, J7, J300, J4A, J31, J30, J14, and J15 of the INTC board are shown in figure 5-39.

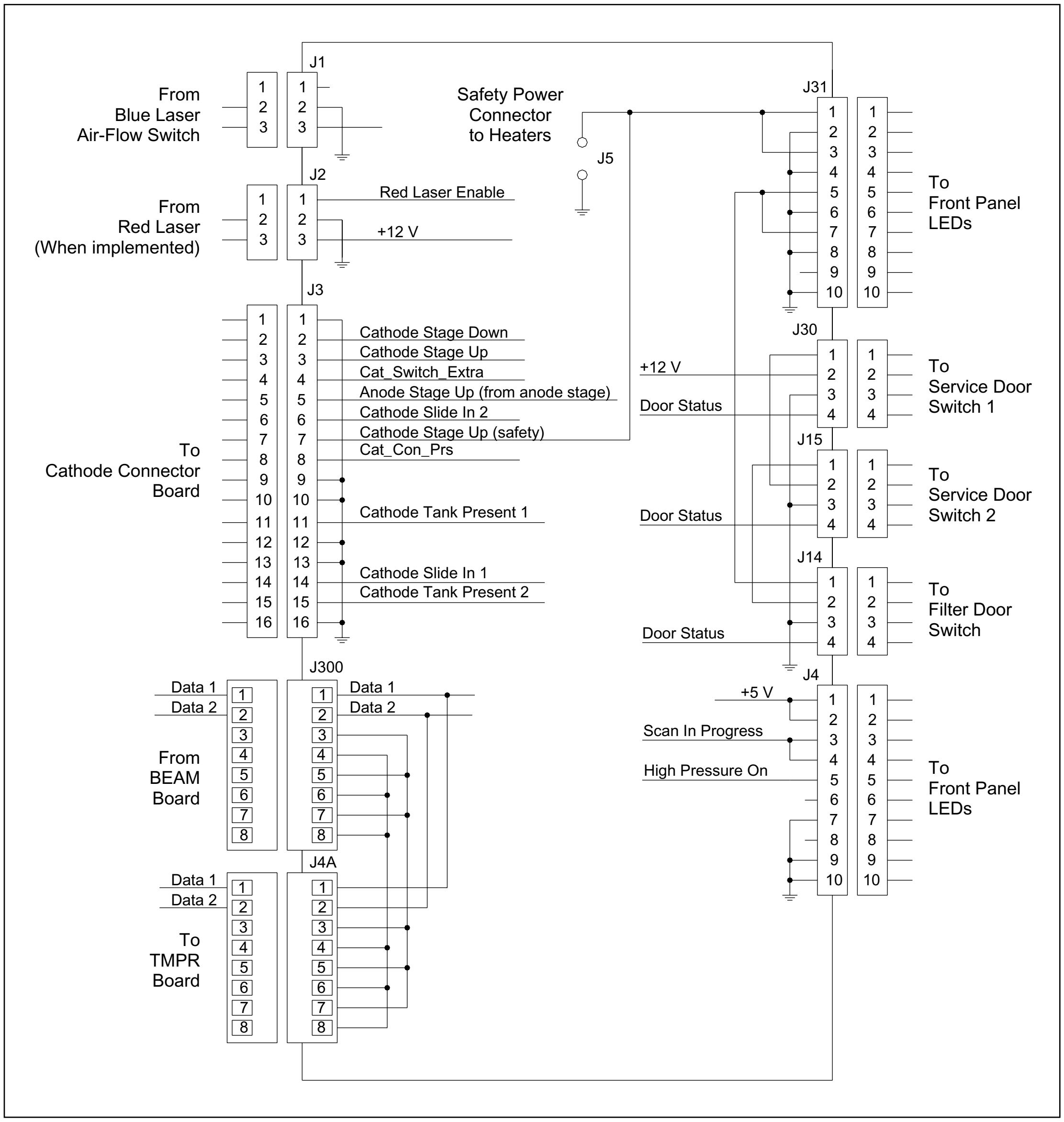



Figure 5-39. INTC Board Connector Detail Diagram (Sheet 1 of 3).

- **Jack J1**—Is a 3-pin connector. It connects to a two-wire cable that routes +12 volts and ground from the blue laser air-flow switch.
- **Jack J2**—Is a three-pin connector. It connects to a two-wire cable that routes +12 volts, ground, and an enable signal to the red laser (when implemented).
- **Jack J3**—Is a 16-pin connector. It connects to a 16-wire cable that routes sensor signals from the cathode stage. These sensor signals are:
  - Cathode stage down.
  - Cathode stage up.
  - Cathode stage up (safety).
  - Anode stage up (from anode stage).
  - Cathode slide in 1.
  - Cathode slide in 2.
  - Cathode tank present 1.
  - Cathode tank present 2.
  - Cathode connector board present.
- **Jack J4**—Is a 10-pin connector. It connects to a 10-wire cable that routes data to the front-panel LED indicators.
- **Jack J300**—Is an eight-pin RJ45 female connector. It connects to a two-wire RJ45 cable that routes communications signals from the BEAM board.
- **Jack J4A**—Is an eight-pin RJ45 female connector. It connects to a two-wire RJ45 cable that routes communications signals to the TMPR board.
- **Jack J31**—Is a 10-pin connector. It routes the interlock power to the shutter and high voltage boards.
- **Jack J30**—Is a four-pin connector. It connects via a four-wire cable to the service-door switch 1.
- **Jack J15**—Is a four-pin connector. It connects via a four-wire cable to the service-door switch 2.
- **Jack J14**—Is a four-pin connector. It connects via a four-wire cable to the filter-door switch.

The connector details for jacks J6, J7, and J8 of the INTC board are shown in figure 5-40.

- **Jack J6**—Is a 14-pin connector. It connects to a 14-wire cable that routes data to the anode LCD.
- **Jack J7**—Is a 14-pin connector. It connects to a 10-wire cable that routes data to the cathode LCD.
- **Jack J8**—Is a 24-pin connector. It connects to a 24-wire cable to the pressure control board.

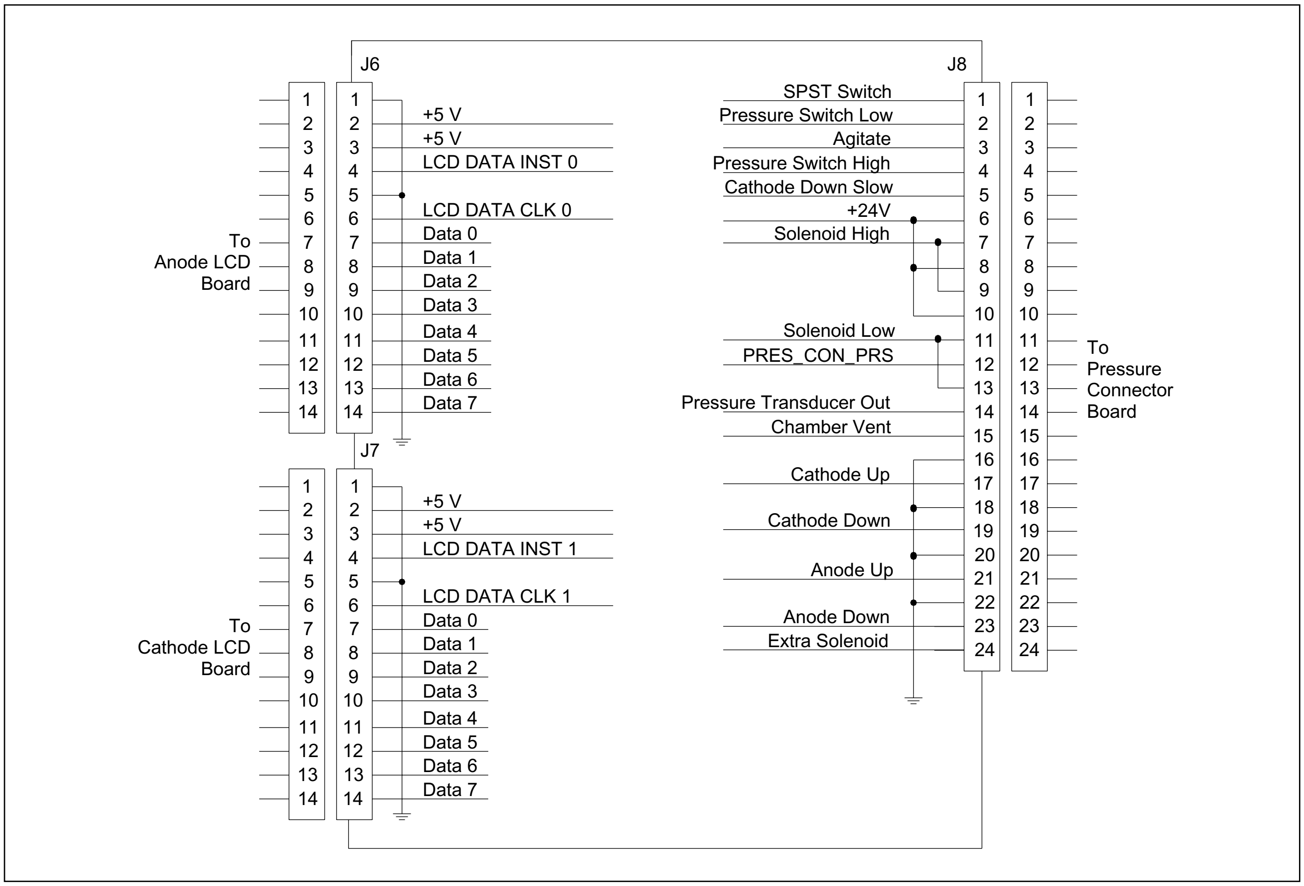



Figure 5-40. INTC Board Connector Detail Diagram (Sheet 2 of 3).

The connector details for jacks J10, J11, J12, and J13 of the INTC board are shown in figure 5-41.

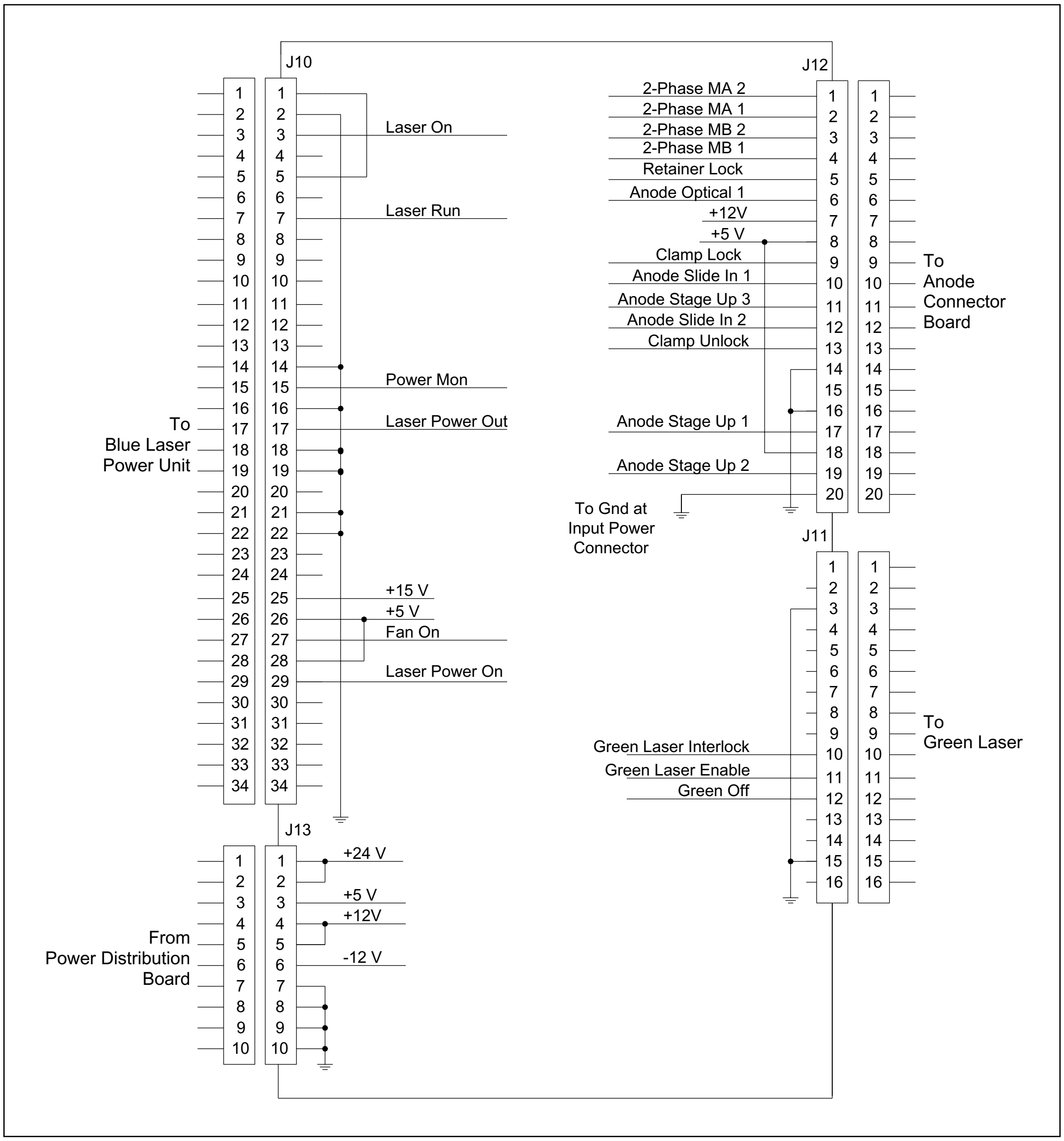



Figure 5-41. INTC Board Connector Detail Diagram (Sheet 3 of 3).

- **Jack J10**—Is a 34-pin connector. It connects to the blue power supply fan module via a 34-wire ribbon cable.
- **Jack J11**—Is a 16-pin connector. It connects to a three-wire cable that routes control signals to the green laser.
- **Jack J12**—Is a 20-pin connector. It connects to a 20-wire cable that routes sensor signals from the anode stage and drive voltages to the anode locking mechanism. The sensor signals are:
  - Retainer lock.
  - Anode optical 1.
  - Clamp lock.
  - Clamp unlock.
  - Anode slide in 1.
  - Anode slide in 2.
  - Anode stage up 1.
  - Anode stage up 2.
  - Anode stage up (to cathode stage).
- **Jack J13**—Is a 10-pin connector. It connects to a six-wire cable that routes +5 volts, +24 volts, and +/–12 volts from the power supply distribution board.

### 5.5.6 INTC Board (Later Model)

The later model of the INTC board (figure 5-42) performs the same functions as the original model. However, the later model has two additional drive buffer/amplifiers to control the 384-well plate indexing, cathode slide latch, and the capillary array actuators for 4x96 operation of the system. Also, to support the 384-well plate indexing operation, the later model of the INTC board provides two additional input ports for sensors. The later board also provides an additional line for the green power supply. The changes to the INTC board are shown within the dashed lines in figure 5-42. This board is backward compatible with the original version of the instrument. When this board is used with the older version of the cathode assembly, the interface between the INTC board and the cathode connector board is a 16-wire ribbon cable connected to jack J17 of the INTC board. When this board is used with the later model of the cathode assembly, the interface between the INTC board and the cathode connector board is a 50-wire ribbon cable connected to jack J3 of the INTC board.

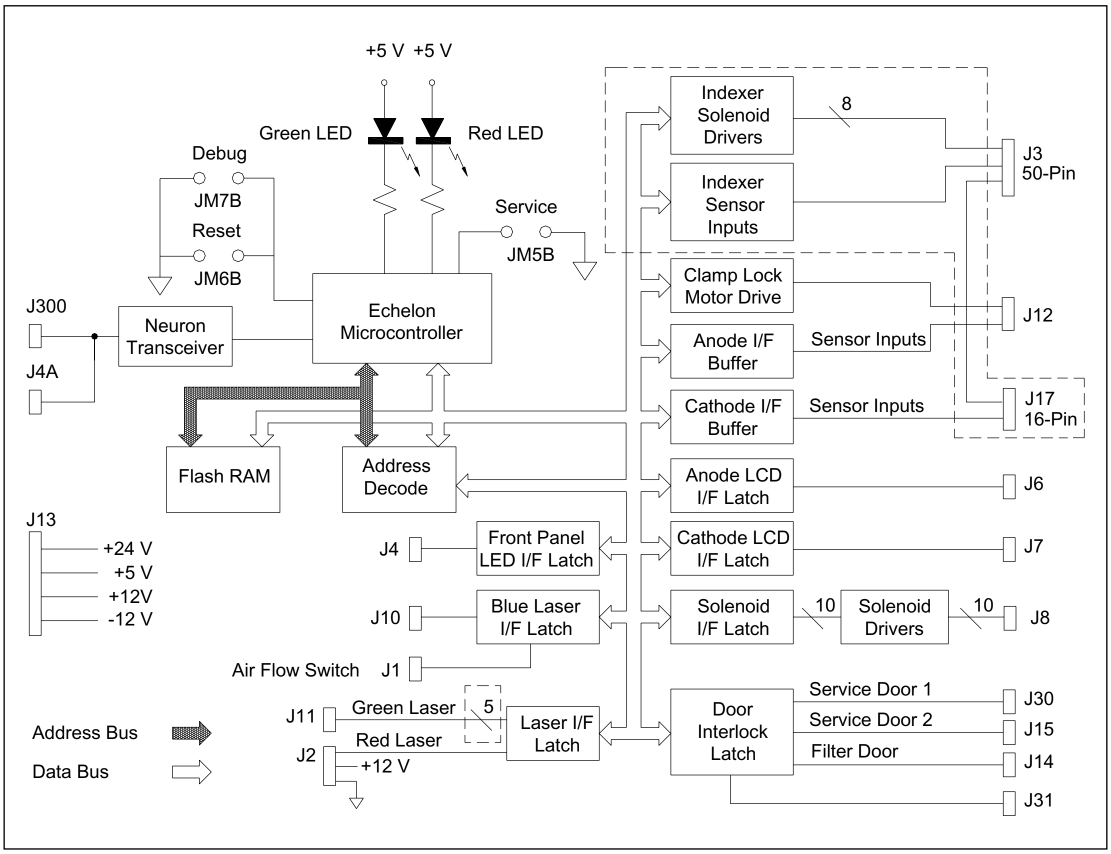



Figure 5-42. INTC Board Block Diagram (Later Model).

#### 5.5.6.1 Component Layout (Later Model)

The component layout of the later model of the INTC board is shown in figure 5-43. The illustration has been simplified to show only the test point, jumper, switch, and connector locations that are relevant to the board functions. Since the test point, jumper, and switch details have not changed, refer to the original model for details. The visible changes to the board are in the connector details. Jack J7 was moved to a different location, the designation for jack J3 was changed to jack J17, and a new 50-pin ribbon connector was added and its designation is now J3.

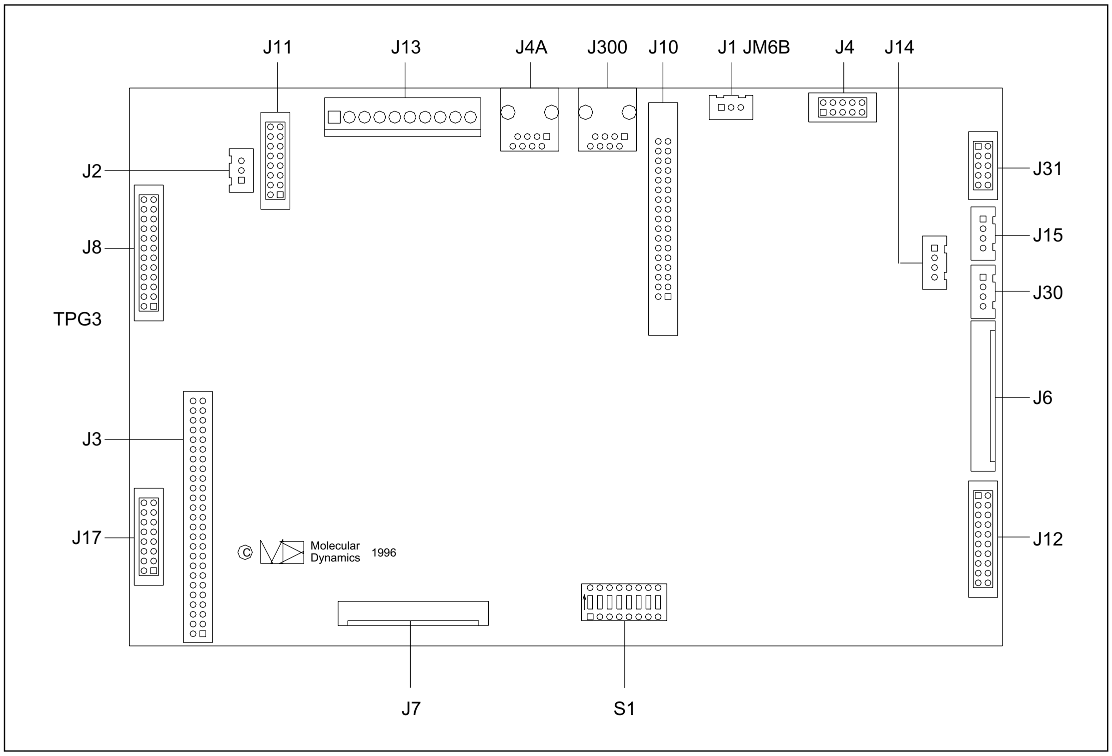



Figure 5-43. INTC Board (Later Model) Component Layout Diagram.

### 5.5.6.2 Connector Details

The connector details for jacks J3 and J17 of the later INTC board are shown in figure 5-44.

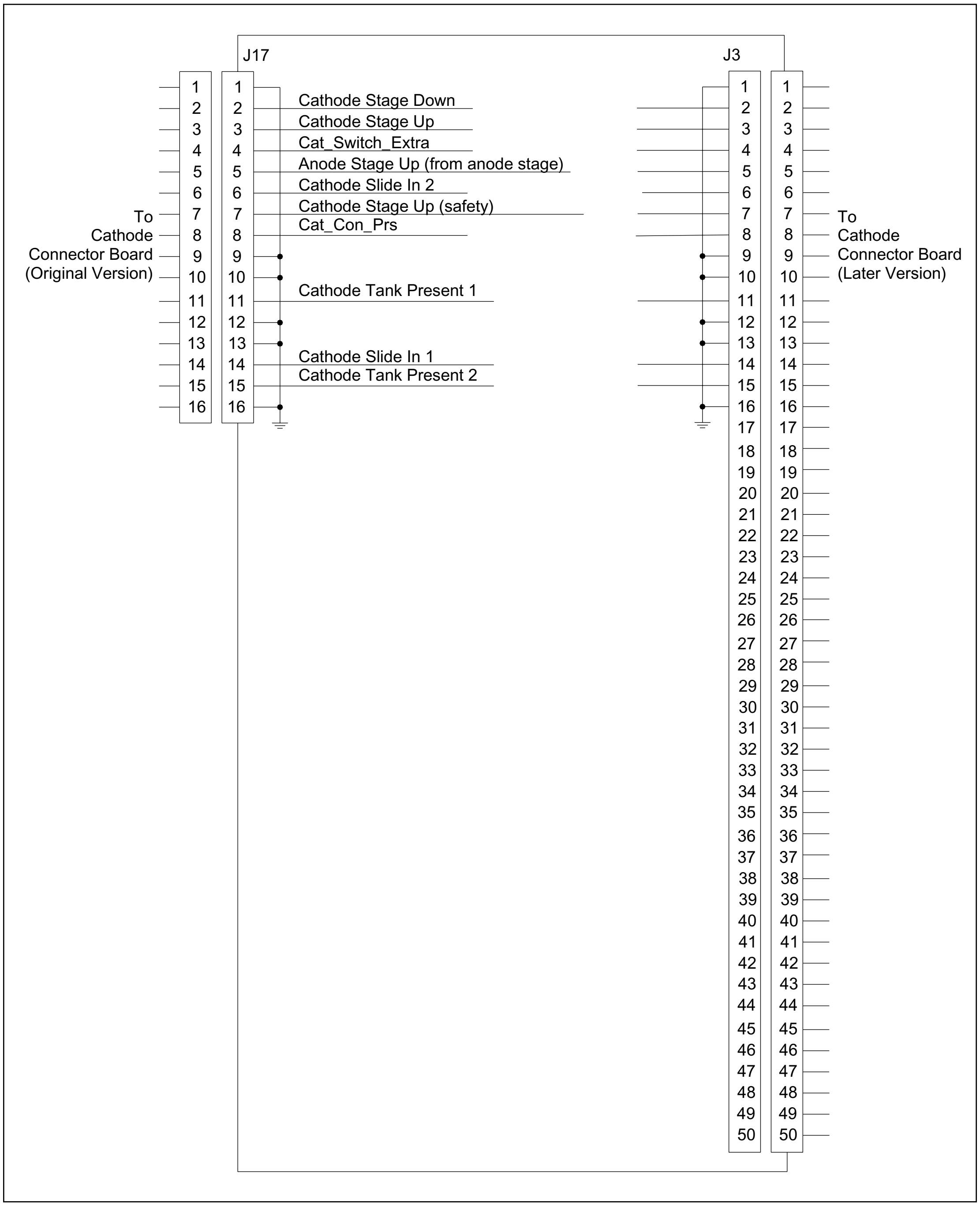



Figure 5-44. INTC Board Connector Detail Diagram (Later Model).

- **Jack J3**—Is a 50-pin connector. It connects to a 50-wire cable that routes solenoid control signals to the cathode stage and sensor signals from the cathode stage. These signals are:
  - Cathode stage down.
  - Cathode stage up.
  - Cathode stage up (to anode stage).
  - Anode stage up (from anode stage).
  - Cathode slide in 1.
  - Cathode slide in 2.
  - Tank present 1.
  - Tank present 2.
  - Cathode connector board present.
  - Indexer Y1 Optical Sensor.
  - Indexer Y2 Optical Sensor.
  - Indexer X1 Optical Sensor.
  - Indexer X2 Optical Sensor.
  - Slide Locked Optical Sensor.
- **Jack J17**—Is a 16-pin connector. It connects to a 16-wire cable that routes sensor signals from the original model of the cathode stage. These sensor signals are:
  - Cathode stage down.
  - Cathode stage up.
  - Cathode stage up (to anode stage).
  - Anode stage up (from anode stage).
  - Cathode slide in 1.
  - Cathode slide in 2.
  - Tank present 1.
  - Tank present 2.
  - Cathode connector board present.

### 5.5.7 TMPR Board

The TMPR board (figure 5-45) controls the temperature in the electrophoresis (capillary) compartment by modulating the power to the heaters. The TMPR board controls the crossflow blower, the heater assembly, and the TE (thermoelectric) cooler. One sensor in the electrophoresis compartment monitors the temperature near the capillaries and provides the input to the TMPR board. Debug and service jumpers with respective LEDs (green and red) are provided for testing the TMPR board.

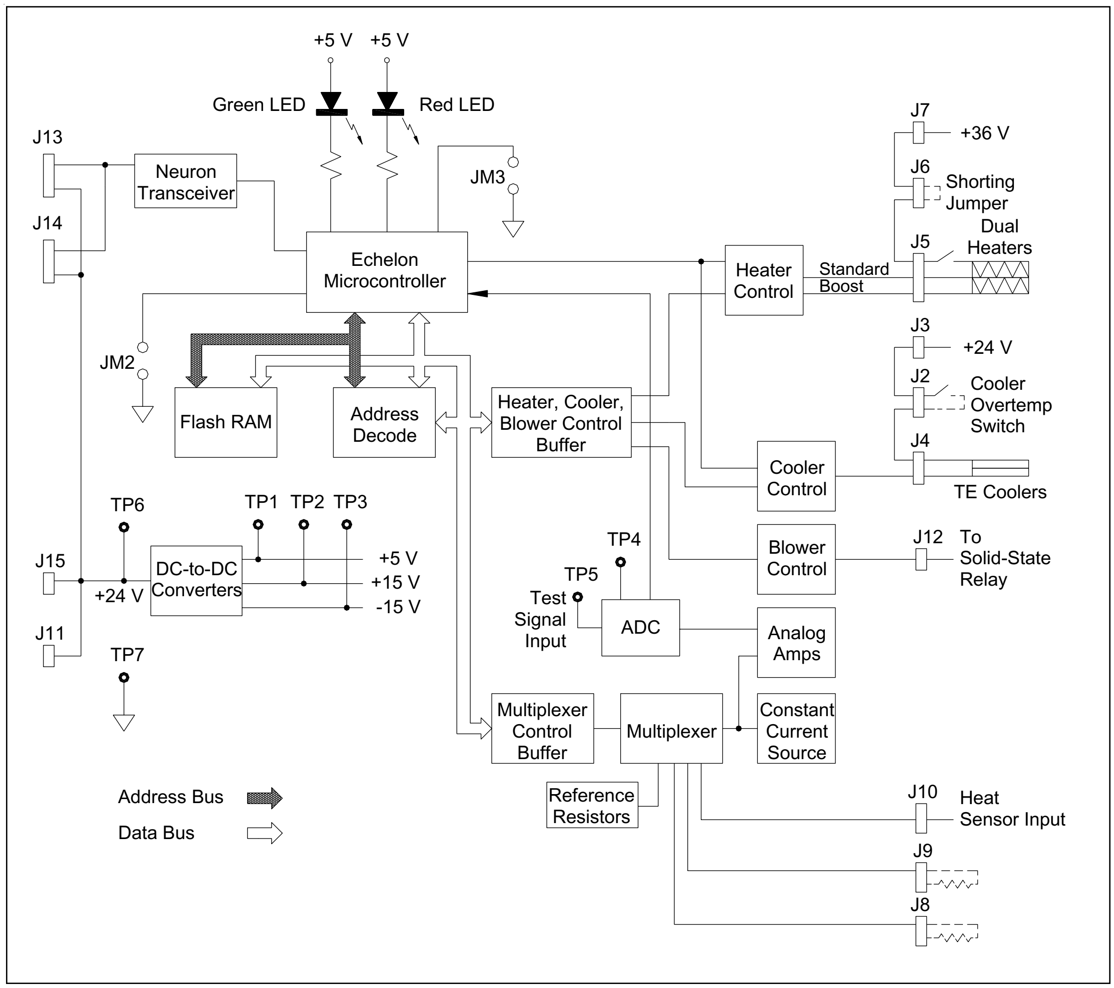



Figure 5-45. TMPR Board Block Diagram.

#### 5.5.7.1 Block Diagram Analysis

The control messages enter the board through the Neuron network connectors (J13 and J14) and are processed by the communications transceiver. The transceiver passes the messages to the Echelon microcontroller, which interprets the messages and sends the appropriate control signals over the data bus to the control buffers.

The Echelon microcontroller reads the thermistor input from the electrophoresis compartment and adjusts the heater output to maintain the electrophoresis compartment at the proper temperature. The thermistor provides a resistive input that varies with the temperature to the constant current source through the multiplexer. The multiplexer sets up a voltage output based on the input resistance. The voltage out of the thermistor is fed to the analog amplifiers, where it is amplified and sent to the A/D converter. The A/D converter converts the voltage to a digital signal and sends it to the Echelon microcontroller, which converts it to a temperature. The microcontroller compares this temperature to the setpoint sent by the user and, depending on the error between the actual temperature and the setpoint, determines how much power to apply to the heaters.

The Echelon microcontroller can turn on the standard heaters alone, or it can turn on the standard heaters plus the boost heaters, depending on the amount of heat required. The heaters are controlled by pulse-width modulating the control voltage. If more heat is required, a longer pulse is sent. If less heat is required, a shorter pulse is sent. When the user sets the temperature at or near room temperature, the microcontroller turns on the TE coolers to a given setpoint depending on how cool the user wants it. With the coolers set to a fixed power level, the power to the heaters is still modulated to maintain the temperature.

The TE coolers have heat sinks mounted to the hot side and the cold side. Three fans are mounted above the hot side of the TE coolers to remove heat from the coolers. The cold side heat sink is mounted in the path of the cross-flow blower. When the coolers are turned on, cold air is blown through the heaters and into the electrophoresis chamber.

### 5.5.7.2 Component Layout

The component layout of the TMPR board is shown in figure 5-46. The illustration has been simplified to show only the test point, jumper, switch, and connector locations that are relevant to the board functions. Test point, jumper, and switch details are provided below.

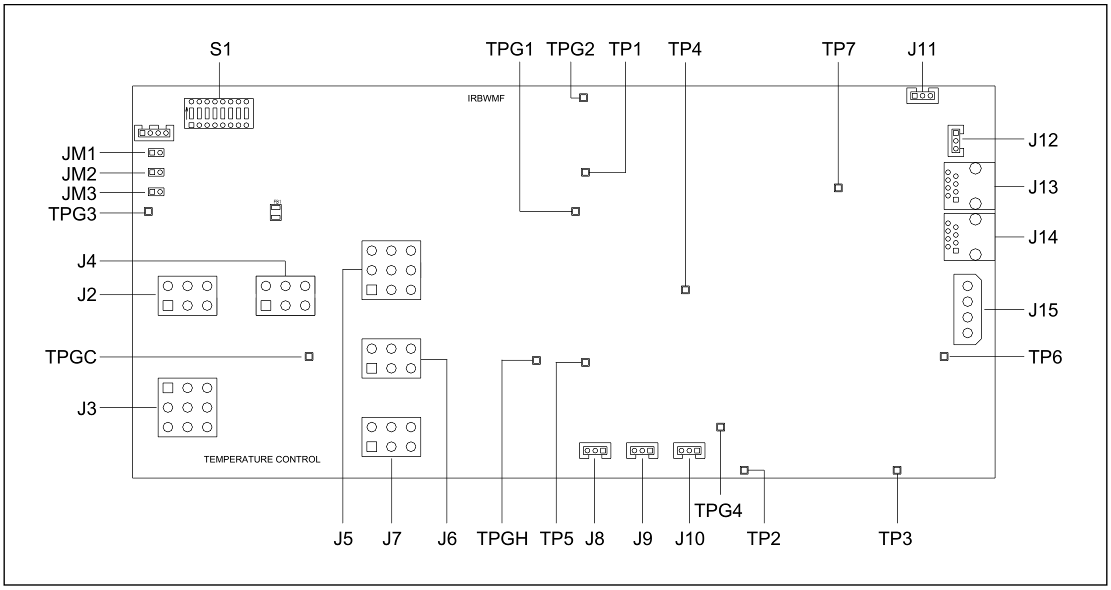



Figure 5-46. TMPR Board Component Layout Diagram.

- **Test Point TP1—** +5 volts out of DC-to-DC converter.
- **Test Point TP2—** +15 volts out of DC-to-DC converter.
- **Test Point TP3—** –15 volts out of DC-to-DC converter.
- **Test Point TP4**—Input to ADC.
- **Test Point TP5**—Test-signal input to ADC (0–5.7 volts).
- **Test Point TP6—** +24-volt input from Neuron network connector.
- **Test Point TP7**—System ground.
- **Test Points TPG1, TPG2, TPG3, TPGH, and TPGC—**Ground test points.
- **Jumper JM1**—Service jumper. This jumper is programming the Echelon microcontroller.
- **Jumper JM2**—A test jumper causes the green LED to light.
- **Jumper JM3**—Manual reset jumper. When this jumper is shorted, the Echelon microcontroller is reset.
- **Switch S1**—Address DIP switch. Sets the network address for the board (positions 1, 2, 4, and 6 are on).

### 5.5.7.3 Connector Details

The connector details for the TMPR board are shown in figure 5-47.

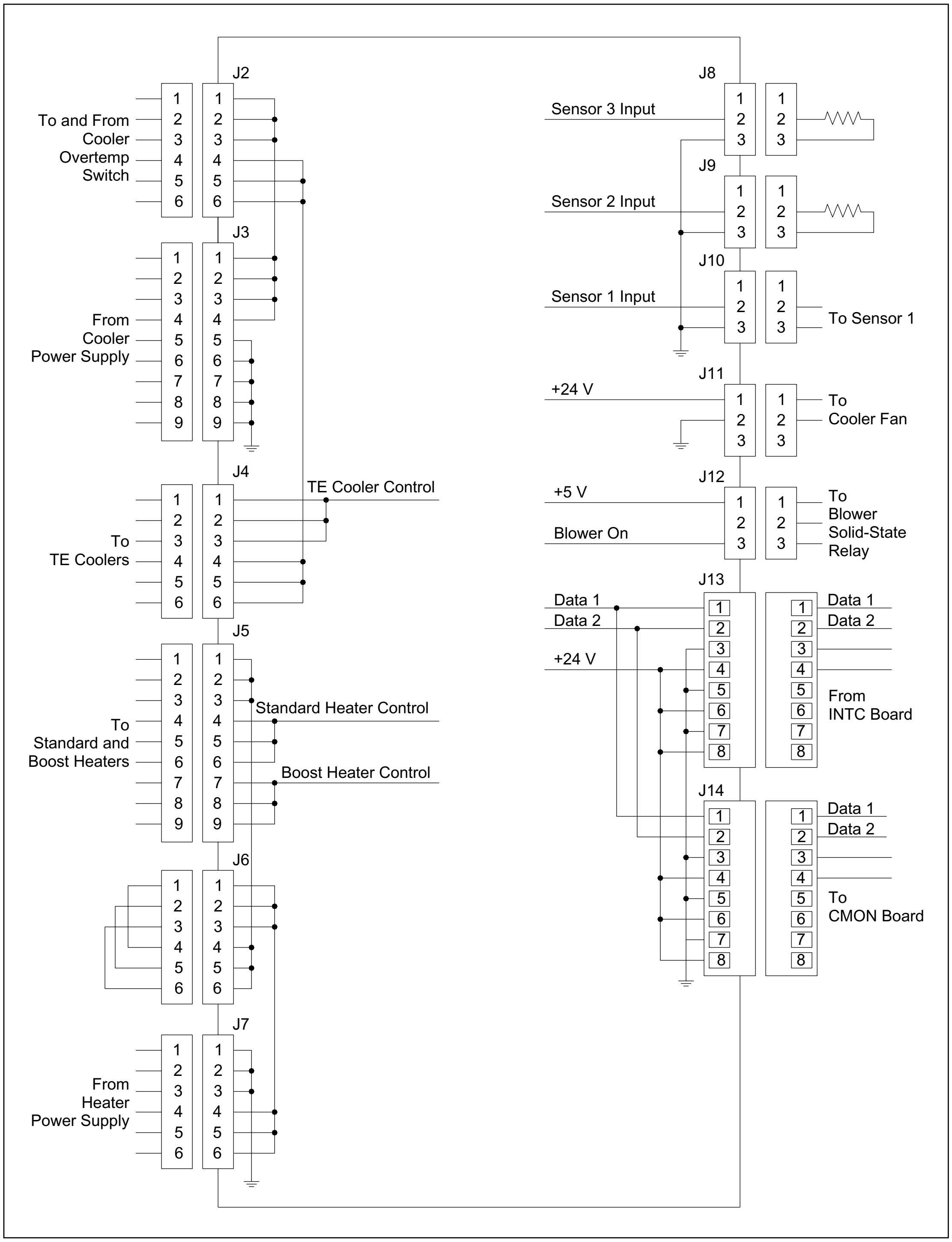



Figure 5-47. TMPR Board Connector Detail Diagram.

- **Jack J2**—Is a six-pin connector. It connects to a six-wire cable that connects to the cooler overtemp switch.
- **Jack J3**—Is a nine-pin connector. It connects to a nine-wire cable that routes +24 volts and ground from the power distribution board.
- **Jack J4**—Is a six-pin connector. It connects to a six-wire cable that routes +24 volts and control signals to the TE coolers.
- **Jack J5**—Is a nine-pin connector. It connects to a nine-wire cable that routes +36 volts and control signals to the standard and boost heaters.
- **Jack J6**—Is a six-pin connector. It jumpers the connections in place of an overtemp switch. The actual overtemp switches are located directly on the standard and boost heaters.
- **Jack J7**—Is a six-pin connector. It connects to a nine-wire cable that routes +36 volts and ground from the power distribution board.
- **Jacks J8 and J9**—Are three-pin connectors. Pins 2 and 3 are connected across terminating resistors.
- **Jack J10**—Is a three-pin connector. This connects to a temperature sensor via two-wire cables.
- **Jack J11**—Is a three-pin connector. It provides +24 volts and ground for the cooler blower via a two-wire cable.
- **Jack J12**—Is a three-pin connector. It provides +5 volts and control signals for the blower via a two-wire cable.
- **Jack J13**—Is an eight-pin RJ45 female connector. It connects to a three-wire RJ45 cable that routes communications signals and 24-volts power from the INTC board.
- **Jack J4A**—Is an eight-pin RJ45 female connector. It connects to a two-wire RJ45 cable that routes communications signals and 24-volt power to the CMON board.

### 5.5.8 CMON Board

The CMON board (figure 5-48) provides a negative reference point for the capillaries and monitors the current levels through the capillaries. The CMON board sets up a simple electronic circuit between the capillary connection (platinum electrodes) on the CMON board and the anode assembly high voltage connection. The current flowing through the capillaries to the anode assembly is monitored and sampled on the CMON board. All 96 of the platinum electrodes on the CMON board are connected to 100k resistor networks to draw current for monitoring and to multiplexers for current sampling. The multiplexers feed the individual electrodes to an analog-to-digital converter (ADC). The ADC converts the current levels to a digital output that is sent to the Echelon microcontroller.

The Echelon microcontroller sends the sampled current data over the Neuron network to the network interface board. The current data is stored on the internal computer before being passed to the host computer. The sampled current levels provide information necessary for determining the status of the capillaries.

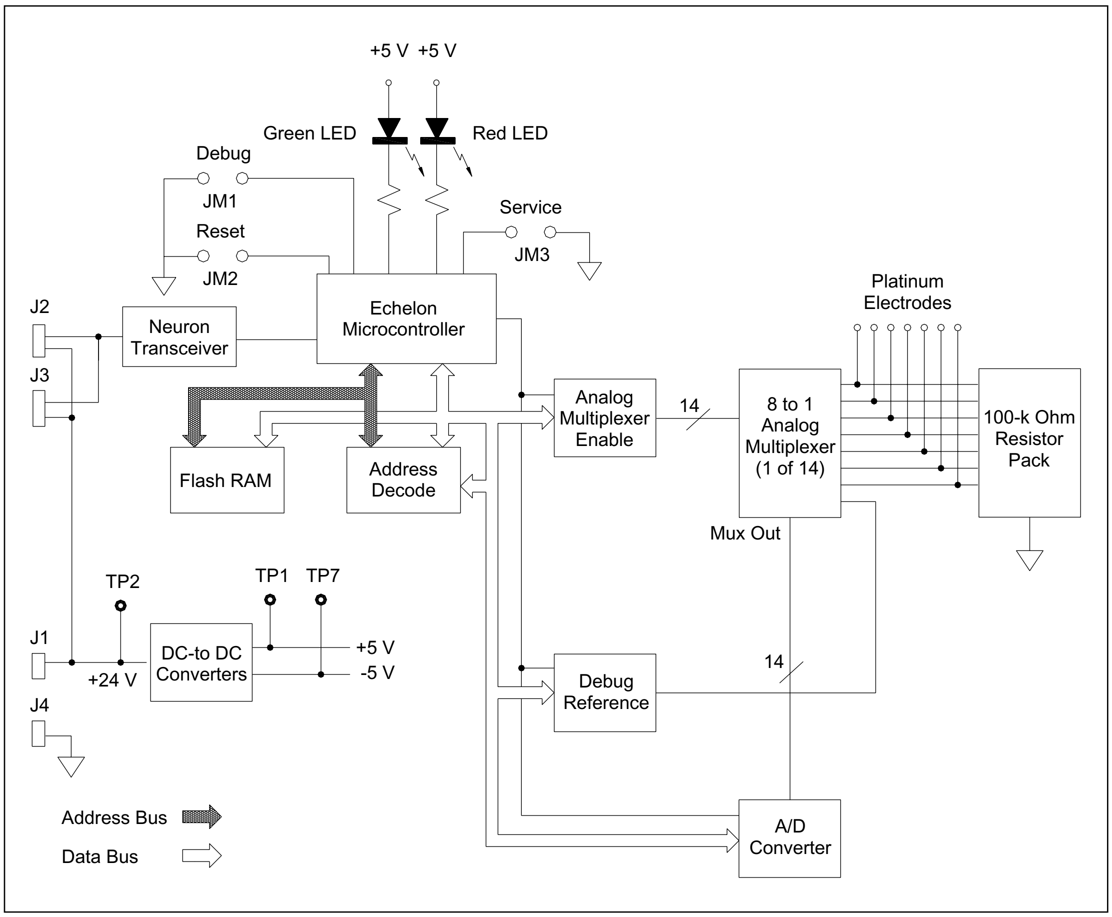



Figure 5-48. CMON Board Block Diagram.

#### 5.5.8.1 Block Diagram Analysis

The control messages enter the board through the Neuron network connectors (J2 and J3) and are processed by the communications transceiver. The transceiver passes the messages to the Echelon microcontroller, which interprets the messages and sends the appropriate control signals over the data bus to the analog multiplexer enable, debug reference, and ADC circuits. The analog multiplexer enable circuit provides the enable signals for the 14 analog multiplexers. Each of the 14 analog multiplexers samples seven electrodes. The eighth input to each multiplexer is the debug reference signal. The output from the 14 analog multiplexers is sent to the ADC where it is put on the bus to the Echelon microcontroller.

The debug reference is an internally generated voltage that is sent to each multiplexer. This voltage is used as a self-diagnostic on the CMON board. Under microcontrol, a voltage is sent to each multiplexer, and the digital value from the ADC is read back. An error message is sent to the ESC if a voltage is wrong.

#### 5.5.8.2 Component Layout

The component layout of the CMON board is shown in figure 5-49. The illustration has been simplified to show only the test point, jumper, switch, and connector locations that are relevant to the board functions. Test point, jumper, and switch details are provided below.

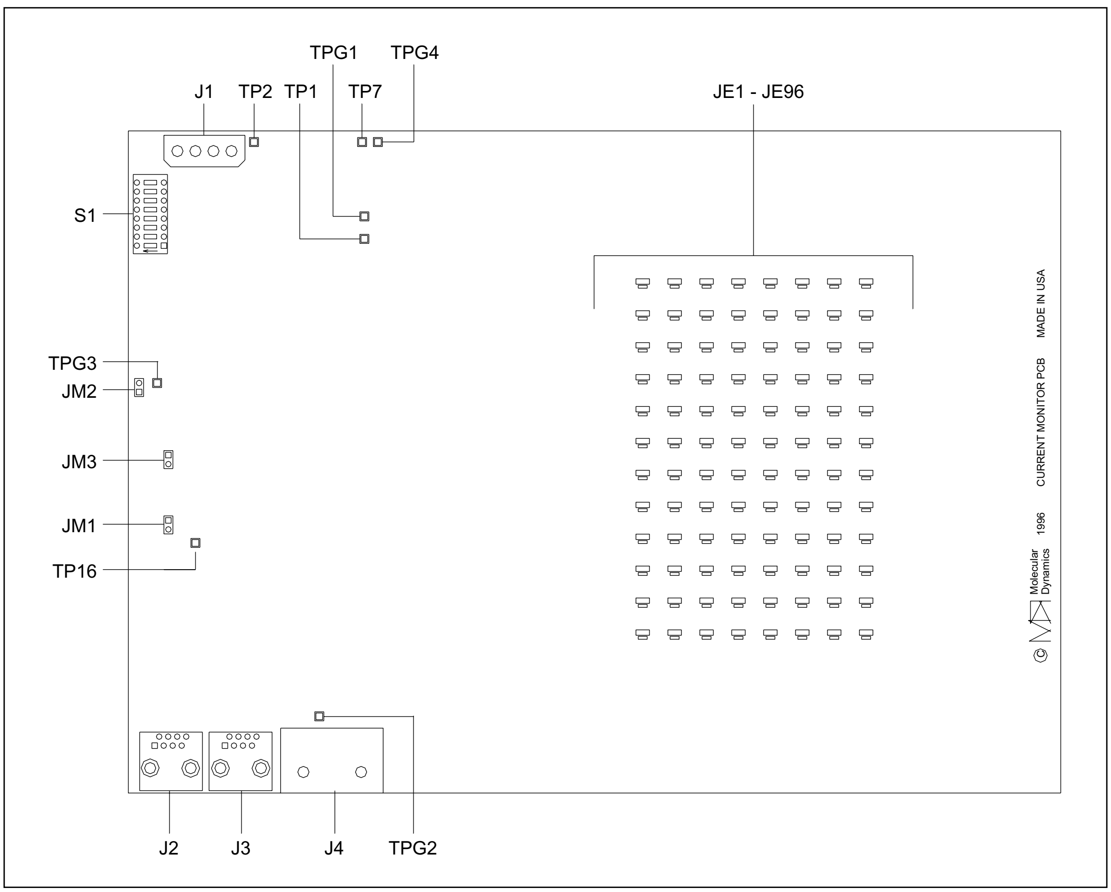



Figure 5-49. CMON Board Component Layout Diagram.

- **Test Point TP1**— +5 volts out of DC-to-DC converter.
- **Test Point TP2**— +24 volts input power.
- **Test Point TP7**— –5 volts out of DC-to-DC converter.
- **Test Points TP16**—Ground test points.
- **Jumper JM1**—Not used.
- **Jumper JM2**—Manual reset jumper. When this jumper is shorted, the Echelon microcontroller is reset.
- **Jumper JM3**—Service jumper. This jumper is programming the Echelon microcontroller.
- **Electrode Jacks JE1 through JE96** —These electrodes are bonded to the board and extend down from the bottom of the board
- **Switch S1**—Address DIP switch. Sets the network address for the board (positions 2, 3, 4, and 6 are on).

#### 5.5.8.3 Connector Details

The connector details for the CMON board are shown in figure 5-50.

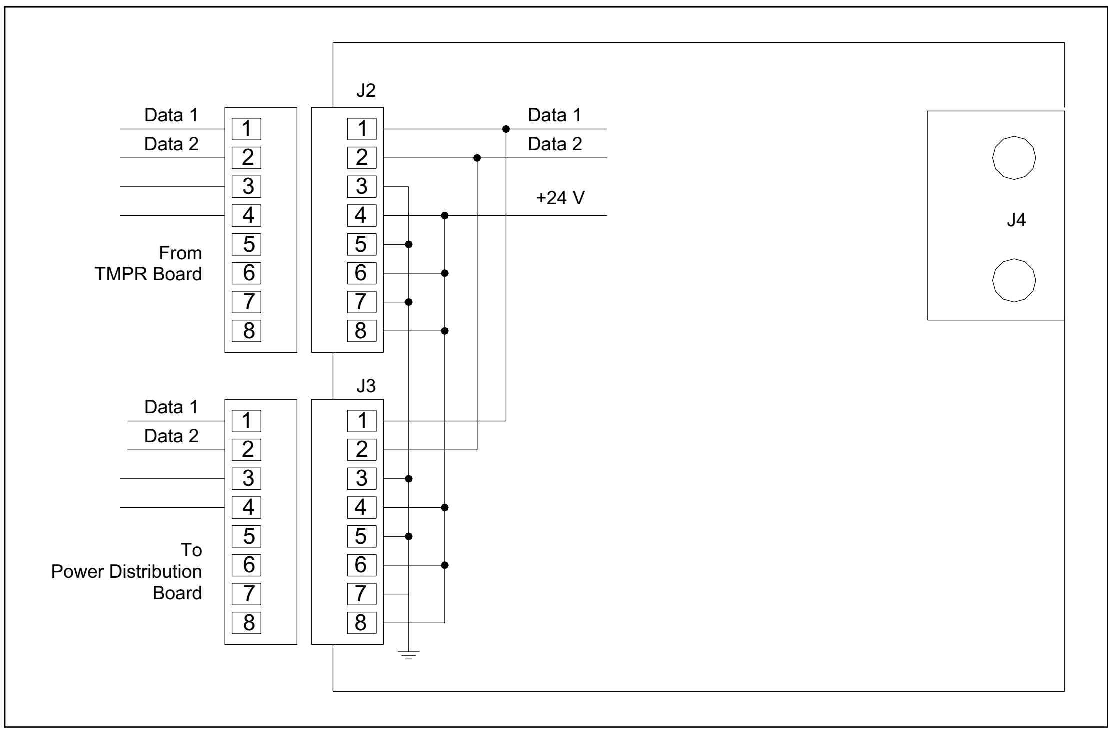



Figure 5-50. CMON Board Connector Detail Diagram.

- **Jack J1**—Is not used.
- **Jack J2**—Is an eight-pin RJ45 female connector. It connects to a three-wire RJ45 cable that routes communications signals and 24-volt power from the TMPR board.
- **Jack J3**—Is an eight-pin RJ45 female connector. It connects to a two-wire RJ45 cable that routes communications signals and 24-volt power to the power distribution board.
- **Jack J4**—HV Ground return point.

### 5.5.9 ADAQ Board

The ADAQ board (figure 5-51) acquires analog signals from the two PMT channels, converts the analog signals to digital information, and transfers the digital information to the interface board though a dedicated cable.

The instructions for starting and stopping conversions come from the Neuron network. The converted digital information is continuously written to the memory on the interface board.

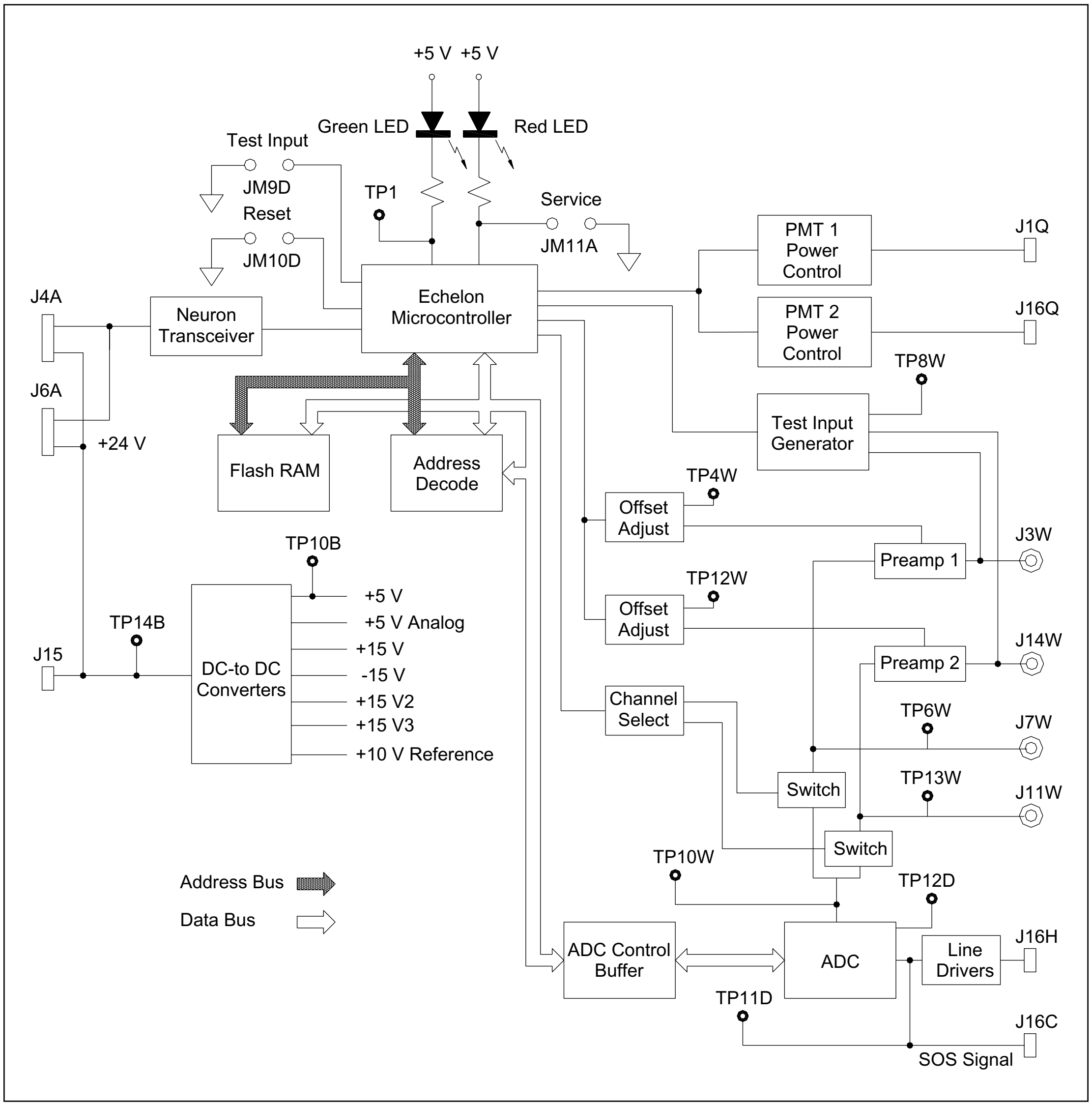



Figure 5-51. ADAQ Board Block Diagram.

The low-level current signals received from the two PMT channels are amplified and then converted into voltages. The converted voltages from each PMT channel are sent to a 12-bit ADC where the voltages are digitized. The resulting digital signals are sent to the PC interface board for storage, until the host computer reads the data.

An offset circuit corrects for the voltage offset introduced by the amplifiers and broadens the voltage swing of the output (from 0 to +10 volts to –10 to +10 volts). Before each run, the calibration circuit automatically calibrates the amplifier.

The Echelon microcontroller generates the data acquisition clock for the ADC, sets the levels for the PMT high voltage, provides calibration and test capabilities, and communicates with the Neuron network.

Power for the board comes in from the Neuron network at +24 volts to power a DC-to-DC converter that generates the +5 volts for the electronic circuits and three DC-to-DC converters that generate additional voltages for the analog electronics and PMT power supplies.

#### 5.5.9.1 Block Diagram Analysis

The control messages enter the board through the Neuron network connectors (J4A and J6A) and are processed by the communications transceiver. The transceiver passes the signals to the Echelon microcontroller, which interprets the messages and sends the appropriate signals over the data bus to the ADC control buffer. The low-level current signals from the two PMT channels enter the ADAQ board through coaxial cables to J3W (PMT 1) and J14W (PMT 2). The signals are amplified, and the output (0–10 volts) is fed to another amplifier along with the offset adjust voltage to compensate for offset errors. The adjusted voltage is then fed to a switching circuit where the channel voltages are alternately fed to the ADC. The digitized data is then fed to the line drivers, and the output leaves the board and goes to the PC interface board. If test signals are required, the Echelon microcontroller controls the test signal levels to the preamp circuits.

### 5.5.9.2 Component Layout

The component layout of the ADAQ board is shown in figure 5-52. The illustration has been simplified to show only the test point, jumper, switch, and connector locations that are relevant to the board functions. Test point, jumper, and switch details are provided below.

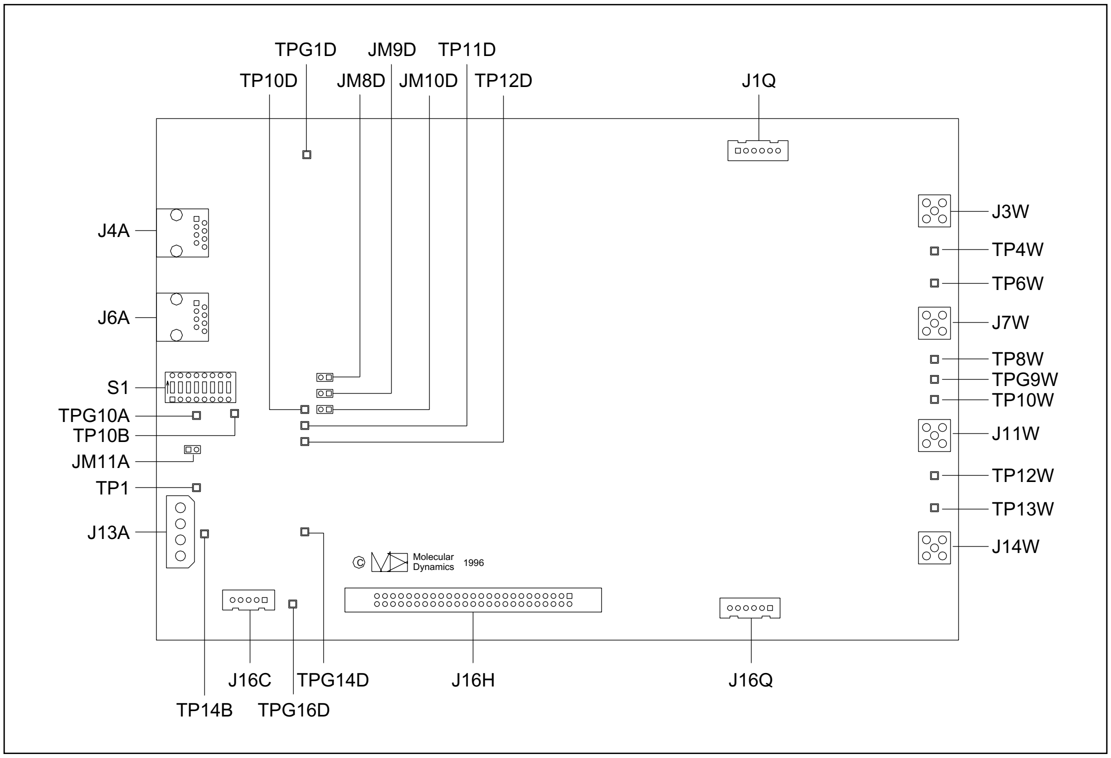



Figure 5-52. ADAQ Board Component Layout Diagram.

- **Test Point TP1**—Software scan state. This test point is high during data acquisition and low during turnaround time.
- **Test Point TP4W**—Offset adjust for preamp 1.
- **Test Point TP6W**—Output of preamp 1.
- **Test Point TP8W**—Output of preamp test generator.
- **Test Point TP10D**—Reset.
- **Test Point TP10B**— +5 volts out of DC-to-DC converter.
- **Test Point TP10W**—Selected input to ADC.
- **Test Point TP11D**—Start-of-scan signal. This test point is low during scan time and high during turnaround time.
- **Test Point TP12D**—BUSY signal from the ADC. Signal is low when conversion is complete.
- **Test Point TP12W**—Offset adjust for preamp 2.
- **Test Point TP13W**—Output of preamp 2.
- **Test Point TP14B**— +24-volts input.
- **Test Point TPG9W**—Ground for +/–15-volt DC-to-DC converter.
- **Test Point TPG1D, TPG10A, TPG14D, and TPG16D**—Ground test points.
- **Jumper JM8D**—If the 0-ohm resistor R9H is removed, an external trigger signal can be connected to this jumper to trigger the ADC. Otherwise, it can be used to monitor the trigger generated by the Echelon microcontroller.
- **Jumper JM9D**—Input bit to test the I/O on the Echelon microcontroller. When the jumper is shorted, the NTEST_INPUT bit should be read as a 0, otherwise, it is a 1.
- **Jumper JM10D**—Manual reset jumper. When this jumper is shorted, the Echelon microcontroller is reset.
- **Jumper JM11A**—Service jumper. This jumper is for programming the Echelon microcontroller.
- **Switch S1**—Address DIP switch. Sets the network address for the board (positions 3, 4, and 6 are on).

#### 5.5.9.3 Connector Details

The connector details for the ADAQ board are shown in figure 5-53.

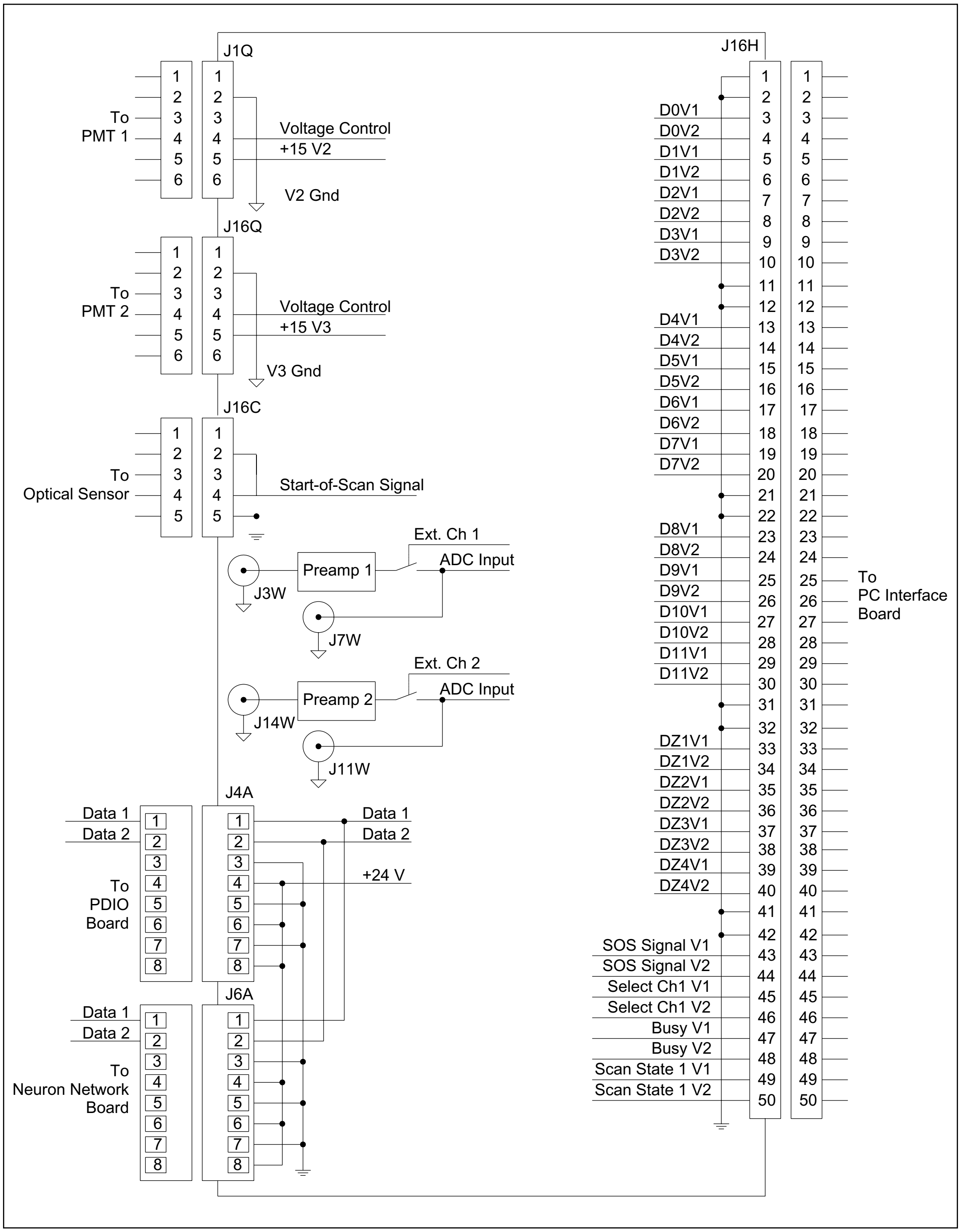



Figure 5-53. ADAQ Board Connector Detail Diagram.

- **Jack J1Q**—Is a six-pin connector. It connects to a three-wire cable that routes +15 volts, ground, and control signals to the HV power supply for PMT 1.
- **Jack J16Q**—Is a six-pin connector. It connects to a three-wire cable that routes +15 volts, ground, and control signals to the HV power supply for PMT 2.
- **Jack J16C**—Is a five-pin connector that connects to the SOS sensor located on the stage assembly. The SOS signal tells the ADAQ board when the stage is at constant velocity (scan time) or in the turnaround time.
- **Jack J3W**—Is a coaxial connector. It connects to a coaxial cable that routes analog data signals from PMT 1 to the input of preamp 1.
- **Jack J7W**—Is a coaxial connector. It provides an external test input to the board in place of the signal from PMT 1.
- **Jack J11W**—Is a coaxial connector. It provides an external test input to the board in place of the signal from PMT 2.
- **Jack J14W**—Is a coaxial connector. It connects to a coaxial cable that routes analog data signals from PMT 2 to the input of preamp 2.
- **Jack J4A**—Is an eight-pin RJ45 female connector. It connects to a three-wire RJ45 cable that routes communications signals and 24-volt power from the PDIO board.
- **Jack J6A**—Is an eight-pin RJ45 female connector. It connects to a three-wire RJ45 cable that routes communications signals and 24-volt power to the Neuron network board.
- **Jack J16H**—Is a 50-pin ribbon connector. It connects to a 50-wire ribbon cable that routes digital data and control signals to the PC interface board.

### 5.5.10 PDIO Board

The PDIO board (figure 5-54) acquires an analog signal from the capillary detection photodiode, converts the analog signal to digital information, and transfers the digital information to its associated PC interface board through a dedicated cable. The PDIO board is physically identical to the ADAQ board. It is a two-channel preamp, but only one channel is used.

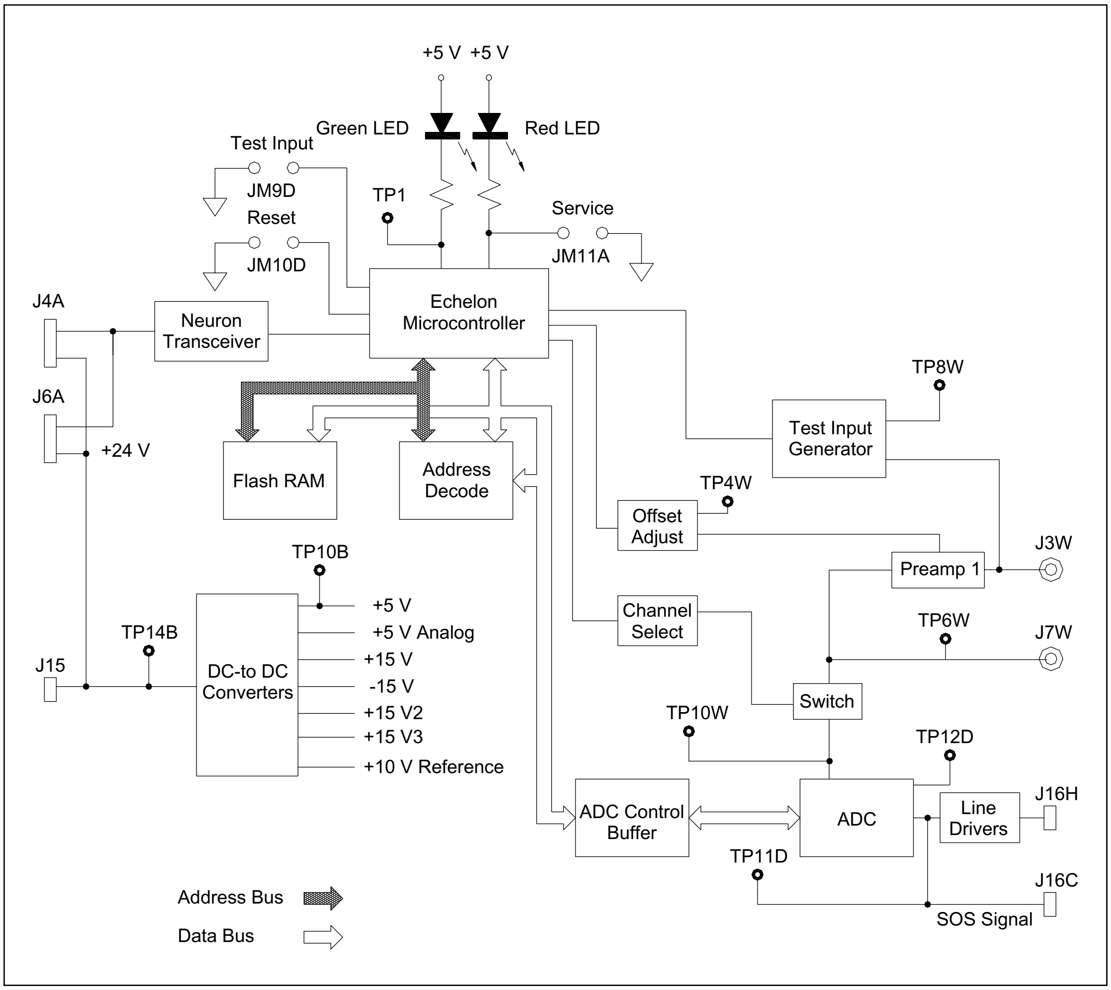



Figure 5-54. PDIO Board Block Diagram.

The low-level current signal received from the photodiode is amplified and then converted into a voltage. The converted voltage is sent to a 12-bit ADC where the voltage is digitized. The resulting digital signal is sent to the PC interface board for storage. The CPU reads the data and processes it to determine the locations of the capillaries.

The Echelon microcontroller generates the data acquisition clock for the ADC, provides calibration and test capabilities, and communicates with the Neuron network.

Power for the board comes in from the Neuron network at +24 volts to power a switching regulator that generates the +5 volts for the electronic circuits and three DC-to-DC converters that generate the additional voltages.

### 5.5.10.1 Block Diagram Analysis

The control messages enter the board through the Neuron network connectors (J4A and J6A) and are processed by the communications transceiver. The transceiver passes the messages to the Echelon microcontroller, which interprets the messages and sends the appropriate control signals over the data bus to the ADC control buffer. The low-level current signal from the photodiode enters the PDIO board through a coaxial cable to J3W. The signal is amplified, and the output (0–10 volts) is fed to another amplifier along with the offset adjust voltage to compensate for offset errors. The adjusted voltage is then fed to a switching circuit where the voltage is fed to the ADC. The digitized voltage is then fed to the line drivers, and the output leaves the board and goes to the PC interface board. If test signals are required, the Echelon microcontroller controls the test signals levels to the preamp circuit.

### 5.5.10.2 Component Layout

The component layout of the PDIO board is shown in figure 5-55. The illustration has been simplified to show only the test point, jumper, switch, and connector locations that are relevant to the board functions. Test point, jumper, and switch details are provided below.

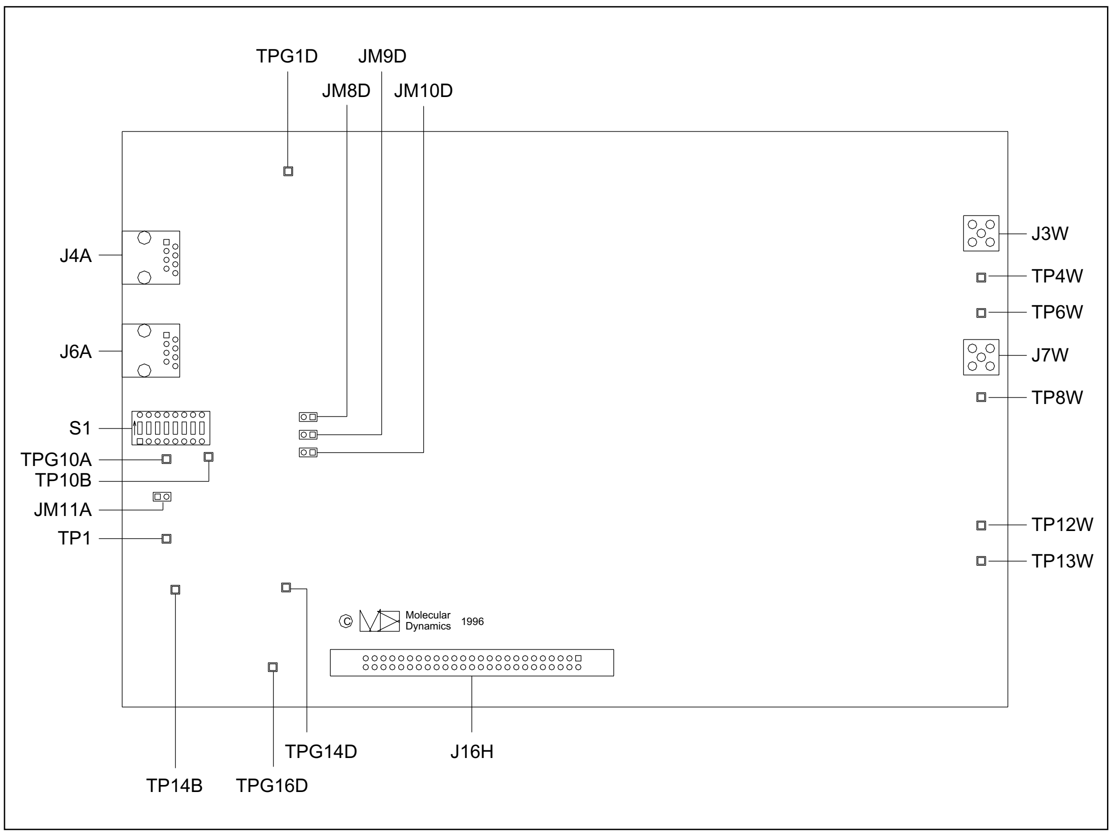



Figure 5-55. PDIO Board Component Layout Diagram.

- **Test Point TP1**—Software scan state. This test point is high during data acquisition and low during turnaround time.
- **Test Point TP4W**—Offset adjust for preamp 1.
- **Test Point TP6W**—Output of preamp 1.
- **Test Point TP8W**—Output of preamp test generator.
- **Test Point TP10B**— +5 volts out of DC-to-DC converter.
- **Test Point TP12W**—Offset adjust for preamp 2.
- **Test Point TP13W**—Output of preamp 2.
- **Test Point TP14B**— +24-volt input.
- **Test Point TPG1D, TPG10A, TPG14D, and TPG16D**—Ground test points.
- **Jumper JM8D**—If the 0-ohm resistor R9H is removed, an external trigger signal can be connected to this jumper to trigger the ADC. Otherwise, the jumper can be used to monitor the trigger generated by the Echelon microcontroller.
- **Jumper JM9D**—Input bit to test the I/O on the Echelon microcontroller. When the jumper is shorted, the NTEST_INPUT bit should be read as a 0; otherwise, it is a 1.
- **Jumper JM10D**—Manual reset jumper. When this jumper is shorted, the Echelon microcontroller is reset.
- **Jumper JM11A**—Service jumper. This jumper is for programming the Echelon microcontroller.
- **Switch S1**—Address DIP switch. Sets the network address for the board (positions 2, 3, and 6 are on).

### 5.5.10.3 Connector Details

The connector details for the PDIO board are shown in figure 5-56.

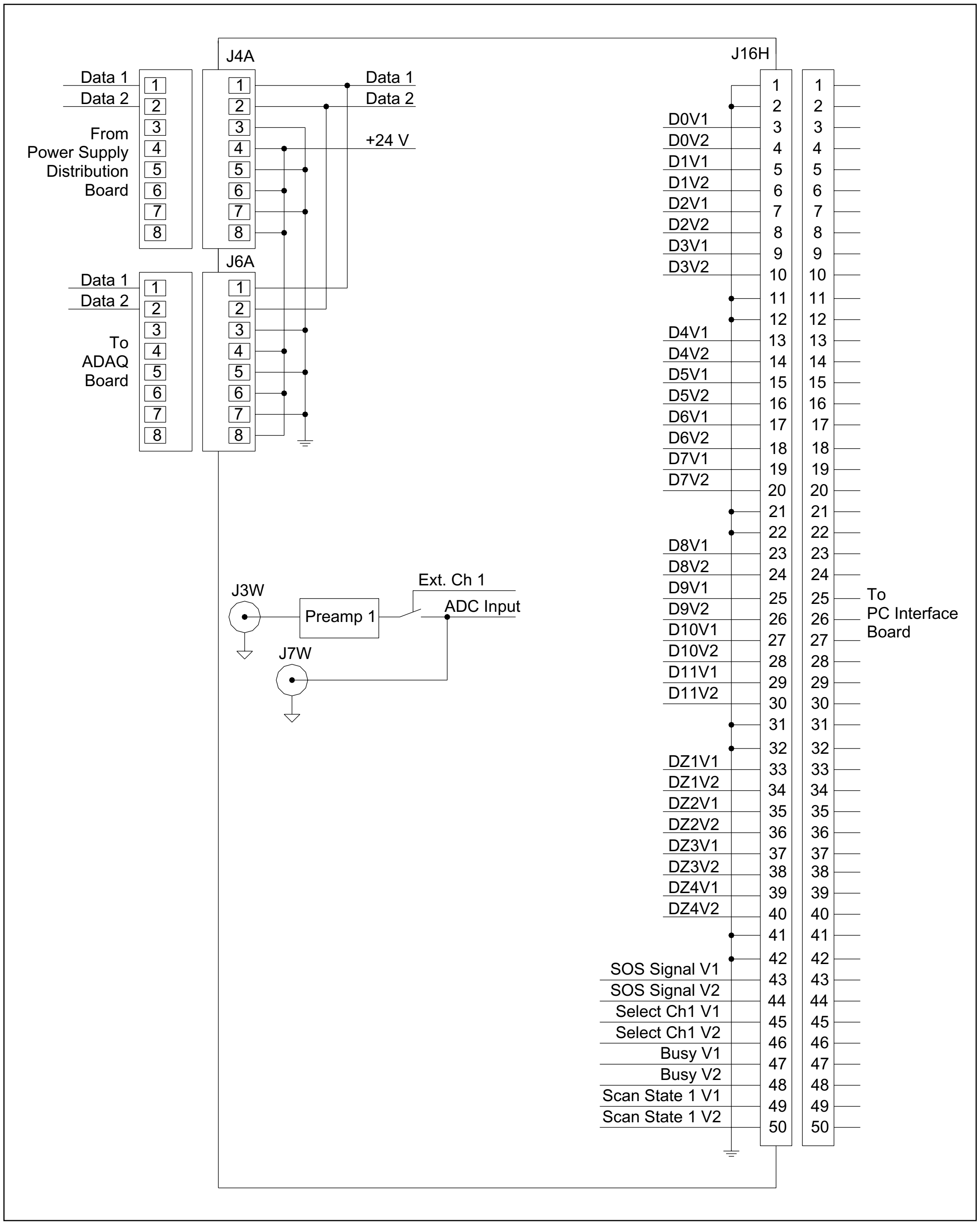



Figure 5-56. PDIO Board Connector Detail Diagram.

- **Jack J3W**—Is a coaxial connector. It connects to a coaxial cable that routes analog data signals from the photodiode to the input of preamp 1.
- **Jack J7W**—Is a coaxial connector. It provides an external test input to the board in place of the signal from the photodiode.
- **Jack J4A**—Is an eight-pin RJ45 female connector. It connects to a three-wire RJ45 cable that routes communications signals and 24-volt power from the power supply distribution board.
- **Jack J6A**—Is an eight-pin RJ45 female connector. It connects to a three-wire RJ45 cable that routes communications signals and 24-volt power to the PDIO board.
- **Jack J16H**—Is a 50-pin ribbon connector. It connects to a 50-wire ribbon cable that routes digital data and control signals to the PC interface board.

## 5.6 Miscellaneous Boards

### 5.6.1 Cathode Connector Board (MB 1000)

The cathode connector board provides a connection point for the cathode assembly's sensor switches. The cathode connector board output leaves the board at J2 where it is routed to the INTC board. Individual cables run between the cathode connector board and the seven sensors on the cathode assembly.

#### 5.6.1.1 Component Layout

The component layout of the cathode connector board is shown in figure 5-57. The illustration shows the test point and connector locations. Test point details are provided below. All test points measure 0 volts (ground) when the switch is closed.

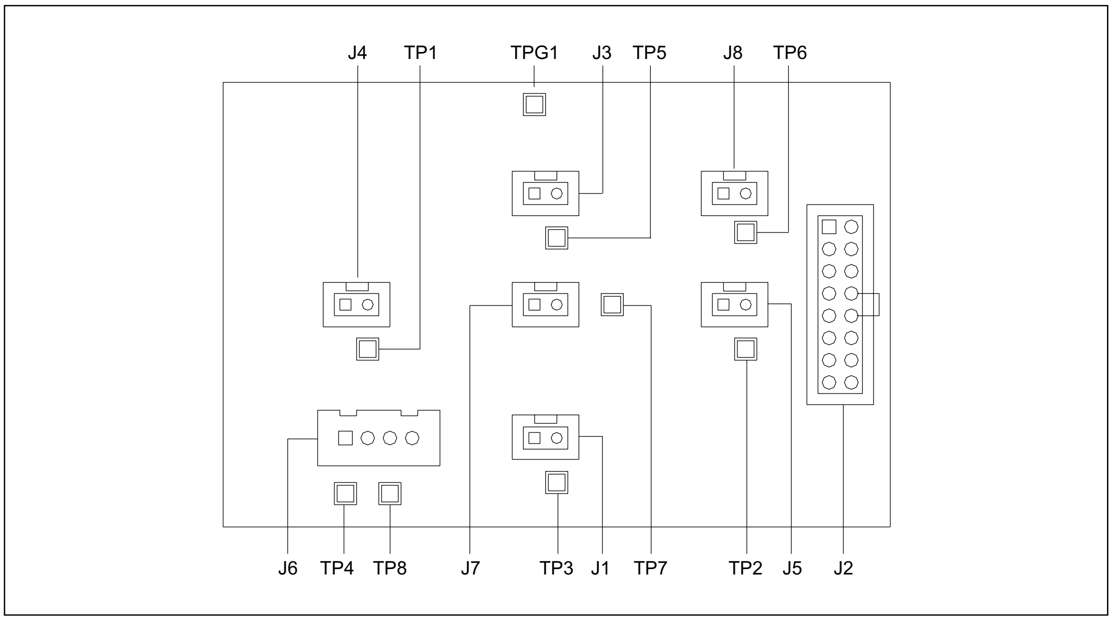



Figure 5-57. Cathode Connector Board Component Layout Diagram.

- **Test Point TP1**—Cathode slide in 1.
- **Test Point TP2**—Cathode slide in 2.
- **Test Point TP3**—Cathode switch extra.
- **Test Point TP4**—Cathode stage up (safety).
- **Test Point TP5**—Cathode tank present 1.
- **Test Point TP6**—Cathode tank present 2.
- **Test Point TP7**—Cathode stage down.
- **Test Point TP8**—Cathode stage up.
- **Test Point TPG1**—Ground.

### 5.6.1.2 Connector Details

The connector details for the cathode connector board are shown in figure 5-58.

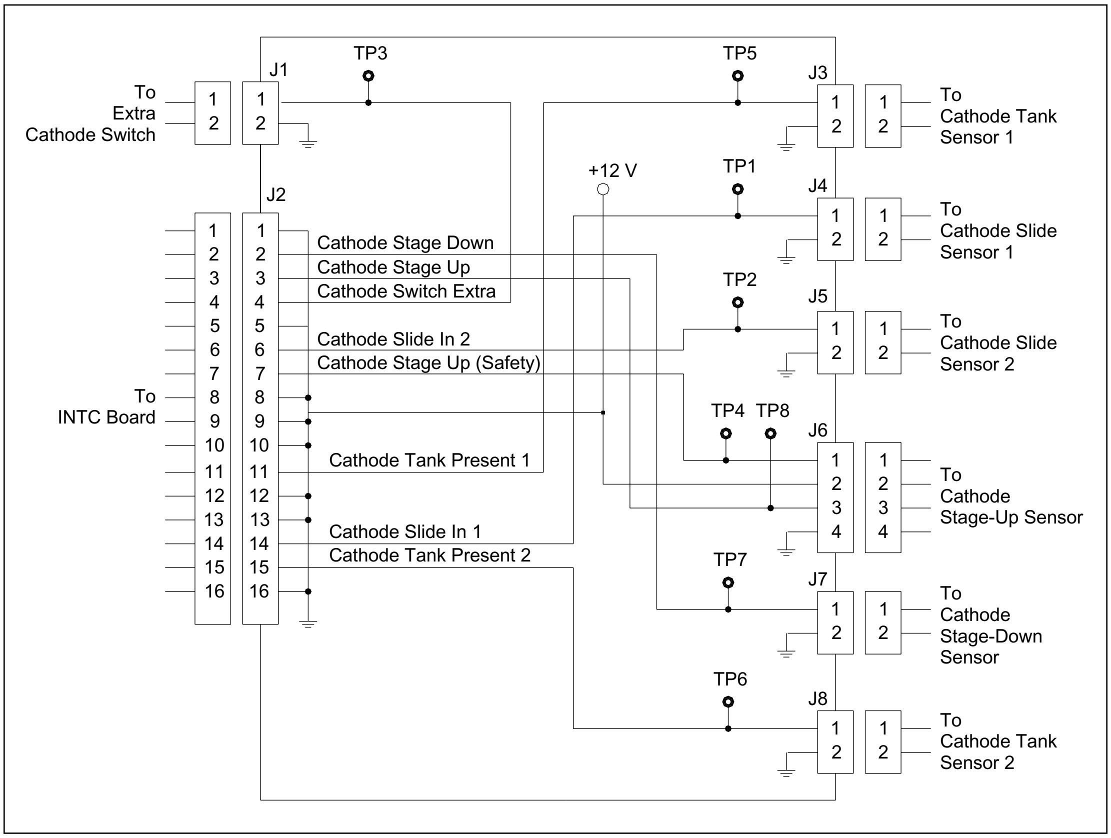



Figure 5-58. Cathode Connector Board Connector Detail Diagram.

- **Jack J1**—Is a two-pin connector. It connects to the capillary array stand detection sensor via a two-wire cable.
- **Jack J2**—Is a 16-pin connector. It connects to a 16-wire cable that routes the cathode stage sensor signals to the INTC board.
- **Jack J3**—Is a two-pin connector. It connects to the first cathode tank detection sensor via a two-wire cable.
- **Jack J4**—Is a two-pin connector. It connects to the first cathode slide-in detection sensor via a two-wire cable.
- **Jack J5**—Is a two-pin connector. It connects to the second cathode slide-in detection sensor via a two-wire cable.
- **Jack J6**—Is a four-pin connector. It connects to the two cathode stage-up detection sensors via a four-wire cable.
- **Jack J7**—Is a two-pin connector. It connects to the cathode stage-down detection sensor via a two-wire cable.
- **Jack J8**—Is a two-pin connector. It connects to the second cathode tank detection sensor via a two-wire cable.

### 5.6.2 Cathode Connector Board (MB 2000)

The cathode connector board provides a connection point for the cathode assembly's sensor switches. The cathode connector board output leaves the board at J2 where it is routed to the INTC board. Individual cables run between the cathode connector board and the ten sensors and seven of the eight ports of the pneumatic manifold on the cathode assembly.

#### 5.6.2.1 Component Layout

The component layout of the cathode connector board is shown in figure 5-59. The illustration shows the test point and connector locations. Test point details are provided below. All test points measure 0 volts (ground) when the switch is closed.

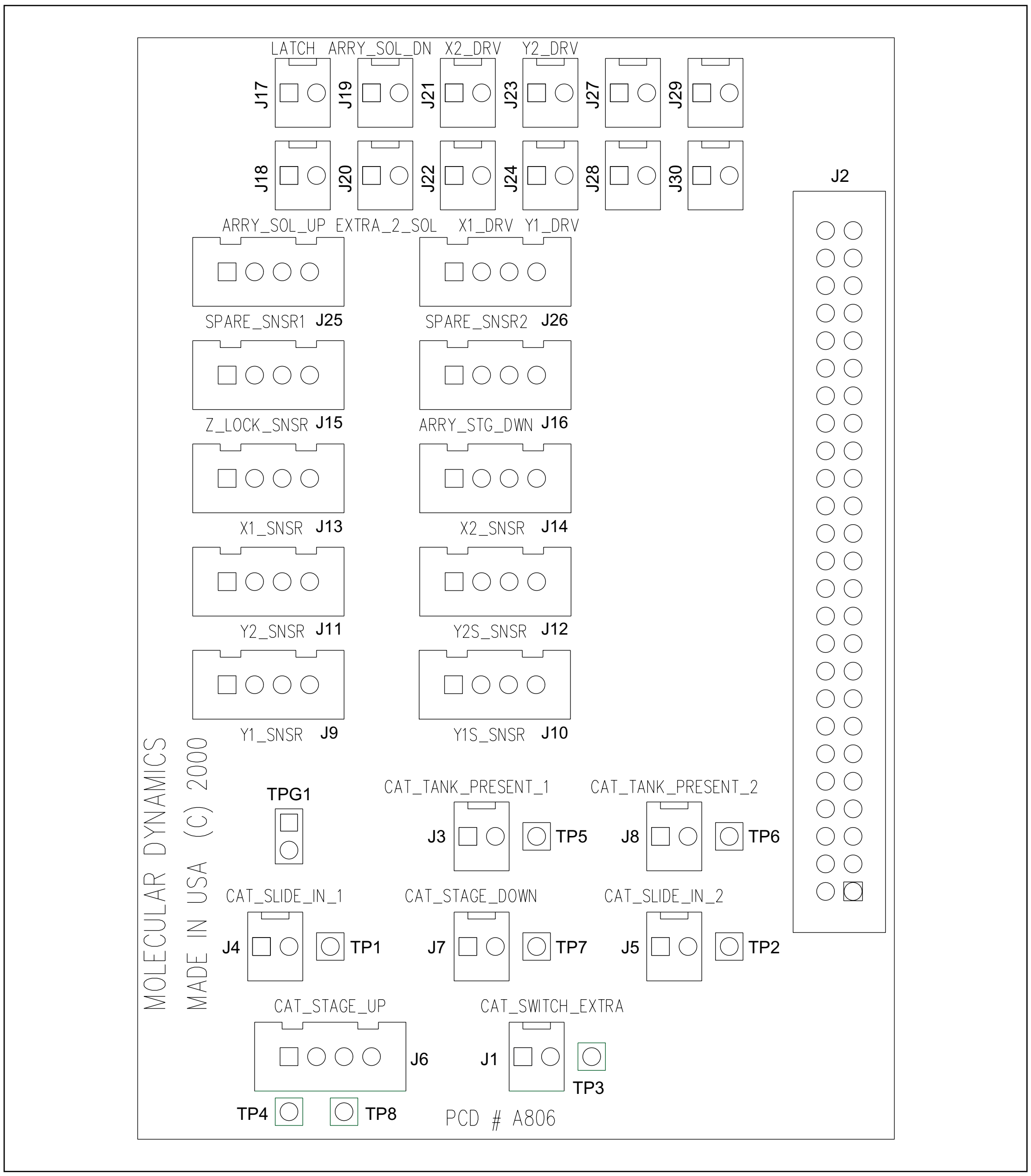



Figure 5-59. Cathode Connector Board Component Layout Diagram (MB 2000).

- **Test Point TP1**—Cathode slide in 1.
- **Test Point TP2**—Cathode slide in 2.
- **Test Point TP3**—Cathode switch extra.
- **Test Point TP4**—Cathode stage up (safety).
- **Test Point TP5**—Cathode tank present 1.
- **Test Point TP6**—Cathode tank present 2.
- **Test Point TP7**—Cathode stage down.
- **Test Point TP8**—Cathode stage up.
- **Test Point TPG1**—Ground.

### 5.6.2.2 Connector Details

The connector details for the cathode connector board are shown in two figures. Figure 5-60 illustrates that some of the connectors are identical to the connectors on the MB 1000 instrument (figure 5-58). Figure 5-61 illustrates the rest of the connectors on the MB 2000 instrument. These connectors were added to support the additional sensors and the solenoids for the plate indexers.

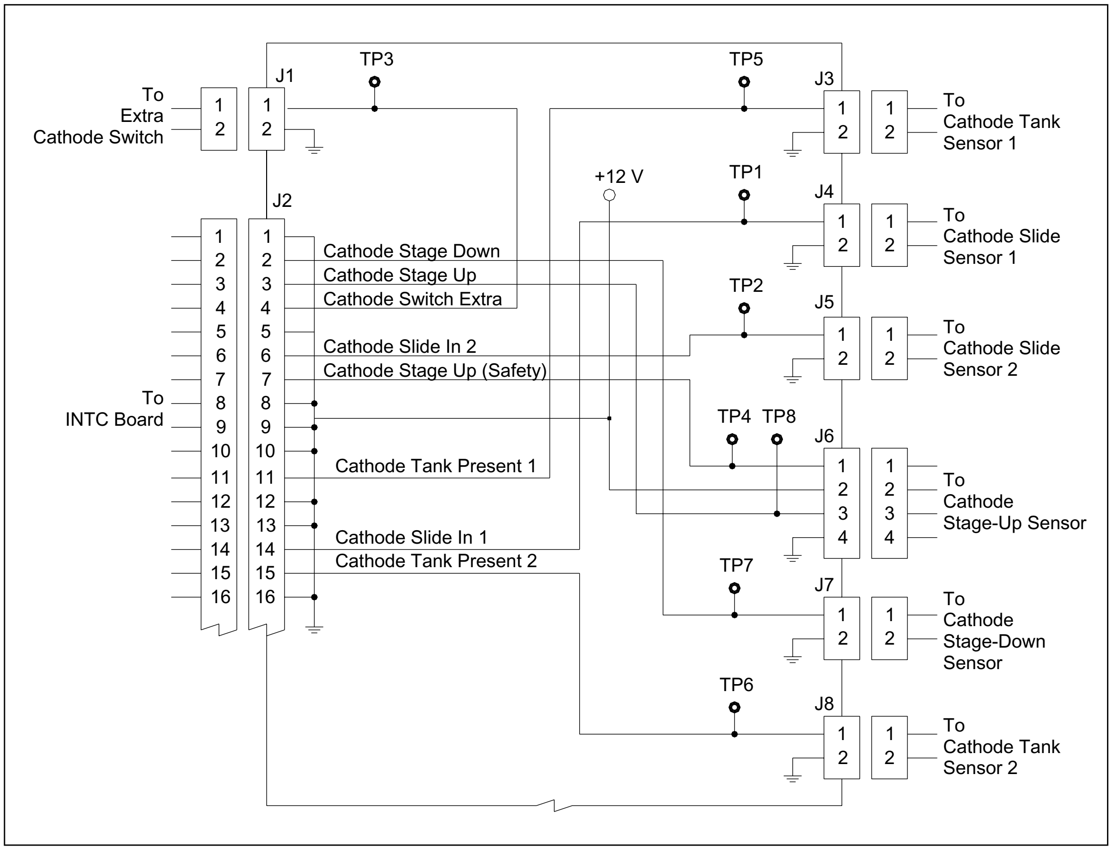



Figure 5-60. Cathode Connector Board Connector Detail Diagram (MB 2000) (Sheet 1 of 2).

- **Jack J1**—Is a two-pin connector. It connects to the capillary array stand detection sensor via a two-wire cable.
- **Jack J2**—Is a 50-pin connector. It connects to a 50-wire cable that routes the cathode stage sensor signals to the INTC board and the solenoid control signals from the INTC board to the cathode.
- **Jack J3**—Is a two-pin connector. It connects to the first cathode tank detection sensor via a two-wire cable.
- **Jack J4**—Is a two-pin connector. It connects to the first cathode slide-in detection sensor via a two-wire cable.
- **Jack J5**—Is a two-pin connector. It connects to the second cathode slide-in detection sensor via a two-wire cable.
- **Jack J6**—Is a four-pin connector. It connects to the two cathode stage-up detection sensors via a four-wire cable.
- **Jack J7**—Is a two-pin connector. It connects to the cathode stage-down detection sensor via a two-wire cable.
- **Jack J8**—Is a two-pin connector. It connects to the second cathode tank detection sensor via a two-wire cable.

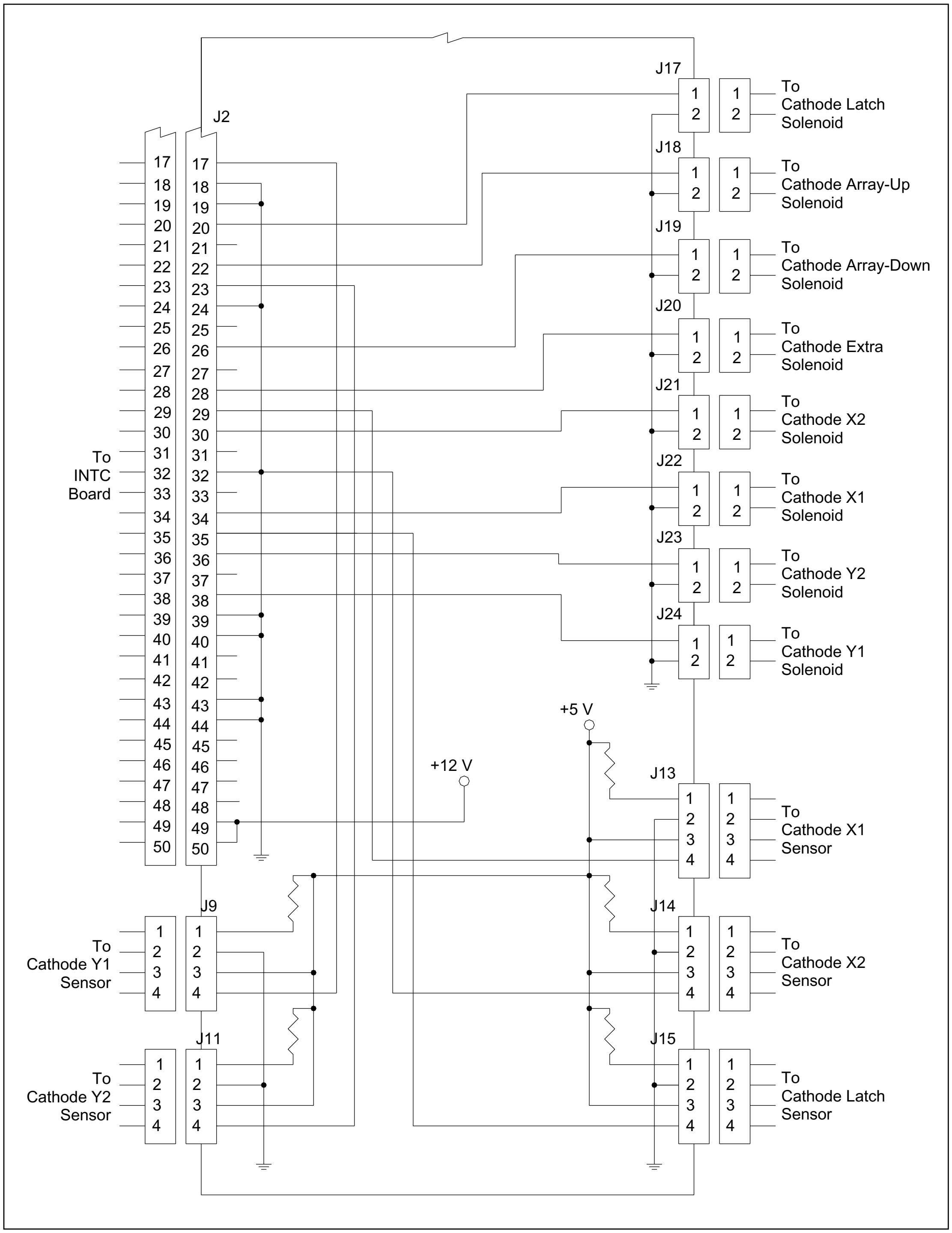



Figure 5-61. Cathode Connector Board Connector Detail Diagram (MB 2000) (Sheet 2 of 2).

- **Jack J2**—Is a 50-pin connector. It connects to a 50-wire cable that routes the cathode stage sensor signals to the INTC board and the solenoid control signals from the INTC board to the cathode.
- **Jack J9**—Is a four-pin connector. It connects to the cathode Y1 optical sensor via a four-wire cable.
- **Jack J11**—Is a four-pin connector. It connects to the cathode Y2 optical sensor via a four-wire cable.
- **Jack J13**—Is a four-pin connector. It connects to the cathode X1 optical sensor via a four-wire cable.
- **Jack J14**—Is a four-pin connector. It connects to the cathode X2 optical sensor via a four-wire cable.
- **Jack J15—**Is a four-pin connector. It connects to the latch optical sensor via a two-wire cable.
- **Jack J17**—Is a four-pin connector. It connects to the latch solenoid via a two-wire cable.
- **Jack J18—**Is a two-pin connector. It connects to the array-up solenoid via a two-wire cable.
- **Jack J19—**Is a two-pin connector. It connects to the array-down solenoid via a two-wire cable.
- **Jack J20**—Is a two-pin connector. It connects to a spare solenoid via a two-wire cable.
- **Jack J21**—Is a two-pin connector. It connects to the X2 drive solenoid via a two-wire cable.
- **Jack J22**—Is a two-pin connector. It connects to the X1 drive solenoid via a two-wire cable.
- **Jack J23—**Is a two-pin connector. It connects to the Y2 drive solenoid via a two-wire cable.
- **Jack J24—**Is a two-pin connector. It connects to the Y1 drive solenoid via a two-wire cable.

### 5.6.3 Anode Connector Board

The anode connector board provides a connection point for the anode assembly optical sensors, safety switches, and clamp motor drive. The anode connector board output leaves the board at jack J2 where it is routed to the INTC board.

#### 5.6.3.1 Component Layout

The component layout of the anode connector board is shown in figure 5-62. The illustration shows the test point and connector locations. Test point details are provided below.

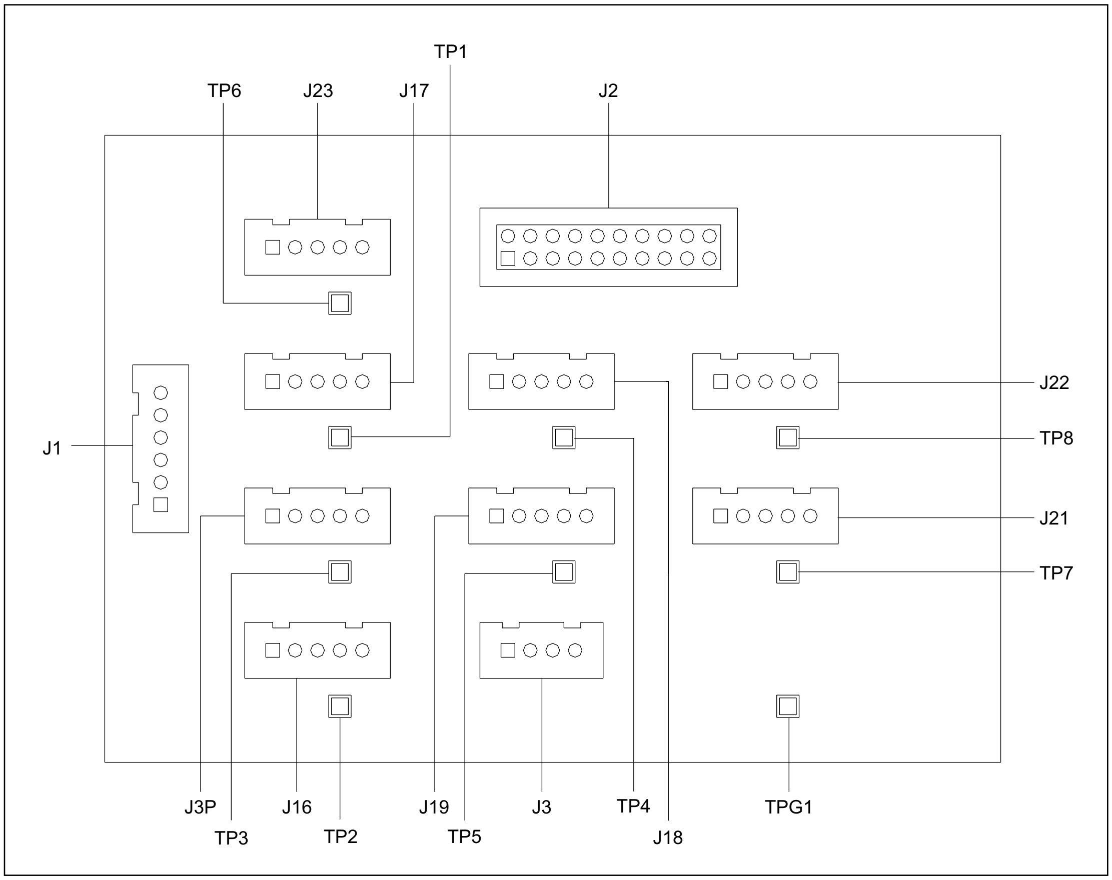



Figure 5-62. Anode Connector Board Component Layout Diagram.

- **Test Point TP1**—Clamp unlock.
- **Test Point TP2**—Clamp lock.
- **Test Point TP3**—Retainer lock.
- **Test Point TP4**—Anode stage up 1.
- **Test Point TP5**—Anode stage up 2.
- **Test Point TP6**—Anode optical 1.
- **Test Point TP7**—Anode slide in 1.
- **Test Point TP8**—Anode slide in 2.
- **Test Point TPG1**—Ground.

### 5.6.3.2 Connector Details

The connector details for the anode connector board are shown in figure 5-63.

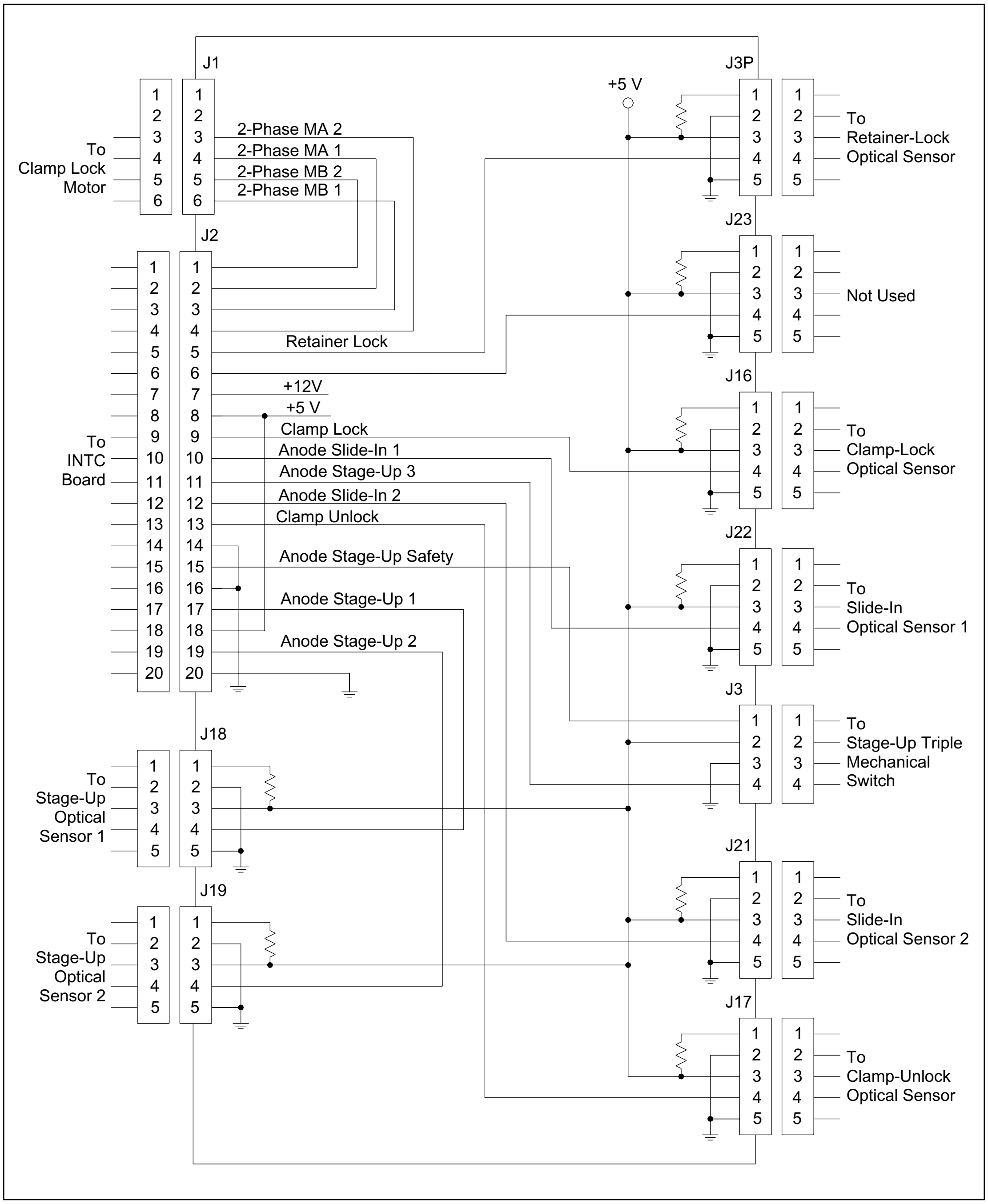



Figure 5-63. Anode Connector Board Connector Detail Diagram.

- **Jack J1**—Is a six-pin connector. It connects to the clamp-lock motor on the anode stage via a four-wire cable.
- **Jack J2**—Is a 20-pin connector. It connects to a 20-wire cable that routes the anode stage sensor signals to the INTC board and clamp-lock motor control voltages from the INTC board.
- **Jack J3**—Is a four-pin connector. It connects to the triple mechanical switch via a two-wire cable. Two of the three switches serve as redundant interlocks for the high-voltage circuit. The other switch provides an additional indication that the anode stage is up.
- **Jack J3P**—Is a five-pin connector. It connects to the retainer-lock optical sensor via five-wire cable.
- **Jack J16**—Is a five-pin connector. It connects to the clamp-lock optical sensor via a five-wire cable.
- **Jack J17**—Is a five-pin connector. It connects to the clamp-unlock optical sensor via a five-wire cable.
- **Jack J18**—Is a five-pin connector. It connects to the stage-up optical sensor 1 via five-wire cable.
- **Jack J19**—Is a five-pin connector. It connects to the stage-up optical sensor 2 via a five-wire cable.
- **Jack J21**—Is a five-pin connector. It connects to the slide-in optical sensor 2 via a five-wire cable.
- **Jack J22**—Is a five-pin connector. It connects to the slide-in optical sensor 1 via a five-wire cable.
- **Jack J23**—Not used.

### 5.6.4 Pressure Connector Board

The pressure connector board provides a connection point for the pneumatic assembly solenoid power connections. The pressure connector board input comes into the board at jack J2 from the INTC board.

#### 5.6.4.1 Component Layout

The component layout of the pressure connector board is shown in figure 5-64. The illustration shows the connector locations.

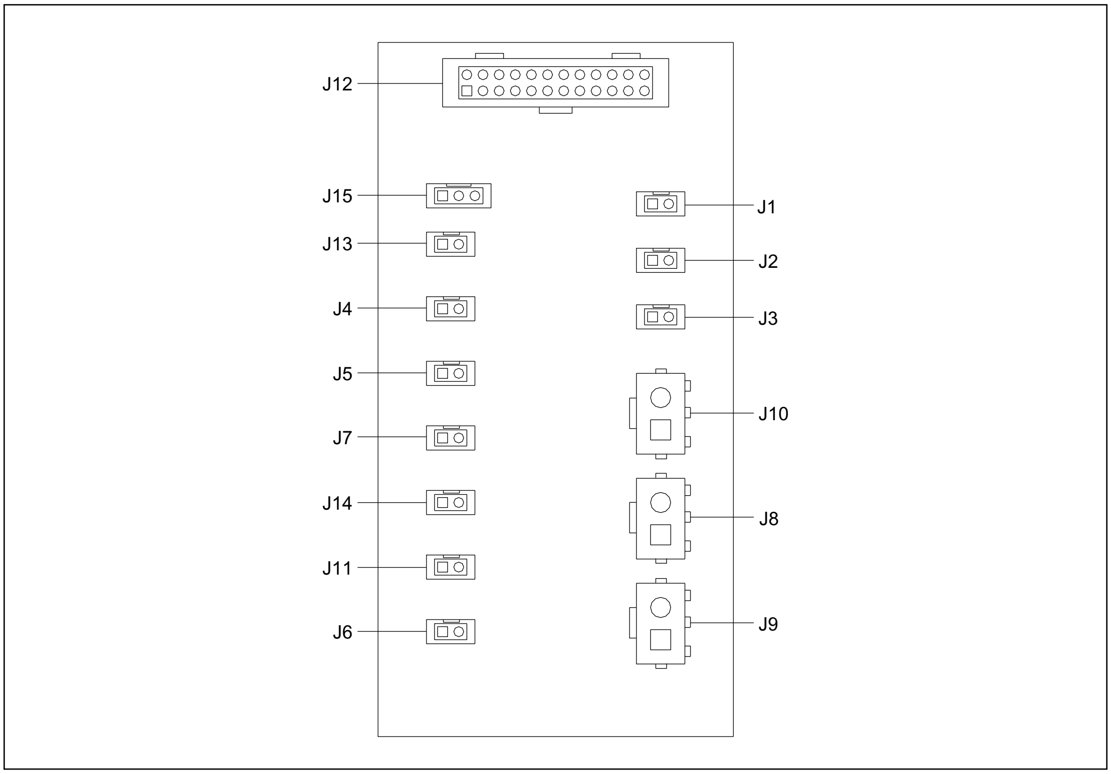



Figure 5-64. Pressure Connector Board Component Layout Diagram.

### 5.6.4.2 Connector Details

The connector details for the pressure connector board are shown in figure 5-65.

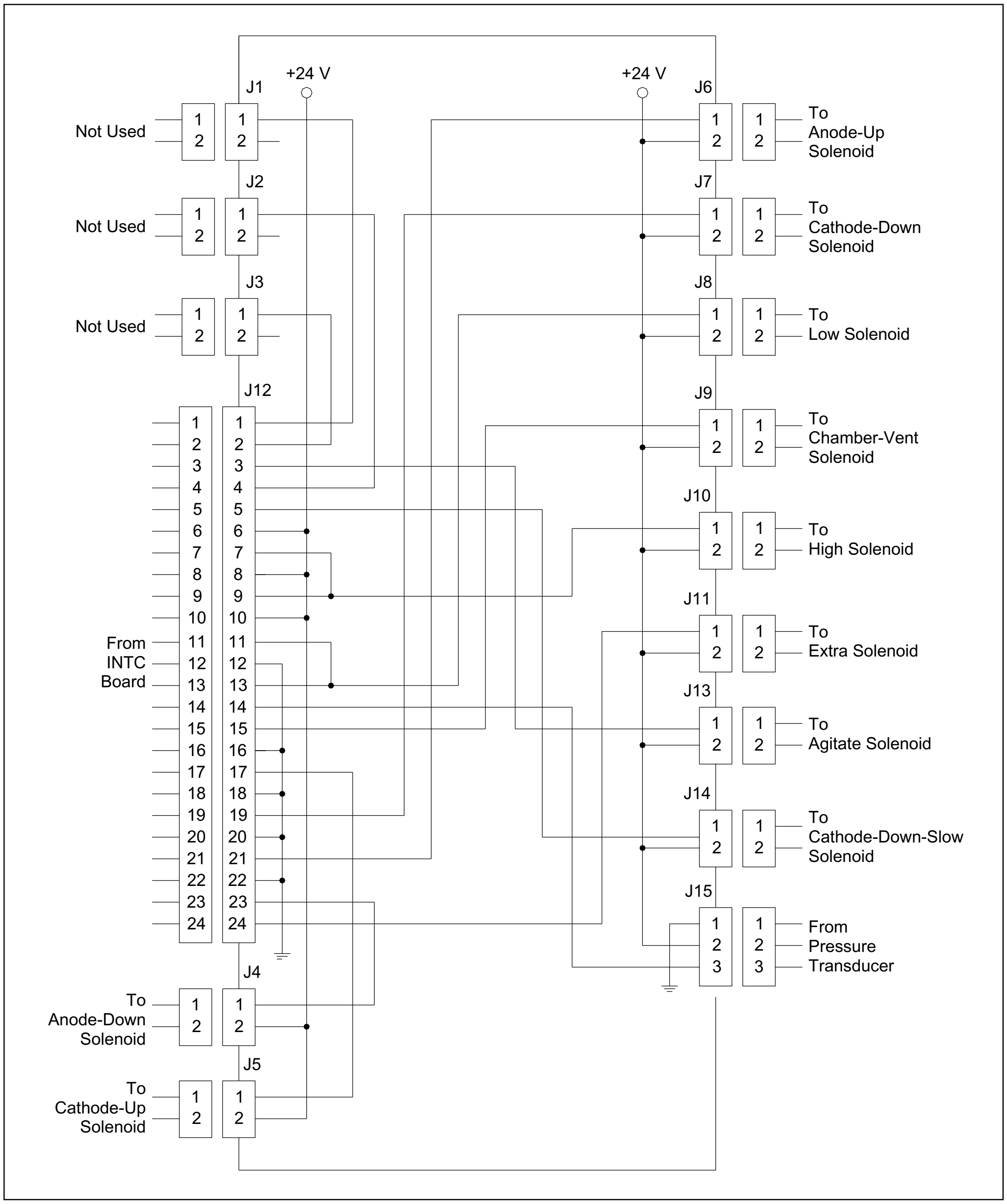



Figure 5-65. Pressure Connector Board Connector Detail Diagram.

- **Jack J1**—Not used.
- **Jack J2**—Not used.
- **Jack J3**—Not used.
- **Jack J4**—Is a two-pin connector. It connects to the anode-down solenoid via a two-wire cable.
- **Jack J5**—Is a two-pin connector. It connects to the cathode-up solenoid via a two-wire cable.
- **Jack J6**—Is a two-pin connector. It connects to the anode-up solenoid via a two-wire cable.
- **Jack J7**—Is a two-pin connector. It connects to the cathode-down solenoid via a two-wire cable.
- **Jack J8**—Is a two-pin connector. It connects to the low-pressure solenoid via a two-wire cable.
- **Jack J9**—Is a two-pin connector. It connects to the chamber-vent solenoid via a two-wire cable.
- **Jack J10**—Is a two-pin connector. It connects to the high-pressure solenoid via a two-wire cable.
- **Jack J11**—Is a two-pin connector. It connects to extra solenoid via a two-wire cable.
- **Jack J12**—Is a 24-pin connector. It connects to the INTC board via a 24-wire cable.
- **Jack J13**—Is a two-pin connector. It connects to the agitate solenoid via a two-wire cable.
- **Jack J14**—Is a two-pin connector. It connects to the cathode-down-slow solenoid via a two-wire cable.
- **Jack J15**—Is a three-pin connector. It connects to the high-pressure transducer via a three-wire cable.

### 5.6.5 LED Board

The LED board provides three LEDs indicating the visual status of the instrument to the operator. The holes for the three LEDs are located in the front right panel where the operator can see the visual status clearly. The LEDs indicate power on, scan on, and high pressure on.

### 5.6.6 LCD Message Boards

The cathode and anode LCD message boards use 32-character LCD chips to display status and operating instructions to the operators. The signals for the two LCD chips are sent from the INTC board. The LCD message boards have plastic lenses to protect the LDC chip when installed in the instrument.

## 5.7 Green Laser Power Supply

The green laser power supply provides the high voltages to the diode laser and is supplied |with +12 volts to drive the high voltage. The green laser power supply should never be disconnected from the laser head.

## 5.8 Service Door

The service door provides access to the electrophoresis (capillary) compartment where the capillaries attach to the cathode array stand, the window platform, and the anode assembly. During a run operation, the anode stage is at an extremely high voltage potential. To protect the user and to maintain a constant temperature in the electrophoresis compartment, the service door must remain closed.

The service door is hinged at the two sides and actuates the two door switches when closed. The door switches are in series with the other system interlock switches and carry the +12 volts that keep two safety relays closed. When the service door is opened or when one of the other interlocks is opened, the +12 volts is removed from the safety relays. When these relays de-energize, the high voltage is turned off, and the power to the shutter motor is interrupted. The shutter is pulled to the home position, blocking both lasers. The service door also actuates a sensing signal to turn off the blower motor, heater elements, and TE cooler to the electrophoresis compartment. This prevents hot air from blowing into the operator’s face when the service door is opened.

## 5.9 Safety Interlock System

The safety interlock system provides protection for both the instrument and the operator. Figure 5-66 is a functional block diagram of the safety interlock system. In figure 5-66, all the contacts of the mechanical switches and relays are shown in the open position. During normal operation, all these contacts will be closed. Venting the vessel chamber and raising the anode and cathode stages also rely on software commands. Position data for the anode and cathode stages are provided by various switches and sensors. The CPU reads this data and, when all appropriate conditions are met, sends the software commands to raise the stages or vent the vessel chamber. The interlock circuits are described below.

- Mechanical switches are located on either side of the service door and are connected in series. During normal operation, +12 volts is routed through the closed contacts of these switches to a relay located on the shutter motor driver board. The contacts of this relay route the +24-volt operating potential to the shutter motor driver circuit. When the service door is opened, these switches open, causing the relay on the shutter motor driver board to de-energize. With no power to the motor driver circuit, the spring on the shutter pulls the shutter to the home position, blocking the laser beams. If the interlock system is activated but the shutter fails to return to the home position, a software command to the laser control logic shuts down all lasers.
- An air switch senses the air flow to the blue laser and shuts the laser down when the air flow ceases. This circuit protects the blue laser only.
- Mechanical switches are located on the rear of the anode and cathode stages and are connected in series with the service door interlock switches. The anode and cathode stage switches are closed when the stages are in the up position. During normal operation, +12 volts is routed through the closed contacts of these switches to one input of an AND function. The other input to this AND function is a software command. When both the inputs are true, a relay located on the EPHV board energizes. The contacts of this relay route the +24-volt operating potential to the HV power supply. When the service door is opened or either the anode or cathode stage is lowered, one or more of these switches open, causing the relay on the EPHV board to de-energize and disable the high voltage.

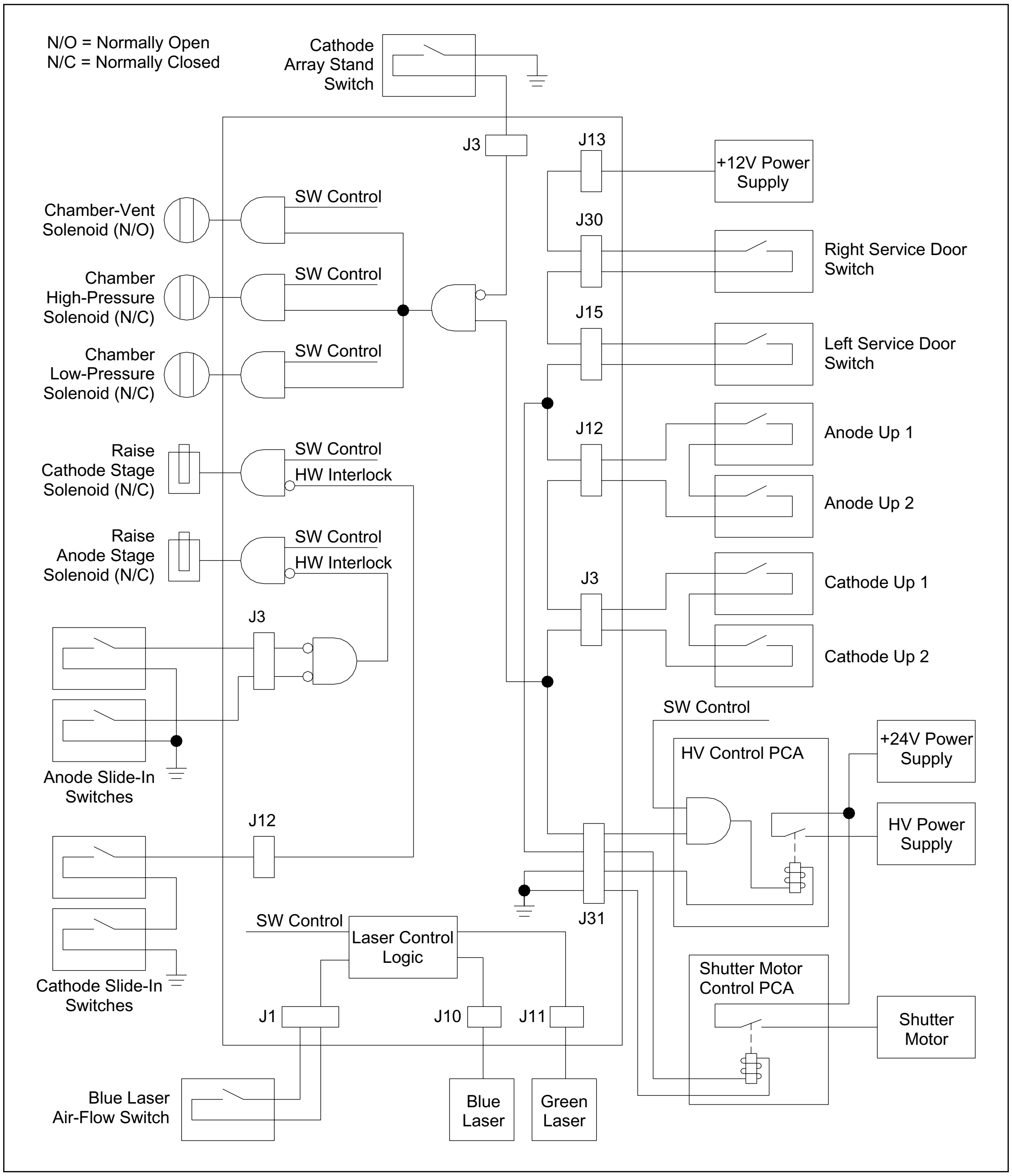



Figure 5-66. Safety Interlock System Block Diagram.

- An AND function combines the high level felt through the service door switches and the anode and cathode stage switches with the low level from the capillary array stand interlock switch. The output of the AND function enables three additional AND functions that control the chamber-vent solenoid, chamber high-pressure solenoid, and the chamber low-pressure solenoid. The other inputs to these AND functions are software commands. This circuitry ensures that the anode and cathode stages are raised, the service door is closed, and the capillary array stand is lowered before the vent is closed and the chamber can be pressurized. The chamber will be vented automatically if any of the interlocks is opened or if power is lost.

*WARNING* **The automatic venting is for the chamber only. The pressure lines entering the instrument are not vented.**

- Two mechanical switches located on the rear of the anode stage sense when the anode-stage slide is not pushed in all the way. When either of these switches is opened, the AND function that controls the anode-up solenoid is disabled. The other input to the AND function is the software command to raise the anode stage. This circuitry ensures that the stage can be raised only if its slide is pushed in all the way and the software command has been sent.
- Two mechanical switches located on the side of the cathode stage sense when the cathode-stage slide is not pushed in all the way. When either of these switches is opened, the AND function that controls the cathode-up solenoid is disabled. The other input to the AND function is the software command to raise the cathode stage. This circuitry ensures that the stage can be raised only if its slide is pushed in all the way, and the software command has been sent.

# Part Three

## Maintenance

# Chapter 6 Operation

## 6.1 Introduction

This chapter describes the general startup operation of the instrument and the operations you may need to perform when servicing the instrument. Because there are times when you will have to operate the instrument with the covers removed and the interlocks defeated, pay particular attention to the safety hazards that you may encounter.

## 6.2 Safety Precautions

This section discusses the following safety issues—

- General Precautions
- Cathode and Anode Compartments
- Electrophoresis Compartment
- Filter Compartment
- Internal Electronics
- Chemicals
- Nitrogen Cylinders and Pressure Regulators
- Lasers
- PMTs
- Power Supply Fan Module, Computer, and Monitor
- System Electrical Connections
- Serial Number Labels
- Location of Important Labels

## 6.3 General Precautions

Under normal operating conditions, you are protected from laser light, high voltage, high pressure, and moving parts. The cathode and anode drawers and the lid of the electrophoresis compartment are fitted with sensors and interlocks. The access lid of the filter compartment has a safety switch. Figure 6-1 shows the location of the drawers and lids used during routine operation of the instrument.

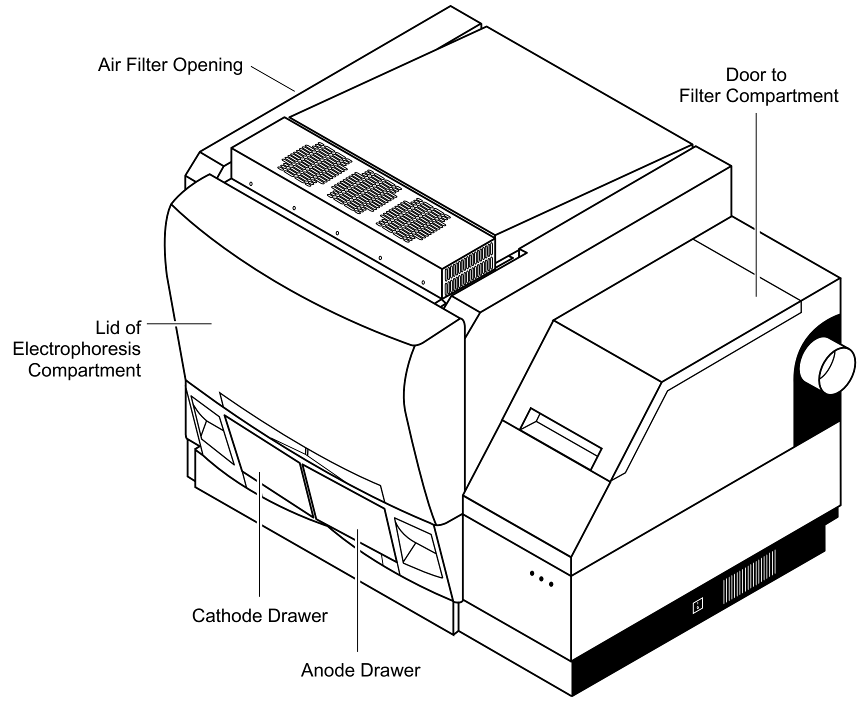



Figure 6-1. Instrument Access Ports.

*WARNINGS* **Defeat the sensors and interlocks only when absolutely necessary. After you gain access to the interior of the instrument, you are exposed to hazards that can cause injury or death.**

**Do not attempt to lift the instrument. The instrument weighs approximately 272 kg (600 lb). Lifting the instrument can cause injury.**

## 6.4 Cathode and Anode Compartments

When the workflow requires access to the cathode or anode compartment, the system shuts off the high voltage and nitrogen pressure and lowers the cathode or anode stage before unlocking the corresponding drawer. Then the LCDs on the front of the instrument instruct you to perform the next step.

No voltage, pressure, or laser light can be applied as long as either drawer remains open. When you close the cathode or anode drawer, the software assumes that you have performed the step displayed on the LCD. The drawer locks, and the system raises the stage. The system automatically moves to the next step.

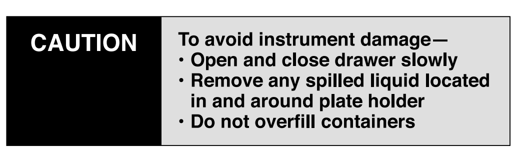



Figure 6-2. The liquid spillage caution label.

## 6.5 Electrophoresis Compartment

You may occasionally need to open the lid to the electrophoresis compartment.

*WARNING* **When the lid of the electrophoresis compartment is open, do not place your hands on or near the two support bars on each side of the lid. If the lid moves, your fingers can be pinched.**

*Achtung* **WENN DER DECKEL DER ELEKTROPHORESE-KAMMER GEÖFFNET IST, FINGER NICHT AN ODER AUF DIE BEIDEN HALTESCHIENEN AUF JEDER SEITE DES DECKELS LEGEN. WENN DER DECKEL SICH BEWEGT, KÖNNEN FINGER EINGEKLEMMT WERDEN.**

The label shown in figure 6-3 warns of this pinching hazard. Figure 6-12 shows the locations of two pinching hazard labels, one on each side of the top portion of the instrument.

Figure 6-3.  Pinching Hazard Label.

Under normal operating conditions, you are protected from high voltage. Nevertheless, during the prerun and sample electrophoresis, voltages up to 20 kV are present in the electrophoresis compartment. The label in figure 6-4 warns of this danger and is located on the left side of the instrument on the side wall inside the electrophoresis compartment and on the PMT cover. Figure 6-12 shows the location of the label.

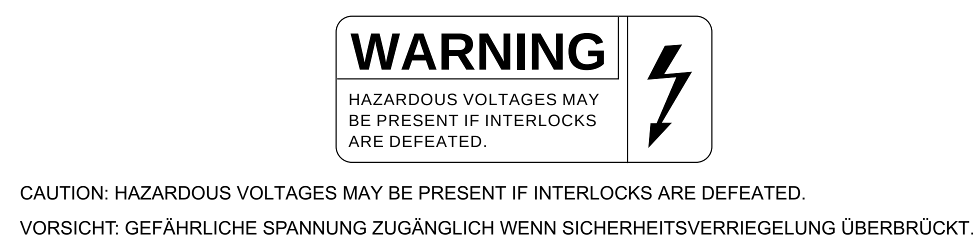



Figure 6-4.  High-Voltage Warning Label.

*WARNINGS* **The instrument has sensors and interlocks that are designed to protect you from moving parts, high pressure, hazardous voltage, or laser light. Do not defeat the sensors or interlocks. Do not remove panels for any reason. Exposure to these hazards can cause injury or death.**

**Check the operation of the interlock on the electrophoresis compartment lid periodically to make sure the interlock is functioning properly.**

**Do not pull on the capillaries to release the cathode bar or the anode plug. The capillaries are fine glass tubes and can break, leaving sharp ends or fragments, which can damage the instrument or cause injury.**

*CAUTIONS* **Do not leave any objects inside the electrophoresis compartment or on the stages. Metal objects can cause arcing when high voltage is applied during electrophoresis, possibly damaging the instrument.**

**Always avoid touching the windows of the capillaries. Oils and salts from your skin could result in arcing between capillaries during high-voltage electrophoresis, which could damage the instrument.**

**Avoid spills in the chamber and below the sample stages. Clean all spills immediately. A spill in the high-voltage area can cause arcing and damage the instrument.**

*CAUTION* **Opening the electrophoresis compartment lid during an electrophoresis run interrupts the data recording. Open the lid between runs only. If you need to open the lid during a run, stop the run first to protect the data you have already collected.**

*NOTE* **The capillaries become warm during electrophoresis.**

For your protection, sensors make sure that when the lid opens—

- If the electrophoresis voltage is on, the high-voltage power supply shuts off, and the voltage drains.
- If the laser shutter is open, the shutter closes and blocks laser light from entering the compartment.
- If nitrogen pressure is present in the anode vessel, the pressure shuts off, and the pressure vents.

In addition, the temperature control for the electrophoresis compartment turns off. You cannot scan until you close the lid.

## 6.6 Filter Compartment

To ensure proper data recording, you should check that the appropriate filters and beamsplitters are installed before starting an electrophoresis run.

When you open the filter compartment lid, the system shuts off voltage to the PMTs, which protects the PMTs and stops the data collection.

## 6.7 Internal Electronics

Under normal operating conditions, you are protected from high voltage within the instrument electronics. Nevertheless, voltages up to 20 kV are present in the instrument during a scan. The label in figure 6-4 warns of this danger. Figure 6-12 shows the location of the label on the left side of the instrument inside the electrophoresis compartment.

## 6.8 Chemicals

*WARNING* **Some of the chemicals used in the sample and matrix preparation are hazardous. Use good laboratory procedures and follow the manufacturer’s precautions when working with chemicals.**

## 6.9 Nitrogen Cylinders and Pressure Regulator

The system requires the use of high-pressure nitrogen sources.

### 6.9.1 Handling High-Pressure Cylinders and Tubing

Always use good laboratory procedures when handling a high-pressure cylinder and follow any instructions provided with the cylinder.

*WARNING* **High-pressure connection. Do not disconnect tubing without bleeding the tubes. Disconnecting without bleeding can cause injury.**

*Achtung* **HOCHDRUCKVERBINDUNG. SYSTEM ENTLÜFTEN BEVOR SCHLAUCHVERBINDUNG GELÖST WIRD. LÖSEN DER VERBINDUNG OHNE ENTLÜFTEN KANN ZU VERLETZUNGEN FÜHREN.**

The label in figure 6-5 warns of this danger. Figure 6-13 shows the location of the label on the back of the instrument.

Figure 6-5. Nitrogen Pressure General Hazard Label.

*WARNING* **Make sure you bolt a standard cylinder bracket to a solid permanent structure in a manner that meets or exceeds all local seismic and safety code requirements.**

### 6.9.2 Instrument Pressure System

The regulators on the external nitrogen cylinder(s) control the amount of nitrogen pressure applied within the instrument. The hose size, hose characteristics, and the fittings inside the instrument are designed to withstand the working pressures.

*WARNINGS* **Do not attempt to adjust the regulators to pressure settings above those described in this user's guide. If you are using separate cylinders for high and low pressure, make sure that the correct pressure is applied to each line.**

**The nitrogen pressure in the high-pressure line must not exceed 6.89 x $10^3$ kPa (1 000 psi) of pressure. The nitrogen pressure in the low-pressure line must not exceed 6.89 x $10^2$ kPa (100 psi) of pressure. Never apply high pressure to the low-pressure line. This can damage the instrument or the low-pressure line and can cause injury.**

Figure 6-6 shows the labels that are placed on the back of the instrument next to the high- and low-nitrogen pressure line connections. Figure 6-13 shows the locations of the labels.

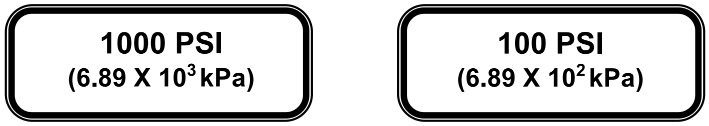



Figure 6-6. High- and Low-pressure Nitrogen Labels.

*WARNING* **Use only hose types with ratings that exceed the required operating pressures. Do not use a frayed or damaged hose, which can rupture and cause injury.**

## 6.10 Lasers

*WARNING* **Changing controls, making adjustments, or performing procedures other than those specified in this user's guide can result in hazardous laser light exposure.**

### 6.10.1 Class 1 Laser Product Label

The instrument satisfies the Class 1 requirements of IEC 825-1:1993 and EN 60825-1. Figure 6-7 shows the Class 1 Product label. Figure 6-12 shows the location of the label on the lower right side of the instrument.

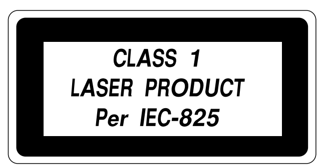
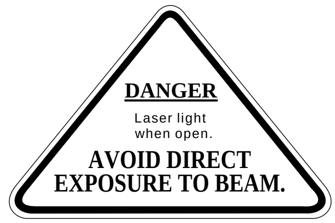



Figure 6-7. The Class 1 Product Label.

### 6.10.2 Laser Light Warning Label

The instrument does not allow operator exposure to laser light. Nevertheless, a blue argon-ion laser with power up to 25 mW at 488 nm with a 0.95 mrad divergence and/or a green solid-state laser with power up to 50 mW at 532 nm with 1.2 mrad divergence are present in the interior of most of the instruments.

The label in figure 6-8 warns of laser light danger. Figure 6-12 shows the locations of the label on the PMT cover and in the electrophoresis compartment of the instrument. If the label becomes illegible for any reason, please contact Molecular Dynamics for a free replacement label.



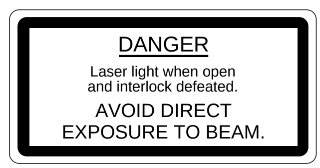

DANGER: LASER LIGHT WHEN OPEN. AVOID DIRECT EXPOSURE TO BEAM.

GEFAHR: LASER! NACH DEM ÖFFNEN DIREKTEN KONTAKT ZUM LASERSTRAHL VERMEIDEN.

Figure 6-8. Laser Light Warning Label.

### 6.10.3 Safety Interlock Danger Label

The label in figure 6-9 warns of the laser danger from defeating the interlock on the electrophoresis compartment. The label is located on the left side of the instrument on the side wall inside the electrophoresis compartment. Figure 6-12 shows the location of the label.




CAUTION: LASER LIGHT WHEN OPEN AND INTERLOCK DEFEATED. AVOID DIRECT EXPOSURE TO BEAM.

VORSICHT: LASERSTRAHLUNG, WENN ABDECKUNG GEÖFFNET UND SICHERHEITSVERRIEGELUNG ÜBERBRÜCKT.

Figure 6-9. Interlock Defeat Danger Label.

## 6.11 PMTs

The PMTs are covered by a protective housing and are not accessible by the operator. During a prerun or electrophoresis run, the PMTs carry a high voltage, which can cause injury if you touch them.

*WARNING* **Exposure to high voltage from the PMTs can cause injury or even death.**

## 6.12 System Electrical Connections

The system includes four devices that require electrical power: the instrument, the power supply fan module, the computer, and the monitor. Molecular Dynamics supplies a total of four electrical power cords with each system, one for each of these main components.

*WARNING* **Use only the power cords supplied. Make sure the cords are in good condition and are not frayed. Use of incorrect power cords can cause damage to the instrument. Use of frayed or damaged power cords can cause injury.**

## 6.13 Serial Number Labels

### 6.13.1 Instrument Serial Number Label

You can find the serial number and model number of your instrument on the serial number label (figure 6-10). The label is located on the lower-right side of the instrument. Figure 6-12 shows the location of the label. You will need the serial number when contacting Molecular Dynamics about your instrument.

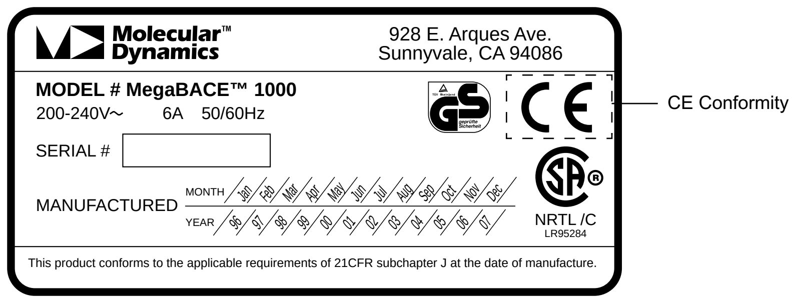



Figure 6-10. The Instrument Serial Number Certification Label.

### 6.13.2 Power Supply Fan Module Serial Number Label

You can find the serial number and model number of the power supply fan module on the serial number label (figure 6-11). The label is located on the back of the power supply fan module. Figure 6-14 shows the location of the label. You will need the serial number when contacting Molecular Dynamics about your instrument.

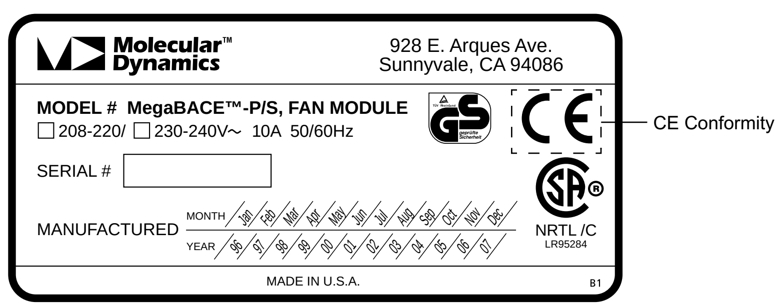



Figure 6-11. The Power Supply Fan Module Serial Number Certification Label.

## 6.14 Location of Important Labels

The locations of important labels on the instrument are shown in figures 6-12 and 6-13. Figure 6-14 shows the location of the serial number label on the power supply fan module.

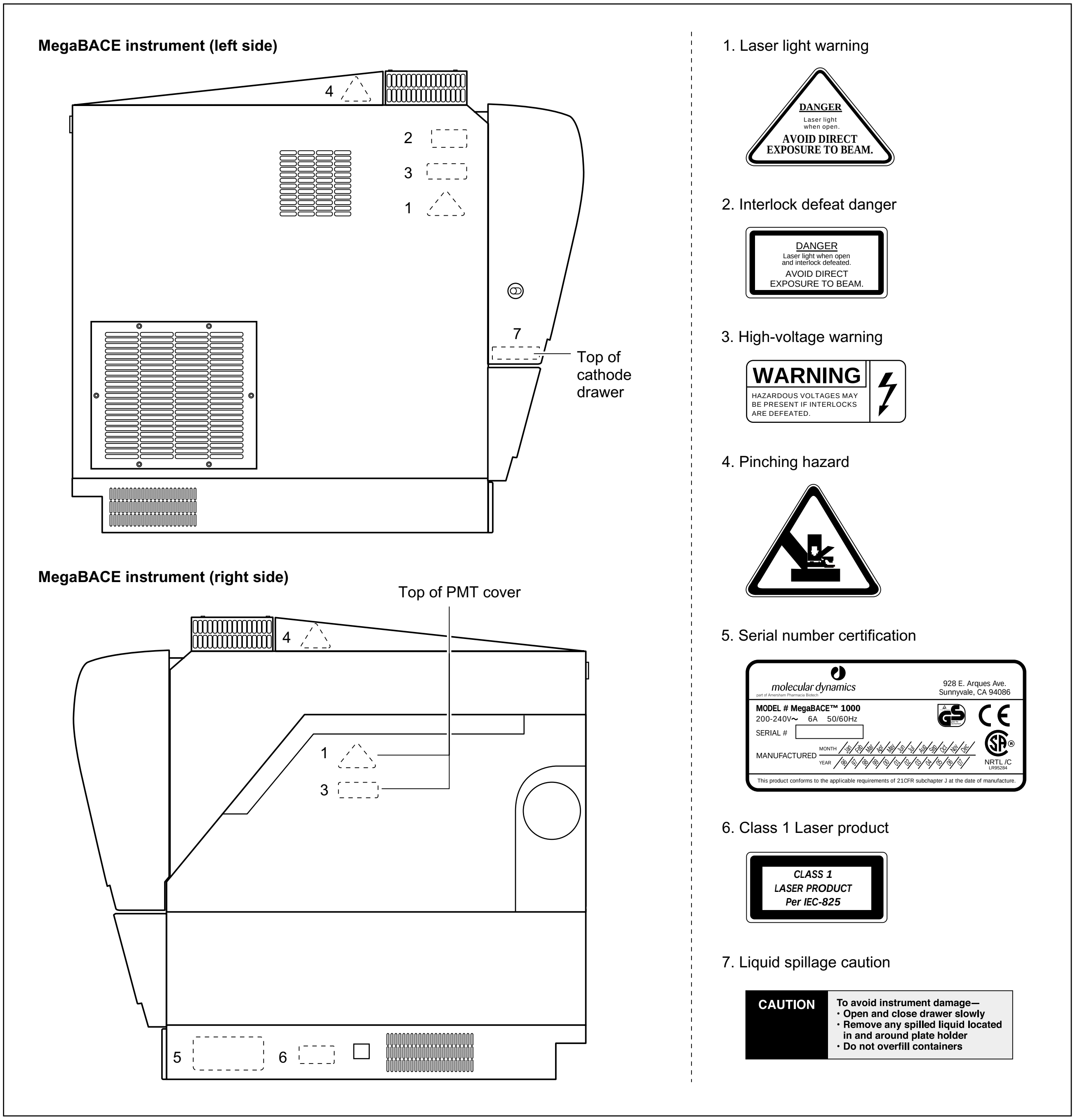



Figure 6-12. Location of Important Labels On The Instrument (Side Views).

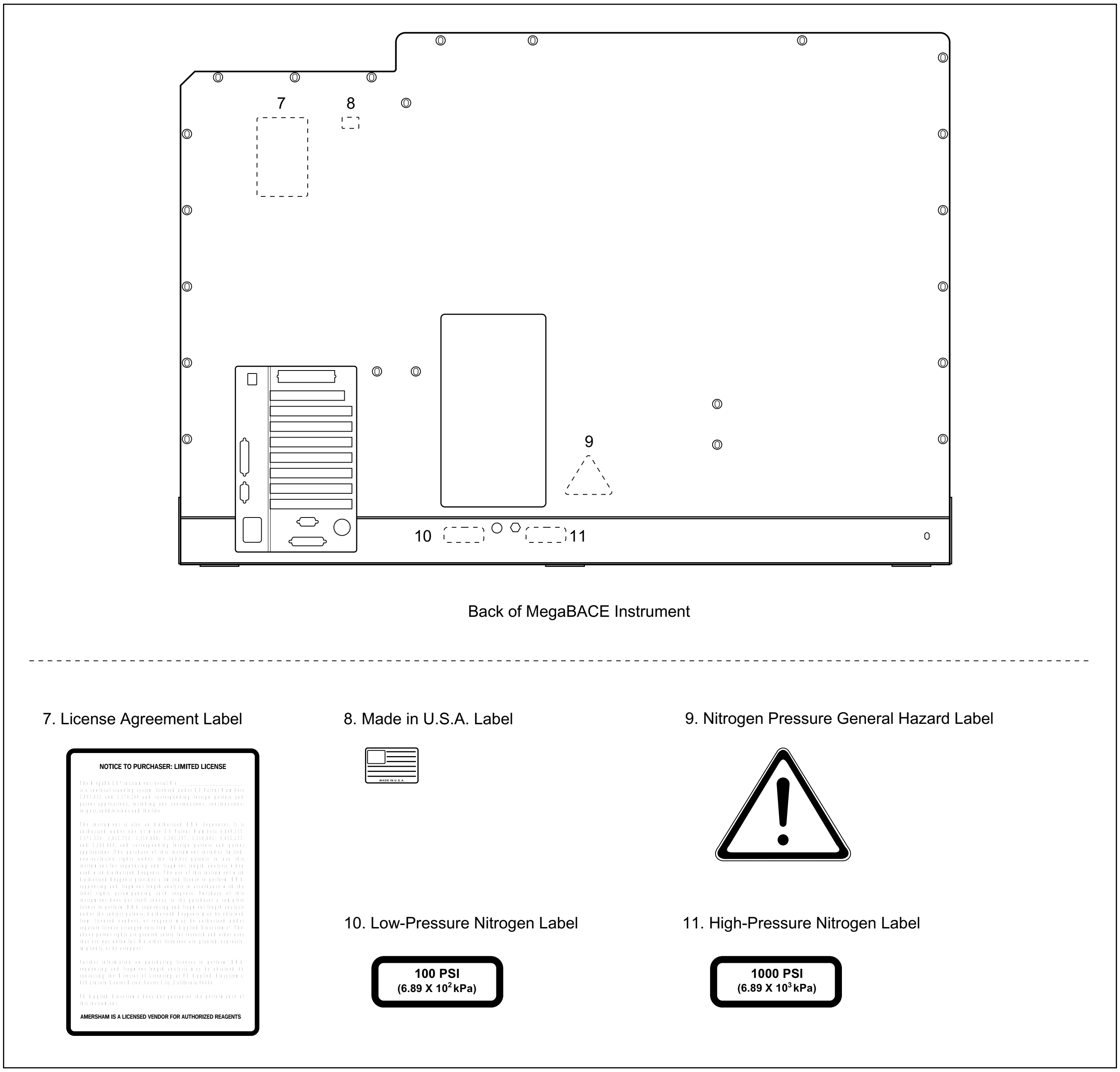



Figure 6-13. Locations of Important Labels on the Instrument (Back View).

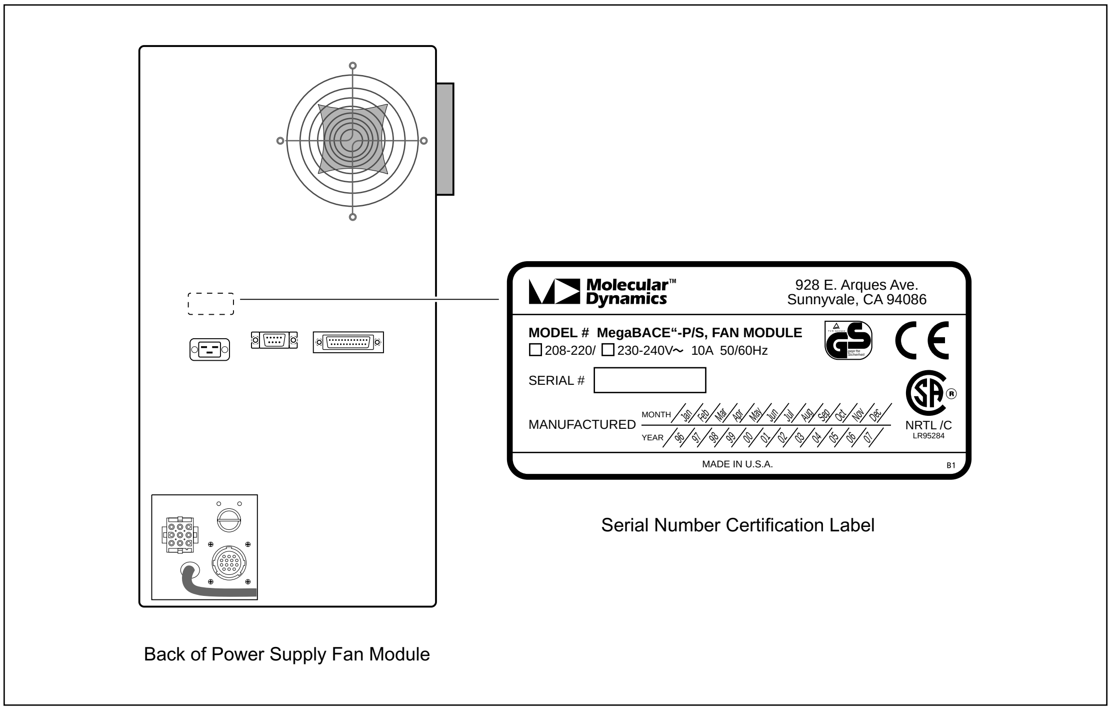



Figure 6-14. Location of the Serial Number Certification Label on the Power Supply Fan Module.

## 6.15 Preparing for Operation

Before turning on the instrument, check the following:

**Nitrogen Pressure System**—

- The nitrogen cylinder(s), regulators, and tubing are correctly connected and in good condition.
- The cylinder(s) contain sufficient pressure to complete one run (based on usage in the lab).

**Laser, Cooling, and Cables**—

- The laser-cooling air hoses and the control cables are correctly connected and in good condition.
- Nothing is blocking free air access to the air vents on the sides and top of the instrument and on the back of the power supply fan module (figure 6-14). The exhaust on the side of the power supply fan module can be connected to an exhaust hose that is vented out of the room. If the exhaust fan is external to the power supply fan module, make sure the fan is on.

**Power Connections**—

- The instrument, computer, and monitor are plugged in.
- The power supply fan module is plugged in, and the key on the back of the unit is in the horizontal (on) position (figure 6-15).

*NOTE* **The new CE version of the power supply fan module does not have a key. On this module, set the 220/100 voltage switch to 220 and the HIGH/LOW switch to HIGH if your voltage is 230–264 VAC and to LOW if your voltage is 180–229 VAC.**

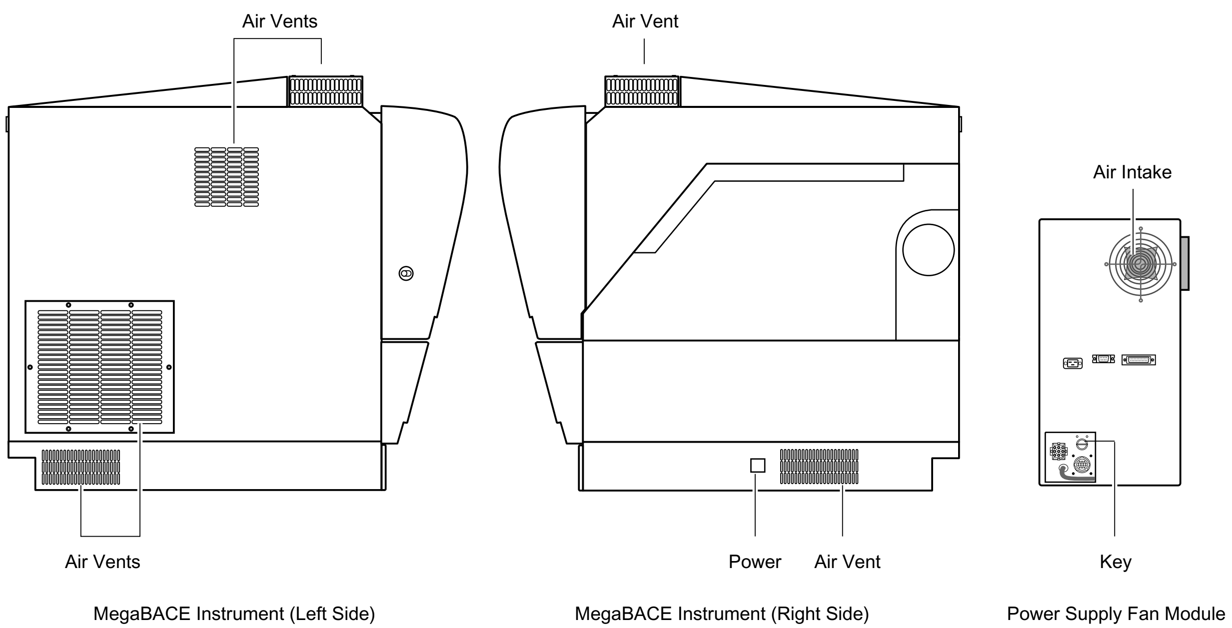



Figure 6-15. Instrument Airflow Openings.

## 6.16 Starting the System

To start up the system, turn on the nitrogen pressure system to regulate it to the correct pressure, turn on the instrument to warm up the instrument electronics, and turn on the computer.

You can use the computer without turning on the instrument. To do this, leave the nitrogen pressure off and the instrument power switch off. If you later decide to turn on the instrument, follow the instructions in the next sections.

### 6.16.1 Nitrogen Pressure System

If the nitrogen pressure system is not already on, turn on the valve at the top of the cylinder and set the high- and low-pressure valves.

### 6.16.2 Instrument and Computer

Always turn on the instrument and computer in the following order:

1. Turn on the **power** switch on the right side of the instrument (figure 6-15). The instrument starts up—
   - The power light on the front of the instrument turns on.
   - The electronics in the instrument begin to warm up.
   - After the internal diagnostics are complete, the displays on the front of the instrument display the message, **MegaBACE DNA Sequencing System.**

2. Wait at least 45 seconds after turning on the instrument. Then turn on the computer and the monitor.

*NOTE* **After the computer is turned on, it checks for connected instruments that have been turned on. The computer then tracks these instruments and their SCSI locations as long as the computer remains on. If you leave the computer on and turn off the instrument, when you turn on the instrument again, the computer still recognizes and can communicate with the instrument. However, if you turn off the computer, you must repeat steps 1 and 2 above.**

## 6.17 Warm-up Times

After you turn on the power switch of the instrument, the internal electronics take approximately 5 minutes to warm up.

The blue laser warms up in 5 minutes, and the green laser warms up in 10 minutes. The blue laser remains in the standby mode until you perform a scan. The green laser does not have a standby mode.

The air in the electrophoresis compartment reaches the temperature set in the Instrument Parameters window in a few minutes. The components in the compartment stabilize at the set temperature in approximately 3 hours, depending on the temperature change involved.

Table 6-1 provides examples of approximate warm-up times from room temperature or for changes in setpoint.

**Table 6-1 Examples of Warm-up Times from Room Temperature or for Changes in Setpoint**

| Temperature Change | Wait Time |
|---|---|
| <5 °C (<41 °F) | 1 minute |
| 5–10 °C (41–50 °F) | 10 minutes |

*CAUTION* **Opening the electrophoresis compartment lid causes the temperature in the compartment to drop. You must allow time for the electrophoresis compartment to rewarm to the temperature you set for the run. Insufficient temperature may cause unreliable data collection results.**

Table 6-2 provides examples of warm-up times necessary before running samples. If you run samples before the compartment has stabilized to the set run temperature, the quality of the run will be unpredictable.

**Table 6-2 Examples of Warm-up Times for the Electrophoresis Compartment for a Set Temperature of 44°C**

| Time Open | Warmup Time |
|---|---|
| 1 minute | 1 hour |
| 1 to 15 minutes | 2 hours |
| > 15 minutes | 3 hours |

## 6.18 Starting the Host Scan Controller software

You use the Host Scan Controller software to start communication between the MegaBACE instrument and the Instrument Control Manager software. After you start the Instrument Control Manager, you can minimize the Host Scan Controller and use the Command Log tab on the Instrument Control window to monitor the running of the system (section 5.1 of the *MegaBACE Instrument Operator's Guide*).

To start the Host Scan Controller software—

1. Double-click the MegaBACE folder on the Windows NT or Windows 2000 desktop (figure 6-16) to open the folder and display the icons for the MegaBACE software. (Alternatively, you can start the Host Scan Controller software using the Start menu.)

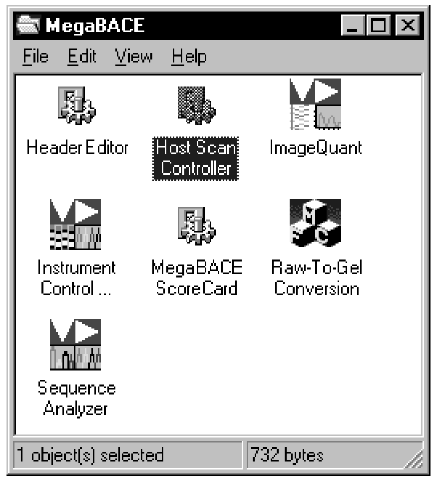



Figure 6-16. The MegaBACE folder. Note that the icon for the applicable analysis software appears in this folder (Sequence Analyzer or Genetic Profiler).

2. Double-click the **Host Scan Controller** icon. The Host Scan Controller window appears.
3. (Optional) You can minimize the Host Scan Controller and monitor the run using the Command Log tab on the Instrument Control window.

**Note:** After starting, the Host Scan Controller downloads the firmware, and displays the instrument model number.

*IMPORTANT* **Wait about 10 seconds for the Host Scan Controller to complete initialization before starting the Instrument Control Manager.**

## 6.19 Starting the Instrument Control Manager software

***IMPORTANT*** **The Host Scan Controller must be running to start the Instrument Control Manager (section 3.3 of the *MegaBACE Instrument Operator's Guide*).**

The Instrument Control Manager software provides the various protocols that step you through using the instrument.

To start the Instrument Control Manager, open the MegaBACE folder and double-click the **Instrument Control** icon. The Instrument Control Manager opens and displays the Plate Setup window (figure 6-17).

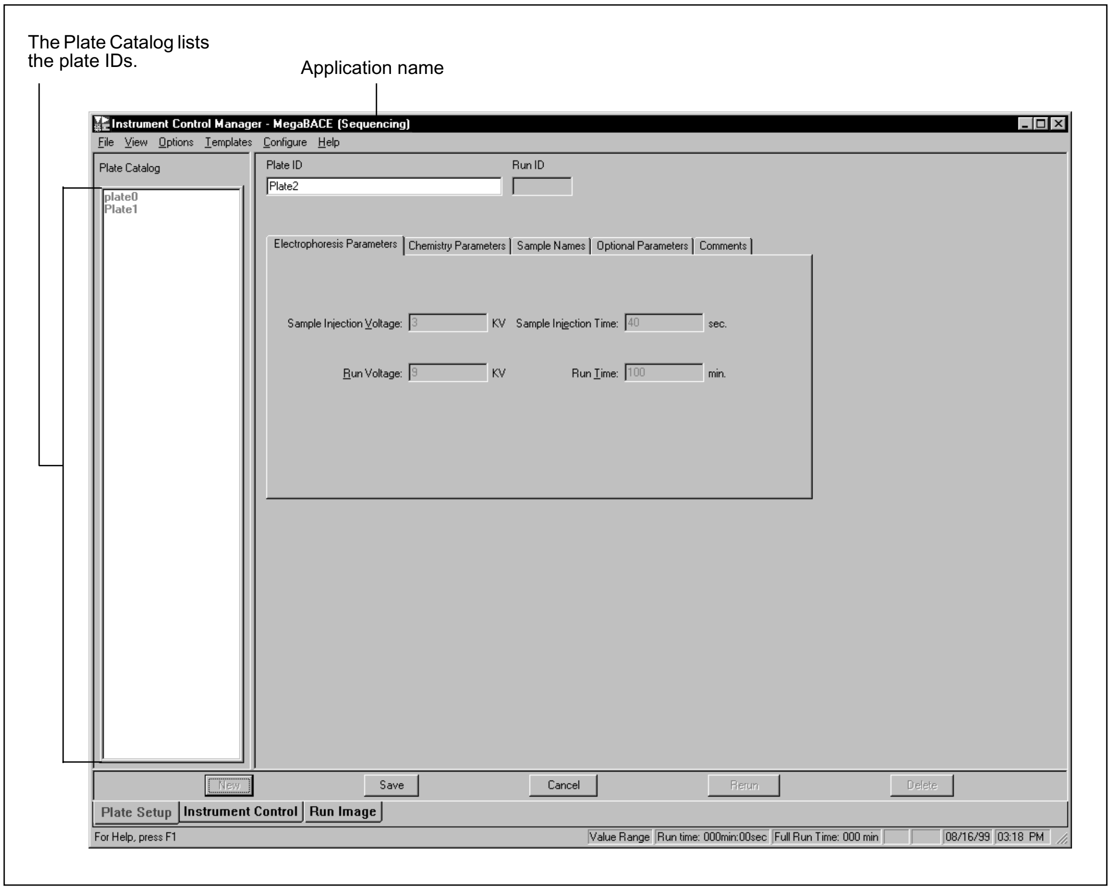



Figure 6-17. The Instrument Control Manager software displaying the Plate Setup window and the Plate Catalog. Note that sequencing is selected as the application and displayed in the title bar.

To use the protocols for running the instrument, click the **Instrument Control** tab to display the window. The Instrument Control window appears with the list of protocols (figure 6-18).

For details on performing runs, see chapter 4 of the *MegaBACE Instrument Operator's Guide*.

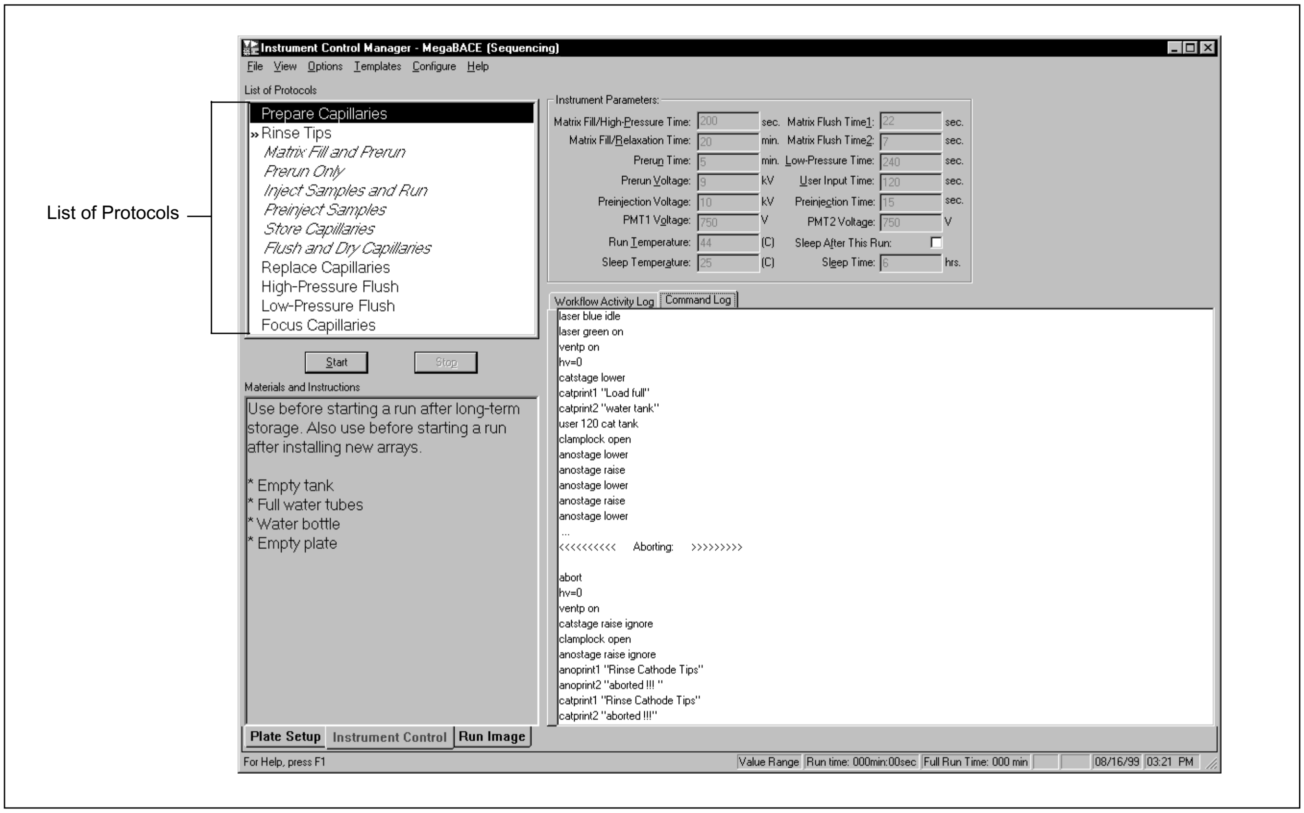



Figure 6-18. The Instrument Control window for sequencing.

## 6.20 Changing the application

The Instrument Control Manager allows you to use multiple applications. Currently, sequencing and genotyping are the two applications that are available.

*CAUTION* **Check the filter compartment to make sure the correct filters are installed for the application you are selecting and the dye set in your plate. See the instrument maintenance and troubleshooting guide and the administrator's guide for instructions.**

To change to a different application—

1. From the Configure menu, point to **Applications** and then choose **the name of the application** you want to use (sequencing or genotyping). A check mark appears in front of the selected application (figure 6-19).

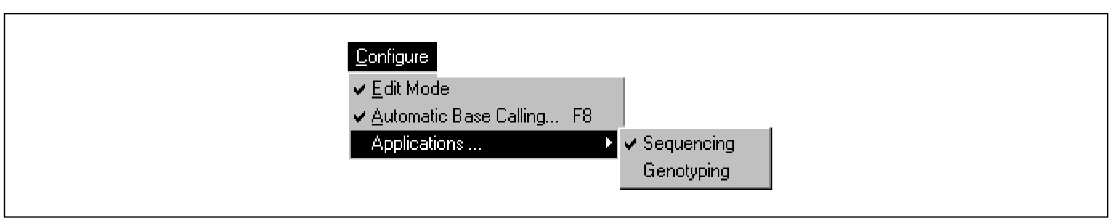



Figure 6-19. The Configure menu with the sequencing application selected.

2. In the Instrument Control Manager window, click the **Plate Setup** tab, and then click **New** to set up a new plate.

3. From the Templates menu, point to **Plate Setup Templates** and then choose **Select Template.** The Select Template window appears.
4. In the Select Templates window, choose the appropriate plate setup template (.tpl), and then click **Open.** The Plate Setup window displays the parameters for the selected template.

   (For genotyping, the default is **StdGenotyping.tpl.)**
5. Click the **Instrument Control** tab.
6. From the Templates menu, point to **Instrument Templates** and choose **Select Template.** The Select Template window appears.
7. In the Select Template window, choose the **.icp file** that you want to use.
   - For sequencing, the default is **Normal.icp.**
   - For genotyping, the default is **Genotyping.icp.**
8. Click **Open.** The Instrument Control window displays the parameters for the selected template.

The name of the selected application changes in the title bar of each of the Instrument Control Manager windows (figure 6-20). The Instrument Control Manager displays only the plate IDs and plate setups for the selected application in the Plate Setup window.

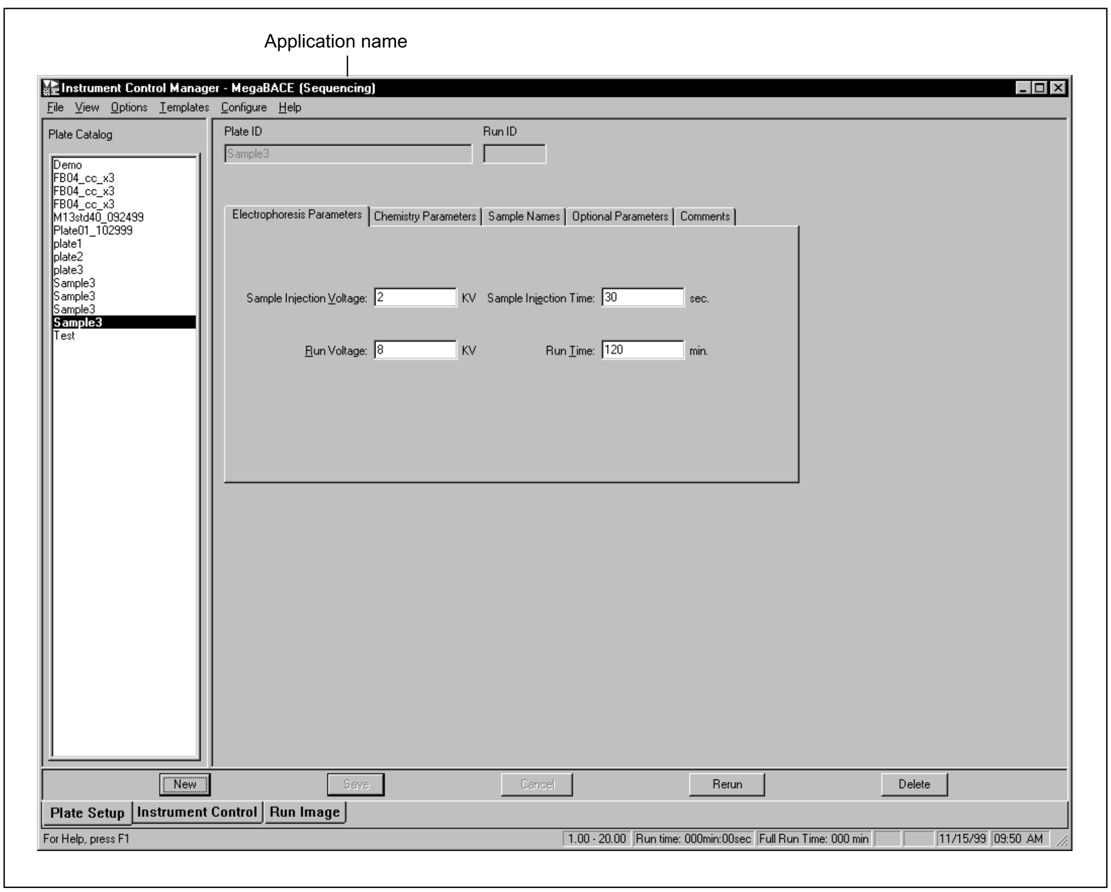



Figure 6-20. The Plate Setup window. The name of the selected application appears in the title bar of each of the Instrument Control Manager windows.

## 6.21 Leaving the Instrument Idle Overnight or Over Weekends

Leaving the instrument idle means that the instrument power is on, but you are not using the instrument to run samples. If you are leaving the instrument idle overnight or over the weekend (including a 3-day weekend) and you are using linear polyacrylamide (LPA) matrix, you should store the capillaries wet. You do not need to flush the matrix from the capillaries.

You can store the capillaries two different ways when you are leaving the instrument idle for short periods of time—

- Use the Sleep After This Run check box in the Instrument Control window to store the capillaries in LPA matrix and buffer for up to 16 hours. See section 4.15 for instructions.
- Use the Store Capillaries protocol to store the capillaries in water for more than 16 hours, up to 3 days (section 6.21.1).

See section 6.22 for instructions on storing the capillaries for more than 3 days.

### 6.21.1 About the Store Capillaries Protocol

The Store Capillaries protocol allows you to add water to the water tank on the cathode stage and place fresh water tubes in the reservoir on the anode stage to cover the tips of the capillaries. The protocol then turns off the lasers and reduces the temperature in the electrophoresis compartment to 25 °C (77 °F) or the temperature you set in the Sleep Temperature box in the Instrument Control window. The protocol stores the stages in the up position.

### 6.21.2 Materials required

For the Store Capillaries protocol, you need (figure 6-21)—

- A clean tank filled with deionized filtered water
- One 2-ml tube for each array installed in the instrument, each containing 1.8 ml deionized filtered water

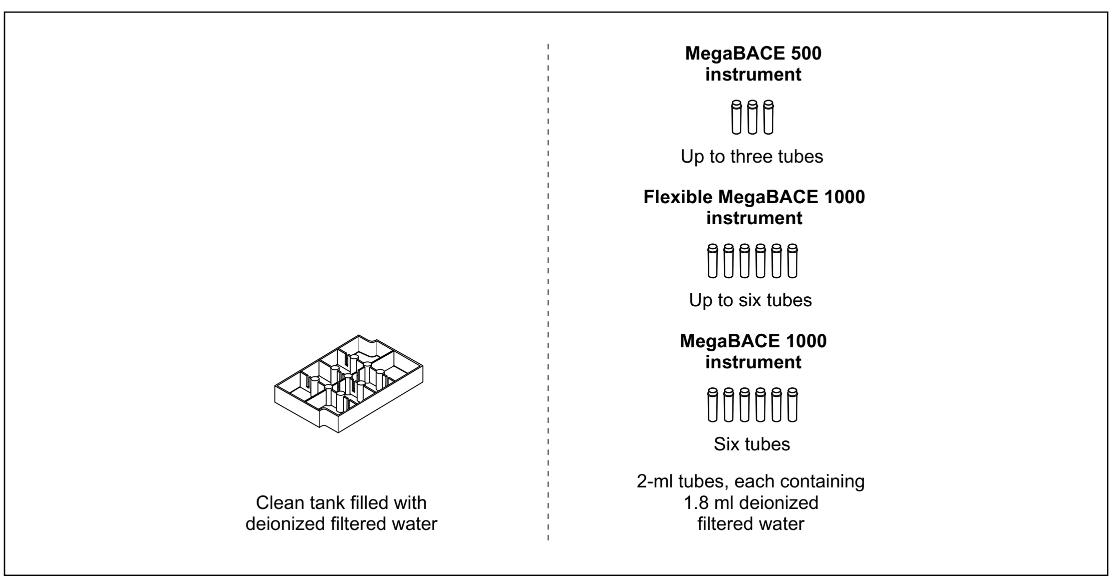



Figure 6-21. The Materials for the Store Capillaries Protocol. **Note:** You use one tube of water for each capillary array installed in the instrument.

*CAUTION* **Do not fill the water tank too full. Open the cathode drawer slowly to prevent spilling the water on the cathode stage. Spilled water (or other material) can damage the electrodes in the cathode stage.**

### 6.21.3 Using the Store Capillaries Protocol

To use the Store Capillaries protocol—

1. Click the **Instrument Control** tab (figure 6-22) to display the Instrument Control window.
2. In the Instrument Parameters area, type a temperature in the **Sleep Temperature** box. The temperature range is 25–30 ºC (77–83 ºF), and the default temperature is 25 °C (77 ºF).
3. Type the length of time the instrument will be idle in the **Sleep Time** box. The time range is 1–72 hours, and the default time is 12 hours.
4. In the List of Protocols, click **Store Capillaries,** and then click **Start.**

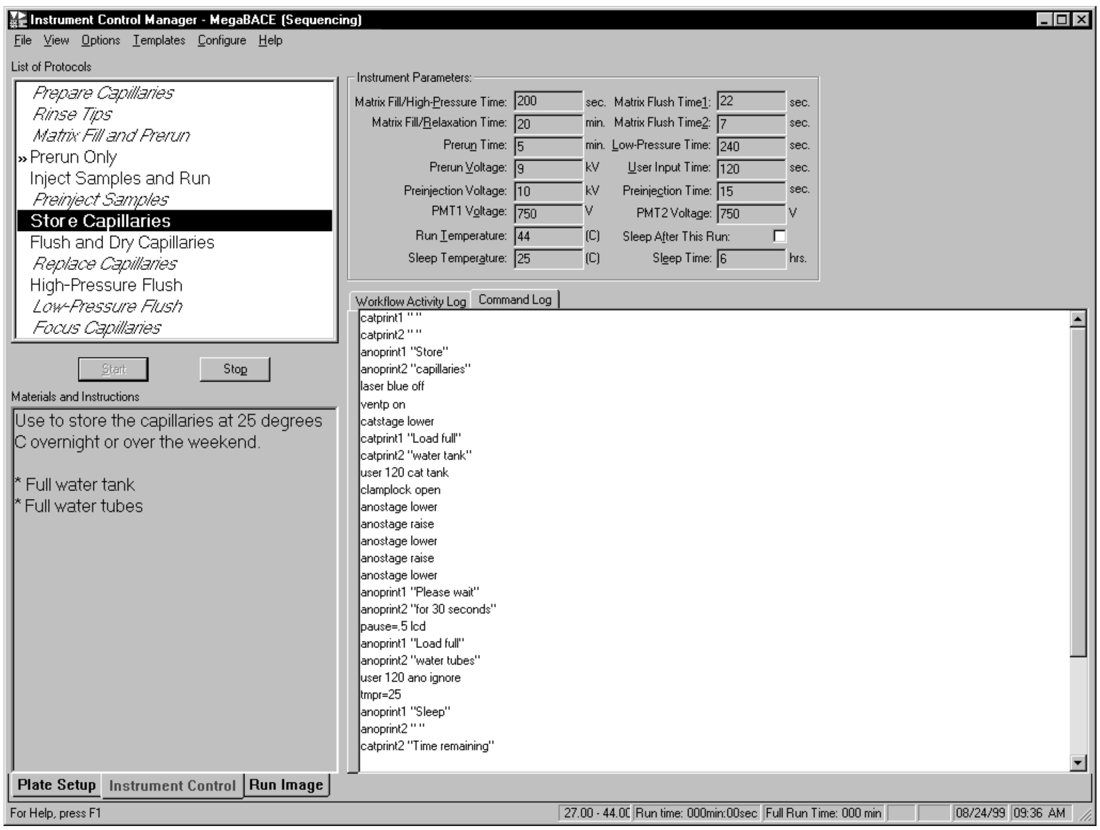



Figure 6-22.  The Instrument Control Window.

5. When instructed by the instrument displays, load a **full water tank** into the left side of the instrument and load the **water tubes** into the right side of the instrument.

   After you close the drawers, the instrument raises the stages to cover the tips of the capillaries with water. The software turns off the laser and reduces the temperature of the electrophoresis compartment to 25 °C (77 ºF) or the temperature you set in the Sleep Temperature box in the Instrument Control window (figure 6-23).

   Leave the nitrogen source, the instrument power, and the computer on. Leave the Instrument Control Manager and the Host Scan Controller software running.

*CAUTION* **The nitrogen pressure must remain on to keep the stages in the up position and keep the capillary tips covered with water, preventing the capillaries from clogging.**

When the sleep time elapses, the instrument starts warming up the electrophoresis compartment to the default temperature setting of 44 °C (111.2 ºF). The left display counts up the time since the temperature was turned on.

*IMPORTANT* **Before starting a run, you should allow approximately 3 hours to stabilize the components in the electrophoresis chamber at the set temperature.**

The software selects the Rinse Tips protocol (section 4.5 of the *MegaBACE Instrument Operator's Guide*) as the next protocol.

## 6.22 Shutting Down the System for More than 3 Days

In general, shut down the system completely only when you will be leaving the instrument continuously unattended for more than 3 days. Before shutting down the system, use the Instrument Control Manager to perform the Flush and Dry Capillaries protocol.

Although it is not required, after you use the Flush and Dry Capillaries protocol, you can log off or shut down the computer and turn off the nitrogen pressure (sections 6.22.2 and 6.22.4). Then you turn off the instrument.

*CAUTION* **If you are shutting down the instrument for more than 3 days and the instrument will be continuously unattended, always flush the matrix from the capillaries at the end of the last run and store the capillaries dry. Make sure you use the Flush and Dry Capillaries protocol to preserve the capillaries. If the capillaries are not properly flushed and stored dry, they will become clogged and will have to be replaced.**

### 6.22.1 Flushing and Drying the Capillaries

Before shutting down the system, you must flush the matrix from the capillaries with water and store the capillaries dry. This section contains detailed instructions on using the Flush and Dry Capillaries protocol.

#### 6.22.1.1 Materials required

For the Flush and Dry Capillaries protocol, you need (figure 6-23)—

- An empty water tank
- One 2-ml tube for each array installed in the instrument, each containing 1.8 ml fresh deionized filtered water
- A squirt bottle filled with fresh deionized filtered water
- One empty 2-ml tube for each array installed in the instrument

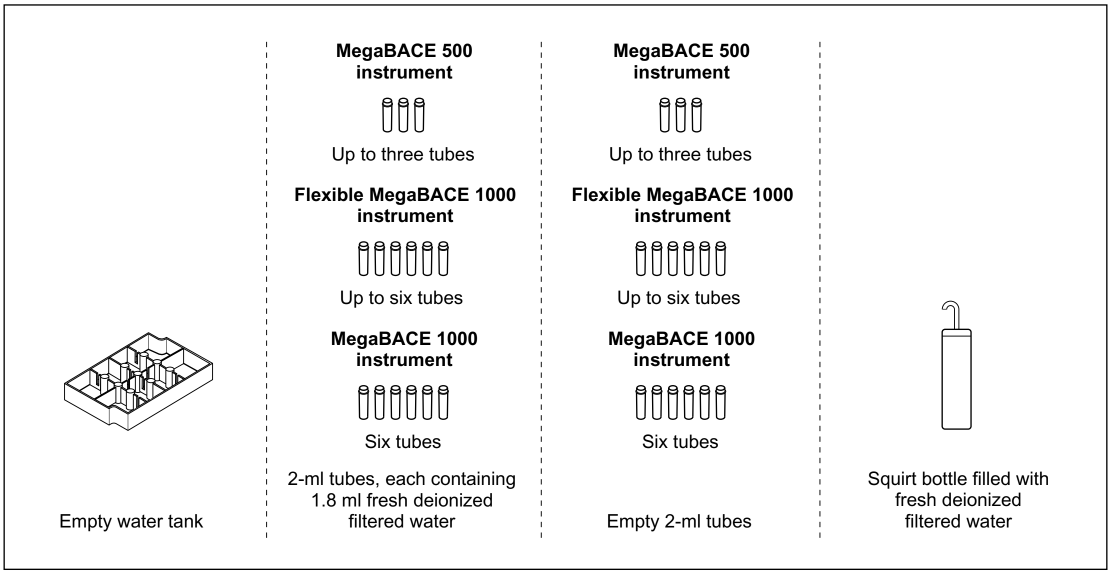



Figure 6-23. The Materials for the Flush and Dry Capillaries Protocol. **Note:** You use one tube of water for each capillary array installed in the instrument.

#### 6.22.1.2 The Flush and Dry Capillaries Protocol

To flush out the matrix and dry the capillaries—

1. Click the **Instrument Control** tab (figure 6-22) to display the Instrument Control window.
2. In the List of Protocols, click **Flush and Dry Capillaries,** and then click **Start.**
3. When instructed by the left instrument display, remove the **tank** from the left side of the instrument and replace it with an **empty water tank.**

*CAUTION* **When the instrument displays instruct you to load an empty water tank into the left side of the instrument, make sure the water tank is completely empty. Otherwise, the tank will overflow and spill inside the instrument.**

4. When instructed by the right instrument display, load **one water tube for each array installed in the instrument** into the right side of the instrument.

   The instrument rinses the capillary tips, and the instrument displays tell you the tip rinse is in progress. Then the instrument displays tell you that the first high-pressure flush is in progress.

*IMPORTANT* **Always use fresh deionized filtered water to flush the capillaries. Stale water can cause damage to the capillaries.**

5. Follow the instructions on the instrument displays to complete the Flush and Dry Capillaries protocol.

When the protocol is finished, the instrument displays tell you that capillary drying is complete and display the time elapsed since completion. The Workflow Activity Log in the Instrument Control window lists the end time.

The software selects and places a double arrow in front of the Prepare Capillaries protocol in the List of Protocols (figure 6-23). See section 6.25 for instructions on how to prepare the capillaries.

*IMPORTANT* **Remember to run the Prepare Capillaries protocol (section 6.24) when you start up normal operation after storing the capillaries dry. The Prepare Capillaries protocol hydrates the capillaries and prepares them for the matrix fill and sample injection protocols.**

### 6.22.2 Logging off or shutting down the computer

You can leave the computer running and log off so that another user can log on, or you can shut down the computer. If you decide to log off or shut down the computer, you should close the Instrument Control Manager (choose **Exit** from the File menu) and the Host Scan Controller (type **bye** in the command line). Next, shut down and then turn off the computer.

### 6.22.3 Turning off the instrument

*CAUTION* **Before leaving the instrument, make sure that the electrophoresis and filter compartments are closed. Closing the compartments protects the capillaries and filters and helps keep dust out of the system.**

To turn off the instrument, turn off the power switch on the right side of the instrument.

### 6.22.4 Turning off the nitrogen pressure system

When storing the system for more than 3 days, you can leave the external nitrogen source on, or you can turn it off. To turn off the nitrogen pressure system, follow the procedure established in your laboratory.

## 6.23 Recovering from a power failure with a UPS

### 6.23.1 Brief power failure

If your instrument and computer are connected to an uninterruptible power supply (UPS), the battery power stored in the UPS should handle all brief power failures with a duration of less than 10 minutes without a problem. Because 90 percent of all power failures last less than 5 minutes, the UPS should allow the instrument to continue its activities without interruption.

**Note:** Contact MegaBACE System Technical Support for information about a recommended UPS. See Assistance in the preface for contact information.

### 6.23.2 Extended power failure

*CAUTION* **You should always stop the scan and shut off the power-consuming devices early enough to save enough battery power to store the capillaries.**

If the power does not return within several minutes, you should check the time left on the battery. The time remaining will help you decide whether you have time to finish the scan or if you should stop the scan immediately and use the Store Capillaries protocol (section 6.21.3) before the battery reserves are exhausted.

If the capillaries contain matrix and you experience a power failure that lasts more than 10 minutes (depending on the time on the battery backup), you should stop whatever activity the instrument is performing. Because the duration of a power failure is unpredictable, use the Store Capillaries protocol (section 6.21.3) to store the capillaries properly.

### 6.23.3 Storing the capillaries in the event of an extended power failure

To store the capillaries—

1. Click the **Instrument Control** tab to display the Instrument Control window.
   - If the **Flush and Dry Capillaries** protocol is running, allow the flushing and drying to continue until it is complete.
   - If another protocol is running, click **Stop** to end the activity and save whatever data the instrument has collected.
2. Use one of the two following protocols depending on how long you intend to leave the instrument idle:
   - If you plan to continue running the instrument after the power comes on, use the **Store Capillaries** protocol (section 6.21.3) to turn off the lasers and reduce the temperature of the electrophoresis chamber to 25 °C (77 ºF) or the temperature you specified in the Sleep Temperature box in the Instrument Control window. This protocol allows you to store the capillaries filled with matrix for short-term storage (overnight or over the weekend).
   - If you will be leaving the instrument for more than 3 days, use the **Flush and Dry Capillaries** protocol to clear the capillaries of the matrix (section 6.22.1). Then turn the instrument power switch to off. The switch is on the right side of the instrument.

*IMPORTANT* **Use the Prepare Capillaries protocol when you start up normal operation after flushing and storing the capillaries dry (section 6.24). The Prepare Capillaries protocol hydrates the capillaries and prepares them for matrix and sample injection.**

## 6.24 Recovering from a power failure without a UPS

If a power outage occurs during a run and you do not have your instrument and computer connected to a UPS, you will lose all the collected data.

*CAUTION* **To prevent damage to the instrument and computer, turn off the power switches immediately after losing the power.**

### 6.24.1 Brief power failure

If the power returns in less than 12 hours—

- Use the Rinse Tips protocol (section 4.6 of the *MegaBACE Instrument Operator's Guide*) when you start operation to rinse any excess matrix off the tips, and then use the Inject Matrix and Prerun protocol to fill the capillaries with new matrix. This should allow you to collect data using the Inject Samples and Run protocol.
- Use the Store Capillaries protocol (section 6.21.1) to store the capillaries wet and filled with matrix if you are leaving the instrument overnight or over the weekend. Then use the Rinse Tips protocol as you normally would at the start of operation.

### 6.24.2 Extended power failure

After a power failure of more than 12 hours—

- Use the Flush and Dry Capillaries protocol as soon as the power comes on and you are able to begin normal operation (section 6.22.1).
- Then use the Prepare Capillaries protocol. (See section 6.25 for instructions.) You can use extra high-pressure flushes to help clear any clogged capillaries.

## 6.25 Preparing the capillaries

The Prepare Capillaries protocol rinses the capillaries with water at high pressure to hydrate the capillaries and prepare them for matrix and sample injection. This protocol also allows you to inspect the plate to determine if any capillaries are clogged.

### 6.25.1 Materials required

For the Prepare Capillaries protocol, you need (figure 6-24)—

- An empty water tank
- One 2-ml tube for each array installed in the instrument, each containing 1.8 ml deionized filtered water
- A squirt bottle filled with deionized filtered water
- An empty plate

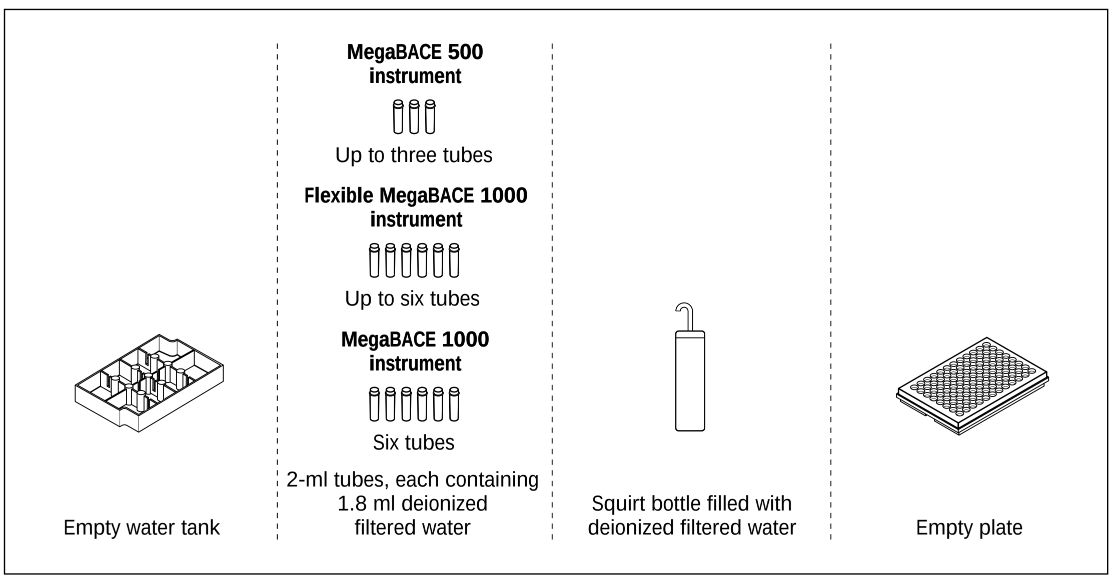



Figure 6-24. The Materials for the Prepare Capillaries Protocol. **Note:** You use one tube of water for each capillary array installed in the instrument.

# Chapter 7 Troubleshooting

## 7.1 Introduction

This chapter describes the Basic Input/Output Services (BIOS) in the MegaBACE instrument and the Power-on Self Test (POST). It then describes basic troubleshooting procedures and provides a list of on-screen error messages. This chapter then describes the two diagnostic software packages that exercise the instrument and allow you to call up screens of diagnostic data.

## 7.2 Basic Input/Output Services

The Basic Input/Output Services (BIOS) in MegaBACE consist of two parts: the SCSI BIOS and the internal computer BIOS. The internal computer BIOS initializes the instrument hardware when instrument power is applied and provides rudimentary diagnostics of the system. The internal computer BIOS is located in the EPROM on the CPU board. The boot program on the PC interface board enables the SCSI.

## 7.3 Power-On Sequence

When powering on the system, the instrument must be powered on before the host computer. After the host computer has recognized the instrument as a SCSI device, the instrument can be turned on or off as needed until the host computer is either rebooted or shut down. When the host computer is restarted, the instrument must already be on. After the instrument has completed its power-on sequence and the host computer has booted up, the Host Scan Controller (HSC) software is loaded from a DOS window. After the HSC has been started, the Instrument Control Manager (ICM) software and the Instrument Control Studio (ICS) can be started.

## 7.4 Power-On Self Test

When the instrument is powered up, all the Echelon boards perform a power-on self test (POST). Each board stores the results of the POST and waits for the host computer to query them. The internal computer of the instrument performs its own POST and then searches for BIOS extensions. One BIOS extension is located in the flash memory of one of the PC interface boards. This extension reprograms the hard disk interrupt so that the interrupt will execute the code on the PC interface board. When the main BIOS attempts to boot from the hard disk, the BIOS extension on the PC interface board is executed instead. This code programs the SCSI board to be a target and can now download code and process interrupts from the host computer.

After the host computer has booted and the HSC has started, the HSC will check the instrument to see if it can communicate with it. If it cannot, an error message is displayed. Possible causes of miscommunication are:

- The host computer was turned on before the instrument.
- The SCSI cable is not properly plugged into both the host computer and the instrument.
- The SCSI chain is not properly terminated.

When the HSC can communicate with the instrument, it begins to download the code from **nap.exe,** which runs the instrument from then on. The instrument accepts commands from the host computer to perform all the instrument functions and sends status back to the host computer.

After the HSC is up, the ICS can be started. From the ICS, you can check the basic status of all nine Echelon network boards in one dialog box. You can also call up a dialog box for each of the nine individual boards that provides detailed status and displays the actual error message. The individual error messages for each of the Echelon network boards are listed in Table 7-1.

At the start of the scan, all the boards go through a self-diagnostic as they did on powerup and the ICS can be used to interrogate them for failures.

## 7.5 Basic Instrument Troubleshooting

Basic troubleshooting of the instrument consists of powering on the instrument and workstation and observing the indicator lights and workstation display.

### 7.5.1 On-Screen Error Messages

Table 7-1 lists and describes the error messages that may be encountered during instrument operation when a problem occurs with one of the Echelon network boards. When the Instrument Control Manager (ICM) software is running, these error messages appear in a dialog box. When the Instrument Control Studio (ICS) is running, a message appears, stating that a problem has occurred and the name of the problem network board. You then select that board from the ICS screen, and the actual error message is displayed. The following table lists the error messages, problems, and solutions to the some of the problems.

**Table 7-1 On-Screen Error Messages**

| ERROR MESSAGE | PROBLEM | SOLUTION |
|---|---|---|
| **EPHV Board** | | |
| The input voltage to the HV power supply is off when it should be on. | Corrupts the scan data. Should stop the scan? | |
| DANGER! Input voltage to HV power supply is on when it should be off. Call service. | Danger: | Shut system down and call service personnel. |
| One of the high voltage interlocks is open. | Does not allow HV to come on until interlock is closed. | Close the interlocks. |
| The high voltage is too far below setpoint. | Corrupts the scan data. Should stop the scan. | Lower current draw on capillaries. |
| The high voltage is too far above setpoint. | Corrupts the scan data. Should stop the scan. | |
| The HV current output is at its maximum. | Can cause output voltage to go low if current is too high. | Use higher-resistance matrix. Look for possible anode short to ground. |
| HV board self-test failure—analog to digital converter. | Does not allow HV to come on. Possible EPHV board failure. | Replace EPHV board. |
| HV board self-test failure—+10v onboard reference. | Does not allow HV to come on. Possible EPHV board failure. | Replace EPHV board. |
| HV board self-test failure—Voltage Digital/Analog converter. | Does not allow HV to come on. Possible EPHV board failure. | Replace EPHV board. |
| HV board self-test failure—Current Digital/Analog converter. | Does not allow HV to come on. Possible EPHV board failure. | Replace EPHV board. |
| HV board self-test failure—+5V supply voltage. | Does not allow HV to come on. Possible EPHV board failure. | Replace EPHV board. |
| The data just sent to the high voltage board was out of range. | Setpoint not changed. Notifies ESC. | Resend correct data. |
| An unknown command was sent to the high voltage controller. | No action. | Send correct command. |
| **TMPR Board** | | |
| The temperature is not at setpoint. | Keeps trying, notifies ESC of error. | Depends on cause. |
| Power to the heaters has been lost. | Heaters shut down. No temperature control. | Replace heater power supply. |
| Power to the coolers has been lost. | Heaters shut down. No temperature control. | Replace cooler power supply. |
| The temperature control is off. | Temperature will not go to setpoint. | Turn heaters on, or send a setpoint. |
| The electrophoresis compartment door is open. | Causes heaters to go off. | Close the door. |
| A temperature sensor is bad. | Heaters shut down. No temperature control. | 1. Check plug on TMPR board.<br>2. Replace sensor. |
| One or more of the heaters is not working. | Heaters shut down. No temperature control. | 1. If there is power to the TMPR board, replace the heater.<br>2. If there is no power to the TMPR board, replace the heater power supply. |
| One or more of the TE Coolers has failed. | Heaters shut down. No temperature control. | 1. If there is power to the TMPR board, replace the TE cooler.<br>2. If there is no power to the TMPR board, replace the cooler power supply. |
| Temperature board self-test failure—A/D ground input test. | Does not allow heaters to come on. Possible TMPR board failure. | Replace TMPR board. |
| Temperature board self-test failure—A/D 1K reference test. | Does not allow heaters to come on. Possible TMPR board failure. | Replace TMPR board. |
| Temperature board self-test failure—A/D 10K reference test. | Does not allow heaters to come on. Possible TMPR board failure. | Replace TMPR board. |
| Temperature board self-test failure—A/D Maximum reference test. | Does not allow heaters to come on. Possible TMPR board failure. | Replace TMPR board. |
| The data just sent to the temperature board was out of range. | Setpoint does not change, notifies ESC. | Resend correct data. |
| An unknown command was sent to the Temperature controller. | No action, notifies ESC. | Send correct command. |

**Table 7-1 On-Screen Error Messages**

| ERROR MESSAGE | PROBLEM | SOLUTION |
|---|---|---|
| **CMON Board** | | |
| A current read in switch (mux) has failed. Fatal error. | Cannot scan.<br>Possible CMON board failure. | Replace CMON board. |
| **ADAQ Board** | | |
| The offset calibration for preamp channel #1 failed. | Possibly corrupted data. | 1. Reload firmware.<br>2. Replace ADAQ board. |
| The offset calibration for preamp channel #2 failed. | Possibly corrupted data. | 1. Reload firmware.<br>2. Replace ADAQ board. |
| The full scale calibration for preamp channel #1 failed. | Possibly corrupted data. | 1. Reload firmware.<br>2. Replace ADAQ board. |
| The full scale calibration for preamp channel #2 failed. | Possibly corrupted data. | 1. Reload firmware.<br>2. Replace ADAQ board. |
| The linearity test for preamp channel #1 failed. | Possibly corrupted data.<br>Possible CMON board failure. | Replace ADAQ board. |
| The linearity test for preamp channel #2 failed. | Possibly corrupted data.<br>Possible CMON board failure. | Replace ADAQ board. |
| An unknown command was just sent to the preamp board. | No action, notifies ESC. | Send correct command. |
| **INTC Board** | | |
| No air flow in blue laser. | Blue laser turns off. | Fix air flow problem.<br>Suspect:<br>1. Air-flow switch.<br>2. House exhaust too weak. |
| Green laser did not turn on. | Possible green laser failure. | Replace green laser. |
| Green laser over temperature. | Green laser turns off.<br>Possible heatsink problem. | Replace heatsink. |
| Blue laser not on. | | Check cables and air flow. |
| Blue laser power is low. | | Check cables and key switch position on power supply. |
| Blue laser not changed. Scan in progress. | | Check cables and reload software. |
| Anode stage not down. Sensor 1. | Stage didn't make it. | 1. Check the lever arms on the sensor switches. They may need to be bent slightly to activate the switch.<br>2. Check low-pressure supply.<br>3. Check INTC board.<br>4. Check pressure connector board. |
| Anode stage not down. Sensor 2. | Stage didn't make it. | 1. Check the lever arms on the sensor switches. They may need to be bent slightly to activate the switch.<br>2. Check low-pressure supply.<br>3. Check INTC board.<br>4. Check pressure connector board. |
| Anode stage not up. Sensor 3. | Stage didn't make it. | 1. Check the lever arms on the sensor switches. They may need to be bent slightly to activate the switch.<br>2. Check low-pressure supply.<br>3. Check INTC board.<br>4. Check pressure connector board. |
| Anode stage not up. Sensor 2. | Stage didn't make it. | 1. Check the lever arms on the sensor switches. They may need to be bent slightly to activate the switch.<br>2. Check low-pressure supply.<br>3. Check INTC board.<br>4. Check pressure connector board. |
| Anode stage not up. Sensor 1. | Stage didn't make it. | 1. Check the lever arms on the sensor switches. They may need to be bent slightly to activate the switch.<br>2. Check low-pressure supply.<br>3. Check INTC board.<br>4. Check pressure connector board. |

**Table 7-1 On-Screen Error Messages**

| ERROR MESSAGE | PROBLEM | SOLUTION |
|---|---|---|
| Anode door open. Sensor 1. | Cannot raise stage. | 1. Check the lever arms on the sensor switches. They may need to be bent slightly to activate the switch.<br>2. Check low-pressure supply.<br>3. Check INTC board.<br>4. Check pressure connector board. |
| Anode door open. Sensor 2. | Cannot raise stage. | 1. Check the lever arms on the sensor switches. They may need to be bent slightly to activate the switch.<br>2. Check low-pressure supply.<br>3. Check INTC board.<br>4. Check pressure connector board. |
| Timer expired while trying to raise the anode stage. | User failed to execute command. | |
| Cannot lower anode stage with pressure on. | Lowering stage is inhibited by software. | Turn off the high pressure. |
| Anode door not closed within time-out period. | | Try opening and closing the door. |
| Cathode stage not in. Sensor 1. | Cannot raise stage. | 1. Open and then fully close the cathode tray.<br>2. Check position and viability of sensors. |
| Cathode stage not in. Sensor 2. | Cannot raise stage. | 1. Open and then fully close the cathode tray.<br>2. Check position and viability of sensors. |
| Cannot lower cathode stage with pressure on. | Lowering stage is inhibited by software. | Turn off the high pressure. |
| Wrong tank on cathode stage. | Cannot raise stage. | Exchange tank for tray and retry. |
| Cathode stage not down. | Stage didn't make it. | 1. Check sensors.<br>2. Check INTC board.<br>3. Check pressure connector board. |
| Cathode stage not up. | Stage didn't make it. | 1. Check sensors.<br>2. Check INTC board.<br>3. Check pressure connector board. |
| No tank on cathode stage. Stage cannot be raised. | Cannot raise stage. | Put a tank on the stage. |
| Cathode door not closed within time-out period. | | Try opening and closing the door. |
| Capillary array holder is not lowered into cathode assembly. | Cannot turn on pressure to fill or flush capillaries. | Open the door and lower the holder until it clicks into place. If it does not click into place, check for debris in the assembly. |
| Service door open. | Temperature, laser, and HV shut off. | Check interlocks. |
| Filter door open. | PMTs shut off. | Check interlocks. |
| Clamp locked. | Cannot raise stage. | Unlock clamp and retry. |
| Clamp is neither unlocked nor locked. | Cannot raise stage or apply pressure. | Retry usually works. If it does not work, check for salt on the sensor or top of anode and clean if necessary. |
| Clamp is unlocked. | Cannot apply pressure. | Lock clamp. |
| Retainer not locked. | Cannot raise stage. | Open door and close retainer on anode. |
| No LED board present. | The cable fell off. | Put the cable back on. |
| Low bottle pressure low. | Stage and injection problems will occur soon. | Change bottle. |
| High bottle pressure low. | Injection problems will occur soon. | Change bottle. |
| High pressure is on. | Can’t unlock clamp or lower stage. | Vent pressure. |
| Pressure not vented. | Can’t unlock clamp or lower stage. | Vent pressure. |
| Pressure is on. Action not preformed. | Any illegal action with pressure on. | |
| A command is already in progress. | Must wait until command has completed before next step. | |
| Unknown command was sent. | No action, notifies ESC. | Send correct command |

**Table 7-1 On-Screen Error Messages**

| ERROR MESSAGE | PROBLEM | SOLUTION |
|---|---|---|
| **SCAN Board** | | |
| The secondary beamsplitter can't move to uncover the home sensor. | | 1. Test the board from the scan diagnostics.<br>2. Check the electrical connections. |
| Secondary beamsplitter can't move to cover the home sensor. | | 1. Test the board from the scan diagnostics.<br>2. Check the electrical connections.<br>3. Visually check optical sensors. |
| Cannot find both edges of the scan flag moving the motor on coarse steps. | | 1. Test the board from the scan diagnostics.<br>2. Check the electrical connections.<br>3. Visually check optical sensors. |
| Cannot find both edges of the scan flag moving the motor on fine steps. | | 1. Test the board from the scan diagnostics.<br>2. Check the electrical connections.<br>3. Visually check optical sensors. |
| The inside edge of the flag was found but was unable to uncover flag. Flag was found covered but should be uncovered. Stage was driven using coarse drive steps. | | 1. Test the board from the scan diagnostics.<br>2. Check the electrical connections.<br>3. Visually check optical sensors.<br>4. Check the flag. |
| The inside edge of the flag was found but was unable to uncover flag. Flag was found covered but should be uncovered. Stage was driven using fine drive steps. | | 1. Test the board from the scan diagnostics.<br>2. Check the electrical connections.<br>3. Visually check optical sensors.<br>4. Check the flag. |
| Scan stage motor can't get to home sensor. | | 1. Test the board from the scan diagnostics.<br>2. Check the electrical connections.<br>3. Visually check optical sensors.<br>4. Check the flag. |
| **Primary Beamsplitter and Shutter Motor Control board** | | |
| Can't move the laser shutter to cover the home switch. | | 1. Test the board from the scan diagnostics.<br>2. Check the electrical connections.<br>3. Visually check optical sensors.<br>4. Check for obstruction. |
| Can't move the laser shutter to uncover the home switch. | Possible BEAM board failure. | Replace BEAM board. |
| | Possible motor failure. | Replace motor. |
| | Possible obstruction. | Clear obstruction. |
| **Filter Changer Motor Control board** | | |
| Filter 1 can't get home. | | 1. Test the board from the Scan diagnostics.<br>2. Check the electrical connections.<br>3. Visually check optical sensors. |
| Filter 2 can't get home. | | 1. Test the board from the Scan diagnostics.<br>2. Check the electrical connections.<br>3. Visually check optical sensors. |
| The filter was commanded to move to uncover the home sensor but the home sensor is still covered. | | Check connections. |

### 7.5.2 Common Instrument Problems

Table 7-2 lists some common instrument problems, the probable cause of the problem, and possible solutions.

**Table 7-2 Common Instrument Problems**

| Problem | Probable Cause | Solution |
|---|---|---|
| Won't power on. No POWER indicator light. | Instrument unplugged | Plug instrument in |
| | Incorrect installation | Verify installation |
| | Fuse blown | Replace fuse |
| | No facility AC power | Verify facility AC power |
| | Bad instrument power supply | Test/R&R instrument power supply |
| Won't boot. POWER and SCAN indicators are normal. | Bad SCSI board BIOS | Replace SCSI board |
| Won't boot. POWER indicator is normal | Bad main system board | Replace main system board |
| | Bad workstation | Check workstation |
| | Bad instrument power supply | Test/Replace instrument power supply |
| | Loose or bad SCSI board | Reseat or replace SCSI board |

## 7.6 Diagnostic Software

There are two diagnostic software programs. One program is a graphical user interface (GUI) called the **Instrument Control Studio (ICS)** and the other is a batch file called **scan.bat** that is run from a DOS window. Both programs allow you to exercise various instrument functions and access screens of diagnostic data.

### 7.6.1 Instrument Control Studio

The ICS allows you to perform all the instrument functions from a graphical user interface. When the ICS is run, the main window appears and the selections are made from a series of icons. The ICS requires that the HSC be running. Resting the pointer on an icon displays the icon function. The ICS also includes a scanner control language (SCL) that allows you to issue commands through a dialog box that you access by pressing the period (.) key. The SCL allows you to build batch files that will issue sequences of commands to the instrument. The SCL is explained in detail later in this chapter.

The ICS main window has a menu section that includes File, View, Control, and Help selections. The menu section has very little functionality and is not discussed here. The ICS window (figure 7-1) has the following functional areas:

- Menu section.
- Instrument parameter data and error message display.
- Instrument control area.
- Echelon network control nodes.
- Display area control.
- Graphical data display area.
- Instrument Parameter Data and Message Displays

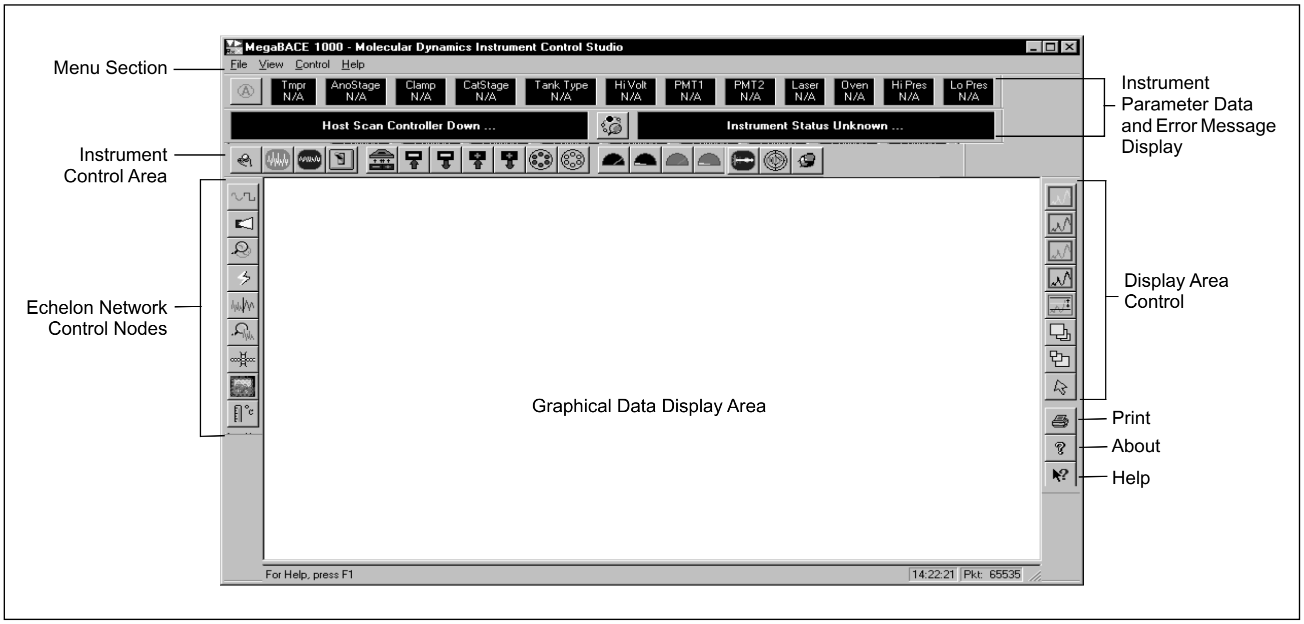



Figure 7-1. ICS Main Window.

The Instrument Parameter Data and Message Displays area (figure 7-2) provides an up-to-date status on the 12 instrument parameters, two message display areas, an icon for displaying current monitoring and graphic control data, and an icon for displaying basic status on all nine Echelon network boards.

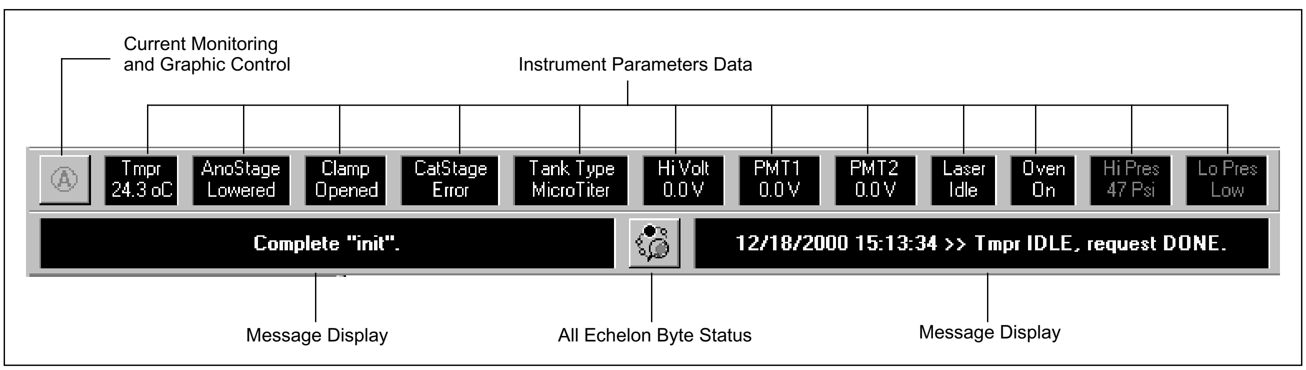
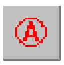



Figure 7-2. Instrument Parameter Data and Message Displays.

The instrument parameters that are monitored include:

- **Tmpr—**Temperature of the electrophoresis compartment.
- **AnoStage—**Status of the anode stage (raised or lowered).
- **Clamp—**Status of the anode cover clamp (opened or closed).
- **CatStage—**Status of the cathode stage (raised or lowered).
- **Tank Type—**Type of tank present in the cathode stage (tank or plate).
- **Hi Volt—**Displays the value of the HV power supply output.

- **PMT 1—**Displays the voltage on PMT 1.
- **PMT 2—**Displays the voltage on PMT 2.
- **Laser—**Displays the status of the blue laser (on, off, or idle).
- **Oven—**Displays the status of the electrophoresis compartment heaters (on or off).
- **Hi Pres—**Displays the amount of pressure in the high-pressure line.
- **Lo Pres—**Displays the amount of pressure in the low-pressure line.



**Current Monitoring and Graphic Control**—This icon brings up the Current Monitoring window (figure 7-3), which displays the current in each of the capillaries and also provides control of the graphical data displayed in the graphical data display area. The typical current per electrode during runs will be in the neighborhood of 5 to 6 microamps. Low current overall should cause you to suspect a poor electrical connection with the high-voltage circuit, a failing HV power supply, or matrix problems. The result of low current overall will be low run performance. Low current reading in one or two electrodes can be caused by failing capillaries or bent or broken electrodes.

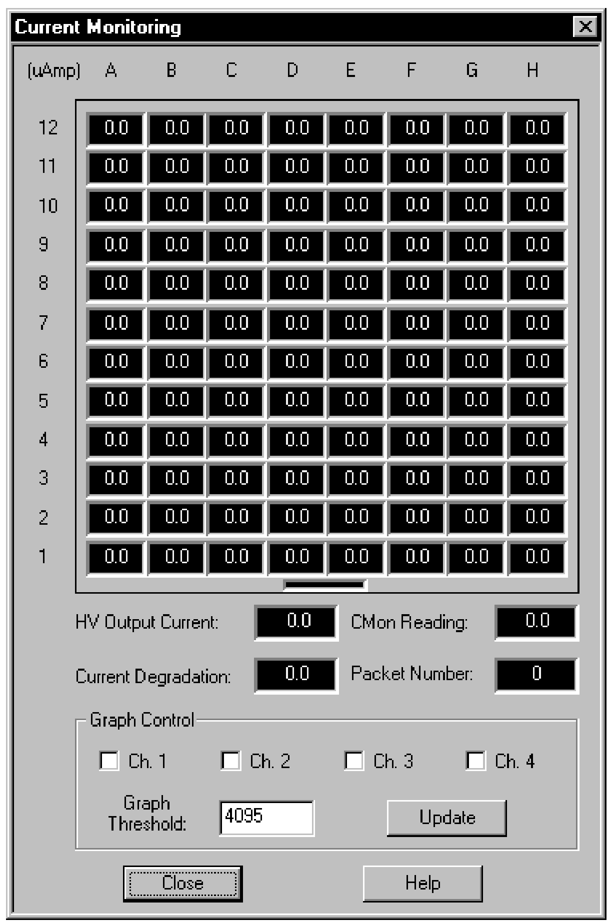
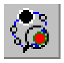



Figure 7-3. Current Monitor and Graph Control Screen.



**All Echelon Byte Status**—This icon brings up the All Echelon Byte Status window (figure 7-4), which displays basic status data for all nine Echelon network boards.

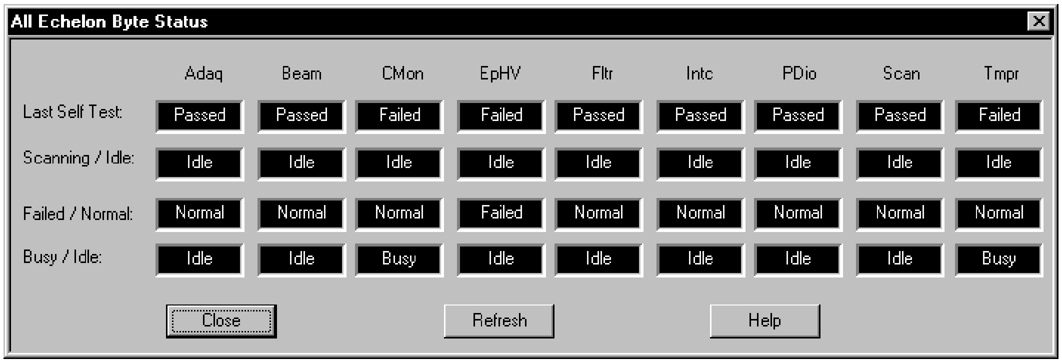



Figure 7-4. All Echelon Byte Status.

### 7.6.2 Instrument Control Area

The instrument control area (figure 7-5) provides 22 icons for instrument control. Most of these icons simply toggle between two states, and the results are reflected in the parameter data and message display areas. Several of these icons have dialog boxes associated with them.

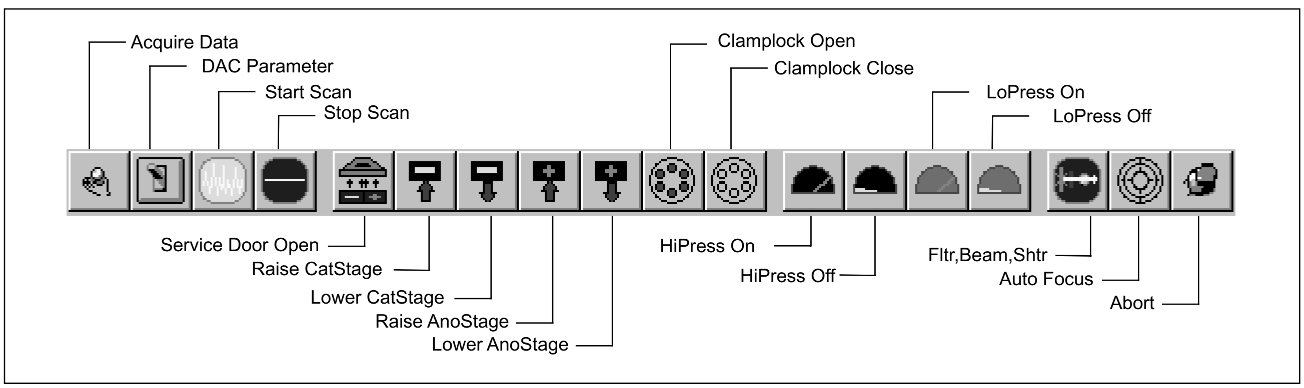
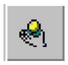



Figure 7-5. Instrument Control Area.



**Acquire Data**—This icon brings up the Data Acquisition window (figure 7-6), which allows you to name the data file in which the data is to be saved, select the type of data to be collected, and to set the acquiring period in either number of scans or minutes.

*NOTE* **Currently, the units section defaults to minutes, not scans.**

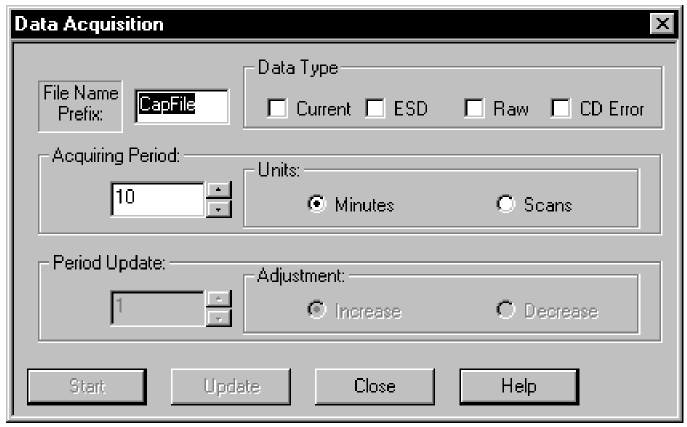
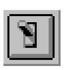



Figure 7-6. Data Acquisition.



**DAC Control Parameter Setting**—This icon brings up the DAC Control Parameter Setting window (figure 7-7), which allows you to turn the current on or off, select channels, set the high voltage for both PMTs, and to select the data types for all four channels.

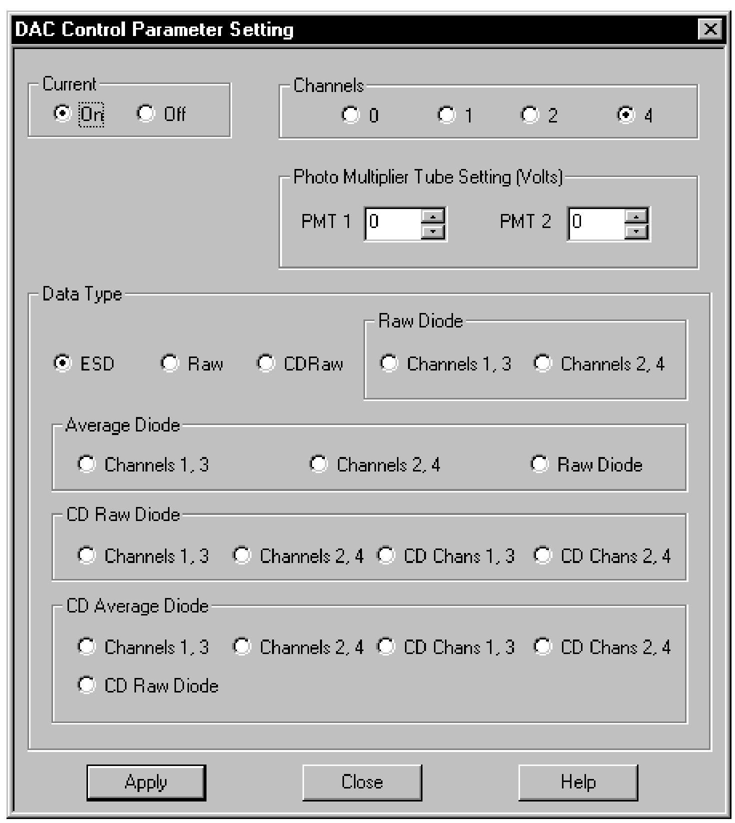



Figure 7-7. DAC Control Parameter Setting.

### 7.6.3 Echelon Network Control Nodes

This area provides nine icons for displaying the status on each of the nine Echelon network boards.

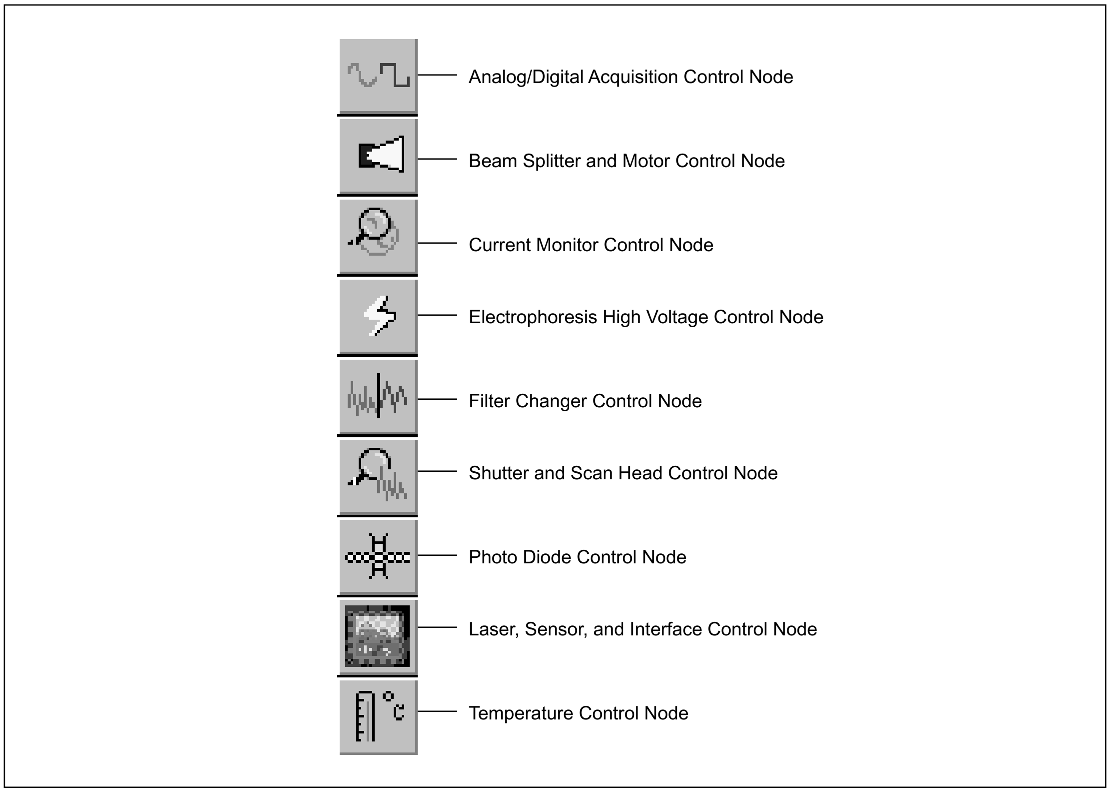



Figure 7-8. Echelon Network Control Nodes.

**ADAQ Control Node**—This icon brings up the Analog Digital Acquisition Node window (figure 7-9), which displays the status of the ADAQ board.

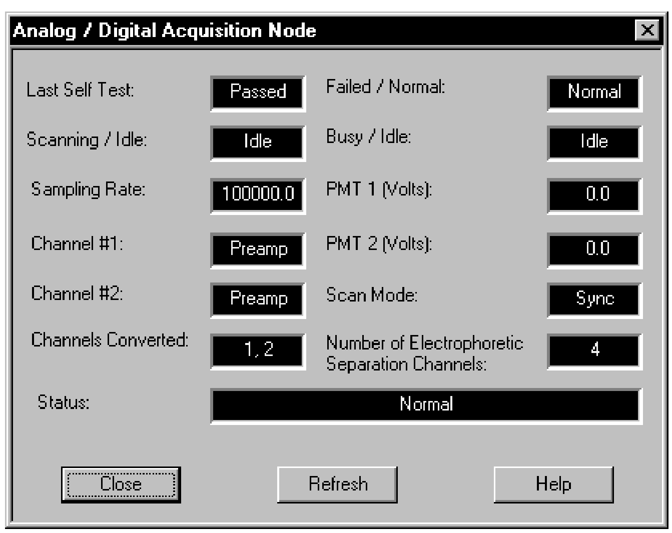
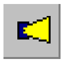



Figure 7-9. ADAQ Control Node.



**Beam Splitter and Motor Control Node**—This icon brings up the Beam Splitter and Motor Control Node window (figure 7-10), which displays the status of the BEAM board.

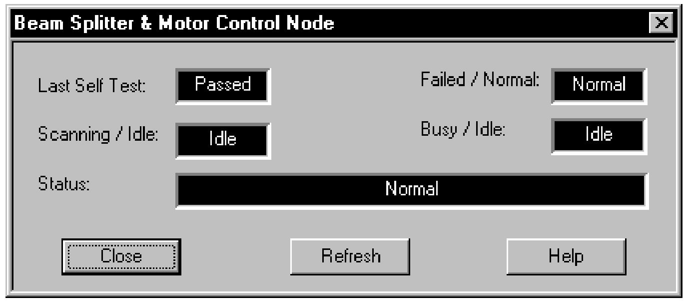
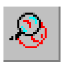



Figure 7-10. Beamsplitter and Motor Control Node.



**Current Monitor Control Node**—This icon brings up the Current Monitoring Node window (figure 7-11), which displays the status of the Current Monitor board.

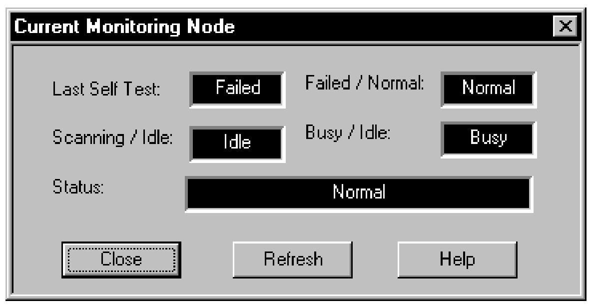
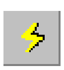



Figure 7-11. Current Monitoring Node.



**Electrophoresis High-Voltage Node**—This icon brings up the Electrophoresis High-Voltage Node window (figure 7-12), which displays the status of the BEAM board.

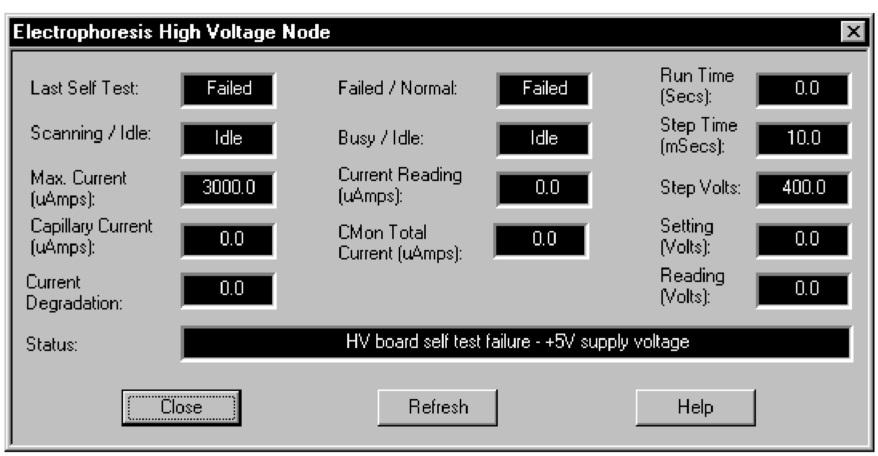
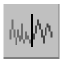



Figure 7-12. Electrophoresis High-Voltage Node.



**Filter Changer Control Node**—This icon brings up the Filter Changer Control Node window (figure 7-13), which displays the status of the FLTR board.

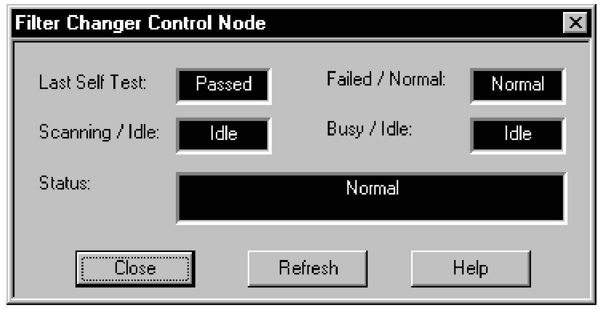



Figure 7-13. Filter Changer Control Node.

**Shutter and Scan Head Control Node**—This icon brings up the Shutter and Scan Head Control Node window (figure 7-14), which displays the status of the SCAN board and controls the power focus.

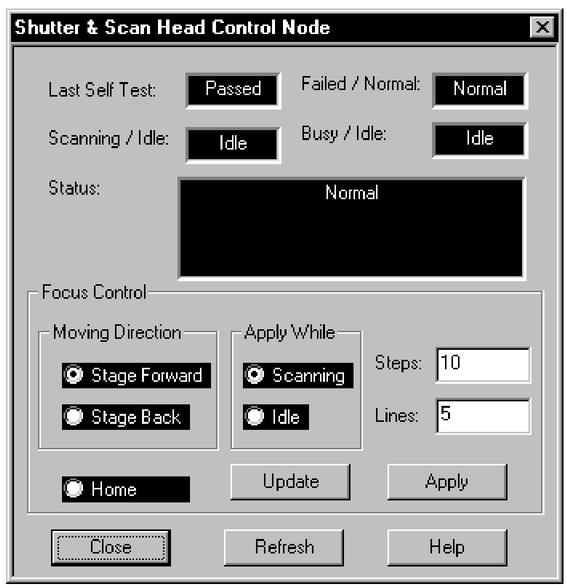
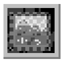



Figure 7-14. Shutter and Scan Head Control Node.



**Laser, Sensor, and Interface Control Node**—This icon brings up the Laser, Sensor, and Interface Control Node window (figure 7-15), which displays the status of the INTC board.

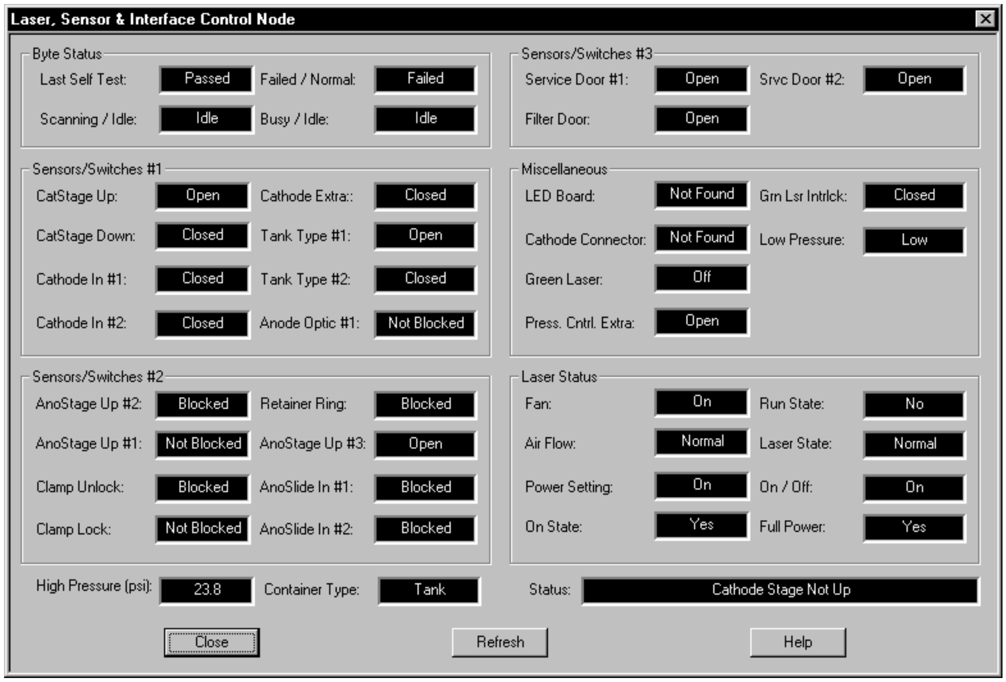



Figure 7-15. Laser, Sensor, and Interface Control Node.

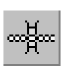


**Photo Diode Control Node**—This icon brings up the Photo Diode Control Node window (figure 7-16), which displays the status of the PDIO board.

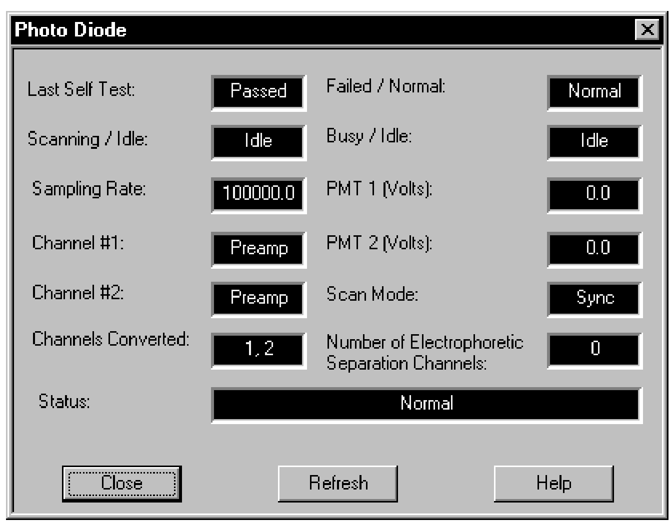
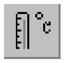



Figure 7-16. Photo Diode Control Node.



**Temperature Control Node**—This icon brings up the Temperature Control Node window (figure 7-17), which displays the status of the TMPR board.

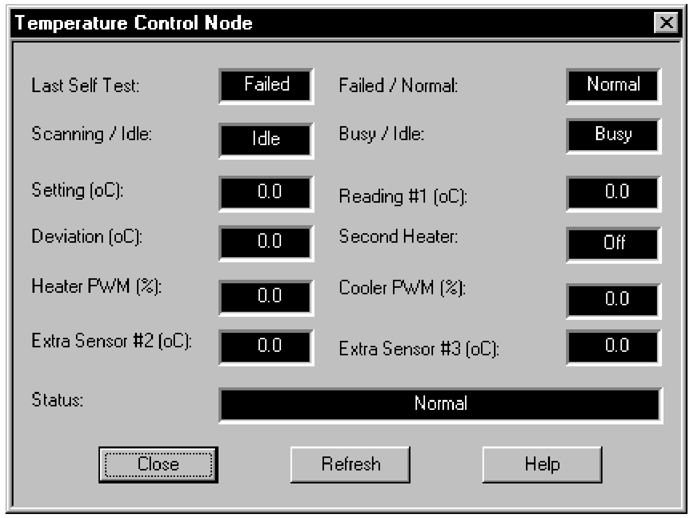



Figure 7-17. Temperature Control Node.

### 7.6.4 Display Area Control

This area displays eight icons for controlling the graphical data in the display area. Five of the icons simply toggle the graphic data on and off the display. Two of the icons zoom the display in or out, and the final icon is the select icon.

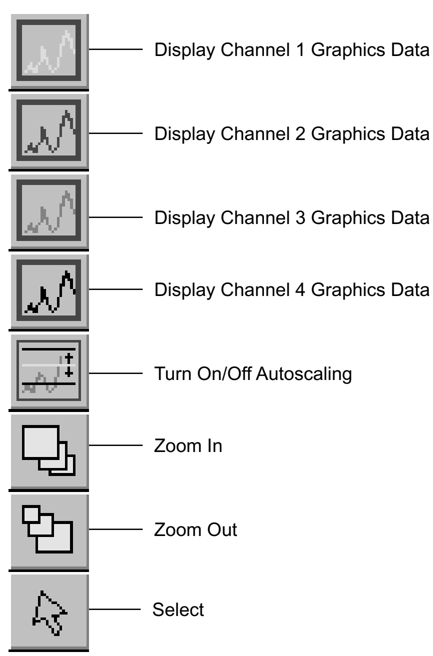



Figure 7-18. Display Area Control Icons.

### 7.6.5 Scanner Control Language (SCL)

The SCL consists of individual commands that can be issued through a dialog box (figure 7-19). You type the command with options and/or text strings and then either click the OK button or press the return or enter key. The instrument then performs the function.

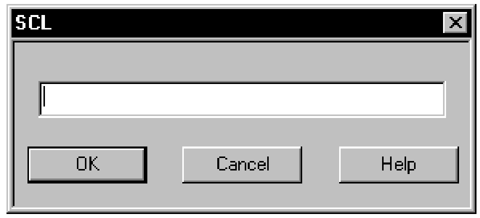



Figure 7-19. SCL Dialog Box.

The syntax rules for the SCL are as follows:

- The SCL is not case-sensitive.
- The texts or keywords within braces { } are optional.
- One of the options within hard brackets [ ] must be selected. If there are several sets of hard brackets, one option from each set of brackets must be selected.
- The bold-type characters in the list of commands below are the minimum text strings that the SCL parser recognizes as keywords.
- Commands and options are separated by spaces, commas, or tabs.
- Comments are preceded by a two forward slashes (//).

Following are the SCL commands with some examples:

**ABORT** **//** real-time SCL abort

**ACQCHAN** = [ **0** | **1** | **2** | **4** ]

**ACQPARM** {Rate =} **1000** {Hz}, [ **PREAMP1** | **EXT1** ], [ **PREAMP2** | **EXT2** ], [ **BOTH** | **CH1** | **CH2** ]

**ANOPRINT1** { "**Text**" } //Displays the text string between the quotes on line 1 of anode LCD.

**ANOPRINT2** { "**Text**" } //Displays the text string between the quotes on line 2 of anode LCD.

**ANOSTAGE** [ **Lower** | **Raise** ]

[ **BOTTLEP**resscheck | **CHECKB**ottlepress | **CHECKPR**ess ] //Checks bottle pressure

**CATPRINT1** { "**Text**" } //Displays the text string between the quotes on line 1 of cathode LCD.

**CATPRINT2** { "**Text**" } //Displays the text string between the quotes on line 2 of cathode LCD.

**CATSTAGE** [ **Lower** | **LR** | **lowercase** ]

**CATSTAGE Raise**, [ **Tank** | **Microtiter** | **Plate** | **Ignore** ]

**CLAMP**lock [ **OPEN | CLOSE** ]

**DACPARM** {[ DATA TYPE]}, {[**CURON** | **CUROFF**]}, {**CHAN**NELS [ **1 | 2 | 3 | 4** ]}, {**PMT1** = **700**, **PMT2** = **700**}

//DATA TYPE includes: RAW | CDRAW | NORM | RPCH13 | RPCH24 | APCH13 | APCH24 | APRP |
//CDRPCH13 | CDRPCH24 | CDRPCDCH13 | CDRPCDCH24 | CDAPCH13 | CDAPCH24 |
//CDAPCDCH13 | CDAPCDCH24 | CDAPCDRP

//CD—capillary detection enabled; P—photodiode data; A—averaging; CH—fluorescence channels

//Example: CDAPCDCH24—enables capillary detection and performs signal averaging on photodiode
//signals on PMT1; activates capillary detection and collects fluorescence data on PMT2 (channels 2 and
//4).

**HIPRES**s [ **ON** | **OFF** ] { **LCD** }

**HIPRES**s {time =} **20** {secs}

**HV** [ **ON** | **OFF** ]

**HV** = **11000** {volts} { **LCD** }

**HV** [ **RUNTIME** | **RT** ] = **20** {secs}

**HV** [ **TIMESTEP** | **TS** ] = **5** {msecs}

**HV** [ **VOLTSTEP** | **VS** ] = **10** {volts}

[ **INTCSTATUS** | **SENSOR** | **STATUSINTC** | **UPDATEIN** ] // for INTC Status Update

**LASER BLUE** [ **OFF** | **IDLE** | **RUN** ]

**LASER** [ **GREEN | RED** ] [ **ON** | **OFF** ]

**LCDPRINT** [ **ANO**de | **CAT**hode ] { "**Text**" } // same as catprint1 {"Text"} or anoprint1 {"Text"}

**LOPRES**s [ **ON** | **OFF** ] { **LCD** }

**LOPRES**s {time = } **20** {secs}

**MACRO** // Build off-line macro—done on the ESC.

**MACROABORT** // Send off-line abort—done on the ESC.

**OVEN** [ **ON** | **OFF** ]

**PMT1** = **500** {volts}, **PMT2** = **700** {volts}

[**VENTP**ress | **PRESSV**ent | **PRESSUREV**ent ] { [ **ON** | **OFF** ] }// vents pressure

**FOCUS HOME**

**FOCUS [ IDLE | STATIC ] [ FWD | BACK ] STEP 20**

**FOCUS [ SCAN | DYN ] [ FWD | BACK ] STEP 20, LINE 30**

//Example: AUTOFOCUS SCANRATE 1 CYCLE 750 STEP 4 SKIP 100 PMT1 = 550 PMT2 = 550

//Scan at 3 Hz. ( scanrate=1 for 3 Hz; scanrate=0 for 1.75 Hz). Skip 100 steps before collecting 750 cycle //data, move 4 steps/cycle. Set pmt1 and pmt 2 to 550.

//RSKIP/ESKIP = -1 (not both) means skipping RAW/ESD scan focusing phase. If ESKIP>0, phase 1 will //be ignore and autofocusing will be performed from scratch at phase 2. In this case, how well the //focusing is adjusted will totally depend on the knowledge of the users.

**SCANMODE** [ **SYNC** | **STARTLINE** | **FREE** ]

**SRVCDOOR OPEN**

**TIMER** [ **UP** | **DOWN** ], {time =} **20** {secs}, { **PRINT** { "**Text**" } }

**TIMER STOP**

**TMPR** = **27.05** {oC}

**USER**input {time =} **20** {secs}, {side =} [ **ANO**de | **CAT**hode ], {container =} [ **TANK** | **MICROTITER** | **PLATE** | **IGNORE** ]

[ **ECHN**status | **NODE**status ] [ **ADAQ** | **CMON** | **EPHV** | **INTC** | **SCAN** | **TMPR** ] // Check detail node status.

// Set beam, filters, shutter to position A, position B or home position.

**BEAM1** [ **BLUE** { **RED** } { **POSA** } | **GREEN** { **POSB** } | **HOME** ]

**SHTR** [ **BLUE** { **RED** } { **POSA** } | **GREEN** { **POSB** } ]

**BEAM2** [ **POSA** | **POSB** | **HOME** ]

**FLTR HOME**

[ **FLTR1** | **FLTR2** ] [ **POSA** | **POSB** ]

// Start / stop ramping dac.

**RAMPDAC** [ **BEAM** | **FLTR** | **SCAN** ] [ **START** | **STOP** ]

// Adjust scan positions for filters, shutter, first & secondary beam splitters. Issue before start scan.

[ **SCANFLTR1** | **SCANFLTR2** | **SCANBEAM2** ] [ **POSA** | **POSB** | **DYN** ]

// Unless the positions of beam and shutter are individually specified, either one of the two //commands sets both beam and shutter to the same position.

{ **SCANSHTR** [ **BLUE** { **RED** } { **POSA** } | **GREEN** { **POSB** } | **DYN** ] } { **SCANBEAM1** [ **BLUE** { **RED** } { **POSA** } | **GREEN** { **POSB** } | **DYN** ] }

**SCANSTAGE** [ **MOVE** | **IDLE** ] // Start / stop moving scan stage.

[ **STARTSCAN** | **STOPSCAN** ] // Start or stop scanning.

// Host-related commands

**DATASET** "**FileName**" [ **MINS** { **LCD** } | **SCANS** ] **100** [ **CUR**, **ESD**, **RAW**, **CDERR]**

**STOPRUN** // close data files

**TIMEMARK** [ **START** | **STOP** ] // mark start or end time

// If TIMEMARK is specified, pause for sleeping period—TIMEMARK(stop–start).

[ **SLEEP** | **PAUSE** ] **10** {mins} { **LCD** , **TIMEMARK** }

**STATUS** [ **ON** | **OFF** ] // Resume / stop detail node status interrogation from HSC.

**SCANRATE** [ **0** | **1** ] // Set the moving rate of the scan stage to 1.75 (0) or 3.02 Hz (1).

**BANKUSE** [ **ALL | NONE** ], [ **0, 1, 2, 3, 4, 5, 6** ]

**CAPUSE** [ **ALL | NONE** ] {, [ **BAD 1, 2, 3,**… ], [ **UNUSED 10, 20,** … ], [ **USED 40, 50**, … ] }

**RUNINFO** { **RUNID** "**RunName**" }, **PLATEID** "**PlateName**" // Update result to database.

**RUNLENGTH** [ **MINS** { **LCD** } | **SCANS** ] ±**100** // Update acquisition period.

**DRYRUN** [ **START** | **STOP** ] //Start or stop the dry run for system integration test.

[ **//** | **#** ]**Comment**" //Comment keywords

**WORKFLOW** "**Name**" // ICM or user specific

### 7.6.6 ISCL Macros

Multiple SCL commands can be combined in a macro to issue sequences of commands to the instrument. These macros are simple text files that can be built in any type of text editor. The commands are entered one per line. Once built, the file is saved with a .scl extension. To run the macro, simply type a period while in the ICS window, enter the macro file name (without extension) in the dialog box, and click on the OK button or press enter or return.

## 7.7 Scan Diagnostic

The Scan diagnostic software was developed by the design engineers during instrument development. Scan was never intended for field diagnostic work. Scan may not be supported in future builds and some bugs may be encountered. However, Scan remains a powerful tool for troubleshooting the instrument.

### 7.7.1 Scan Subdirectory

**Scan.bat** is located in the **c:\program files\MolecularDynamics\megabace\scan** subdirectory and is the main diagnostic program. This subdirectory contains the following files:

- **SCAN.BAT—**Runs the DOS version of the scan code. Allows you to perform instrument control and perform scans on a command-by-command basis.
- **LON_INST.BAT—**Downloads and configures all the internal microprocessor boards. This file also tests various aspects of the internal computer and records the results in a file called RESULT.TXT (located in the c:\temp directory).
- **ESCTEST.BAT—**Does a check of the internal computer CMOS RAM, BIOS, and echo and flash ROM disk. This file also checks each of the Echelon boards, reports their status and firmware date, and records the results in a file called RESULT.TXT.
- **SERVICE.BAT—**Allows the service personnel access to the internal computer through the serial port. It requires a null-modem connection between COM2 of the internal computer and a COM port on the host workstation.
- **????INST.BAT—**Each of these batch files begins with the name of one of the internal Echelon microprocessor boards listed below. Each batch file performs a download and configuration for the specified board and records the results in a file called RESULT.TXT.
    - ADAQ
    - PDIO
    - BEAM
    - SCAN
    - FLTR
    - TMPR
    - INTC
    - EPHV
    - CMON
- **NEWROM.BAT—**Stores the serial number and model number of the instrument, and programs the flash ROM disk on the PC interface board.

For all of these batch files, you can watch the progress of the programs running on the internal computer by connecting a null-modem cable from COM2 of the internal computer to a serial port on the host workstation. Set up a terminal emulator (like HyperTerminal PE) for 115K baud, 8-bit data, 1 stop bit, and no parity.

### 7.7.2 Scan Main Menu

When you run the **Scan** program, you see the screen shown in figure 7-20. As you can see from the main menu, **Scan** performs many functions. The following paragraphs deal with only the Instrument Commands selection and, because many of the menu selections and data screens are self-explanatory, only selected menus and data screens are described.

```
firmware version: 1.7,  files already downloaded

Select command by entering the parenthesized letter:
B - Soft re(B)oot Instrument.
C - (C)onfigure debug options.
D - (D)ownload icode files.
F - (F)ile and system io.
G - (G)et result file and check for errors.
H - (H)elp.
I - (I)nstrument Commands.
J - (J)ettison from target program (restart it).
N - (N)V Config table saved from target.
O - (O)pen scanner.
P - (P)ort I/O access in Instrument.
Q - in(Q)uiry command.
R - (R)eceive data.
S - (S)end data.
X - e(x)it.

>_
```

Figure 7-20. Scan Main Menu.

### 7.7.3 Instrument Commands

The Instrument Commands menu (figure 7-21) allows you to control many of the instrument functions and to extract instrument parameters and present them on the screen. From this menu you can interface directly with each of the Echelon network boards.

```
>(I)nstrument Commands
 6. LED   - blink LED n times (AHA-1520A LED)
 7. ECHO  - echo garbage data (same single pkt out, n pkts in; compare)

 a. STATUS
 b. Open Service door
 d. DAQ_PARMS
 e. START_SCAN
 f. Stop Scan
10. ESC DIAG
11. ECHN NODE CMD(Pass-through)
12. INIT  INSTRUMENT CODE CMD
13. CLOSE INSTRUMENT CODE CMD
16. Prepare Capillaries Macro
17. Diag Start Scan
51. EPHV commands
52. TMPR commands
53. INTC non macro commands
54. Motor Commands
55. ADAQ commands
56. PDIO commands

99. Return to main cmd level
 [0x99]         :
```

Figure 7-21. Instrument Commands Menu.

### 7.7.4 Status

The Instrument Status screen (figure 7-22) presents information on the status of the Echelon network boards.

*NOTE* **Status will report failures in some cases. This merely indicates that the interlocks have not been defeated or that the stages are not up.**

```
99. Return to main cmd level
 [0x99]         :a
Node Sts':
[ADAQ]=2 not scanning, no errors
[BEAM]=2 not scanning, no errors
[CMON]=ff not communicating.
[EPHV]=7 not scanning, self test failed, error ocurred,
[FLTR]=2 not scanning, no errors
[INTC]=2 not scanning, no errors
[PDIO]=2 not scanning, no errors
[SCAN]=2 not scanning, no errors
[TMPR]=ff not communicating.

One or more interlocks are open.
```

Figure 7-22. Instrument Status Screen.

### 7.7.5 Prepare Capillaries Macro

The prepare capillaries macro allows you to perform three capillary procedures. Once implemented, these macros perform the same functions as would be performed during an application protocol.

```
99. Return to main cmd level
 [0x99]         :16
MACRO
1.  Fill Capillaries
2.  Flush Capillaries
3.  Low Pressure Rinse
4.  Does Nothing
99. Return to main cmd level
 [0x99]         :_
```

Figure 7-23. Prepare Capillaries Macro.

### 7.7.6 EPHV Commands

The EPHV Commands menu (figure 7-24) allows you to set up various parameters of the HV power supply through the HV power supply control board. From this menu, you can read the current voltage and status, run high-voltage diagnostics, and start and stop the high voltage.

```
99. Return to main cmd level
 [0x99]         :51

1. Set Voltage
2. Set Run Time
3. Set Ramp Step Time
4. Set Ramp Step Value
5. Read Present Voltage & Status
6. Run the High Voltage Diagnostics
7. Start the High Voltage
8. Stop the High Voltage

: [255]         :_
```

Figure 7-24. EPHV Commands Menu.

### 7.7.7 TMPR Commands

The TMPR Commands menu (figure 7-25) allows you to perform actions on the TMPR board. From this menu, you can set the temperature of the electrophoresis compartment, turn the oven on or off, read the current temperature and status, and run temperature diagnostics.

```
99. Return to main cmd level
 [0x99]          :52

1. Set Temperature
2. Turn oven ON of OFF
3. Read Present Temperature and Status
4. Run the Temperature Diagnostics

: [255]          :_
```

Figure 7-25. TMPR Commands Menu.

### 7.7.8 Read Present Temperature and Status Screen

The screen shown in figure 7-26 is the result of selecting item 3 from the TMPR commands menu.

```
: [255]          :3
SCSI_RECEIVE=idle
cmd 0
Temperature Setpoint  = 0.00 degC
Real Temp of Sensor1  = 0.00 degC
Real Temp of Sensor2  = 0.00 degC
Real Temp of Sensor3  = 0.00 degC
Error from setpoint   = 0.00 degC
Heater Pulse Width    = 0 percent
Cooler Pulse Width    = 0 percent
Boost heater status   = 0 (1=ON, 0=OFF)
ERROR CONDITION(s):  error status = 0 hex
   No Errors
```

Figure 7-26. Read Present Temperature and Status Screen.

### 7.7.9 INTC Commands

The INTC Commands menu (figure 7-27) allows you to perform many instrument functions through the interface control board. Examples of two of the selections from this menu are described in the following two paragraphs.

```
99. Return to main cmd level
 [0x99]          :53

0.  Raise cathode Stage   2.  Raise Anode Stage
1.  Lower Cathode Stage   3.  Lower Anode Stage
16. Clamp Lock            17. Clamp Unlock
4.  High Pressure On      6.  Low Pressure On
5.  High Pressure Off     7.  Low Pressure Off
9.  Green Laser Off       11. Red Laser Off
8.  Green Laser On        10. Red Laser On
12. Blue Laser Idle       13. Blue Laser Off       14. Blue Laser Run

19. Program DAC           20. Program Cathode LCD  21. Program Anode LCD
15. Read INTC Status      18. Read Bottle Pressure 24. Run Macros
27. Wiggle Cat Stage      28. Vent Pressure        29. Vent Pressure on
30. Vent Pressure off
31. Read Sensor Status    32. Read High Pressure A/D
33. Open Service Door Latch
34. Read Cathode Sensors 35. Read Anode Sensors

: [255]          :
```

Figure 7-27. INTC Commands Menu.

### 7.7.10 Read Cathode Sensors Screen

The screen shown in figure 7-28 is the result of selecting item 34 from the INTC commands menu.

```
: [255]         :34
SCSI_RECEIVE=idle
SCSI_RECEIVE=idle
.SCSI_RECEIVE=idle

Cathode stage up mechanical *Closed*    Cathode stage down mechanical

Cathode stage in left (1) mechanical *Closed*
Cathode stage in right (2) mechanical *Closed*

Cathode array stage mechanical *Down*

Cathode Tank Microtiter Plate
```

Figure 7-28. Read Cathode Sensors Screen.

### 7.7.11 Read Anode Sensors Screen

The screen shown in figure 7-29 is the result of selecting item 35 from the INTC commands menu.

```
: [255]         :35
SCSI_RECEIVE=idle
SCSI_RECEIVE=idle
.SCSI_RECEIVE=idle

Anode stage up 2 Optical *Blocked*      Anode stage up 1 Optical *Blocked*

Clamp unlocked Optical *Blocked*        Clamp locked Optical *Blocked*

Retainer ring locked Optical *Blocked*  Anode stage up 3 mechanical *Closed*

Anode slide in 1 Optical *Blocked*      Anode slide in 2 Optical *Blocked*
```

Figure 7-29. Read Anode Sensors Screen.

### 7.7.12 Motor Commands

The Motor Commands menu (figure 7-30) is a very versatile menu. This menu allows you to set up the optical path in various configurations by moving the shutter, the beamsplitter changers, and filter changers individually, and to perform scans in the various configurations.

```
99. Return to main cmd level
 [0x99]         :54
1.  Move Filter 1 to A            2.  Move Filter 1 to B
3.  Move Filter 2 to A            4.  Move Filter 2 to B
5.  Home Filters

6.  Move Secondary Beam to A      7.  Move Secondary Beam to B
8.  Home Secondary Beam

9.  Scan With Filter 1 in A       10. Scan With Filter 1 in B
11. Scan With Filter 1 Dynamic
12. Scan With Filter 2 in A       13. Scan With Filter 2 in B
14. Scan With Filter 2 Dynamic

15. Scan With Secondary Beam in A  16. Scan With Secondary Beam in B
17. Scan With Secondary Beam Dynamic

18. Start Scan Stage              19. Stop Scan Stage

20. Move Shutter to Blue          21. Move Shutter to Green
22. Home Shutter

23. Move Primary Beam to Blue     24. Move Primary Beam to Green
25. Home Primary Beam

26. Scan With Shutter & Primary Beam Blue  27. Scan With Shutter & Prim

28. Scan With Shutter & Primary Dynamic


 [0x99]         :
```

Figure 7-30. Motor Commands Menu.

### 7.7.13 ADAQ Commands

The ADAQ Commands menu (figure 7-31) allows you to perform actions on the ADAQ board. From this menu, you can set several data acquisition parameters, read the current data acquisition status, and run diagnostics and self-tests.

```
99. Return to main cmd level
 [0x99]         :55

Control Menu:
1. Set Acquisition Parameters
2. Set PMT Power
3. Set Data Acquisition Mode
4. Set the Number of ES channels
5. Get Current Data Acquisition Status
6. Run Diagnostics
7. Run SelfTests
: [255]         :
```

Figure 7-31. ADAQ Commands Menu.

### 7.7.14 Set Acquisition Parameters

The screen shown in figure 7-32 is the result of selecting item 1 from the ADAQ Commands menu.

```
: [255]         :1
Frequency (0 to 100)KHz in 1KHz steps) [100]    :
Channel #1 Source (Preamp(0), External(1))) [0]         :
Channel #2 Source (Preamp(0), External(1))) [0]         :
Channels to Convert (Both(0), Ch1 only(1), Ch2 only(2))) [0]    :
SCSI_RECEIVE=idle

        Data Acquisition Parameters
Sampling Frequency 100KHz
Ch1 Source is the Preamp input
Ch2 Source is the Preamp input
Convert both Ch1 and Ch2
PMT1 Power 0V
PMT2 Power 0V
Scan mode = Synchronized
Number of Electrophoretic Channels is 4
```

Figure 7-32. Set Acquisition Parameters Screen.

### 7.7.15 PDIO Commands

The PDIO Commands menu (figure 7-33) allows you to perform actions on the PDIO board. From this menu, you can set several data acquisition parameters, read the current data acquisition status, and run diagnostics and self-tests. The secondary screens for the PDIO commands are identical to the screens for the ADAQ Commands menu.

```
: [255]         :1
Frequency (0 to 100)KHz in 1KHz steps) [100]    :
Channel #1 Source (Preamp(0), External(1))) [0]         :
Channel #2 Source (Preamp(0), External(1))) [0]         :
Channels to Convert (Both(0), Ch1 only(1), Ch2 only(2))) [0]    :
SCSI_RECEIVE=idle

        Data Acquisition Parameters
Sampling Frequency 100KHz
Ch1 Source is the Preamp input
Ch2 Source is the Preamp input
Convert both Ch1 and Ch2
PMT1 Power 0V
PMT2 Power 0V
Scan mode = Synchronized
Number of Electrophoretic Channels is 4
```

Figure 7-33. PDIO Commands Menu.

# Chapter 8 Service, Alignment, and Conversions

## 8.1 Introduction

This chapter describes some of the routine maintenance procedures required for the instrument upkeep, alignment procedures for the optical path components, procedures for converting between the various MegaBACE models, and procedures for upgrading the original version of the instrument.

- **Routine Maintenance—**
  - Capillary array replacement (Refer to chapter 4 of the *MegaBACE Instrument Maintenance and Troubleshooting Guide.*)
  - Array stage lubrication (Refer to chapter 4 of the *MegaBACE Instrument Maintenance and Troubleshooting Guide.*)
  - Correcting cathode tray jams (section 8.2)
  - Nitrogen leak test (section 8.3)
- **Alignments and Adjustments—**
  - Optical alignment (section 8.4)
  - Filter changer assembly and prealignment procedure (section 8.5)
  - Cathode and anode alignment (section 8.6)
  - Cathode array stage speed adjustment (MB 2000) (section 8.7)
  - Cathode optical sensor adjustment (MB 2000) (section 8.8)
- **Instrument Conversions—**
  - Converting the MB 1000 to MB 2000 (section 8.9)
  - Converting the MB 1000 to MB 500 (section 8.10)
- **Instrument Upgrades—**
  - Capillary window platform assembly (section 8.4.20)
  - New skirted-plate cathode assembly (section 8.11)
  - New pneumatics panel (section 8.12)

## 8.2 Correcting Cathode Tray Jams

The newer style cathode assemblies and the matching cathode trays have lever mechanisms that automatically lock the Robbins plate or water tank in the tray. Figures 8-1 and 8-2 illustrate the top and bottom of the cathode tray. Sometimes the turning pin (item 2) can stick and not rotate properly. The turning pin will allow the cathode to only go about two-thirds of the way up. Another problem is that the turning pin will not return to its original position and this prevents the plate or tank from being removed easily.

One cause of this problem is the collection of debris around the ends of the turning pin. The customer should be encouraged to keep these areas clean. Another cause of this problem is the lack of lubrication of the turning pin. Currently, the turning pins are being assembled with a light grease during manufacturing. Molecular Dynamics uses a long-lasting, low-vapor inert grease (Christo-Lube MCG109, MD PN 0148-523 (APB P/N 63002672)).

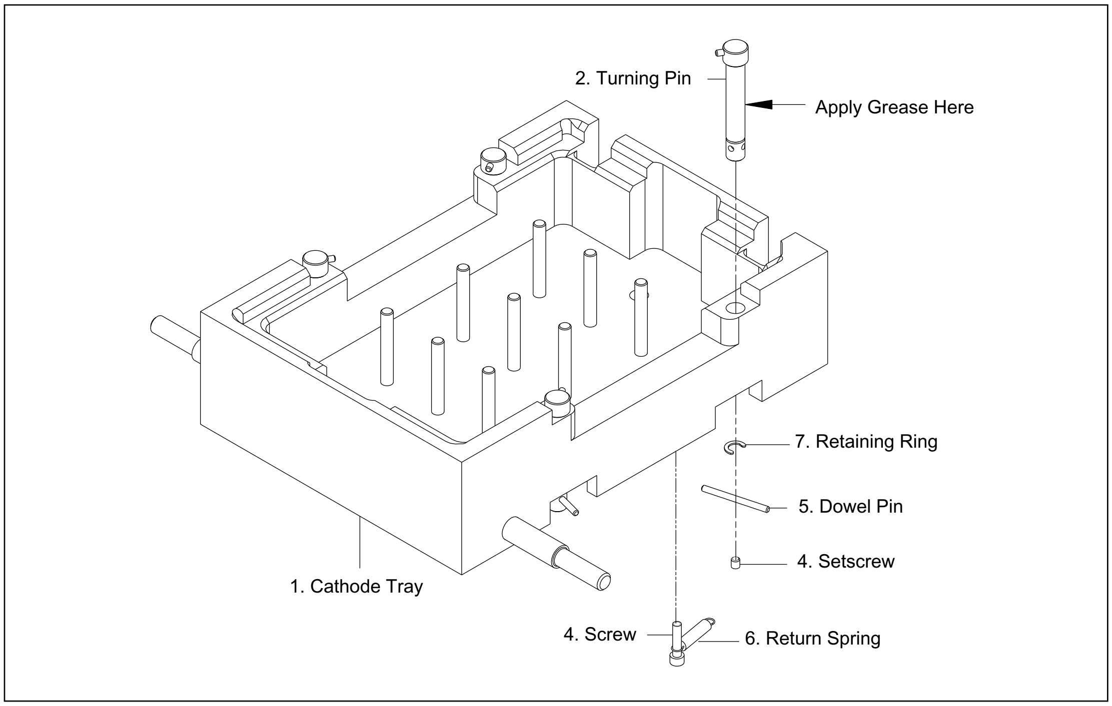



Figure 8-1. Cathode Tray, Top View.

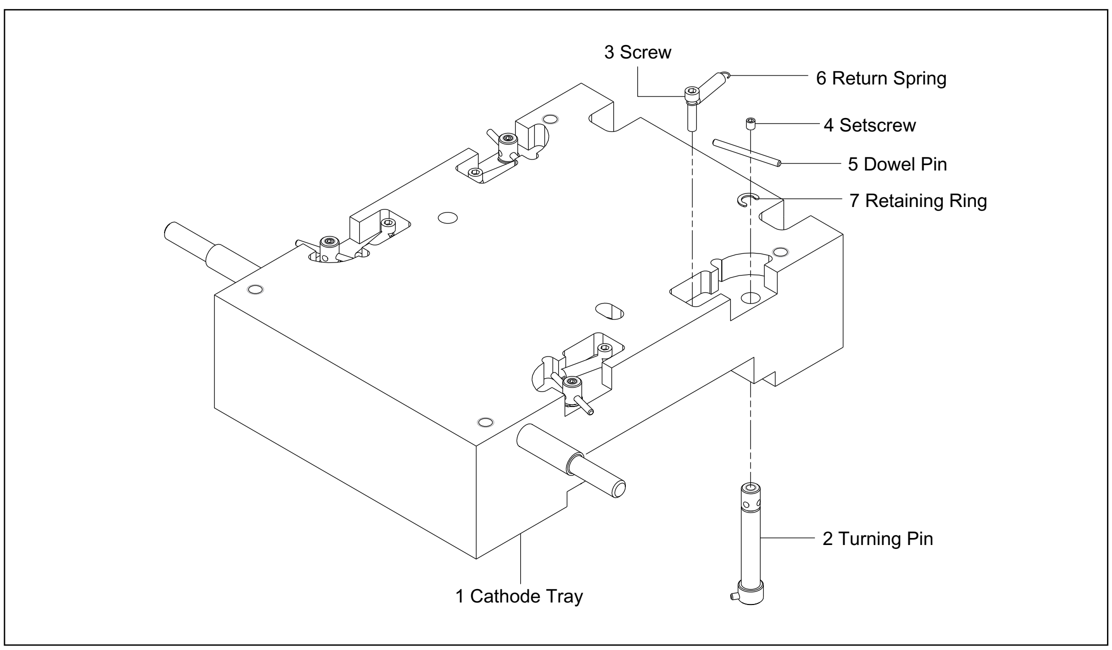



Figure 8-2. Cathode Tray, Bottom View.

The entire assembly (Tray Assembly, Cathode, MD PN 0224-723 (APB P/N 63002842)) can be ordered and replaced easily. However, if you repair the cathode tray, refer to the table below for a list of the various parts and their part numbers. If you need a tool to replace the retaining ring, order Tool, Appl, Ret. Ring, MD PN 0244-957 (APB P/N 63002567).

| Item No. | MD P/N | APB P/N | Description | Qty/Assembly |
|---|---|---|---|---|
| 1 | 0244-824 | 63002895 | Tray Cathode, Cycleplate | 1 |
| 2 | 0244-935 | 63002850 | Pin, Turn, Tray | 4 |
| 3 | 0209-288 | 63002854 | Screw, 2-56,.375, CAS-D | 4 |
| 4 | 0244-618 | 63002851 | Screw, 4-40,.093, SAS-D | 4 |
| 5 | 0244-624 | 63002451 | Pin, Dowel,.062 X.750, SS | 4 |
| 6 | 0245-006 | 63002852 | Spring, Ext.,.125DIA X.375X.012 | 4 |
| 7 | 0244-941 | 63002853 | Ring, Retaining,.135IDX.220D,EX | 4 |

## 8.3 Nitrogen Leak Test

This test detects and isolates nitrogen leaks in the instrument. The test uses the main window of the Instrument Control Studio (ICS) to raise and lower the anode and cathode stages and to monitor the high and low pressures in the instrument. Figure 8-3 illustrates the main ICS window.

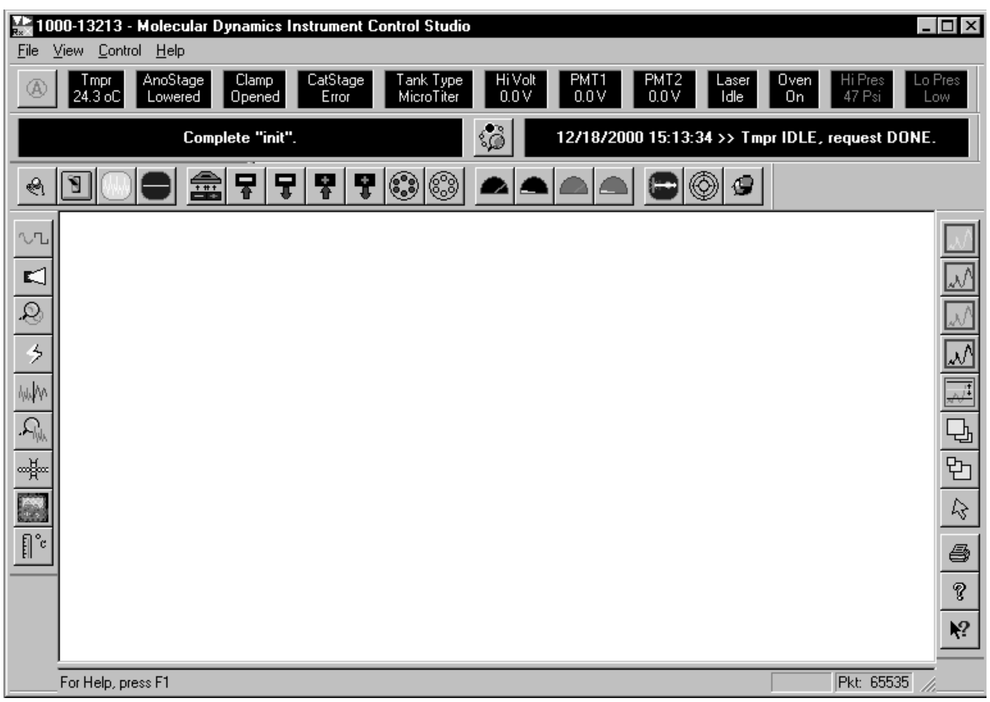



Figure 8-3. ICS Main Window.

### 8.3.1 Low Pressure

1. Open the ICS and monitor the low pressure (Lo Pres).
2. Raise the anode and cathode stages.
3. Shut off the low-pressure supply to the instrument and wait 1 minute.

4. Make a note of the low-pressure status in the ICS and wait 15 minutes.
5. After 15 minutes, the low-pressure status in the ICS should read Normal. If the low-pressure status reads Low, you have a leak in the low-pressure system. Go to step 6.
6. Lower both stages and repeat steps 3 and 4. If the system still leaks, the leak is located in the supply to the pneumatics panel or the pneumatics panel itself. If the system does not leak with both stages lowered, the original leak must be in one of the stages. Go to step 7.
7. To isolate a leak in the anode or the cathode pneumatics, repeat the test with only the anode stage raised or the cathode stage raised. If the system does not leak with both the anode and cathode stages lowered but does leak with one of the stages raised, the leak is in the pneumatics of the raised stage.

### 8.3.2 High Pressure

1. Remove the capillaries from the anode and install the anode plugs.
2. Open the ICS and turn on the high pressure (HiPres).
3. Shut off the high pressure supply to the instrument and wait 1 minute.
4. Make note of the high pressure reading in the ICS and wait 15 minutes.
5. After 15 minutes, read the high pressure again in the ICS. The maximum allowable loss is 5 psi. If the pressure has changed by more that 5 psi you have a leak in the high pressure system. Go to step 6.
6. Turn off the high pressure at the high-pressure shut-off valve on the pneumatics panel (see figure 8-4) and use the supply regulator gauge to monitor for leakage between the supply and the pneumatics panel. If the pressure is stable at the supply regulator, the leak must be in the instrument.

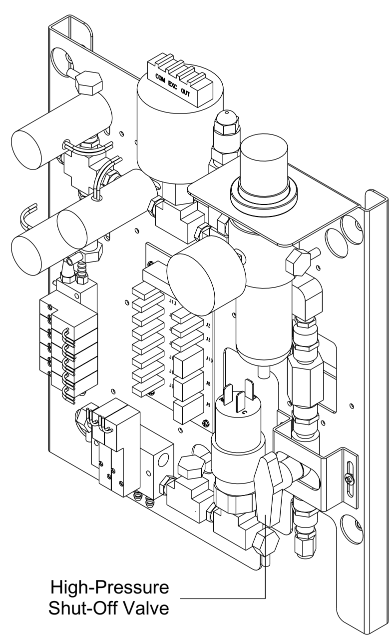



Figure 8-4. High-Pressure Shut-Off Valve.

## 8.4 Optical Alignment Procedure

### 8.4.1 Introduction

These procedures cover the preparation and alignment of the optical components in the equipment. These procedures were written for the alignment of the optical components in the operating environment. The complete alignment consists of an individual procedure for each of the optical components. When an individual optical component is replaced, it may not be necessary to do a complete alignment.

### 8.4.2 Tool Requirements

The following provides a list of all the tools needed for the installation, preparation, and alignment of the optical components in the equipment.

- **General tools and materials**
  - Standard Allen wrench set
  - Metric Allen wrench for M3 socket head
  - Standard flat-head screwdriver
  - Optical power meter
  - 11/32-inch open-end wrench
  - Inspection mirror
- **Special tools**
  - Six anode plugs (come with instrument)
  - Threaded mirror fixture
  - Objective mirror
  - Beam height tool
  - 1-inch mirror mounted on base (comes with instrument)
  - Stage alignment pinholes

### 8.4.3 General Procedures

For these alignment procedures, use the tool positions illustrated in figure 8-5. When using the alignment pinholes, use the one closest to the mirror to adjust for position and the one farthest away to adjust for tilt. Twist the pinhole until the beam is cleanly passing through it before assessing the beam's position at the pinhole. For consistency when installing mirror mounts and their bases, always push the mount away from the beam direction when tightening the mounting screws.

*WARNING* **Serious eye damage can result from looking directly into the laser beam. Be aware of the direction of the laser beam at all times.**

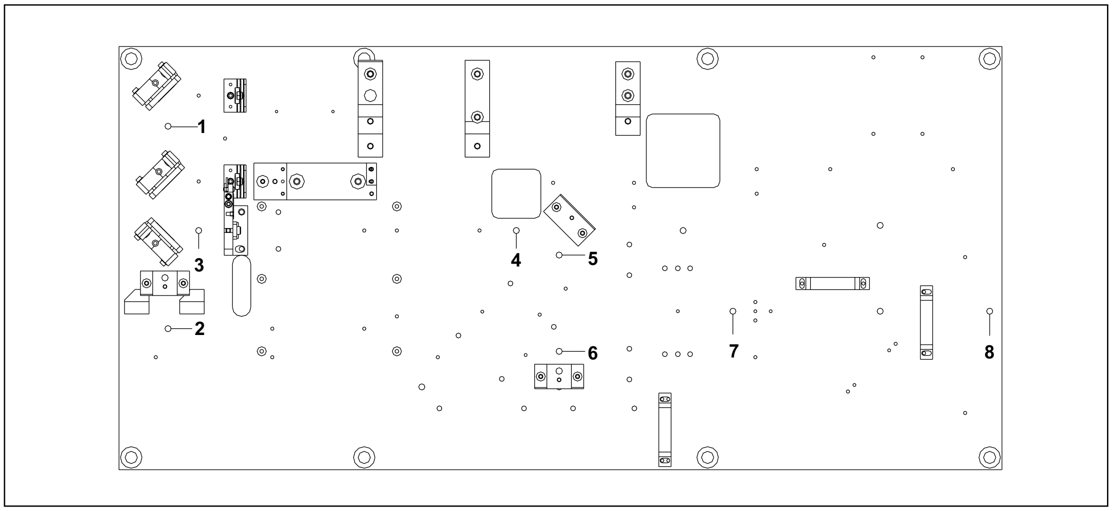



Figure 8-5. Alignment Tool Positions.

### 8.4.4 Blue Laser

1. Turn on the instrument and make sure there is air flow through the laser.

*CAUTION* **To prevent damage to the laser, ensure there is a blower (internal or external) running at all times during laser operation. After shutting down the laser, let the blower run for 5 to 10 minutes to allow for cool-down. An external vent may be left on all the time.**

2. Allow the laser to warm up for at least 30 minutes before measuring the power or aligning the beam.
3. Take a power reading right in front of the blue laser at 488 nm. Power should be approximately 4 mW.
4. Install the 488-nm laser notch filter and bracket.
5. Adjust the tilt of the notch filter bracket for peak power throughput as measured with the power meter. First, adjust the vertical direction, which should be set perpendicular to the beam. Next, adjust the horizontal direction and the recheck threshold.

*NOTE* **Horizontal tilt should be set so there is no reflection back into the laser. This may mean power will not be at the primary peak but at a secondary one.**

6. Tighten the lock nut on the adjustment screw and check the power.

### 8.4.5 First Turning Mirror

The first turning mirror is adjacent to the blue laser line filter and deflects the beam to the beam combiner.

1. Align the blue beam through the two alignment pinholes placed at locations 1 and 2 (figure 8-5).

*NOTE* **Because there is no position adjustment on the blue laser, the first turning mirror is the first adjustable element. Therefore, you may not be able to align the beam perfectly through both pinholes in the *vertical* direction, but you should be able to align the beam through both pinholes in the horizontal direction.**

2. When aligning through the two pinholes, align the vertical direction with the pinhole at location 2 instead of location 1, because location 2 is closer to the next turning mirror.

### 8.4.6 Beam Combiner

1. Install the beam combiner in its location in front of the green laser line filter.
2. Check the height match between the blue and green lasers at the beam combiner.
3. Readjust the height of the green laser as necessary to match the blue. If this is a large adjustment, go back and recheck the vertical tilt of the green laser line filter before continuing. The two lasers should be concentric at the beam combiner and collinear to a distant point as far away as possible (across the room).

*NOTE* **The 540LP laser blocking filter from the primary beamsplitter may be used *after* installing the beam combiner to reduce the green and blue beams while the collinear adjustment is being made.**

*WARNING* **To protect other personnel in the room, make sure you know the paths of the laser beams.**

*NOTE* **Make sure you align the correct beam when making adjustments from this point forward. There may be secondary reflections from the beam combiner.**

### 8.4.7 Second Turning Mirror

1. Install the second turning mirror in its location following the beam combiner.
2. Adjust the second turning mirror so that the blue beam passes through the alignment pinholes at locations 3 and 4 (figure 8-5). Adjust the height of the beam at the second pinhole (just before the third turning mirror).
3. Check to see if the green and blue beams are still collinear at a distant point.

### 8.4.8 Capillary Detection Assembly

1. Install the third turning mirror in its location following the second turning mirror.
2. Install a mirror behind location 6 (figure 8-5) and reflect the beam back on itself.
3. Install the capillary detection optics.
4. Adjust the capillary detection beamsplitter to align the main reflected beam onto the capillary detection diode.

### 8.4.9 Third Turning Mirror

1. Align the blue beam through the alignment pinholes at locations 5 and 6 (figure 8-5).
2. Check that the blue and green beams are still collinear.

### 8.4.10 Primary Beamsplitter

1. Place the 1-inch mounted test mirror in the position near the stage-locating pins and bolt the mirror in place. The beam should be approximately centered in the mirror.
2. Adjust the tilt of the test mirror to reflect the blue beam back to the laser.
3. Check that the green beam is also reflecting back to the laser.
4. Install the primary beamsplitter in its location following the third turning mirror and before the 1-inch test mirror.
5. Remove the two laser blocking filters. A convenient and safe place to store these is to hang them on the green laser heat sink.
6. Apply 24 volts to the SCAN board.

*NOTE* **If the BEAM board is connected to the system via Echelon cables and all the interlocks are closed, you can control the primary beamsplitter changer from the motor command menu in the Scan diagnostic software. If the BEAM board is not connected to the system via Echelon cables, you can activate the motor by shorting across the test pins (JM7B) on the board. When using the test pins, put the last switch (#8) on the DIP switch in the on position for static control.**

7. Check that the primary beamsplitter changer can be commanded to the home, blue, and green positions using the test pins on the SCAN board and then leave the primary beamsplitter changer in the blue position.
8. Adjust the blue primary beamsplitter to send the blue beam through the two alignment pinholes at locations 7 and 8 (figure 8-5). Be careful not to push on the mount while turning the adjustment screws.
9. After the adjustment, check to see if the beams are still reflecting back to the lasers from the 1-inch test mirror.
10. Adjust the green primary beamsplitter to send the beam through the same two locations.

### 8.4.11 Stage and Motor Installation

1. Remove the 1-inch test mirror from the stage location.
2. Place the primary beamsplitter in the path of the beam.
3. Install the stage assembly (including the stage motor and bracket) with the stage base pushed up against the dowel pins in the optics plate.

*NOTE* **Be careful not to move the third turning mirror when installing the stage motor bracket and routing cables in this area.**

4. The stage motor cable is routed through the hole in the optics plate and behind the double board bracket and plugs into the nano-step driver. The home sensors are connected as follows:
   - The back sensor (closest to the beamsplitter) plugs into J9N on the board stage.
   - The front sensor plugs into J7N on the same board.
   - The middle sensor cable (with two connections) is routed through the hole in the optics plate and plugs into the ADAQ and PDIO boards.
5. Do not tighten the screws holding the stage motor bracket to the optics plate. Let it slide freely at this point.
6. Attach the stage alignment pinholes to the stage.
7. With the stage in position nearest the beamsplitter, adjust the side-to-side position of the stage base until the beam is centered horizontally on the first pinhole. To adjust the stage base, loosen the three screws and slide the stage base sideways.

*NOTE* **Make sure that the stage base is pushed against the dowel pins during this adjustment.**

8. Tighten the stage base screws.

### 8.4.12 Head and Bearing Assembly Height Adjustment

1. With the stage head in position nearest the beamsplitter, loosen by 1/4 turn only the four socket-head screws that hold the bearing mounting plate to the upright bracket.
   - To raise the stage height, loosen both the front and back setscrews the same amount. Tighten both the front and back socket-cap screws on top until the front pinhole is centered vertically.
   - To lower the stage height, loosen the front and back screws the same amount, then tighten both front and back setscrews until the pinhole is centered.
2. Retighten the four mounting plate screws, and then retighten the front and back setscrews and the socket-cap screws.
3. Check the beam centering on the second stage pinhole to see how well centered the beam is.
4. Slide the stage head to the most forward position.

*NOTE* **If you feel a slight *catch* at the end of motion (in either direction), stop the slide just before this position.**

5. Observe how well centered the beam is on the two stage pinholes.
6. If the beam is no longer centered vertically, the tilt of the slide needs adjustment. If it is no longer centered horizontally, the tilt of the stage mounting bracket needs adjustment.

### 8.4.13 Slide-Tilt Coarse Adjustment

The slide-tilt adjustment is similar to the head and bearing assembly height adjustment, but only the front or back screws are adjusted.

To adjust the vertical tilt of the head and bearing assembly, use the following:

1. Slide the stage head toward the beamsplitter.
2. Recheck the height and adjust as necessary.
3. Slide the stage forward to the opposite end and again check the centering.
4. Adjust the tilt by adjusting the front screws, if necessary.
5. Continue moving the head back and forth and check for vertical beam centering. Make adjustments until no change is seen in the centering.

### 8.4.14 Stage Mounting-Bracket Tilt Coarse Adjustment

To adjust the horizontal tilt of the stage mounting bracket, use the following:

1. Slide the stage head back toward the beamsplitter.
2. Recheck the horizontal centering and adjust as necessary.
3. Slide the stage forward to the opposite end and check the centering.
4. If the stage is not centered, loosen the socket-head screw holding the bracket to the stage base. Do not loosen the one closest to the primary beamsplitter; it will act as a pivot point.

5. Using the push-pull arrangement of the two setscrews around the pin in front of the socket-head screw, pivot the stage sideways until the beam is centered. Retighten the socket-head screw.
6. Continue to move the head back and forth, and check for horizontal beam centering. Make adjustments until no change is seen in the centering.

### 8.4.15 Belt Tension Adjustment

The coupling of the stage motor to the stage via the stiffener and belt should be done with the stage alignment pinholes in place. This is to allow you to observe any movement of the stage as a result of stress.

1. Loosen the tension on the belt.
2. Loosen the two screws holding the stage motor bracket to the optics plate.
3. Loosen the screws holding the stiffener to the stage motor bracket and the stage mounting bracket and then tighten the screws.
4. Let the stage motor bracket slide left to right as needed to find its natural position.
5. This should put the stiffener in a parallel line with the stage mounting bracket. Tighten the two screws holding the stage motor bracket to the optics plate.
6. Loosen the screws holding the stiffener to both the stage motor bracket and the stage mounting bracket. This should let it relax.
7. Retighten the stiffener at the stage motor bracket and then at the stage mounting bracket.
8. Check the stage centering through the stage alignment pinholes to see if the centering has changed. Remember to move the stage back and forth while looking for changes. If there has been a change in the centering, perform steps 5 and 6 again.
9. To tension the belt, loosen the two screws that attach the pulley block to the stage bracket. This allows the pulley to slide.
10. Unscrew the setscrew against the pulley block until the screw is just not touching the pulley block. This allows the spring to tension the belt properly at 5 to 6 lbs. Tighten the screws and secure the block.

### 8.4.16 Stage Head Turning Mirror

1. Install the stage head turning mirror block assembly onto the stage. Leave the adjustment setscrews loose at this time. Nominally center the block and tighten the mounting screws underneath the block.
2. Screw the threaded mirror fixture into the objective mounting plate on the block. Be sure the two plate mounting screws are secure and the fixture is screwed in up to the shoulder.
3. Observe the reflection of the beam from the mirror fixture. If the beam is not returning to the laser, the block and/or turning mirror need adjustment.
4. To adjust the reflected beam horizontally, loosen the two block mounting screws and rotate the block on its pin until the beam is reflected. Initially, only a *coarse* adjustment is necessary.

5. To adjust the vertical position, use the push-pull screws at the top of the turning mirror mounting plate to move the beam into correct vertical position. Be sure the push-pull screws are tight when you are finished.

6. Return to the horizontal adjustment. Snug the two adjustment setscrews up against the block. Loosen the two block mounting screws (1/4 turn only.) Use the two setscrews to fine-adjust the horizontal tilt by pivoting the block on its pin. Retighten the mounting screws.

7. Move the stage head back and forth and watch the reflected beam at some distant point (that is, back at the laser). If the reflected beam moves or is not centered, small adjustments in mirror/block tilt and/or stage tilt may be needed.

8. Remove the threaded mirror fixture from the block.

### 8.4.17 Objective Lens Installation and Alignment

1. Install the objective lens in the stage head. The lens housing should be screwed into the objective mounting plate on the block. Screw the housing in up to the shoulder.

2. To determine the best plate position, observe the beam on a sheet of white paper held about an arm's length from the output of the lens. (Prop the paper on the rail where the thermal chamber rests when in position.)

3. The beam should be centered through the lens as indicated by the visible concentric rings. To center the beam, proceed as follows:

   - Slide the stage head toward the beamsplitter.
   - Check to see if the beam is centered through the lens.
   - If it is off vertically, loosen the two mounting screws and use the push-pull screws on top of the block to center the beam.
   - If it is off horizontally, loosen the two mounting screws and use the push-pull screws on the side of the block to center the beam.
   - Slide the stage head forward and recheck the centering.

4. If the centering is off vertically, adjust the stage tilt as before.

5. If the centering is off horizontally, adjust the horizontal tilt of the stage mounting bracket as before. You will have to loosen the stage motor bracket again to do this.

6. Slide the stage head toward the beamsplitter and repeat steps 3 through 5 until the beam stays centered in the lens as the stage head slides back and forth.

7. Check that the blue and green beams are still collinear through the aspheric lens. If not, a *small* adjustment of the beam combiner should be made to so that the green beam is well centered through the lens.

8. Check that the stage sensors are positioned in the center of the flag cutout.

### 8.4.18 Circuit Board and Shutter

1. Turn off power to the system (or 24-V supply). Disconnect the connections to the shutter motor control board.
2. Install the board shutter with bracket, being careful as you maneuver it around the stage area. Attach the shutter to the optical plate using *only* the left two screws. *Do not* use the third screw, which is located near the primary beamsplitter.
3. Plug the primary beamsplitter into the board as before along with the 24-V supply, ribbon connector, and two Echelon cables.
4. Install the shutter between the laser line filter and the first turning mirror. Be careful not to bump the mirrors in this area.
5. Plug the shutter into the bottom two connectors, J4P and J5P, on the shutter board.
6. Turn on power to the board (24-V supply or the system). If you are connected to the system, bypass the interlocks so the shutter will open. **Note:** With power to the shutter, you can manually move the shutter from the blue to the green position.
7. Move the primary beamsplitter to the blue laser.
8. Hold the mirror flat against the reference plate as you bring the clamped capillary holder up to it. Push the reference plate flat against the mirror with just enough force to hold mirror in place.

### 8.4.19 Capillary Window Platform Reference Plate adjustment.

Refer to figure 8-6 for this procedure.

1. The reference plate should be preadjusted with a 1/8-inch gap at both ends, top and bottom.
2. Install the capillary clamp assembly and adjust for proper clearance (section 8.4.20).
3. Remove the objective lens.
4. Install the reference plate capillary holder assembly.
5. Install the preload tool with the mirror slide into the capillary clamp assembly.
6. Using the two reference plate tilt adjustments, adjust the tilt of the reference plate until the reflected light is at the same height as the incoming light.

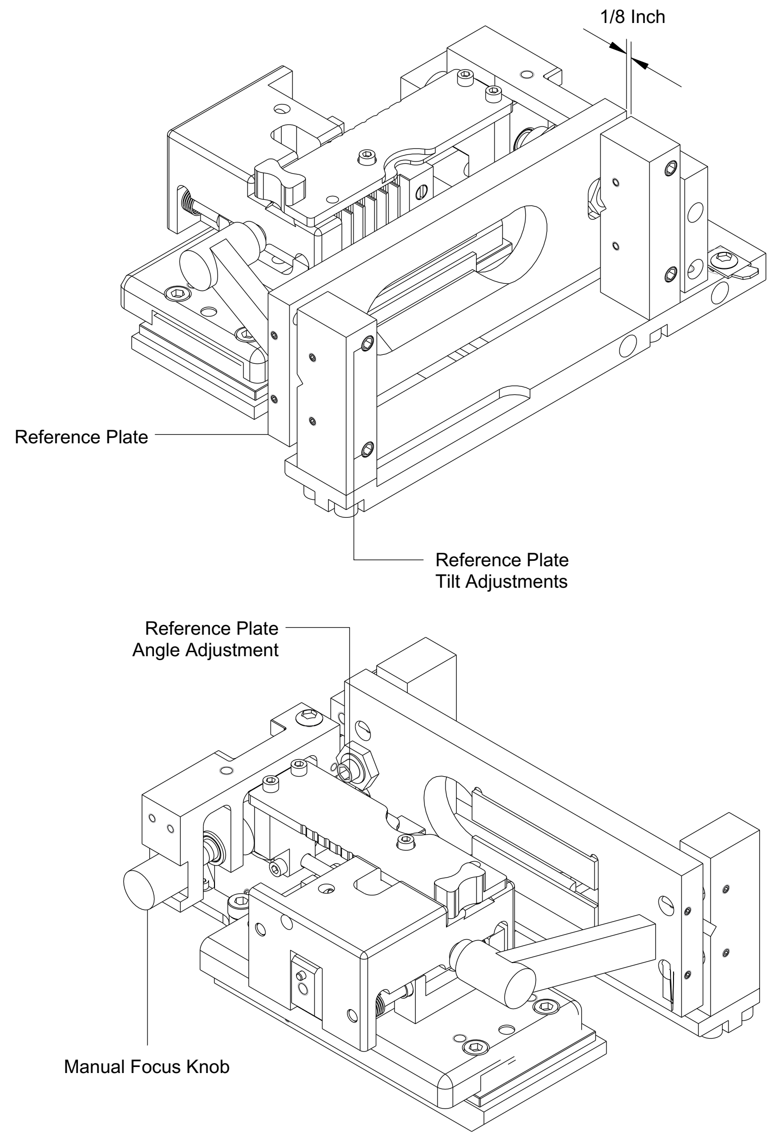



Figure 8-6.  Capillary Clamp Assembly.

7. Remove the reference plate capillary holder assembly and install the objective.
8. Install the reference plate capillary holder assembly with the preload tool still installed.
9. Remove the laser blocking filter from the primary beamsplitter.
10. Look at the reflected laser light from the primary beamsplitter, before the first achromat.
11. Move the scanning stage back and forth on the mirrored slide of the preload tool.
12. The size of the reflected spot should remain the same across the entire scan.
13. If the spot is too large or too small to see size changes, adjust the manual focus knob.
14. If the spot is changing sizes from one end of the scan to the other, adjust the angle of the reference plate with the reference plate angle adjustment.
15. Readjust the capillary clamp for proper clearance (section 8.4.20).

### 8.4.20 Capillary Window Platform Assembly.

Refer to figure 8-7 for this procedure. The capillary clamp is attached to the corners of the bottom plate with four cap screws. The window height is adjusted by controlling the spacing between the bottom plate and the capillary clamp. This distance is controlled by setscrews positioned next to the four cap screws. The adjustment is made by loosening the cap screws slightly and adjusting the four setscrews up or down. The spacing between the bottom plate and the capillary clamp is set at the factory to approximately 0.060 inch. One complete turn of the setscrews will move the window height approximately 0.030 inch.

The preload tool has a shouldered pin stored in a hole and held in place by a retaining screw. This pin is used to help keep the preload tool in place while the adjustments are being made. The larger screw and washer are also used in the preload adjustment.

1. Remove the large screw and washer from the top of the preload tool (figure 8-7) and install the tool on the left side of the capillary clamp assembly. Tighten the screw until the small black plunger is flush with the surface.
2. Remove the retaining screw and the shouldered pin from the top of the preload tool. Replace the retaining screw to keep from losing it.
3. Place the preload tool in position and insert the shouldered pin through the hole in the window latch and into the hole in the preload tool.
4. Loosen the two nuts on the bottom plate.
5. Rotate the locking lever clockwise to position the preload tool until it is against the ceramic strips on the registration plate.
6. Lightly tighten the two nuts on the bottom plate.
7. Turn on the beam and move the scan head back and forth to determine the window height. The beam should be in the center of the groove cut in the middle of the preload tool, at both ends of the tool.
8. Adjust the window height by loosening the four cap-head screws and adjusting the four setscrews. Turn the setscrews clockwise to raise the window height and counterclockwise to lower it.
9. To gain access to the cap-head screw and setscrew in the right-rear corner of the assembly, remove the shouldered pin, slide the window latch forward, and replace the shouldered pin.
10. When you finish the adjustment, lightly tighten the four cap-head screws. Overtightening will deform the parts.

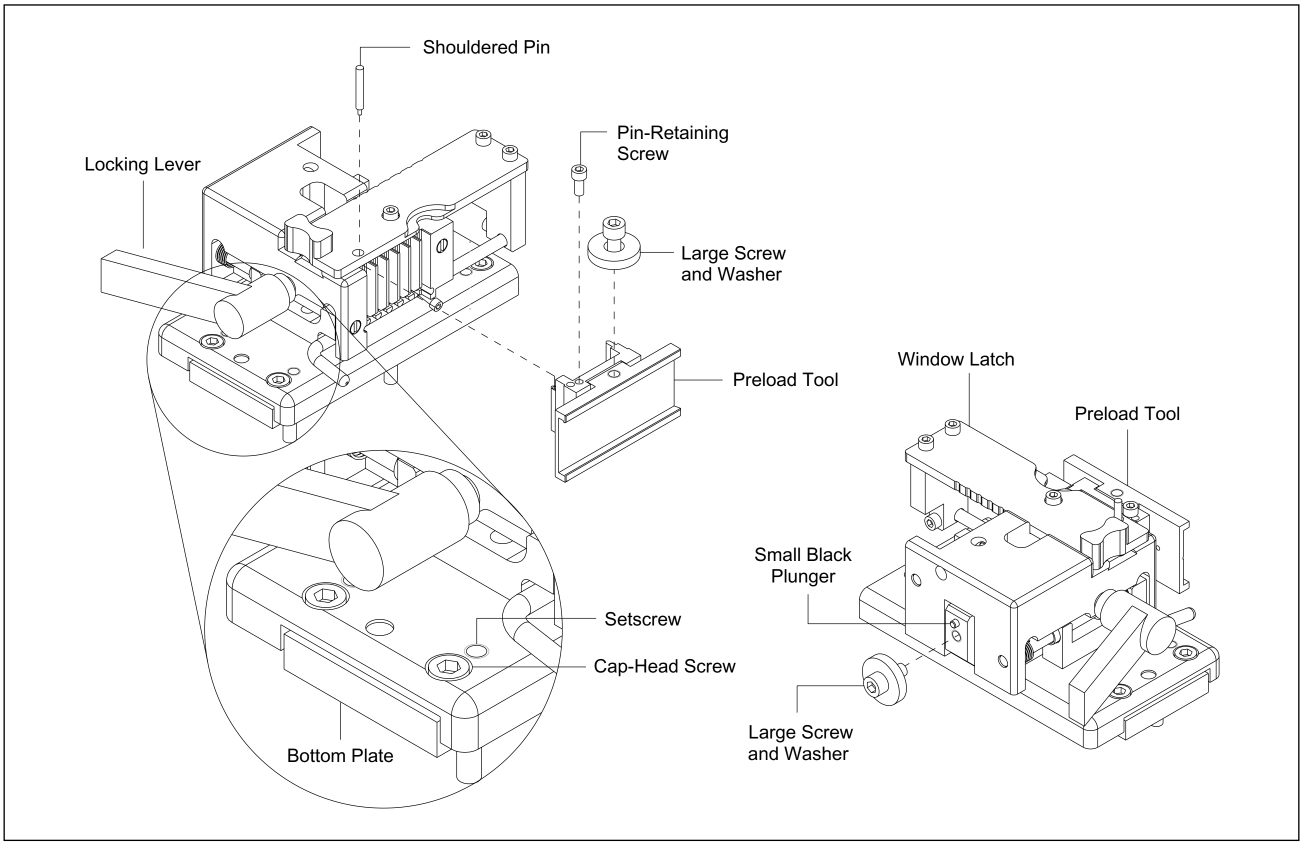



Figure 8-7.  Capillary Clamp Assembly.

### 8.4.21 Second Achromatic Assembly

1. Install the second achromatic assembly with pinhole in its location following the stage motor bracket.
2. Install the laser blocking filters.
3. Install the fluorescent tool at the reference plate to emit fluorescent light through the objective to the achromat.

*NOTE* **Make sure that the lens assembly is secure against the mount and has not popped out.**

4. Using the fluorescent light from the tool, align the second achromatic assembly for the best quality through the pinhole and lens. The beam should be centered in the image of the pinhole and uniform. This can best be viewed when the beam is sent across a darkened room. You may have to adjust the manual focus for best results.

### 8.4.22 First Achromatic Assembly

1. Install the first achromatic assembly in its location between the stage motor bracket and the second achromatic assembly.

*NOTE* **Do not change the Z-position of the first achromatic assembly. The Z-position is preset at the factory.**

2. Adjust the X- and Y-positions of the first achromat lens to center the beam in the image of the pinhole as viewed after the second achromat. The area must be fairly dark to see this accurately.

### 8.4.23 Secondary Beamsplitter

1. Install the secondary beamsplitter.
2. Place the appropriate beamsplitters in slots A and B.
3. Plug the beamsplitter into the two bottom connectors, J4P and J5P, on the board stage.
4. Set position 8 on the DIP switch on this board to the up position for static control. This lets you control the secondary beamsplitter in static mode by shorting across the test pins (JM7B). If connected to the system, you may also use the motor command menu.
5. Set the home sensor so the beam is centered in each of the beamsplitters when activated.
6. Adjust the overall position of the beamsplitter holding plate so that the beam is approximately centered in each position.
7. Adjust the tilt of the holding plate until the reflected beam is centered on the alignment pinhole at location 9.
8. If the relative positions stay the same, put the beamsplitters back in the correct positions.
9. Split the difference in centering around the pinhole. Neither beam should be more than one beam diameter off.
10. Recheck the centering throughout the beamsplitters.

### 8.4.24 Filter Changer Assembly

1. Install the filter changer assembly. The edge of the filter changer should be flush with the end of the optics plate.
2. With one of the secondary beamsplitters in the optical path, verify the beam is approximately centered on the holes leading to the PMTs.
3. With the power off, plug the motor and sensor cables from filter set 1 into the top two connectors, J2P and J3P, and plug the motor and sensor cables from filter set 2 into the bottom two connectors, J4P and J5P, on FLTR board (0146-531). Plug the PMT connections into ADAQ board. Apply 24V to the board (or turn on the system.)
4. Use the test point (JM7B) on the board to activate the changer. If you are connected through the system, you may control the filter changer through the motor command menu.
5. Adjust the optical home sensor positions so that the beam is centered in each filter holder. Check the centering with the secondary beamsplitter in both the A and B positions. Check for both blue and green beamsplitters and both blue and green beams.

## 8.5 Filter Changer Assembly Pre-Alignment Procedure

### 8.5.1 Introduction

The procedures listed here assume motors, optical switches, and PMT sockets are prewired with connectors. It also assumes the filter changer arm assembly and PMT housing assembly are pre-assembled.

Required Tools:

- Optical layout
- Standard Allen wrench set
- 11/32-inch and 3/16-inch open-end wrenches

### 8.5.2 Filter Changer Arm Assembly Installation

To attach a filter changer arm assembly to a motor shaft, use the following procedure.

1. Remove the counterbalance from the bottom of the arm assembly.
2. Loosen the clamping screw.
3. Place the arms on the shaft on the side toward the bracket and the slide assembly onto the shaft.
4. Position the assembly on the shaft as far in as possible. Leave enough space that the assembly clears all Pem nuts when rotated.
5. The slots for the filters should be within the cutout area on top of the bracket.
6. Tighten the clamping screw.
7. Ensure the arm does not hit the optical switch but is approximately centered in the switch when the holder is in the upright position.
8. Adjust the switch position if necessary.
9. Reattach the counterbalance to the bottom of the arm assembly.
10. Install the three captive mounting screws.

## 8.6 Cathode/Anode Alignment

When you install the cathode/anode assembly, the access door may not line up properly, and you will have to reposition the cathode/anode assembly several times to achieve the proper alignment. An alignment tool is now available that ensures the correct alignment when you install the cathode/anode assembly. This procedure describes the alignment tool and its use and is meant to supplement the cathode/anode installation procedures found in chapter nine of the service manual.

Parts Required: Cathode/Anode Alignment Tool, MD P/N 0244-735 (APB P/N 63002199)

The alignment tool (figure 8-8) has four ball studs that are inserted into the four ball-stud receptacles on the chamber normally used by the front panel assembly.

1. Make sure that the cathode/anode stage is in the lowered position.
2. Place the cathode/anode assembly in position and loosely install the four screws that secure the assembly to the sheet metal chassis.
3. Install the Cathode/Anode Alignment tool by aligning the ball studs on the alignment tool with the ball-stud receptacles on the chamber.
4. Position the cathode/anode assembly so that the metal pin at the end of the slide fits into the slot in the alignment tool and the front surface of the slide is flush against the surface of alignment tool. See figure 8-9.
5. Tighten the screws that secure the cathode/anode assembly to the sheet metal chassis.

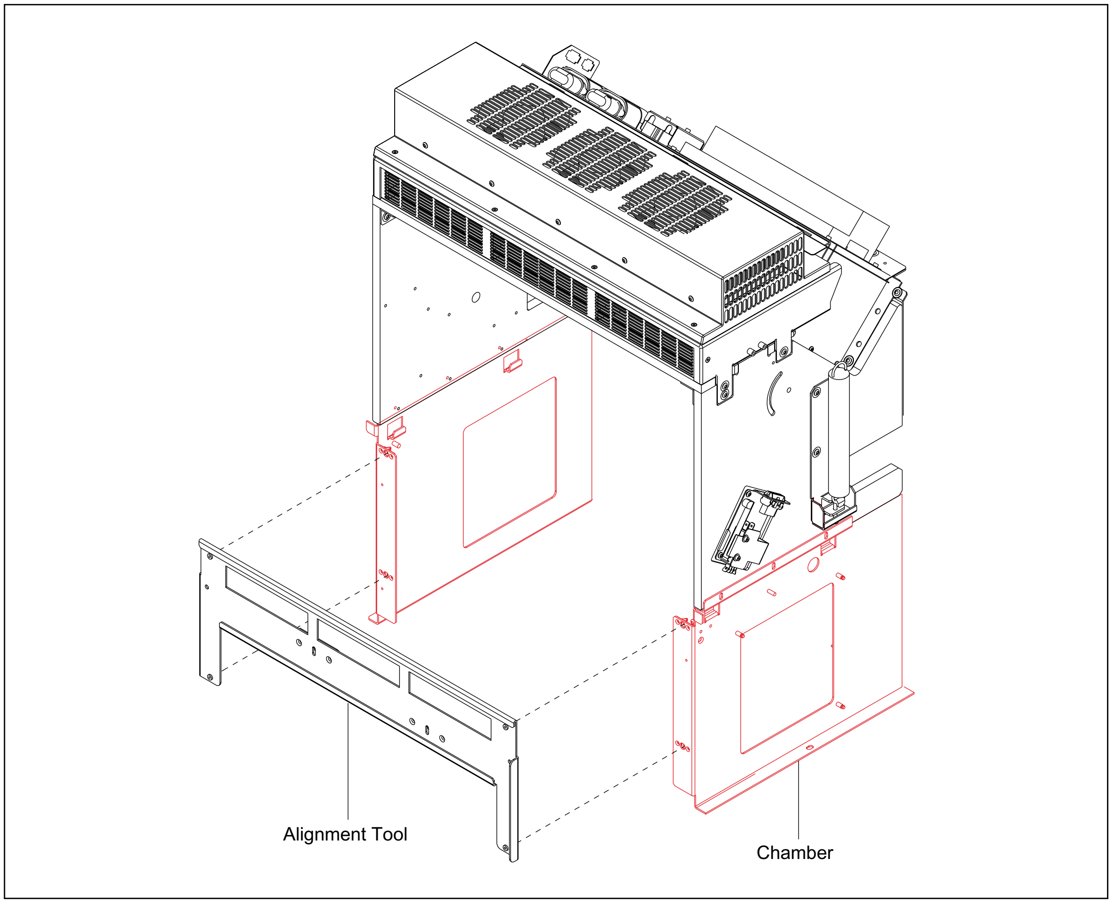



Figure 8-8. Alignment Tool Location.

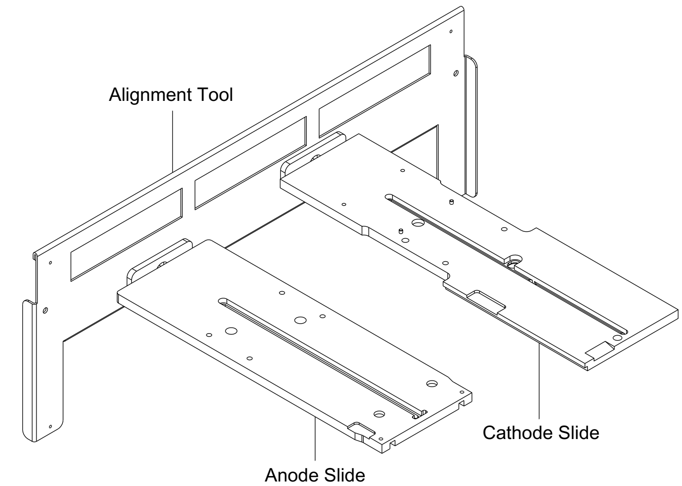



Figure 8-9. Slides Mated with Alignment Tool.

## 8.7 Cathode Array Stage Speed Adjustment (MB 2000)

Two adjustments control the speed with which the array stage moves up and down. These adjustments are located on the outputs of the top two solenoids on the right side of the cathode assembly. The top adjustment controls the speed at which the air escapes from the air cylinder when the stage is moving up. The bottom adjustment controls the speed at which the air escapes from the air cylinder when the stage is moving down.

1. Remove the cathode assembly, place it to the left side of the instrument, and reconnect it.
2. Start the HSC and use it to raise and lower the array stage.
3. Adjust the top adjustment until the array stage takes approximately two seconds to raise to the top position.
4. Adjust the bottom adjustment until the array stage takes approximately two seconds to lower to the bottom position.
5. Reassemble the instrument.

## 8.8 Cathode Optical Sensor Adjustment (MB 2000)

1. Remove the cathode assembly, place it to the left side of the instrument, and reconnect it.
2. Start the HSC and the ICS to monitor the status of the sensors.
3. Adjust the position of the sensors so that the ICS correctly displays the position of the tray when it is in each of the 4 positions (A1, A2, B1, B2).
4. Test and then re-assemble the instrument.

## 8.9 Converting the MB 1000 to the MB 2000

Converting the MB 1000 to the MB 2000 requires the replacement of the cathode assembly and interface (INTC) board and installation of a nitrogen supply from the main pneumatic panel to the new cathode assembly. This procedure requires Cathode/Anode Alignment Tool, 0244-735.

### 8.9.1 Prepare the MegaBACE Instrument for Service

1. Flush and dry the capillaries.
2. Remove and safely store the capillaries.
3. Turn off the power to the instrument and unplug the power cord.
4. Turn off (close) the pressure sources (nitrogen and air) and vent the lines.
5. Remove the top cover (section 9.2.1).
6. Remove the left panel assembly (section 9.4.1).
7. Remove the filter cover assembly (section 9.5.1).
8. Remove the lower right panel assembly (section 9.6.1).
9. Remove the front panel assembly (section 9.9.1).
10. Remove the cathode assembly (section 9.67.1).
11. Remove the interface (INTC) board (section 9.13.1).
12. Install the replacement interface (INTC) board (section 9.13.2).

### 8.9.2 Install Cathode Modifications.

Use the following procedure and figure 8-10 to install the new cathode assembly.

1. Connect the new ribbon cable to the 50-pin INTC board connector. Route the cable forward to the cathode area.
2. Position the new cathode assembly in front of the instrument and connect the 50-wire ribbon cable from the new INTC board to the cathode interface board.
3. Install the new cathode pneumatic assembly in the 100-psi input to the main pneumatic panel.
4. Install the long pneumatic hose of the cathode pneumatic assembly to the bottom fitting on the 8-port manifold on the new cathode assembly.
5. Install the Cathode Assembly (section 9.67.2).
6. Align the cathode and anode as described in section 8.6.
7. Install the new front panel assembly (section 9.9.2).
8. Install the left panel assembly (section 9.4.2).
9. Install the top cover (section 9.2.2).

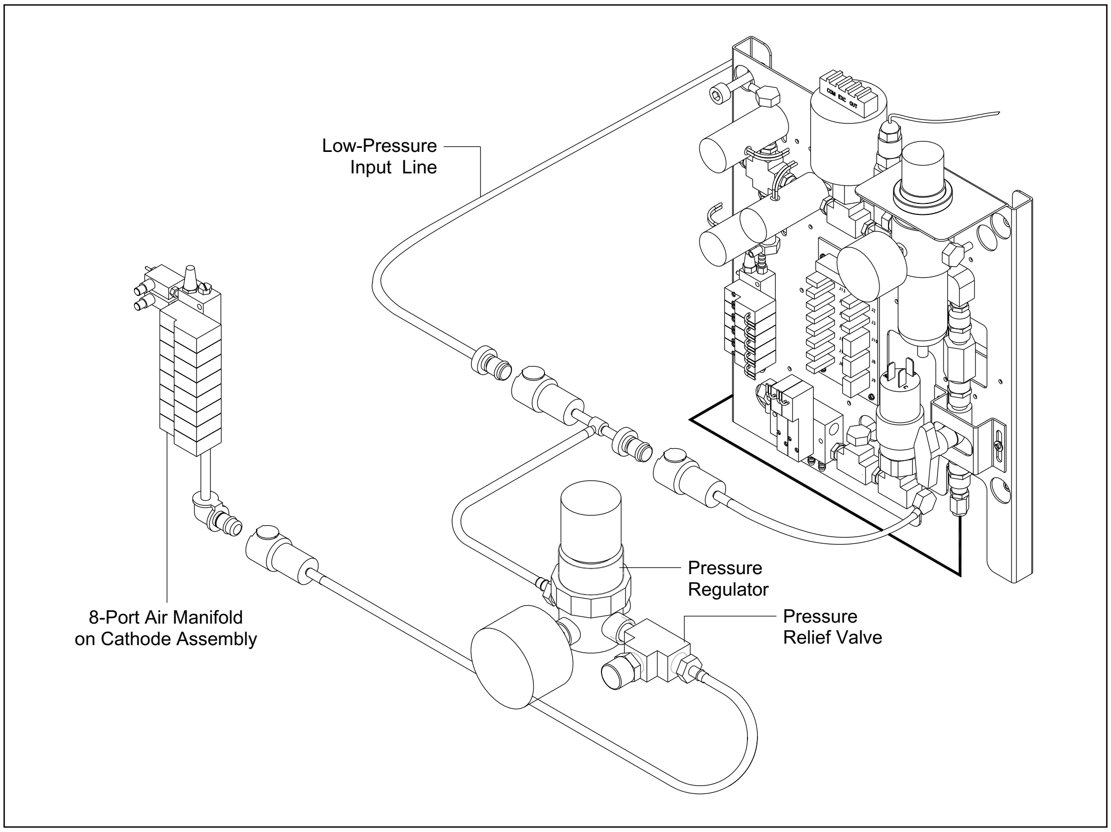



Figure 8-10. New Cathode Pneumatics.

### 8.9.3 Start the MegaBACE Instrument

1. Plug the instrument into the appropriate power source.
2. Turn on the instrument.
3. Turn on the pressurized nitrogen and air. (**Note:** MegaBACE instruments have been supplied that use pressurized nitrogen at 12 and 30 psi.)

### 8.9.4 Replace the Water Tanks

The water tanks used on the MegaBACE 1000 cathode are not appropriate for use with the MegaBACE 2000 instrument. Replace the user's water tanks with those supplied in the MegaBACE 2000 Upgrade Kit.

### 8.9.5 Install the New Software

1. Uninstall the MB 1000 Instrument Control Manager (ICM) software.
2. Install ICM version 2.4 (or higher).
3. Uninstall MB 1000 Instrument Control Software (ICS).
4. Install latest version of the ICS.
5. Use NEWROM.bat (in the SCAN directory) to configure the instrument by model and serial number. Set the model number to 1010. Use the original instrument serial number.
6. Restart the MegaBACE instrument.

### 8.9.6 Install the Capillaries

1. Reinstall and hydrate the capillary arrays.
2. Focus the capillary arrays.

### 8.9.7 Test the MegaBACE Instrument Operation

Run/test the instrument operation using the M13 standard.

### 8.9.8 Perform Customer Training

Familiarize the user with the MB 2000 water tanks, including how to fill and handle them.

## 8.10 Converting the MB 1000 to the MB 500

The procedure for converting the MB 1000 to the MB 500 consists of modifying the cathode and anode assemblies so they can only accept up to three capillary arrays and loading the appropriate upgrade software.

### 8.10.1 Prepare the MegaBACE Instrument for Service

1. Flush and dry capillaries.
2. Remove and safely store the capillaries.
3. Turn off the power to the instrument and unplug the power cord.

### 8.10.2 Install Array Placeholders in the Array Stage

Array placeholders must be installed to take the place of the capillary arrays that are not used. These array placeholders consist of window blanks for the window holder and cathode plunging tools for the capillary array stand. These items are installed in the same way as their counterparts on actual capillary arrays.

### 8.10.3 Install Vessel Inserts in the Anode Reservoir Holder

1. Squeeze the vessel insert between thumb and forefinger and insert it into the reservoir holder (figure 8-11).
2. Push the insert all the way until it is seated on the bottom of the reservoir.
3. Repeat steps 1 and 2 to install the vessel inserts in the remaining two places.

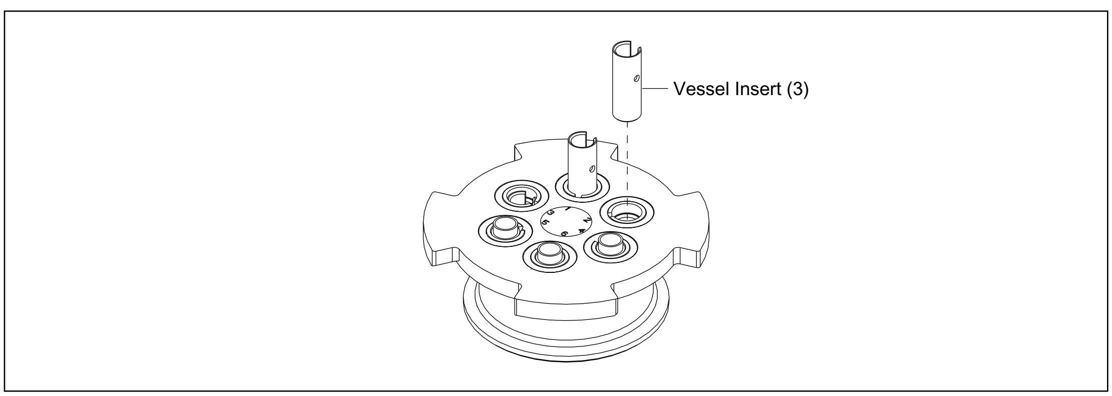



Figure 8-11. Anode Reservoir Holder.

### 8.10.4 Start the MegaBACE Instrument

1. Plug instrument into the appropriate power source.
2. Turn on the instrument.

### 8.10.5 Install the New Software

1. Uninstall the MegaBACE 1000 Instrument Control Manager (ICM) software.
2. Install ICM version 2.4 (or higher).
3. Install MegaBACE 500 Instrument Control Studio (ICS).
4. Use NEWROM.bat (in the SCAN directory) to configure the instrument by model and serial number. Set the model number to 1010. Use the original instrument serial number.
5. Download LON_INST.bat firmware
6. Restart the MegaBACE instrument

### 8.10.6 Install Anode Plugs and Capillaries

1. Install anode plugs in positions 1, 2, and 3 (figure 8-12).
2. Reinstall and hydrate the capillary arrays in positions 4, 5, and 6.

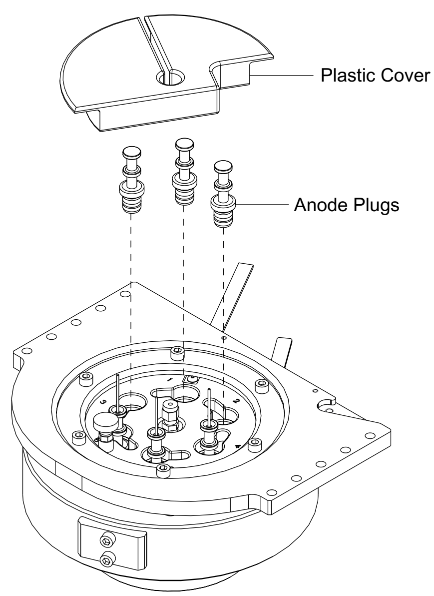



Figure 8-12. Anode Plugs and Plastic Anode Cover.

3. Install the plastic anode cover over positions 1, 2, and 3.
4. Focus the capillary arrays in positions 4,5, and 6.

### 8.10.7 Test the MegaBACE Instrument Operation

Run/test the instrument operation using the M13 standard.

### 8.10.8 Perform Customer Training

Familiarize the user with the MegaBACE 500 operation.

## 8.11 New Skirted-Plate Cathode Assembly Upgrade

A new cathode has been released for the MegaBACE. This cathode allows the customer to use skirted plates with their instruments. The new cathode can also be converted to use Robbins plates if the customer still uses those plates. The conversion to Robbins plates is described below. The Skirted-to-Robbins Conversion Kit can be ordered separately. MegaBACE instruments beginning with Serial Number 13720 have the new cathode. However, a customer can still obtain the Robbins configuration if they order six (6) or more instruments at one time.

The new cathode requires the use of low pressure to operate. Refer to section 8.12 for details of low-pressure cathode operation.

Customers who have older MegaBACE instruments that use Robbins or PE plates can purchase a Skirted Plate Upgrade Kit. That upgrade kit includes the new skirted cathode and the parts required to upgrade the pneumatics panel for low-pressure operation. The following table identifies the skirted plates that can be used with the new cathode, the supplier of the plates, and their product or part number (these plates are not sold by Amersham Pharmacia Biotech).

| Item | Supplier | Product or Part Number |
|---|---|---|
| Microseal™ 96, skirted plate, natural color<br>Microseal 96, skirted plate, bar coded | MJ Research, Inc. http:/www.mjr.com<br>Within US: (1) (888) 729-2165.<br>Outside US: (775) 832-8000 or refer to Web site | MSP-9601<br>MSP-9605 |
| Thermo-Fast™ 96, skirted thin-wall PCR plate, natural color | Abgene http:/www.abgene.com<br>Within US: (1) (716) 241-2870.<br>Outside US: (44) (0) (1372) 723456 or refer to Web site | AB-0800 |
| ABgene™ Thermo-Fast 96, skirted thin-wall PCR plate, natural color | Marsh Biomedical Products, Inc.<br>http:/www.biomar.com<br>Within US: (1) (800) 445-2812.<br>Outside US: (716) 654-4800 or refer to Web site | WAB-0800-N |

Figure 8-13 illustrates the differences between the two kinds of plates and their associated trays.

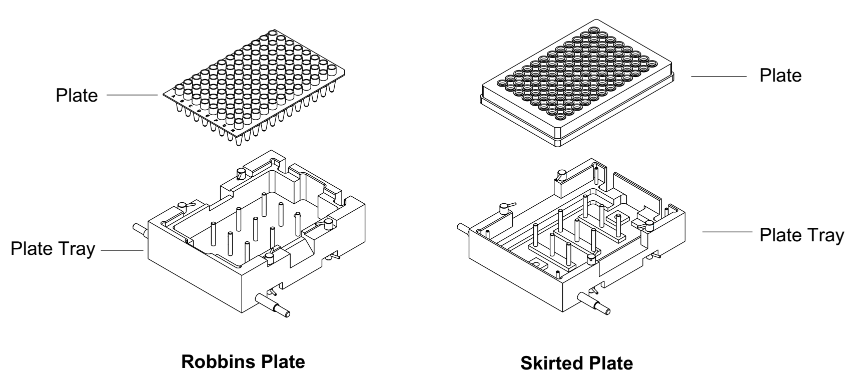



Figure 8-13. The water tank for the Robbins Plate and the Skirted Plate.

A potential problem exists with the skirted-plate water tank if it is not used correctly. This water tank is shallower than the tank used with the older Robbins plates and it can be overfilled. When the tank is overfilled and the cathode door is opened or closed too fast, water can spill inside the instrument and onto the cathode sensor interface board.  The new tank has been designed with "spillways" at the front and back of the tank. These spillways are left empty and provide a place for the excess water that sloshes over when the cathode door is opened or closed too fast. These spillways do not totally eliminate the problem and the customer should be advised to gently open and close the cathode door when using this water tank.

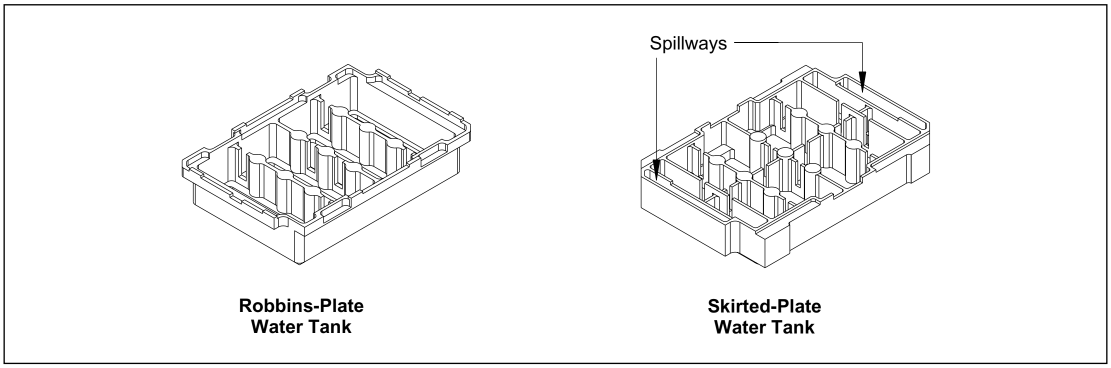



Figure 8-14.  The Robbins Plate and the Skirted Plate.

However, some MegaBACE instruments as well as the skirted-plate cathode upgrade kits were built with the older style water tank. The following MegaBACE instruments and upgrade kits were shipped with the older tanks

- MegaBACE Instruments Serial Numbers 13720 to 13810
- Skirted Cathode Upgrade Kits, Kits ordered before June 30, 2000

Ordering New Water Tanks:

- Water Tank, Skirted Cathode, APB Part Number 63003180

When the new tanks are used, a possibility exists that the tank will not be recognized when it is in the up position because the mechanical switch lever may not be pushed in far enough. This is because the spillways give the new tank a different shape. If the MegaBACE does not recognize the new tank when it is in the up position, adjust the position of the up sensor.

### 8.11.1 Converting Skirted Cathodes to the Robbins Configuration

Items required for the conversion include:

| | |
|---|---|
| Conversion Kit, Skirted to Robbins Plate | APB Part # 63002972 (MD 0285-103) |
| Current Monitor PCA Alignment Pin (2 required) | APB Part # 63001378 (MD 0184-579) |
| Cathode Alignment Tool (Service Bulletin 136A) | APB Part # 63002199 (MD 0244-735) |
| Front Plate Height Tool | APB Part # 63003141 (MD 0287-812) |
| Robbins Plate Alignment Tool | APB Part # 63003128 (MD 0246-705) |

**Note:** The Conversion Kit contains the following items:

| | |
|---|---|
| (2) Robbin's Tank Sensor Levers | APB Part # 63003142 (MD 0246-949) |
| Robbins Plate Cathode Tray | APB Part # 63003612 (MD 0272-120) |
| Tank for the Robbins Tray | APB Part # 63002521 (MD 0244-818) |
| 96-well Robbins plate | APB Part # 63003613 (MD 0244-602) |

Perform the following steps:

1. Flush, dry, remove, and safely store the capillary arrays.
2. Turn off the instrument.
3. Remove the top (section9.2.1), left side (section 9.4.1), and front panels (section 9.9.1).
4. Remove the cathode assembly (section 9.67).
5. Remove the four screws that secure the capillary array stand and current monitor board to the cathode assembly. Use great care not to bend any of the electrodes on the current monitor board.
6. Remove the four screws that secure the current monitor board and white plastic spacer to the capillary array stand. Save the white plastic spacer.
7. Reinstall the current monitor board on the capillary array stand. Do not tighten the four mounting screws.
8. Insert the two alignment pins all the way into the alignment holes, in the positions shown in figure 8-15, tighten the four mounting screws, then remove the alignment pins.
9. Pull the slide assembly all the way out.
10. Remove the four screws that secure skirted-plate tray to the plastic slide (figure 8-16).
11. Position the Robbins plate tray and install the four screws to secure the Robbins plate tray to the plastic slide.
12. Loosen the metal faceplate.
13. Place the height adjustment tool (APB Part # 63003141) in the tray assembly with the Robbins end toward the rear of the cathode and use it to set the height of the metal faceplate. Then tighten the two mounting screws on the faceplate.

14. Locate the tray and tank sensors at the back of the cathode and replace the metal levers on the tray and tank sensors with the two (2) Robbins' levers (see section 9.69 for a description of where the sensors are located).
15. Install the capillary array stand and current monitor board, but do not completely tighten the four mounting screws.
16. Place the Robbin's plate alignment tool (APB Part # 63003128) in the tray assembly, push the slide in, and manually raise the cathode stage.
17. Completely tighten the four capillary array stand mounting screws and then remove the alignment tool.
18. Re-install the cathode assembly. See section 8.12 to properly align the position of the cathode and anode assemblies. Replace all the panels when finished.
19. Turn on the MegaBACE instrument and use the ICS to test the operation of the cathode.
20. Reinstall the capillaries.
21. Test the instrument.

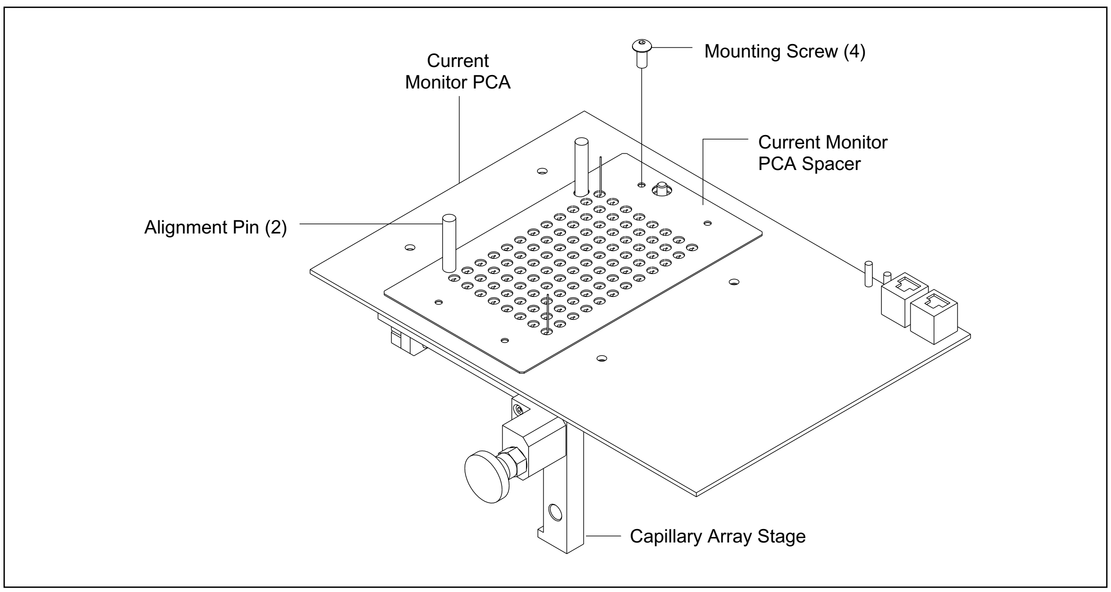



Figure 8-15. Capillary Array Stage.

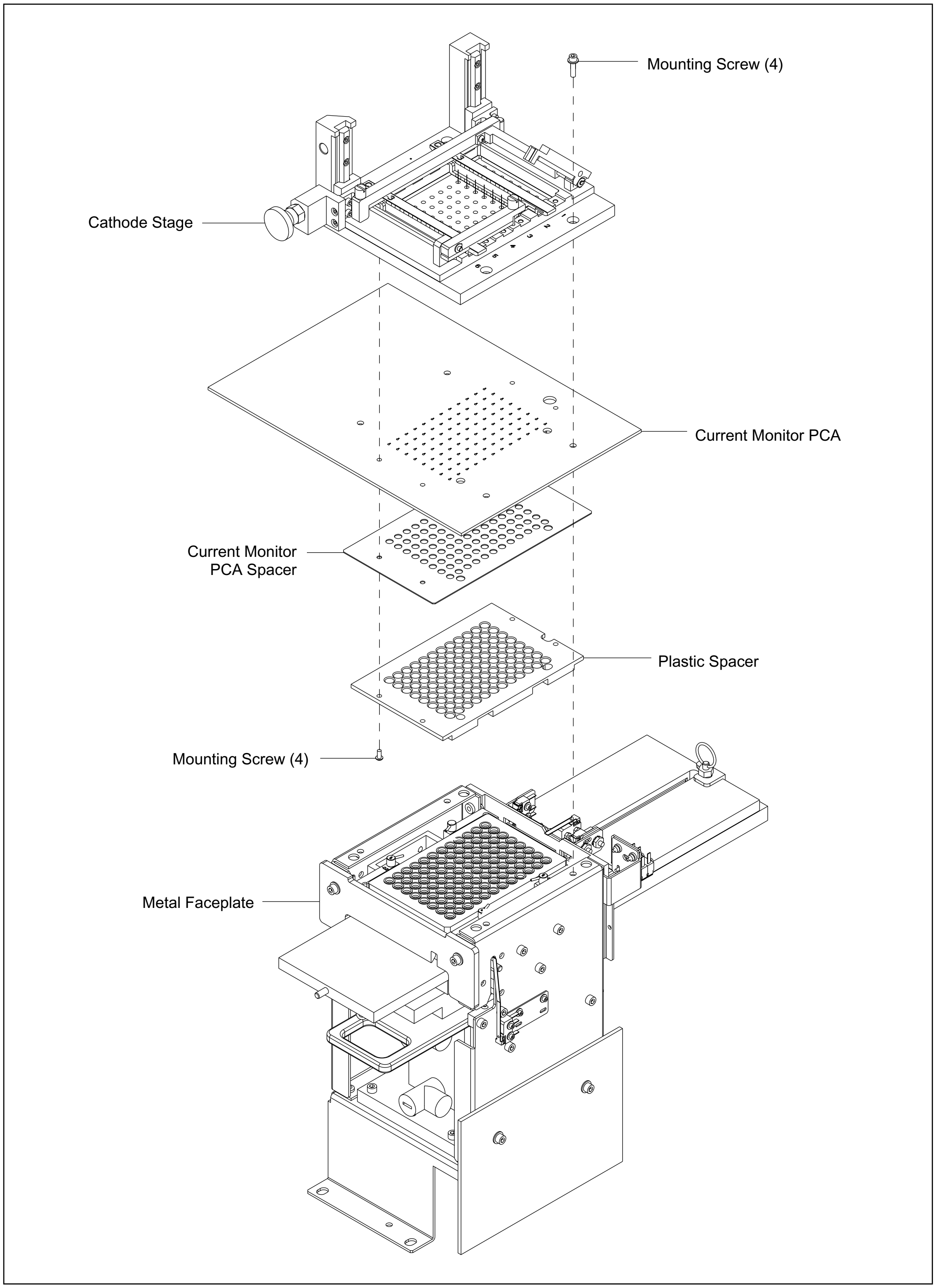



Figure 8-16. Skirted-Plate Cathode.

### 8.11.2 Upgrading Older MegaBACE Instruments with the Skirted Cathode Assembly

Older MegaBACE instruments with the original Robbins or PE plates can be converted to skirted plates if the customer purchases the upgrade. The part number for the upgrade is 63002971. If an older MegaBACE is upgraded by using the Skirted Cathode Upgrade kit (which replaces the entire cathode assembly), the instrument pneumatic system must be updated using section 8.12. The parts needed for the upgrade are included in the upgrade kit.

1. Flush, dry, remove, and safely store the capillary arrays.
2. Turn off the instrument.
3. Remove the top (section 9.2.1), left side (section 9.4.1), and front doors and panels (section 9.9.1).
4. Remove the cathode assembly (section 9.67.1).
5. Update the pneumatics system using section 8.12. **Note:** Only the service door latch, the pressure relief valve, and the regulator setting need to be changed. The plumbing on the bottom of the new cathode assembly has already been updated.
6. Install the new cathode assembly (section 9.67.1).
7. Align the cathode and anode assemblies using section 8.6.
8. Use the ICS to test the operation of the new cathode assembly.
9. Reinstall the capillaries.
10. Replace the doors and all of the panels and test the instrument.

## 8.12 New Pneumatics Panel Upgrade

Nitrogen leaks have been observed from the regulators that are used to control the up and down speed of the cathode assembly. These cathode assembly regulators reduce the nitrogen pressure supplied by the pneumatics panel to 12 psi. To eliminate the leakage and to eliminate the cost of the regulation hardware on the cathode assembly, a new pneumatics panel has been designed that directly supplies the cathode assembly with the required 12 psi. With 12 psi being supplied directly from the pneumatics panel, the cathode assembly regulators are redundant. A new cathode assembly has also been designed that eliminates the regulators. However, replacing the pneumatics panel or the cathode assembly is not required to eliminate the leaking problem. This section provides methods for solving the leaking problems without replacing these two assemblies.

Relevant Part Numbers

- New Pneumatics Panel, Japan Only Model, MD P/N 0245-434 (APB P/N 63002829)
- New Pneumatics Panel, All Others, MD P/N 0245-428 (APB P/N 63002828)
- New Service Door Latch Assembly, MD P/N 0246-650 (APB P/N 63002700)
- New Cathode Assembly, MD P/N 0245-323 (APB P/N 63002884)
- In-line Low-Pressure Relief Valve, MD P/N 0246-644 (APB P/N 63002701)

### 8.12.1 Replacing the Old Pneumatics Panel with a New One

If the old pneumatics panel has failed and you are you replacing it with one of the new ones listed above, you must replace the door latch assembly with a new model so that it will work with the lower pressure.

*NOTE* **Because of regulatory requirements, Japan uses a different pneumatic panel than the rest of the world.**

### 8.12.2 Replacing an Old Regulated Cathode Assembly

If you replace the old regulated cathode assembly with one that is unregulated, you must either upgrade the pneumatics panel to supply the new cathode assembly with lower pressure or replace the pneumatics panel with one of the new models. You must also replace the door latch assembly with a new model so that it will work with the lower pressure.

### 8.12.3 Upgrading an Old Cathode Assembly to Eliminate Leaks

To upgrade an old cathode assembly:

1. Adjust the pressure adjustment on the pneumatics panel for 12 PSI on the pressure gauge (figure 8-17).
2. Turn off instrument, turn off nitrogen supply to the instrument and bleed the remaining pressure.
3. Cut the green hose coming from the pneumatic panel (J5) and install the in-line low pressure relief valve (figure 8-18).
4. Detach the red and clear hoses from the regulator section of the cathode assembly and attach them directly to the cylinder, bypassing the regulators (figures 8-18 and 8-19).
5. Install the new door latch assembly.
6. Turn on the instrument.
7. Turn on nitrogen supply.
8. Test the cathode assembly and the service door latch for proper operation.

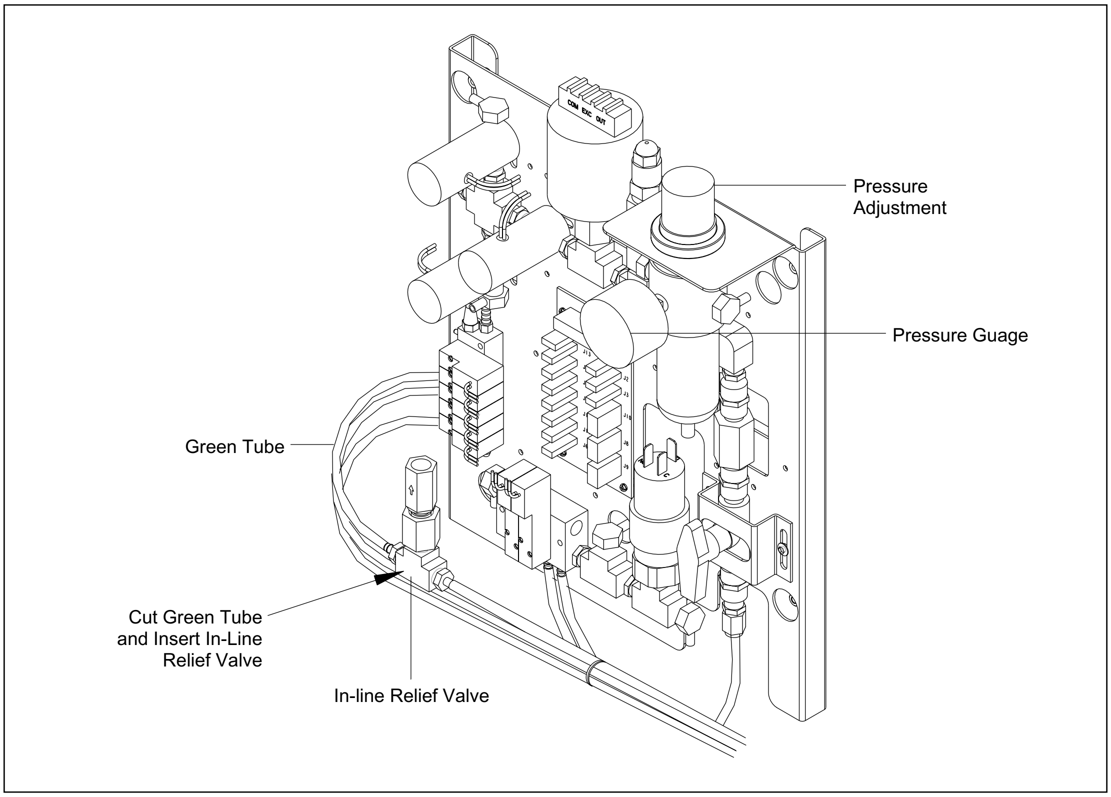



Figure 8-17.  Pneumatics Panel.

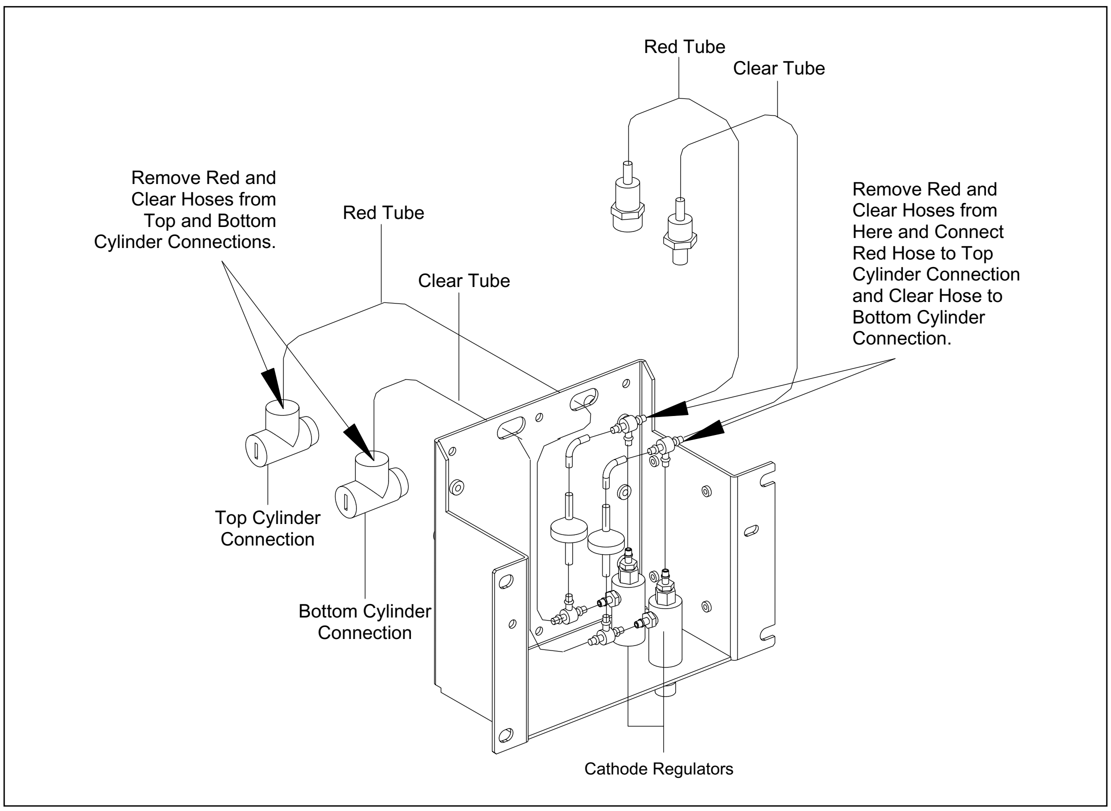



Figure 8-18.  Cathode Regulators.

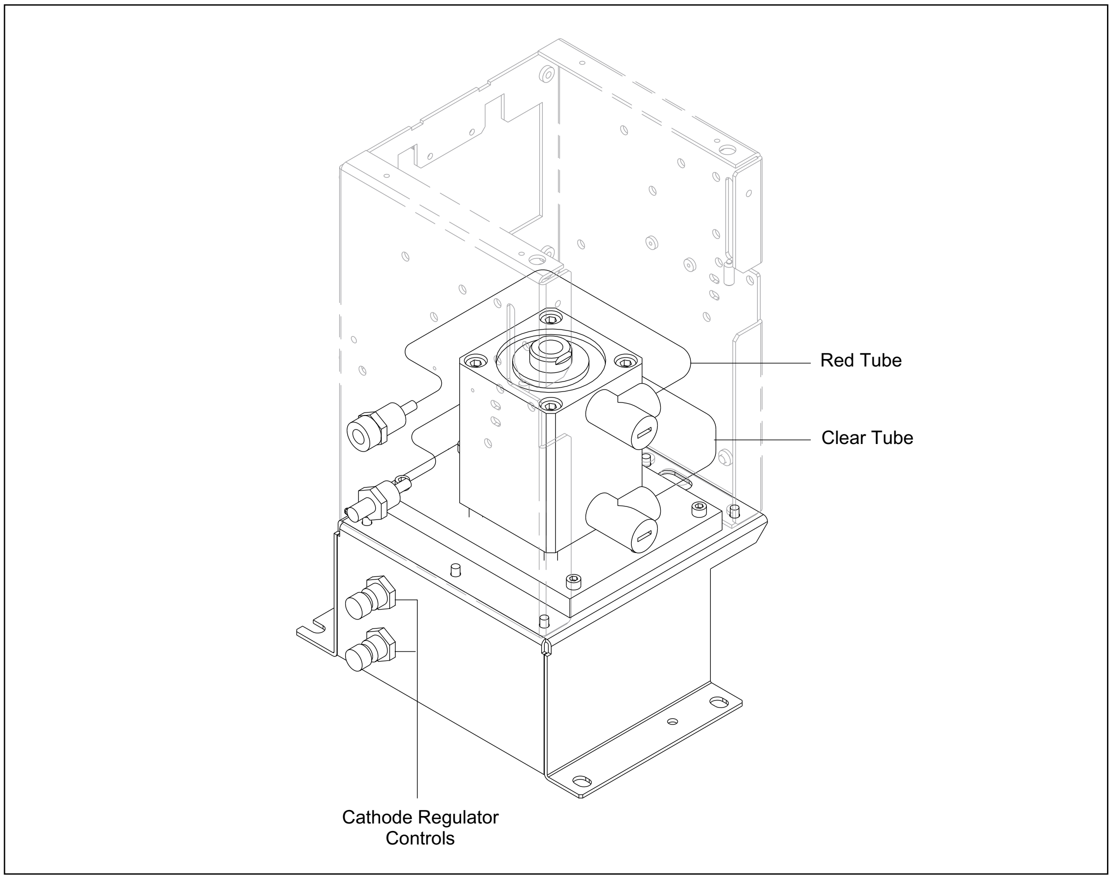



Figure 8-19.  Converted Cathode.

# Chapter 9 Repair

## 9.1 Introduction

This chapter contains the procedures for removing and replacing components that fail during operation. The illustrations in this chapter are simplified representations and do not show all of the assembly hardware. These procedures require a standard set of tools with hex wrenches of various sizes.

*CAUTION* **Always turn off the instrument when performing removal and installation procedures.**

The topics include:


| | |
|---|---|
| Top Cover | (section 9.2) |
| Air Filter Assembly | (section 9.3) |
| Left Panel Assembly | (section 9.4) |
| Filter Cover Assembly | (section 9.5) |
| Lower-Right Cover | (section 9.6) |
| Midcover Support | (section 9.7) |
| LED Board | (section 9.8) |
| Front Panel Assembly | (section 9.9) |
| Anode LCD Board | (section 9.10) |
| Cathode LCD Board | (section 9.11) |
| Power Supply Box | (section 9.12) |
| INTC Board | (section 9.13) |
| Power Supply Distribution Board | (section 9.14) |
| Internal Computer Power Supply | (section 9.15) |
| Echelon/Motor Power Supply | (section 9.16) |
| Cooler Power Supply | (section 9.17) |
| Heater Power Supply (Four-Supply Model) | (section 9.18) |
| Main DC Power Supply (Two-Supply Model) | (section 9.19) |
| Heater Power Supply (Two-Supply Model) | (section 9.20) |
| Main DC Power Supply (CE 2001) | (section 9.21) |
| Heater/Cooler Assembly | (section 9.22) |
| Temperature Control Assembly | (section 9.23) |
| TMPR Board | (section 9.24) |
| TE Cooler Assembly | (section 9.25) |
| Heater Assembly | (section 9.26) |
| Blower Assembly | (section 9.27) |
| Service Door Interlock Switches | (section 9.28) |
| ADAQ Board | (section 9.29) |
| PDIO Board | (section 9.30) |
| Internal Computer | (section 9.31) |
| HV Power Supply | (section 9.32) |
| Host SCSI Interface Board | (section 9.33) |
| Analog Interface Board | (section 9.34) |
| Echelon Network Interface Board | (section 9.35) |
| CPU Board | (section 9.36) |
| Backplane Motherboard Board | (section 9.37) |

| | |
|---|---|
| EPHV Board | (section 9.38) |
| BEAM Board | (section 9.39) |
| SCAN Board | (section 9.40) |
| Scan Motor Driver | (section 9.41) |
| FLTR Board | (section 9.42) |
| Blue Laser | (section 9.43) |
| Green Laser and Power Supply | (section 9.44) |
| Shutter Assembly | (section 9.45) |
| Shutter Drive Motor | (section 9.46) |
| Shutter Home Sensor | (section 9.47) |
| Primary Beamsplitter Changer Assembly | (section 9.48) |
| Primary Beamsplitter Changer Drive Motor | (section 9.49) |
| Primary Beamsplitter Changer Home Sensor | (section 9.50) |
| Scanning Stage Assembly | (section 9.51) |
| Scan Head Drive Motor | (section 9.52) |
| Scan Head Position Sensors | (section 9.53) |
| Scan Head Bearing Assembly | (section 9.54) |
| Focus Assembly | (section 9.55) |
| Focus Drive Assembly | (section 9.56) |
| Focus Assembly Drive Motor | (section 9.57) |
| Focus Assembly Position Sensor | (section 9.58) |
| Capillary Mount Assembly | (section 9.59) |
| Secondary Beamsplitter Changer Assembly | (section 9.60) |
| Secondary Beamsplitter Changer Drive Motor | (section 9.61) |
| Secondary Beamsplitter Changer Home Sensor | (section 9.62) |
| Filter Changer Assembly | (section 9.63) |
| Filter Changer Drive Motors | (section 9.64) |
| Filter Changer Home Sensor | (section 9.65) |
| PMT Assembly | (section 9.66) |
| Cathode Assembly | (section 9.67) |
| Array Stage and CMON Board (MB 1000) | (section 9.68) |
| Cathode Slide-In Sensor Switches | (section 9.69) |
| Cathode Stage-Up Interlock and Sensor Switches | (section 9.70) |
| Cathode Plate or Tank ID Sensor Switches | (section 9.71) |
| Array Stage Position Sensor Switch | (section 9.72) |
| Cathode Stage-Down Sensor Switch | (section 9.73) |
| Capillary Array Stage Actuator (MB 2000) | (section 9.74) |
| Indexer Y-Position Sensors (MB 2000) | (section 9.75) |
| Indexer X-Position Sensors (MB 2000) | (section 9.76) |
| Indexer Y-Position Actuator (MB 2000) | (section 9.77) |
| Indexer Y-Position Lock Sensor (MB 2000) | (section 9.78) |
| Indexer X-Position Actuator (MB 2000) | (section 9.79) |
| Slide Assembly Lock Actuator (MB 2000) | (section 9.80) |
| Anode Assembly | (section 9.81) |
| Anode Cover | (section 9.82) |
| Anode Left Slide-In Optical Sensor | (section 9.83) |
| Anode Right Slide-In Optical Sensor | (section 9.84) |
| Anode Stage-Up Interlock and Sensor Switches | (section 9.85) |
| Cover Clamp-Locked Optical Sensor | (section 9.86) |
| Cover Clamp-Unlocked Optical Sensor | (section 9.87) |
| Anode Plug-Lock Optical Sensor | (section 9.88) |

| | |
|---|---|
| Anode Slide-In Interlock and Sensor Switches | (section 9.89) |
| Anode Stage-Moving-Up Optical Sensor | (section 9.90) |
| Anode Stage-Up Optical Sensor | (section 9.91) |
| Anode Cover Locking Motor | (section 9.92) |
| Nitrogen Pressure Manifold | (section 9.93) |

## 9.2 Top Cover

The top cover is a square, wedge-shaped, sheet-metal cover that is interlocked with the left and right panel assemblies. It is attached to the rear of the sheet-metal chassis with two screws. For the following procedures, see figure 9-1.

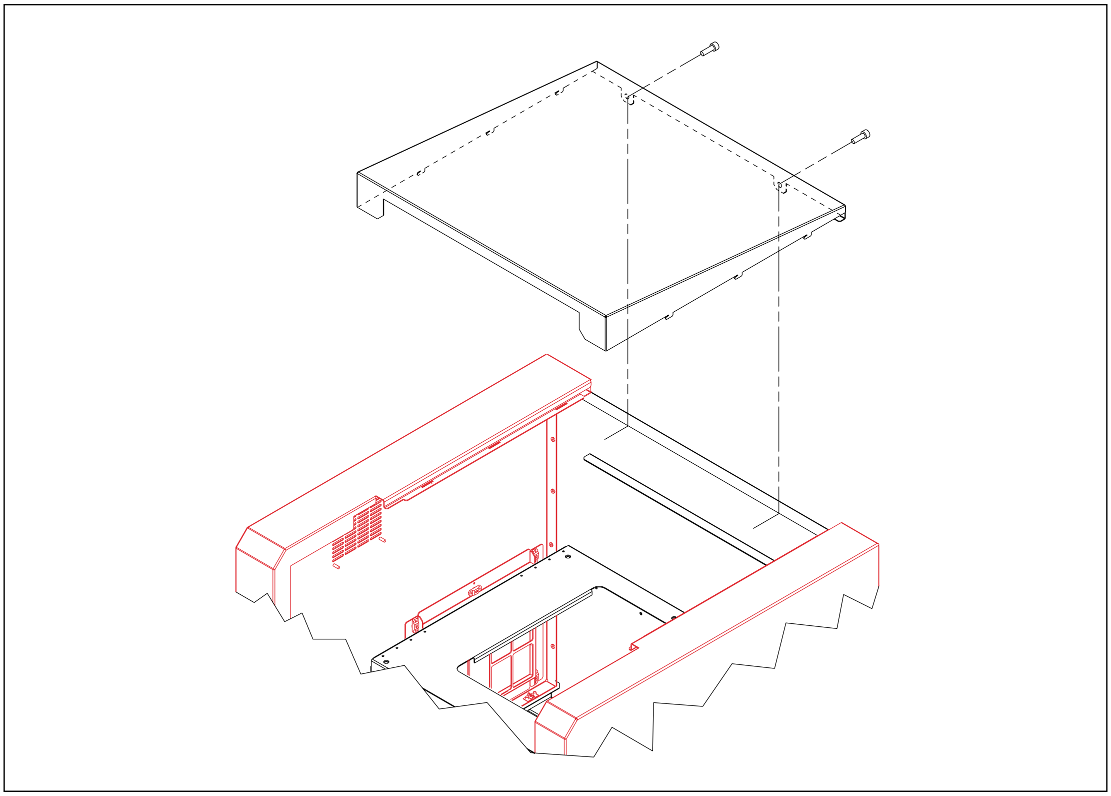


Figure 9-1.  Top Cover Mounting.

### 9.2.1 Removal Procedure

1. Remove the two screws that secure the top cover to the rear of the sheet-metal chassis.
2. Slide the top cover toward the rear to disengage the top cover tabs from the slots in the left and right panel assemblies.

### 9.2.2 Installation Procedure

1. Place the top cover in position and slide the top cover toward the front to engage the top cover tabs with the slots in the left and right panel assemblies.
2. Install the two screws that secure the top cover to the rear of the sheet-metal chassis.

## 9.3 Air Filter Assembly

The air filter assembly is attached to the left panel assembly with eight 1/4-turn studs. For the following procedures, see figure 9-2.

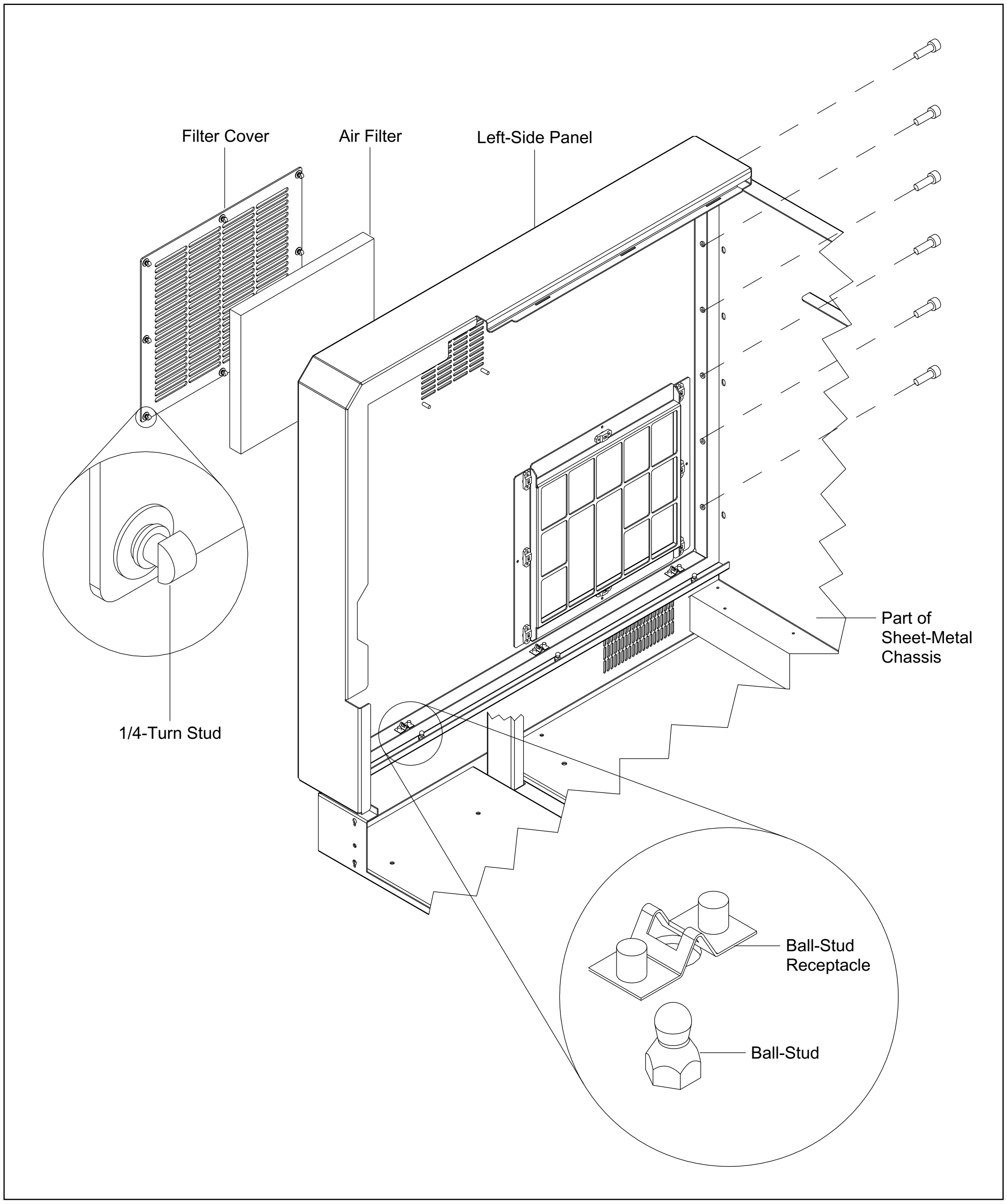



Figure 9-2. Left Panel and Air Filter Assembly Mounting.

### 9.3.1 Removal Procedure

1. Loosen the eight 1/4-turn studs that secure the air filter cover to the left panel assembly.
2. Remove the air filter.

### 9.3.2 Installation Procedure

Place the air filter and air filter cover in place, and tighten the eight 1/4-turn studs that secure the air filter cover to the left panel assembly.

## 9.4 Left Panel Assembly

The left panel assembly is attached to the sheet-metal chassis with ball studs and ball-stud receptacles along its lower edge and with screws along its rear edge. Slots in the right edge of the left panel assembly are interlocked with tabs on the top cover. For the following procedures, see figure 9-2.

### 9.4.1 Removal Procedure

1. Remove the top cover (section 9.2.1).
2. Remove the six screws that secure the left panel assembly to the rear of the sheet-metal chassis.
3. Lift the left panel assembly up to disengage the ball-stud receptacles on the edge of the left panel assembly from the ball studs on the edge of the sheet-metal chassis.

### 9.4.2 Installation Procedure

1. Line up the ball-stud receptacles on the edge of the left panel assembly with the ball studs on the edge of the sheet-metal chassis and push the left panel assembly down firmly.
2. Install the six screws that secure the left panel assembly to the rear of the sheet-metal chassis.
3. Install the top cover (section 9.2.2).

## 9.5 Filter Cover Assembly

The filter cover assembly is attached to the lower-right cover with five ball studs and ball-stud receptacles along its lower edge, to the midcover support with two screws, and to the rear of the sheet-metal chassis with four screws. For the following procedures, see figure 9-3.

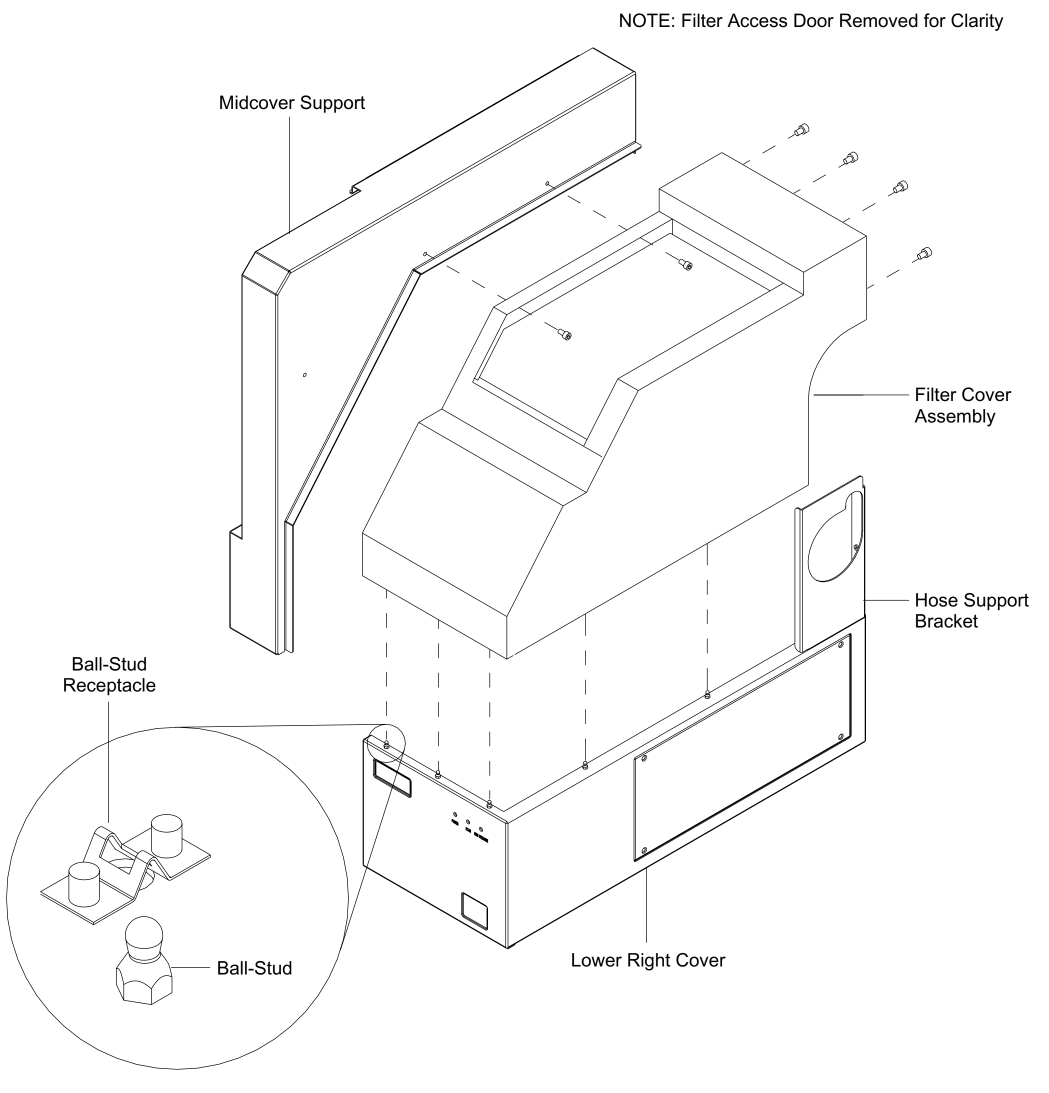



Figure 9-3. Filter Cover Assembly Mounting.

### 9.5.1 Removal Procedure

1. Open the filter cover door.
2. Remove the two screws that secure the filter cover to the midcover support.
3. Remove the four screws that secure the filter cover to the rear of the sheet-metal chassis.
4. Gently pry the filter cover from the lower-right cover, disengaging the five ball studs.

### 9.5.2 Installation Procedure

1. Position the filter cover over the lower-right cover, engaging the five ball studs. Push the filter cover down firmly to seat the ball studs in the ball-stud receptacles.
2. Install the four screws that secure the filter cover to the rear of the sheet-metal chassis.
3. Install the two screws that secure the filter cover to the midcover support.
4. Close the filter cover door.

## 9.6 Lower-Right Cover

The lower-right cover is secured to the sheet-metal chassis with six ball studs and ball-stud receptacles along the edge of the sheet-metal chassis and to the rear of the sheet-metal chassis with two screws. For the following procedures, see figure 9-4.

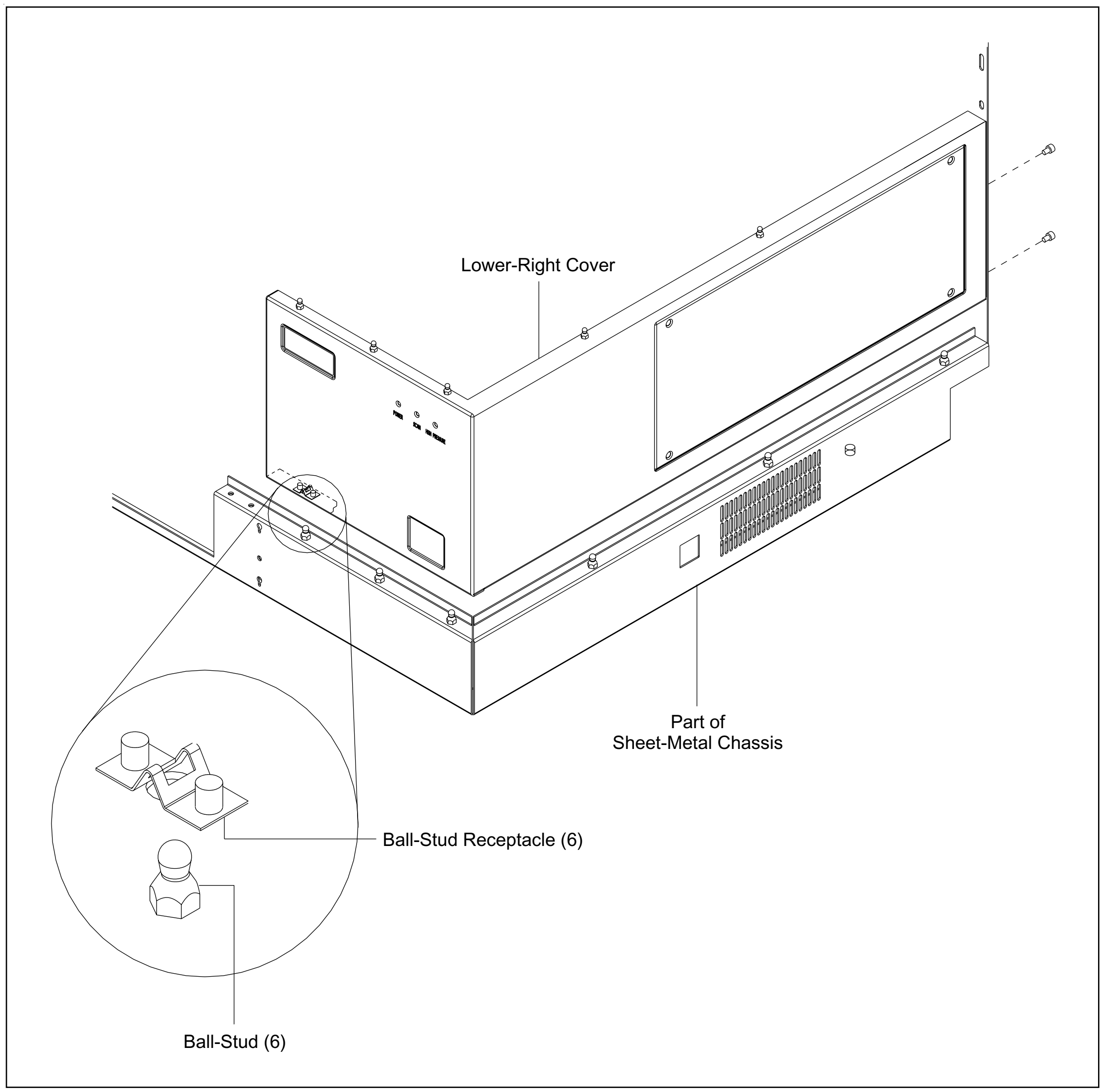



Figure 9-4. Lower-Right Cover Mounting.

### 9.6.1 Removal Procedure

1. Remove the filter cover assembly (section 9.5.1).
2. Remove the two screws that secure the lower-right cover to the rear of the sheet-metal chassis.
3. Disconnect the cable from the LED board.
4. Carefully lift the lower-right cover, disengaging the six ball studs.

### 9.6.2 Installation Procedure

1. Position the lower-right cover on the sheet-metal chassis so that the six ball-stud receptacles are aligned with the six ball studs. Push the lower-right cover down until the ball studs are engaged.
2. Reconnect the cable to the LED board.
3. Install the two screws that secure the lower-right cover to the rear of the sheet-metal chassis.
4. Install the filter cover assembly (section 9.5.2).

## 9.7 Midcover Support

The midcover support is secured to the rear of the sheet-metal chassis with two screws, to the front bottom of the sheet-metal chassis with two screws, and to the electrophoresis chamber with one screw. For the following procedures, see figure 9-5.

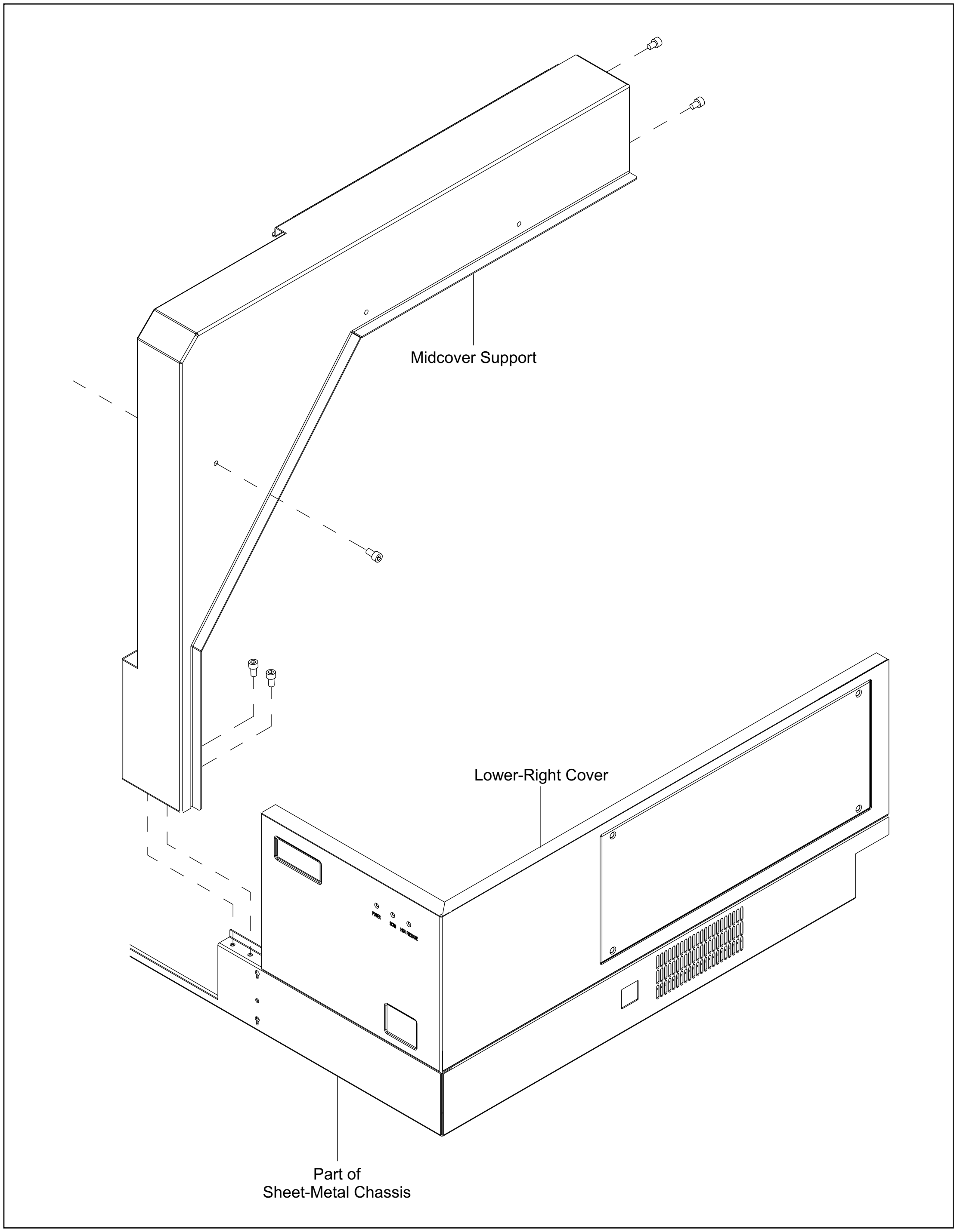



Figure 9-5. Midcover Support Mounting.

### 9.7.1 Removal Procedure

1. Remove the top cover (section 9.2.1).
2. Remove the filter cover assembly (section 9.5.1).
3. Remove the lower-right cover assembly (section 9.6.1).
4. Remove the two screws that secure the midcover support to the rear of the sheet-metal chassis.
5. Remove the two screws that secure the midcover support to the front of the sheet-metal chassis.
6. Remove the screw that secures the midcover support to the electrophoresis chamber assembly.
7. Lift the midcover support off the instrument.

### 9.7.2 Installation Procedure

1. Position the midcover support on the instrument.
2. Install the screw that secures the midcover support to the electrophoresis chamber assembly.
3. Install the two screws that secure the midcover support to the front of the sheet-metal chassis.
4. Install the two screws that secure the midcover support to the rear of the sheet-metal chassis.
5. Install the lower-right cover assembly (section 9.6.2).
6. Install the filter cover assembly (section 9.5.2).
7. Install the top cover (section 9.2.2).

## 9.8 LED Board

The LED board is mounted to the inside of the lower-right cover with four screws. For the following procedures, see figure 9-6.

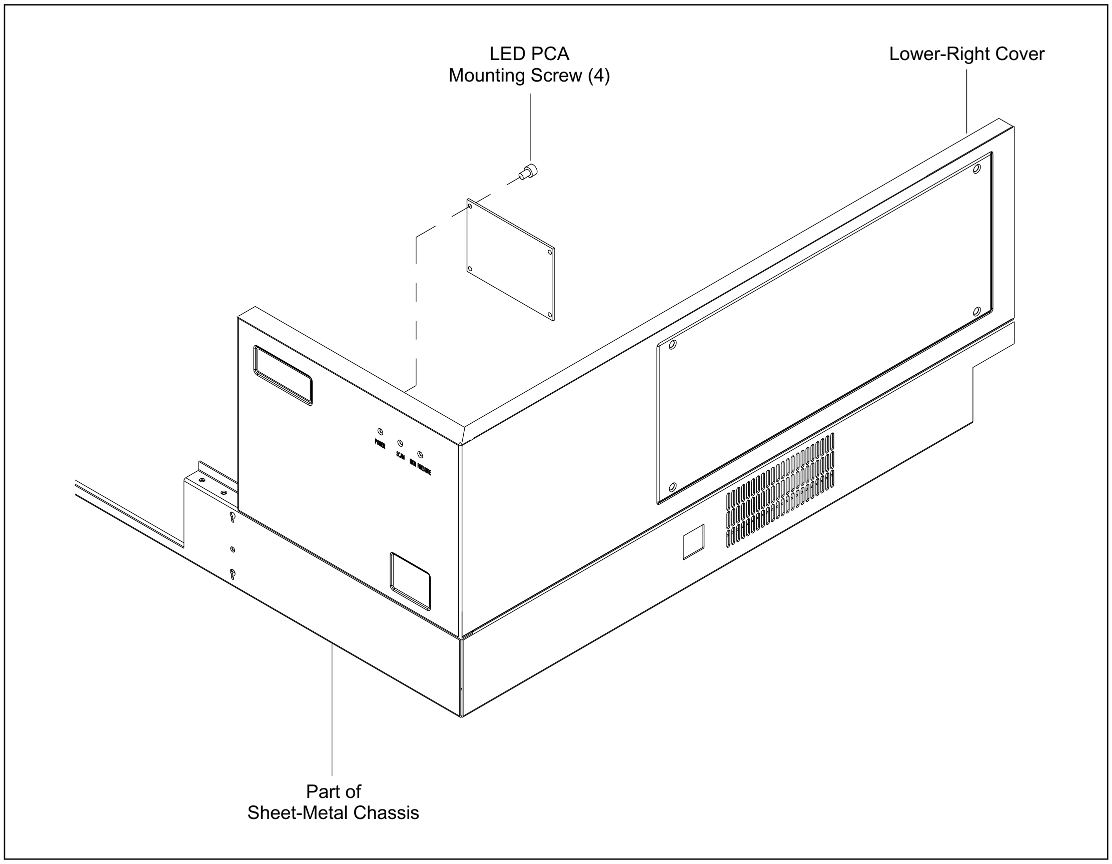



Figure 9-6. LED Board Mounting.

### 9.8.1 Removal Procedure

1. Remove the lower-right cover (section 9.6.1).
2. Remove the four screws that secure the LED board to the lower-right cover.

### 9.8.2 Installation Procedure

1. Position the LED board and install the four screws that secure the LED board to the lower-right cover.
2. Install the lower-right cover (section 9.6.2).

## 9.9 Front Panel Assembly

For the following procedures, see figure 9-7.

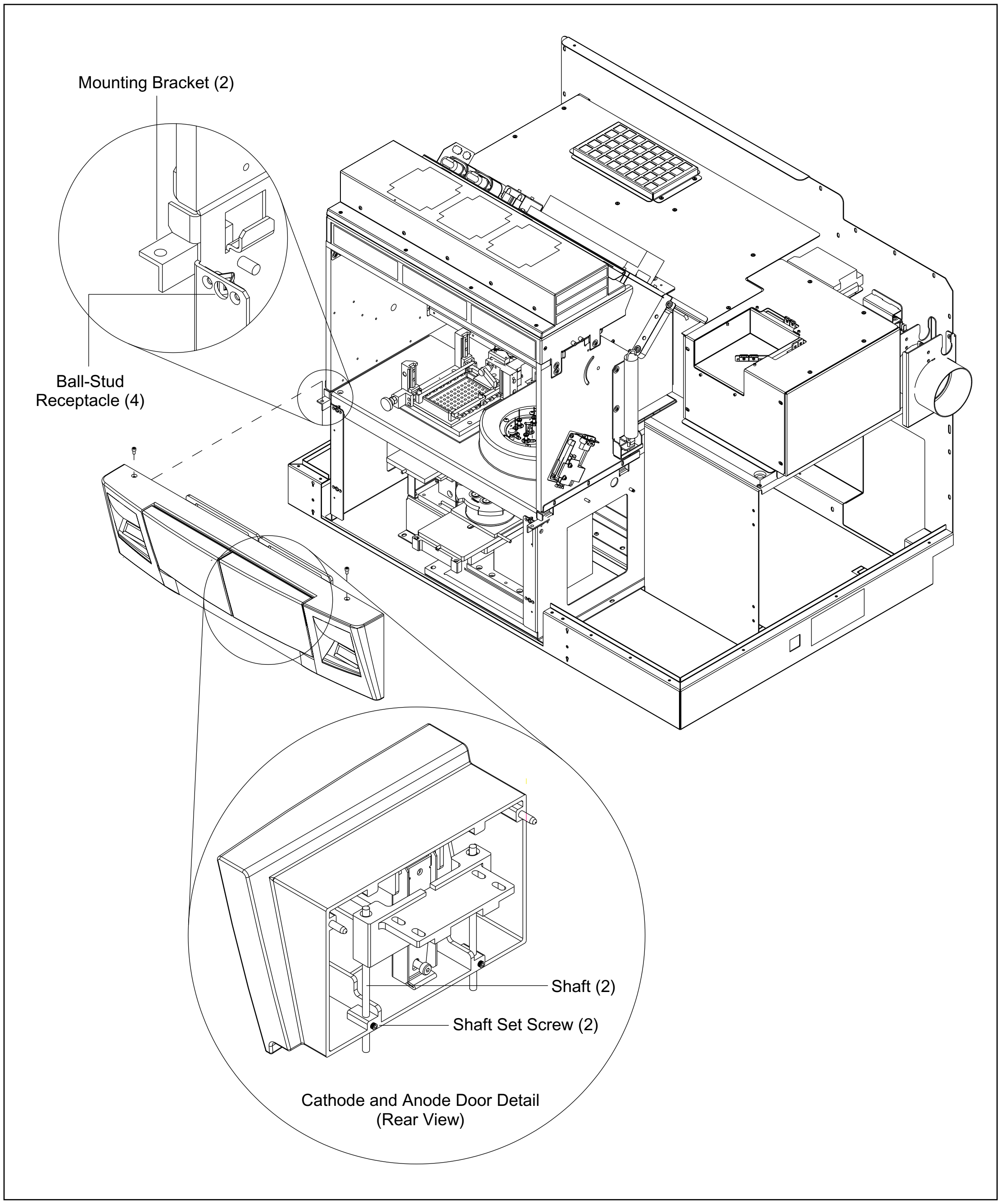



Figure 9-7. Front Panel Assembly Mounting.

### 9.9.1 Removal Procedure

1. Lower the anode and cathode stages, and pull the anode and cathode doors all the way out.
2. From the rear of the anode door, loosen the two setscrews that secure the door to the door shafts and slide the door up off the shafts. The screws must be backed almost all the way out. When sliding the door up, use firm pressure because the shafts tend to stick.
3. Remove the cathode door the same way that you removed the anode door.
4. Remove the two screws that secure the front panel assembly to the brackets on either side of the electrophoresis chamber.
5. Carefully pull the front panel assembly away to disengage the four ball studs on the front panel assembly from the four ball-stud receptacles.
6. Tilt the front panel assembly until the front edge clears the horizontal partition.
7. Disconnect the cables for the anode and cathode LCDs.

### 9.9.2 Installation Procedure

1. Reconnect the cables for the anode and cathode LCDs.
2. Tilt the front panel assembly and position it with the front edge under the front edge of the horizontal partition.
3. Carefully position the front panel assembly to engage the four ball studs on the front panel assembly with the four ball-stud receptacles and push in firmly.
4. Install the two screws that secure the front panel assembly to the brackets on either side of the electrophoresis chamber.
5. Position the anode door onto the door shafts and slide the door down all the way. Tighten the two setscrews that secure the door to the shafts.
6. Install the cathode door the same way that you installed the anode door.

## 9.10 Anode LCD Board

The anode LCD board is mounted to the inside of the front cover assembly with four screws and four washers. For the following procedures, see figure 9-8.

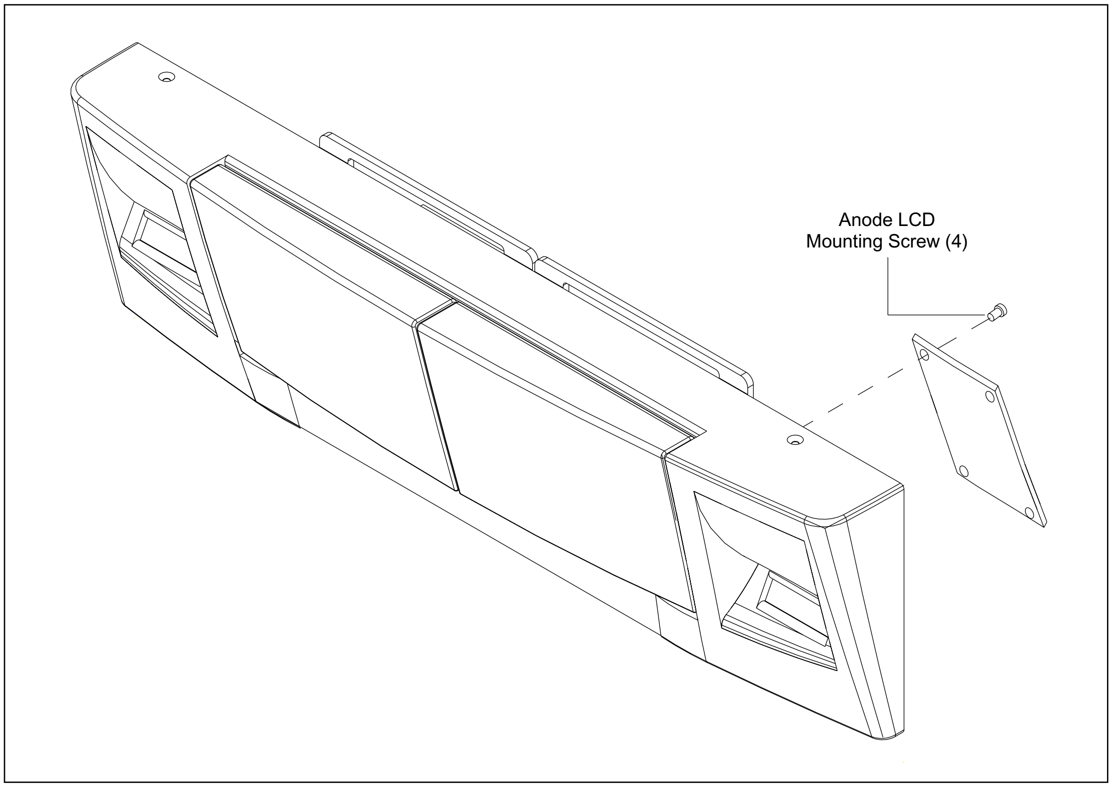



Figure 9-8. Anode LCD Board Mounting.

### 9.10.1 Removal Procedure

1. Remove the front panel assembly (section 9.9.1).
2. Lay the front panel assembly on its face.
3. Remove the four screws and four washers that secure the anode LCD board to the front panel assembly.

### 9.10.2 Installation Procedure

1. Place the anode LCD board in place on the rear of the front panel assembly.
2. Install the four screws and four washers that secure the anode LCD board to the front panel assembly.
3. Install the front panel assembly (section 9.9.2).

## 9.11 Cathode LCD Board

The cathode LCD board is mounted to the inside of the front cover assembly with four screws and four washers. For the following procedures, see figure 9-9.

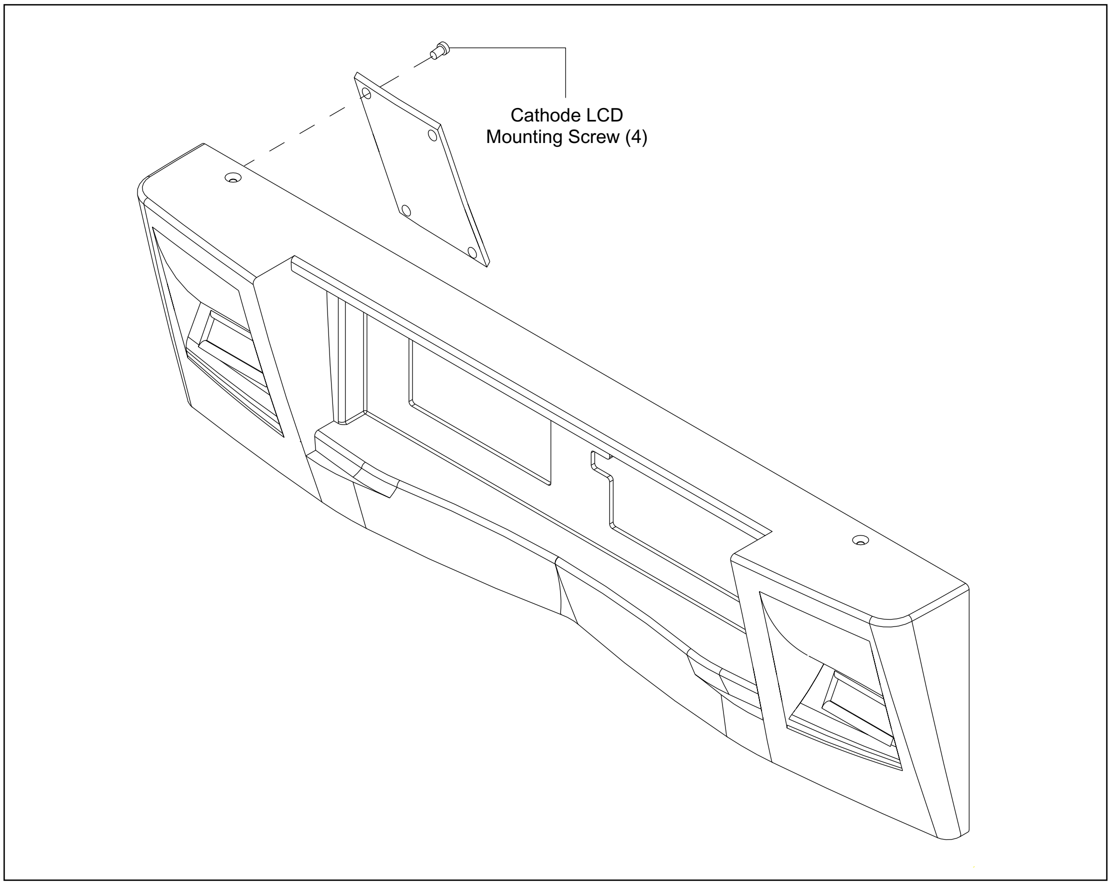



Figure 9-9. Cathode LCD Board Mounting.

### 9.11.1 Removal Procedure

1. Remove the front panel assembly (section 9.9.1).
2. Lay the front panel assembly on its face.
3. Remove the four screws and four washers that secure the cathode LCD board to the front panel assembly.

### 9.11.2 Installation Procedure

1. Place the cathode LCD board in place on the rear of the front panel assembly.
2. Install the four screws and four washers that secure the cathode LCD board to the front panel assembly.
3. Install the front panel assembly (section 9.9.2).

## 9.12 Power Supply Box

For the following procedures, see figure 9-10.

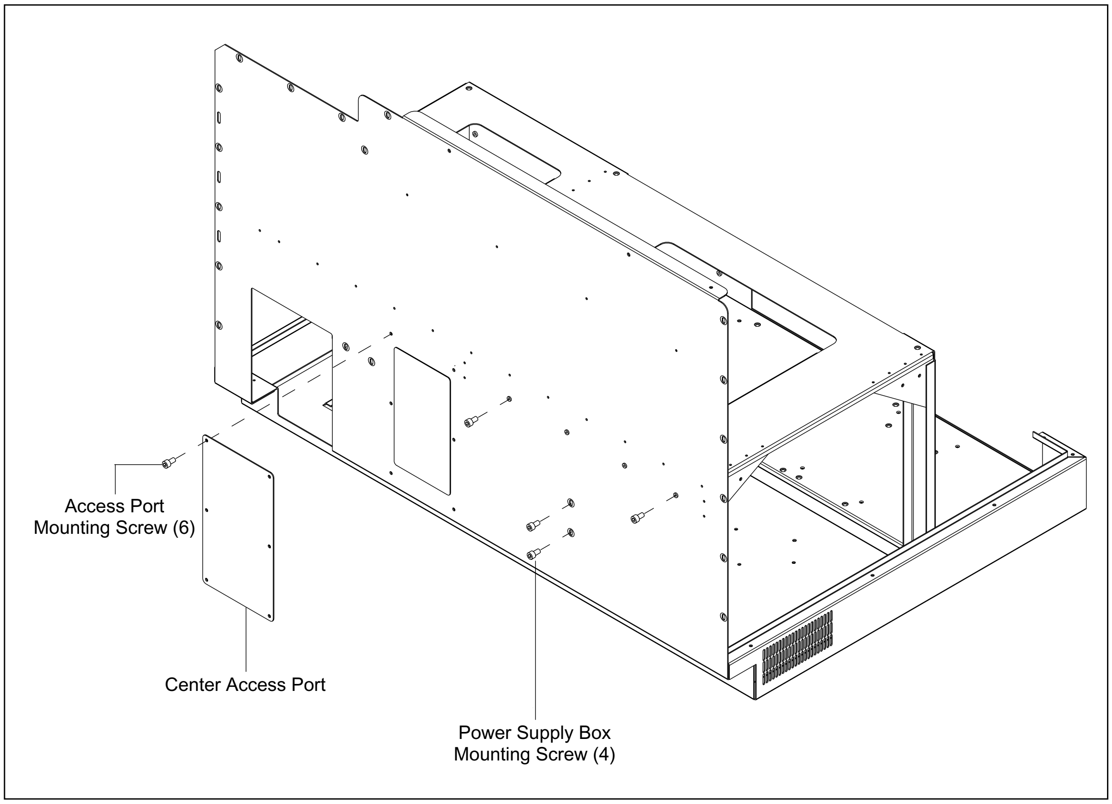



Figure 9-10. Power Supply Box Mounting.

### 9.12.1 Removal Procedure

1. Remove the top cover (section 9.2.1).
2. Remove the left panel assembly (section 9.4.1).
3. Remove the six screws that secure the center access port cover to the rear of the sheet-metal chassis. Remove the access port cover.
4. Disconnect the power plug from the Mat-N-Lok connector on the right end of the power supply box.

*NOTE* **It is not necessary to tag the cables when the plugs are disconnected from the power supply box. When the cables are reconnected, the plugs may be inserted into any matching connector.**

5. Disconnect all the cables from the front of the power supply box.
6. Loosen the four captive screws that secure the INTC board mounting plate to the power supply box.
7. Remove the four screws that secure the power supply box to the rear panel of the sheet-metal chassis.
8. Lift the power supply box to clear the edge of the sheet-metal chassis and slide the power supply box out.

### 9.12.2 Installation Procedure

1. Slide the power supply box in position in the sheet-metal chassis.
2. Install the four screws that secure the power supply box to the rear panel of the sheet-metal chassis.
3. Place the INTC board in position, and tighten the four captive screws that secure the INTC board mounting plate to the power supply box.

*NOTE* **When the cables are reconnected, the plugs may be inserted into any matching connector.**

4. Connect all the cables to the front of the power supply box.
5. From the center access port at the rear of the sheet-metal chassis, connect the power plug to the Mat-N-Lok connector on the right end of the power supply box.
6. Place the access port cover into position over the access port. Install the six screws that secure the center access port cover to the rear of the sheet-metal chassis.
7. Install the left panel assembly (section 9.4.2).
8. Install the top cover (section 9.2.2).

## 9.13 INTC Board

The INTC board is mounted to the mounting plate with five ball-stud standoffs and secured with one screw. The screw is in the lower left-hand corner. The mounting plate is secured to the power supply box with four captive screws. For the following procedures, see figure 9-11.

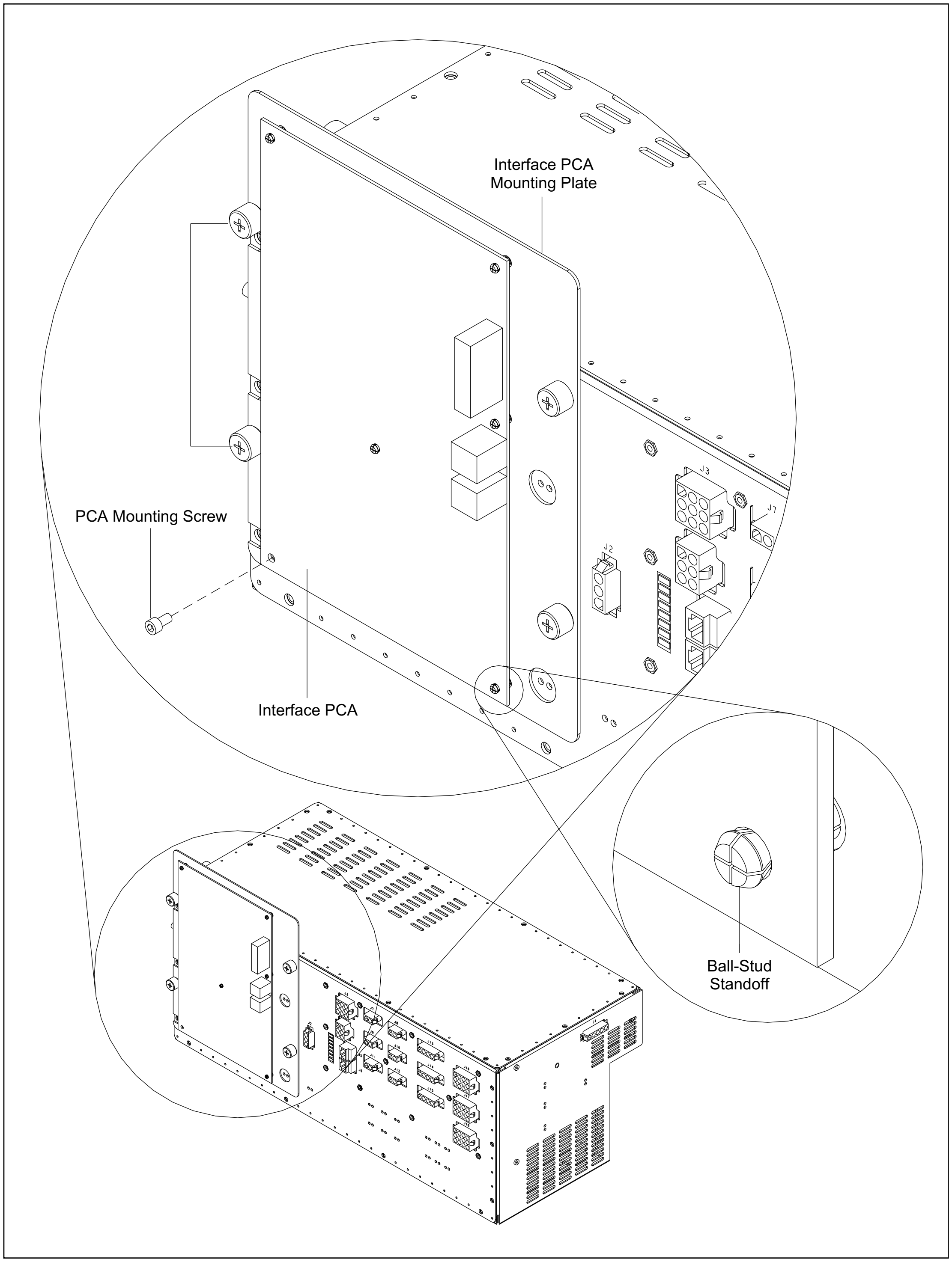



Figure 9-11.  INTC Board Mounting.

### 9.13.1 Removal Procedure

1. Remove the top cover (section 9.2.1).
2. Remove the left panel assembly (section 9.4.1).
3. Disconnect all the cables from the INTC board.
4. Loosen the four captive screws that secure the INTC board mounting plate to the power supply box.
5. Remove the screw that secures the INTC board to the lower-left corner of the mounting plate.
6. Gently pry up the INTC board to separate it from the mounting plate.

### 9.13.2 Installation Procedure

1. Position the INTC board over the mounting plate and line up the ball-stud holes with the ball studs on the mounting plate. Gently push the INTC board onto the mounting plate.
2. Install the screw that secures the INTC board to the lower-right corner of the mounting plate.
3. Place the INTC board and mounting plate in position on the power supply box and tighten the four captive screws that secure the INTC board mounting plate to the power supply box.
4. Connect all the cables to the INTC board.
5. Install the left panel assembly (section 9.4.2).
6. Install the top cover (section 9.2.2).

## 9.14 Power Supply Distribution Board

The power supply distribution board is mounted to the inside of the power supply box front panel with 11 screws. For the following procedures, see figure 9-12.

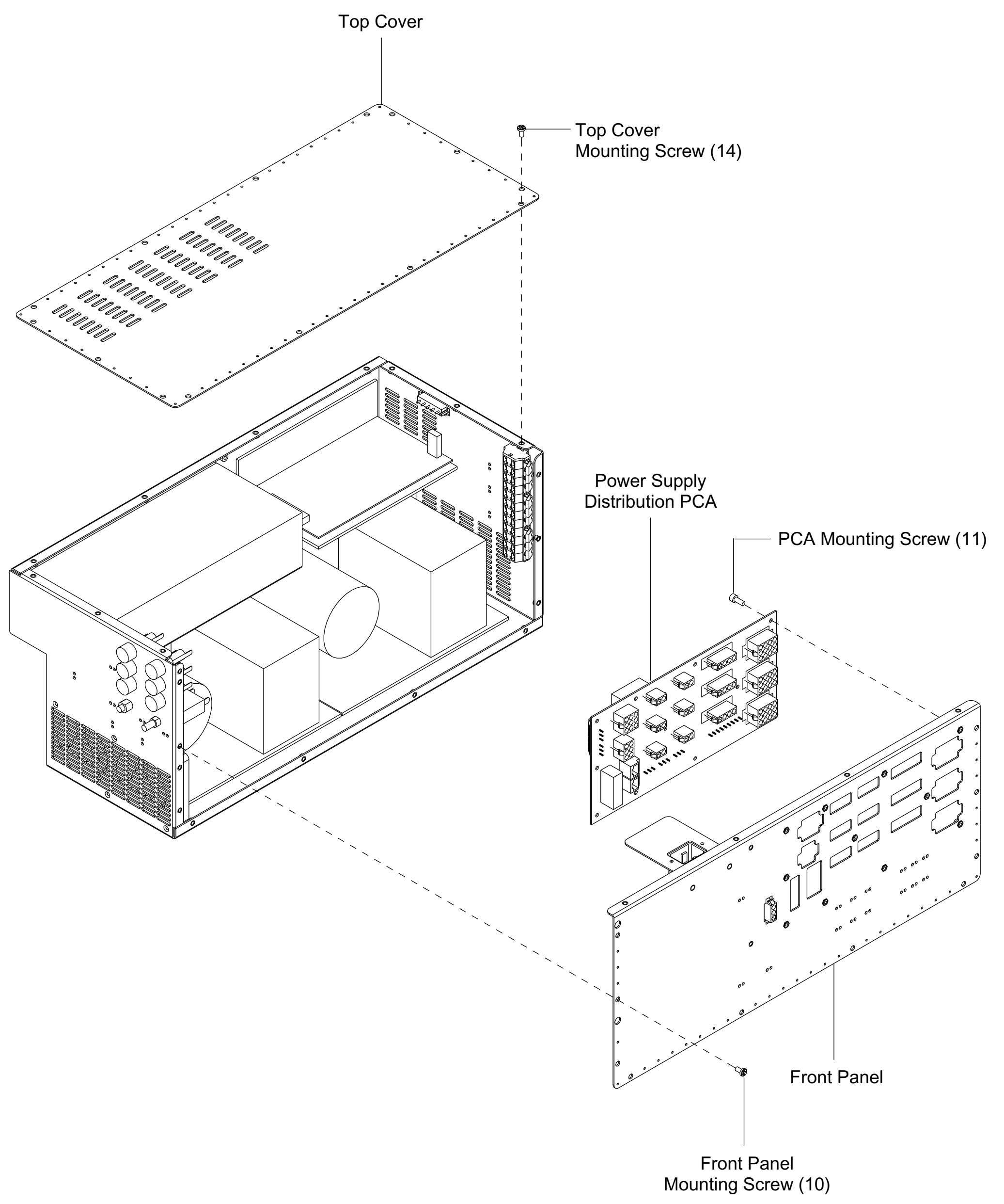



Figure 9-12. Power Supply Distribution Board Mounting.

### 9.14.1 Removal Procedure

1. Remove the power supply box (section 9.12.1).
2. Remove the 14 screws that secure the top cover to the power supply box.
3. Remove the 10 screws that secure the front panel to the power supply box.
4. Lay the front panel on its face next to the power supply box.
5. Loosen the clamping screws on terminal strips J19 through J24 and remove the wires.
6. Remove the 11 screws that secure the power supply distribution board to the front panel.
7. Remove the power supply distribution board.

### 9.14.2 Installation Procedure

1. Place the power supply distribution board in position on the front panel of the power supply box.
2. Install the 11 screws that secure the power supply distribution board to the front panel.
3. Insert the wires into their associated terminal strips (J19 through J24), and tighten the clamping screws on the terminal strips.
4. Install the 10 screws that secure the front panel to the power supply box.
5. Install the 14 screws that secure the top cover to the power supply box.
6. Install the power supply box (section 9.12.2).

## 9.15 Internal Computer Power Supply

For the following procedures, see figure 9-13.

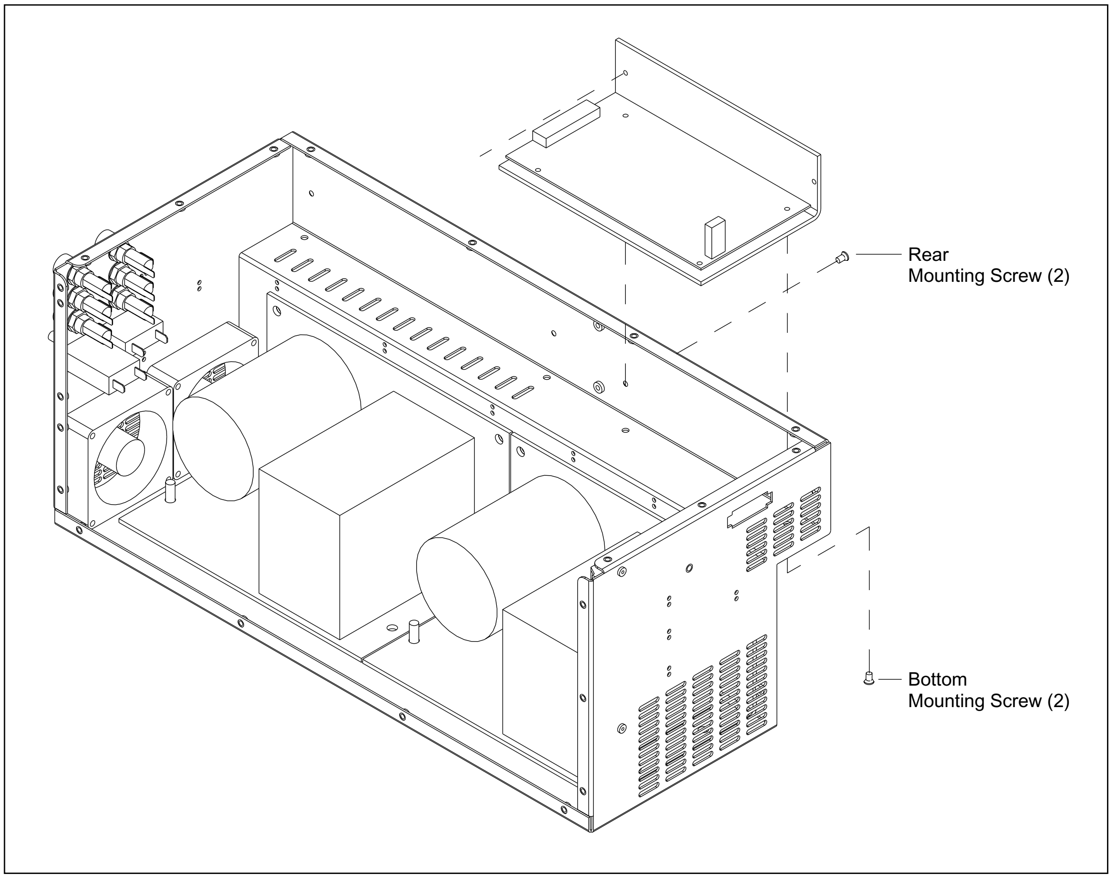



Figure 9-13. Internal Computer Power Supply Mounting.

### 9.15.1 Removal Procedure

1. Remove the power supply box (section 9.12.1).
2. Remove the 14 screws that secure the top cover to the power supply box.
3. Remove the 10 screws that secure the front panel to the power supply box.
4. Lay the front panel on its face next to the power supply box.
5. Remove the screws that secure the connections to the power supply terminal strips and remove the connections.
6. Remove the two bottom mounting screws that secure the power supply to the bottom panel of the power supply box.
7. Remove the two rear mounting screws that secure the power supply to the rear panel of the power supply box.

### 9.15.2 Installation Procedure

1. Place the power supply in position and install the two rear mounting screws that secure the power supply to the rear panel of the power supply box.
2. Place the power supply in position and install the two bottom mounting screws that secure the power supply to the bottom panel of the power supply box.
3. Place the connections onto their associated terminal strip and install the screws that secure the connections to the terminal strips.
4. Place the front panel in position on the power supply box.
5. Install the 10 screws that secure the front panel to the power supply box.
6. Place the top cover in position on the power supply box.
7. Install the 14 screws that secure the top cover to the power supply box.
8. Install the power supply box (section 9.12.2).

## 9.16 Echelon/Motor Power Supply

For the following procedures, see figure 9-14.

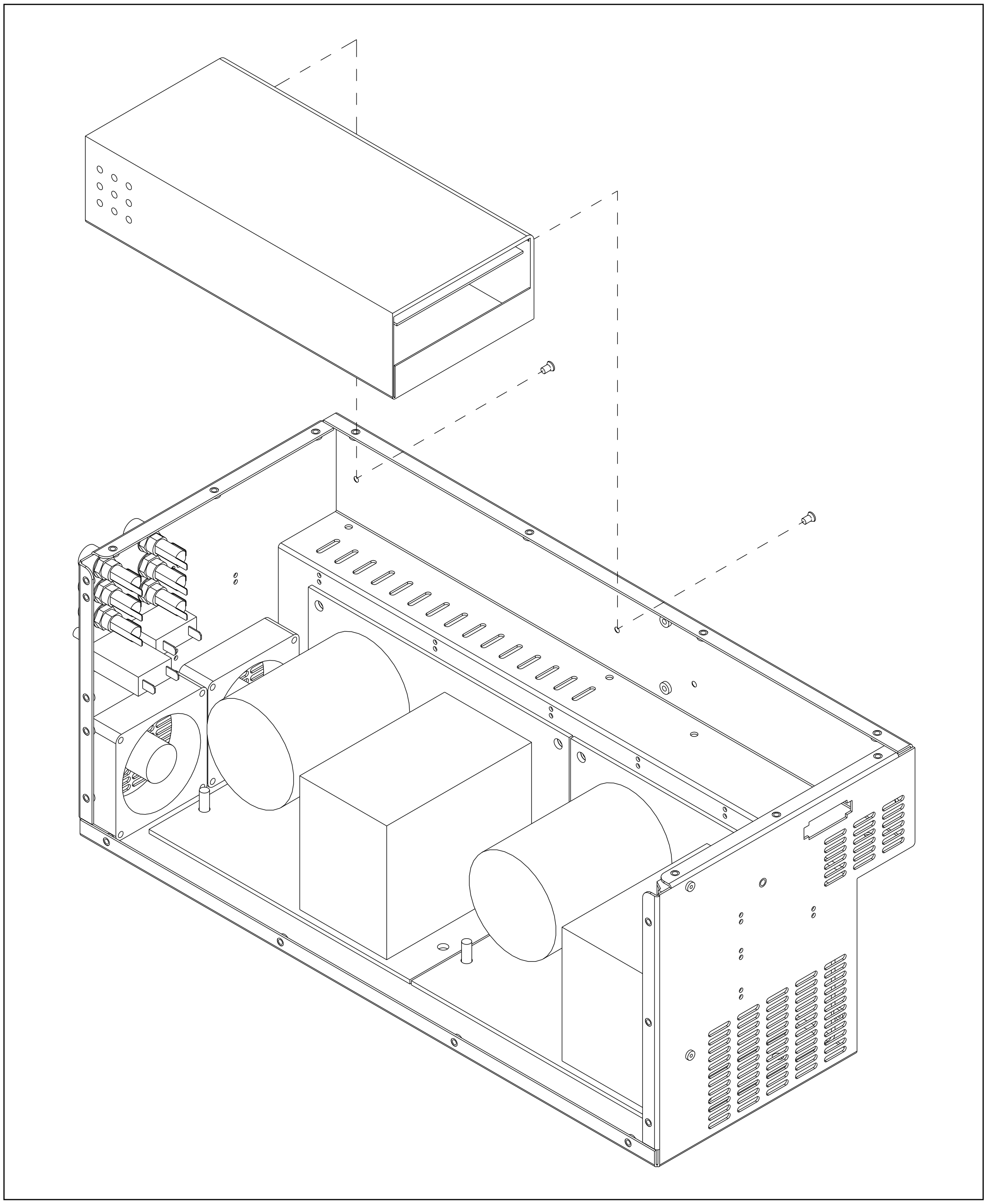


Figure 9-14. Echelon/Motor Power Supply Mounting.

### 9.16.1 Removal Procedure

1. Remove the power supply box (section 9.12.1).
2. Remove the 14 screws that secure the top cover to the power supply box.
3. Remove the 10 screws that secure the front panel to the power supply box.
4. Lay the front panel on its face next to the power supply box.
5. Remove the two screws that secure the Echelon/motor power supply to the rear panel of the power supply box.
6. Turn the Echelon/motor power supply upside down so that its top is lying above the internal computer power supply.
7. Remove the screws that secure the power supply cover to the Echelon/motor power supply. Remove the power supply cover.
8. Remove the screws and nuts that secure the connections to the terminal strips on the Echelon/motor power supply and remove the connections.
9. Reinstall the cover on the Echelon/motor power supply.

### 9.16.2 Installation Procedure

1. Remove the screws that secure the power supply cover to the new Echelon/motor power supply, and remove the cover.
2. Put the connections on their associated terminal strip, and install the screws and nuts that secure the connections to the terminal strips.
3. Place the power supply cover in position on the Echelon/motor power supply. Install the screws that secure the power supply cover to the Echelon/motor power supply.
4. Place the Echelon/motor power supply in position, and install the two screws that secure the Echelon/motor power supply to the rear panel of the power supply box.
5. Place the front panel in position on the power supply box.
6. Install the 10 screws that secure the front panel to the power supply box.
7. Place the top cover in position on the power supply box.
8. Install the 14 screws that secure the top cover to the power supply box.
9. Install the power supply box (section 9.12.2).

## 9.17 Cooler Power Supply

The wiring harness in the power supply box severely limits the movement of the cooler power supply, even when the power supply mounting hardware is removed. To remove the power supply, raise the power supply approximately 3/4 inch so that the bottom plate of the power supply clears the two mounting studs. You may have to remove the tie wraps on the wiring harness that runs along the back edge of the power supply.

For the following procedures, see figure 9-15.

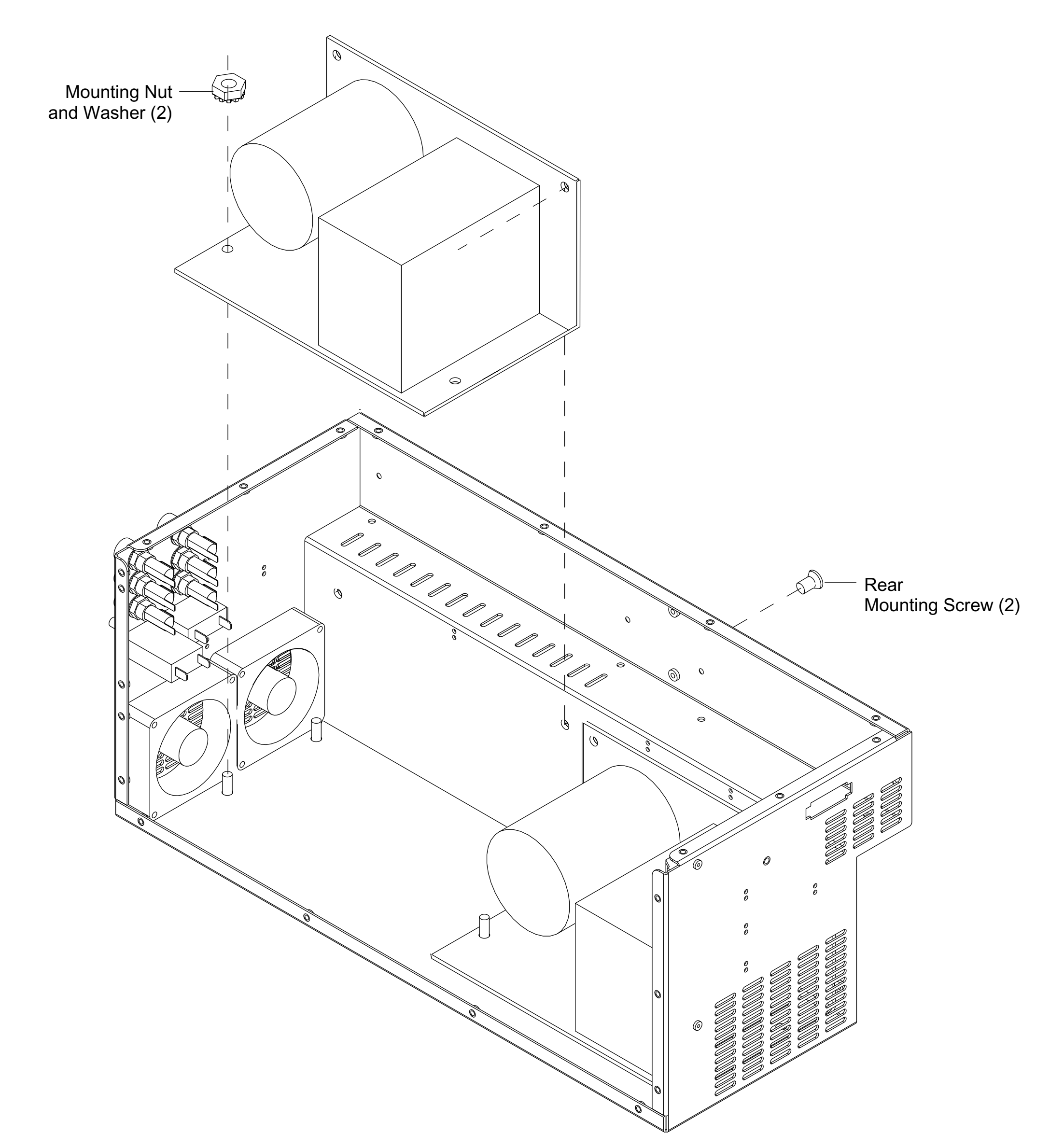



Figure 9-15. Cooler Power Supply Mounting.

### 9.17.1 Removal Procedure

1. Remove the power supply box (section 9.12.1).
2. Remove the 14 screws that secure the top cover to the power supply box.
3. Remove the 10 screws that secure the front panel to the power supply box.
4. Lay the front panel on its face next to the power supply box.
5. Unsolder the black and white wires from the primary of the input transformer. This disconnects the AC input to the cooler power supply.
6. Remove the two screws and washers and the resistor from the two terminals on the large capacitor. This disconnects the DC output from the cooler power supply.
7. Remove the two screws, hex nuts, and washers that secure the cooler power supply to the rear panel of the power supply box.
8. Remove the two hex nuts and washers that secure the cooler power supply to the bottom panel of the power supply box.

*NOTE* **Before the next step, remove the cable tie wraps and move the wiring harness as necessary.**

9. Lift the cooler power supply and pull it from the power supply box.

### 9.17.2 Installation Procedure

1. Place the cooler power supply in position in the power supply box.
2. Install the two hex nuts and washers that secure the cooler power supply to the bottom panel of the power supply box.
3. Install the two screws, hex nuts, and washers that secure the cooler power supply to the rear panel of the power supply box.
4. Resolder the black and white AC input wires to the primary of the input transformer.
5. Install the two screws and washers and the resistor onto the two terminals on the large capacitor.
6. Install new tie wraps to replace the tie wraps removed during the power supply removal.
7. Position the front panel on the power supply box.
8. Install the 10 screws that secure the front panel to the power supply box.
9. Install the 14 screws that secure the top cover to the power supply box.
10. Install the power supply box (section 9.12.2).

## 9.18 Heater Power Supply (Four-Supply Model)

The wiring harness in the power supply box severely limits the movement of the heater power supply even when the power supply mounting hardware is removed. To remove the power supply, raise the power approximately 3/4 inch so that the bottom plate of the power supply clears the two mounting studs. You may have to remove the tie wraps on the wiring harness that runs along the back and right edges of the power supply.

For the following procedures, see figure 9-16.

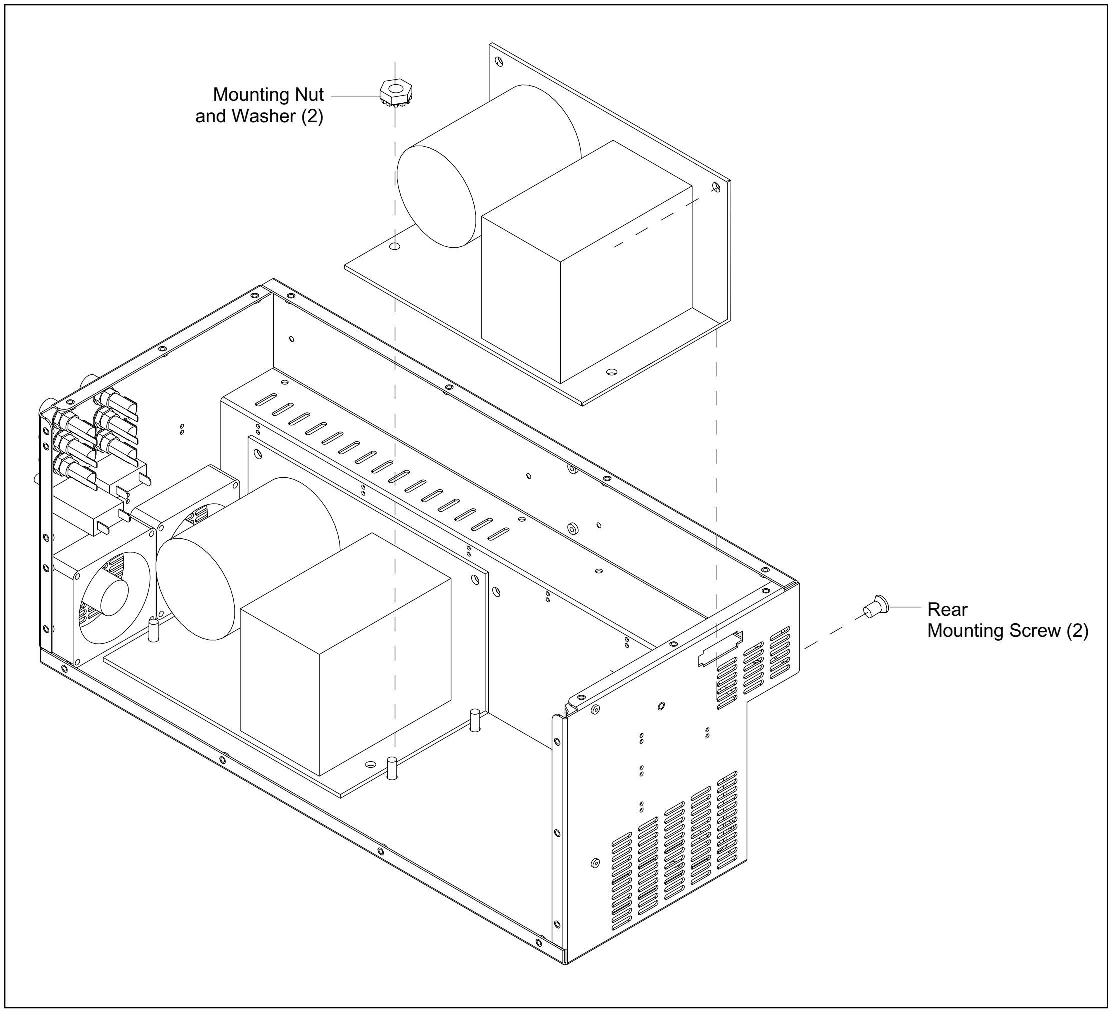



Figure 9-16. Heater Power Supply Mounting (Four-Supply Model).

### 9.18.1 Removal Procedure

1. Remove the power supply box (section 9.12.1).
2. Remove the 14 screws that secure the top cover to the power supply box.
3. Remove the 10 screws that secure the front panel to the power supply box.
4. Lay the front panel on its face next to the power supply box.
5. Remove the two screws and washers and the resistor from the two terminals on the large capacitor. This disconnects the DC output from the heater power supply.
6. Remove the two screws, hex nuts, and washers that secure the heater power supply to the rear panel of the power supply box.
7. Remove the two hex nuts and washers that secure the heater power supply to the bottom panel of the power supply box.

*NOTE* **Before the next step, remove the cable tie wraps and move the wiring harness as necessary.**

8. Lift the heater power supply and pull it from the power supply box.
9. Unsolder the black and white wires from the primary of the input transformer. This disconnects the AC input to the heater power supply.

### 9.18.2 Installation Procedure

1. Resolder the black and white AC input wires to the primary of the input transformer.
2. Place the heater power supply in position in the power supply box.
3. Install the two hex nuts and washers that secure the heater power supply to the bottom panel of the power supply box.
4. Install the two screws, hex nuts, and washers that secure the heater power supply to the rear panel of the power supply box.
5. Install the two screws and washers and the resistor onto the two terminals on the large capacitor.
6. Install new tie wraps to replace the tie wraps removed during the power supply removal.
7. Position the front panel on the power supply box.
8. Install the 10 screws that secure the front panel to the power supply box.
9. Install the 14 screws that secure the top cover to the power supply box.
10. Install the power supply box (section 9.12.2).

## 9.19 Main DC Power Supply (Two-Supply Model)

For the following procedures, see figure 9-17.

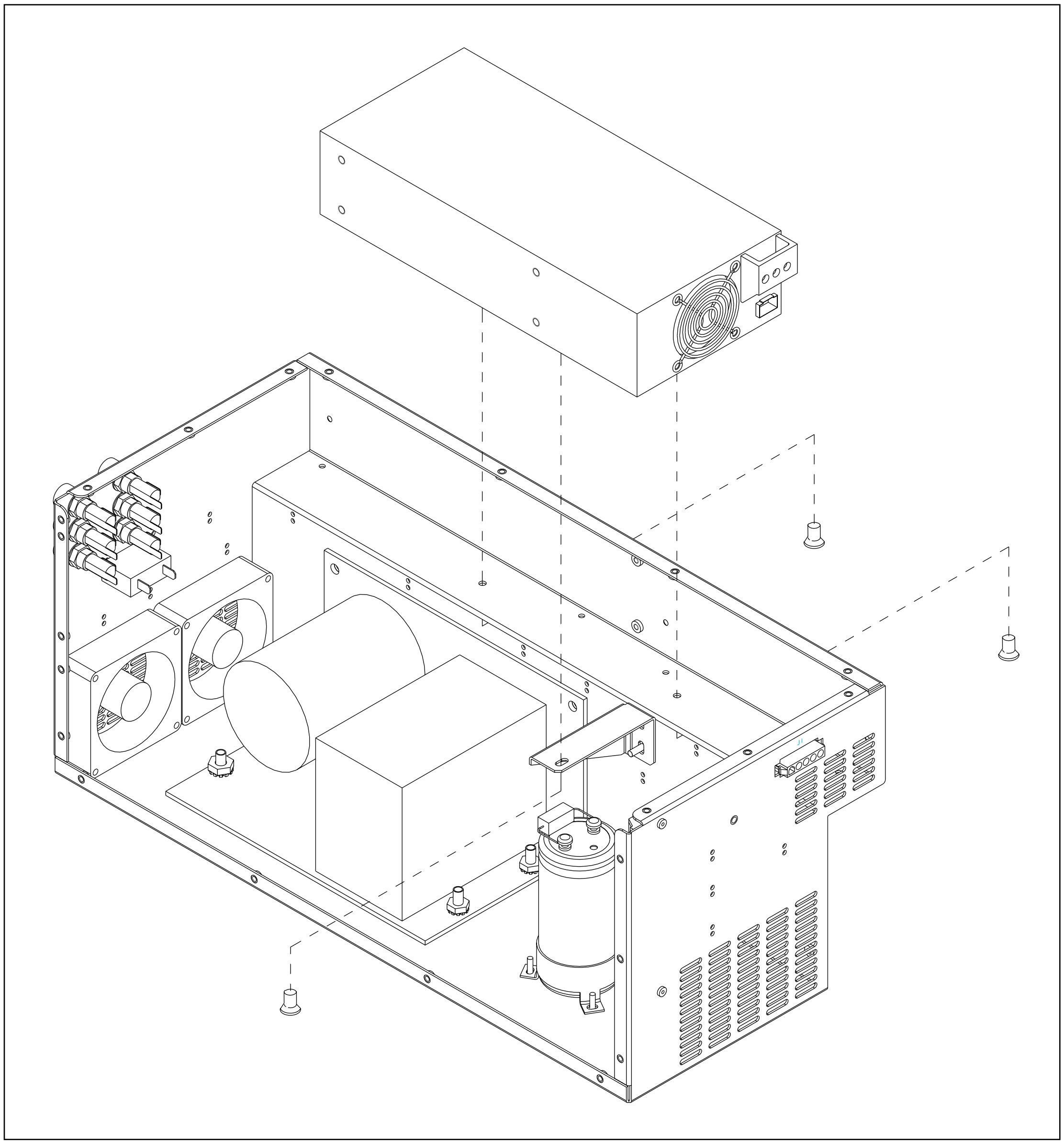


Figure 9-17. Main DC Power Supply Mounting (Two-Supply Model).

### 9.19.1 Removal Procedure

1. Remove the power supply box (section 9.12.1).
2. Remove the 14 screws that secure the top cover to the power supply box.
3. Remove the 10 screws that secure the front panel to the power supply box.
4. Lay the front panel on its face next to the power supply box.
5. Tag and remove the three AC connections on the right end of the main DC power supply.
6. Tag and remove the eight DC connections on the left end of the main DC power supply.
7. Remove the screw that secures the main DC power supply to the support bracket mounted on the rear panel of the power supply box.
8. Remove the two screws that secure the main DC power supply to the rear ledge of the power supply box.

### 9.19.2 Installation Procedure

1. Install the two screws that secure the main DC power supply to the rear ledge of the power supply box.
2. Install the screw that secures the main DC power supply to the support bracket mounted on the rear panel of the power supply box.
3. Reconnect the eight DC connections on the left end of the main DC power supply.
4. Reconnect the three AC connections on the right end of the main DC power supply.
5. Place the front panel in position on the power supply box.
6. Install the 10 screws that secure the front panel to the power supply box.
7. Place the top cover in position on the power supply box.
8. Install the 14 screws that secure the top cover to the power supply box.
9. Install the power supply box (section 9.12.2).

## 9.20 Heater Power Supply (Two-Supply Model)

The wiring harness in the power supply box severely limits the movement of the heater power supply, even when the power supply mounting hardware is removed. To remove the power supply, raise the power supply approximately 3/4 inch so that the bottom plate of the power supply clears the two mounting studs. You may have to remove the tie wraps on the wiring harness that runs along the back edge of the power supply.

For the following procedures, see figure 9-18.

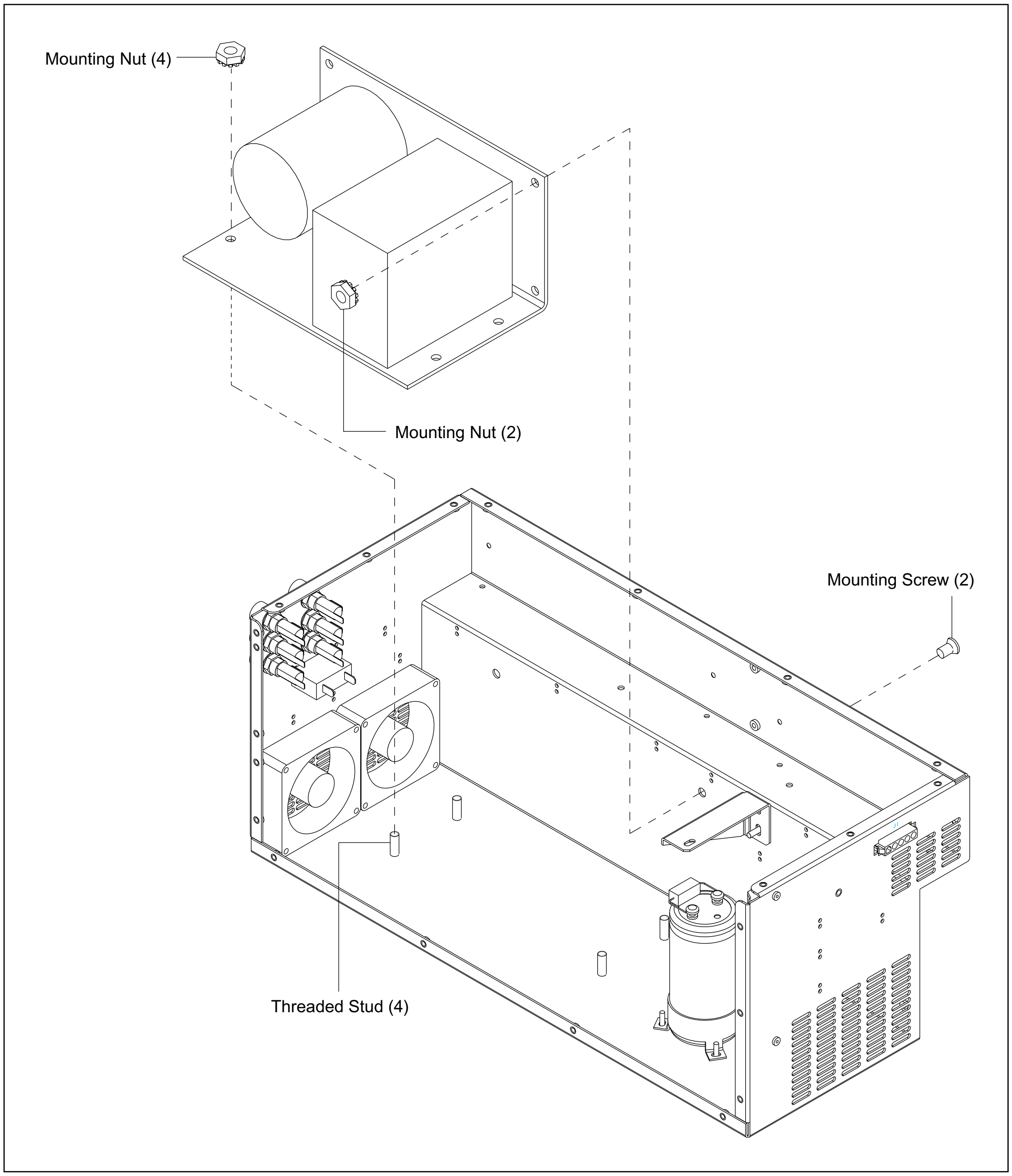



Figure 9-18. Heater Power Supply Mounting (Two-Supply Model).

### 9.20.1 Removal Procedure

1. Remove the power supply box (section 9.12.1).
2. Remove the 14 screws that secure the top cover to the power supply box.
3. Remove the 10 screws that secure the front panel to the power supply box.
4. Lay the front panel on its face next to the power supply box.
5. Unsolder the black and white wires from the primary of the input transformer. This disconnects the AC input to the heater power supply.
6. Remove the two screws and washers and the resistor from the terminals on the large capacitor. This disconnects the DC output from the heater power supply.
7. Remove the two screws, hex nuts, and washers that secure the heater power supply to the rear panel of the power supply box.
8. Remove the four hex nuts and washers that secure the heater power supply to the bottom panel of the power supply box.

*NOTE* **Before the next step, remove the cable tie wraps and move the wiring harness as necessary.**

9. Lift the heater power supply and pull it from the power supply box.

### 9.20.2 Installation Procedure

1. Place the heater power supply in position in the power supply box.
2. Install the four hex nuts and washers that secure the heater power supply to the bottom panel of the power supply box.
3. Install the two screws, hex nuts, and washers that secure the heater power supply to the rear panel of the power supply box.
4. Resolder the black and white AC input wires to the primary of the input transformer.
5. Install the two screws and washers and the resistor onto the two terminals on the large capacitor.
6. Install new tie wraps to replace the tie wraps removed during the power supply removal.
7. Position the front panel on the power supply box.
8. Install the 10 screws that secure the front panel to the power supply box.
9. Install the 14 screws that secure the top cover to the power supply box.
10. Install the power supply box (section 9.12.2).

## 9.21 Main DC Power Supply (CE 2001)

For the following procedures, see figure 9-19.

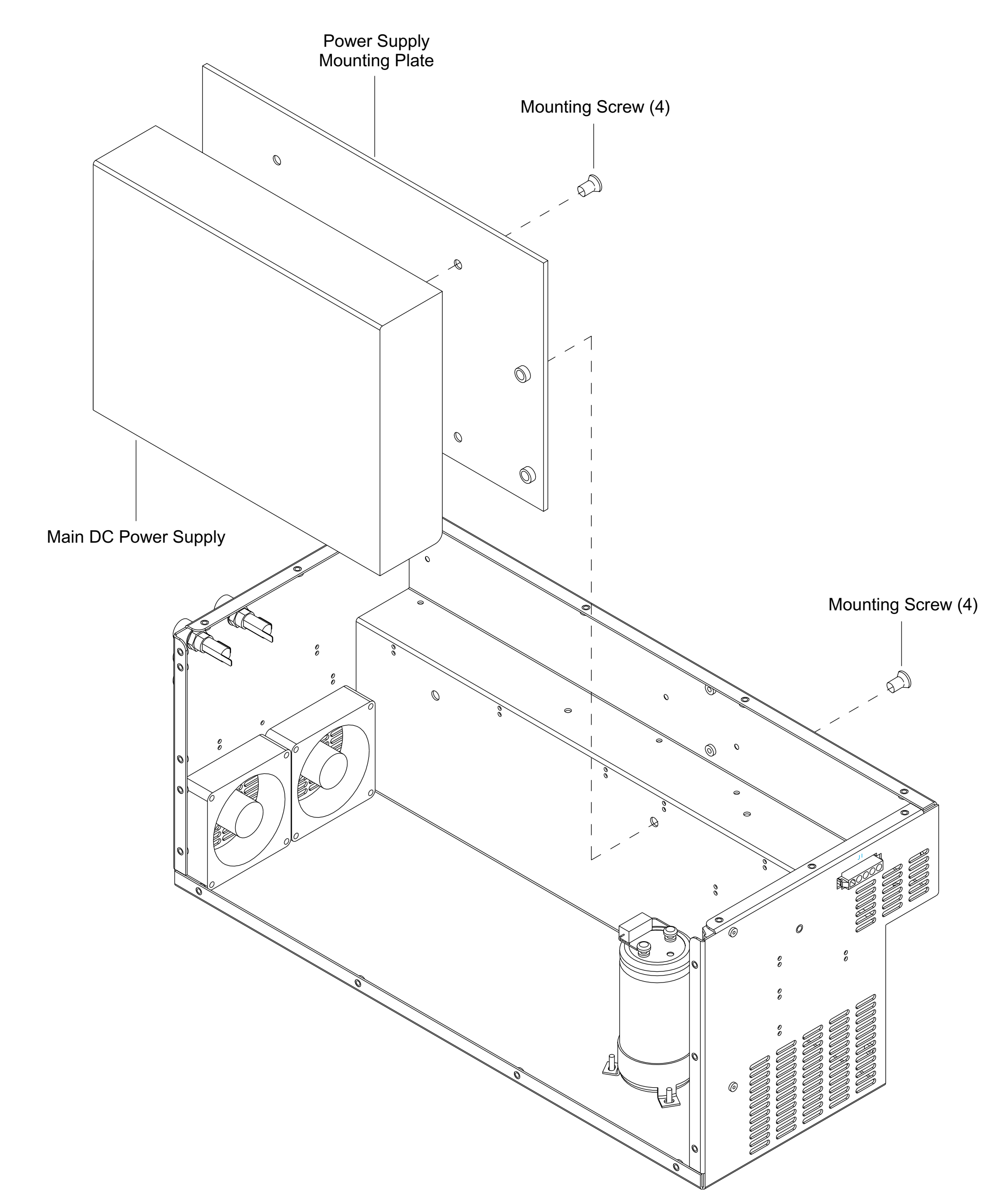



Figure 9-19. Main DC Power Supply Mounting (CE 2001).

### 9.21.1 Removal Procedure

1. Remove the power supply box (section 9.12.1).
2. Remove the 14 screws that secure the top cover to the power supply box.
3. Remove the 10 screws that secure the front panel to the power supply box.
4. Lay the front panel on its face next to the power supply box.
5. Remove the four screws that secure the main DC power supply with mounting plate to the rear panel of the power supply box.
6. Tag and remove the three AC connections on the right end of the main DC power supply.
7. Tag and remove the ten DC connections on the right end of the main DC power supply.
8. Remove the four screws that secure the mounting plate to the main DC power supply.

### 9.21.2 Installation Procedure

1. Install the four screws that secure the mounting plate to the main DC power supply.
2. Reconnect the three AC connections on the right end of the main DC power supply.
3. Reconnect the ten DC connections on the right end of the main DC power supply.
4. Install the four screws that secure the main DC power supply with mounting plate to the rear panel of the power supply box.
5. Place the front panel in position on the power supply box.
6. Install the 10 screws that secure the front panel to the power supply box.
7. Place the top cover in position on the power supply box.
8. Install the 14 screws that secure the top cover to the power supply box.
9. Install the power supply box (section 9.12.2).

## 9.22 Heater/Cooler Assembly

For the following procedures, see figure 9-20.

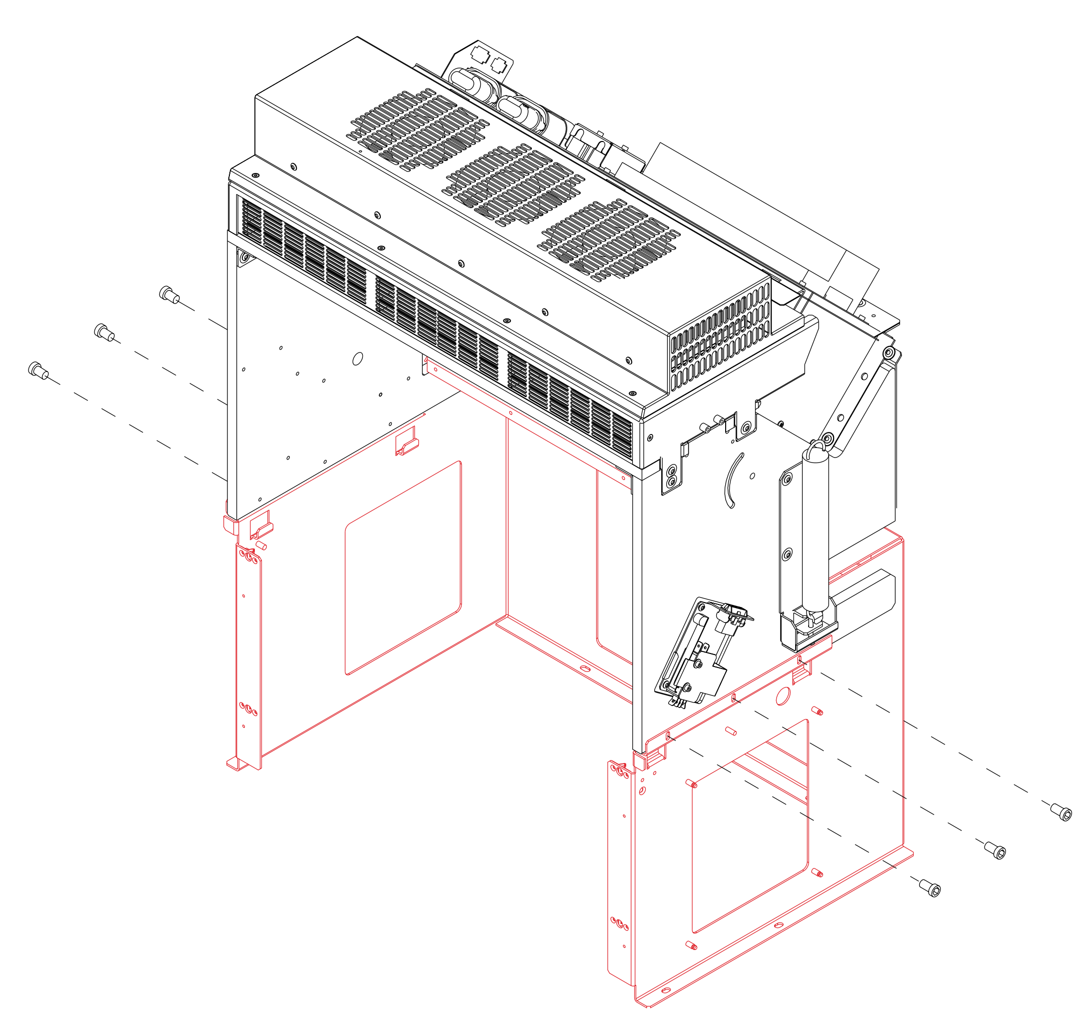


Figure 9-20. Heater/Cooler Assembly Mounting.

### 9.22.1 Removal Procedure

1. Remove the top cover (section 9.2.1).
2. Remove the left panel assembly (section 9.4.1).
3. Remove the midcover support (section 9.7.1).
4. Disconnect the cables from the TMPR board.
5. Disconnect the cables to the interlock switches on the left and right sides of the heater/cooler assembly.
6. Disconnect the pneumatic connection on the left side of the heater/cooler assembly.
7. Disconnect the ground wires on the right side.
8. Remove the six screws that secure the left and right sides of the heater/cooler assembly to the sheet-metal support.

*WARNING* **The heater/cooler assembly is heavy and requires two people to remove it from the instrument. Do not attempt to lift it alone.**

9. Lift the heater/cooler assembly and remove it from the instrument.

### 9.22.2 Installation Procedure

*WARNING* **The heater/cooler assembly is heavy and requires two people to install it in the instrument. Do not attempt to lift it alone.**

1. Lift the heater/cooler assembly, and position it on the sheet-metal support.
2. Install the six screws that secure the left and right sides of the heater/cooler assembly to the sheet-metal support.
3. Reconnect the cables to the TMPR board.
4. Reconnect the cables to the interlock switches on the left and right sides of the heater/cooler assembly.
5. Reconnect the ground wires on the right side.
6. Reconnect the pneumatic connection on the left side of the heater/cooler assembly.
7. Install the left panel assembly (section 9.4.2).
8. Install the midcover support (section 9.7.2).
9. Install the top cover (section 9.2.2).

## 9.23 Temperature Control Assembly

For the following procedures, see figure 9-22.

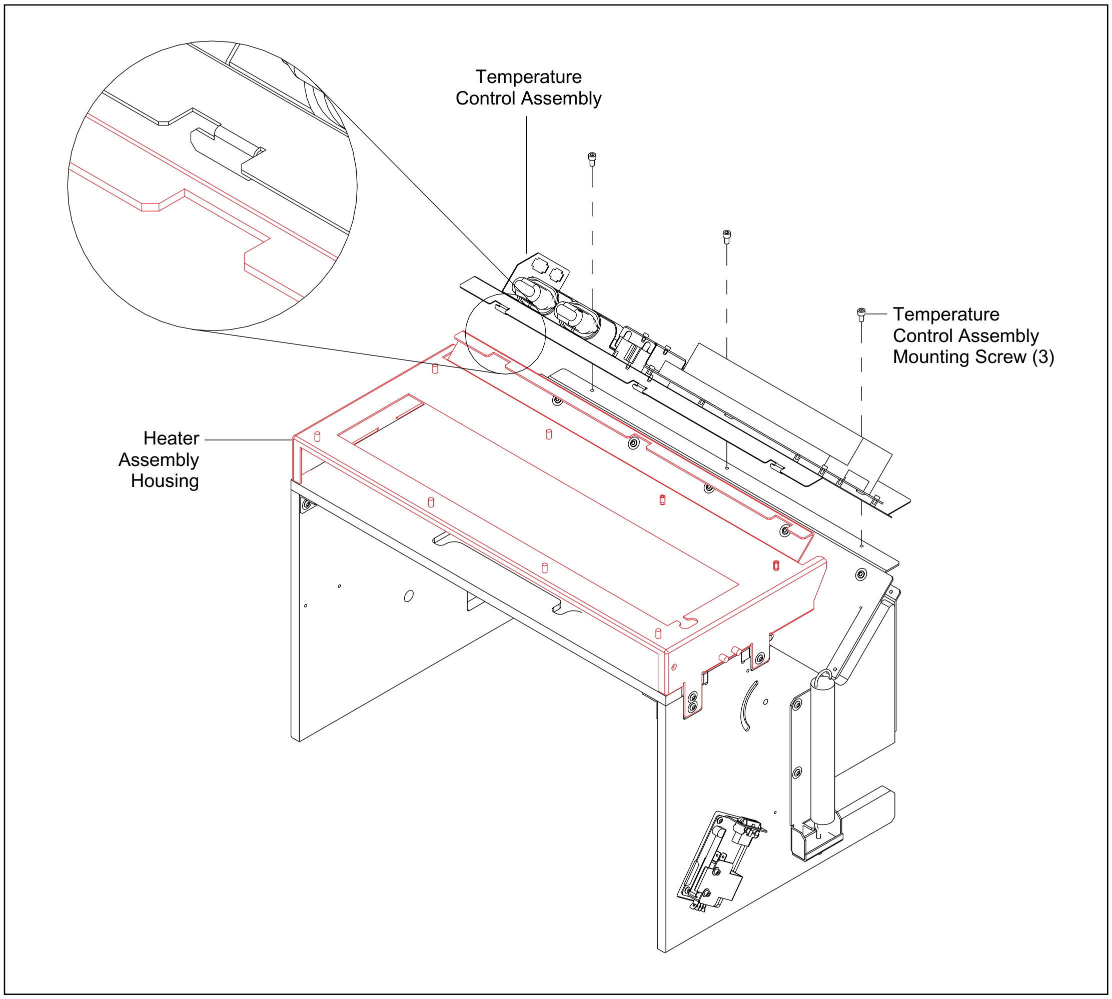



Figure 9-21. Temperature Control Assembly Mounting.

### 9.23.1 Removal Procedure

1. Remove the top cover (section 9.2.1).
2. Disconnect the cables from the TMPR board.
3. Remove the three screws that secure the temperature control assembly to the heater/cooler assembly.

### 9.23.2 Installation Procedure

1. Place the TMPR board in position, and install the three screws that secure the temperature control assembly to the heater/cooler assembly.
2. Reconnect the cables to the TMPR board.
3. Install the top cover (section 9.2.2).

## 9.24 TMPR Board

For the following procedures, see figure 9-21.

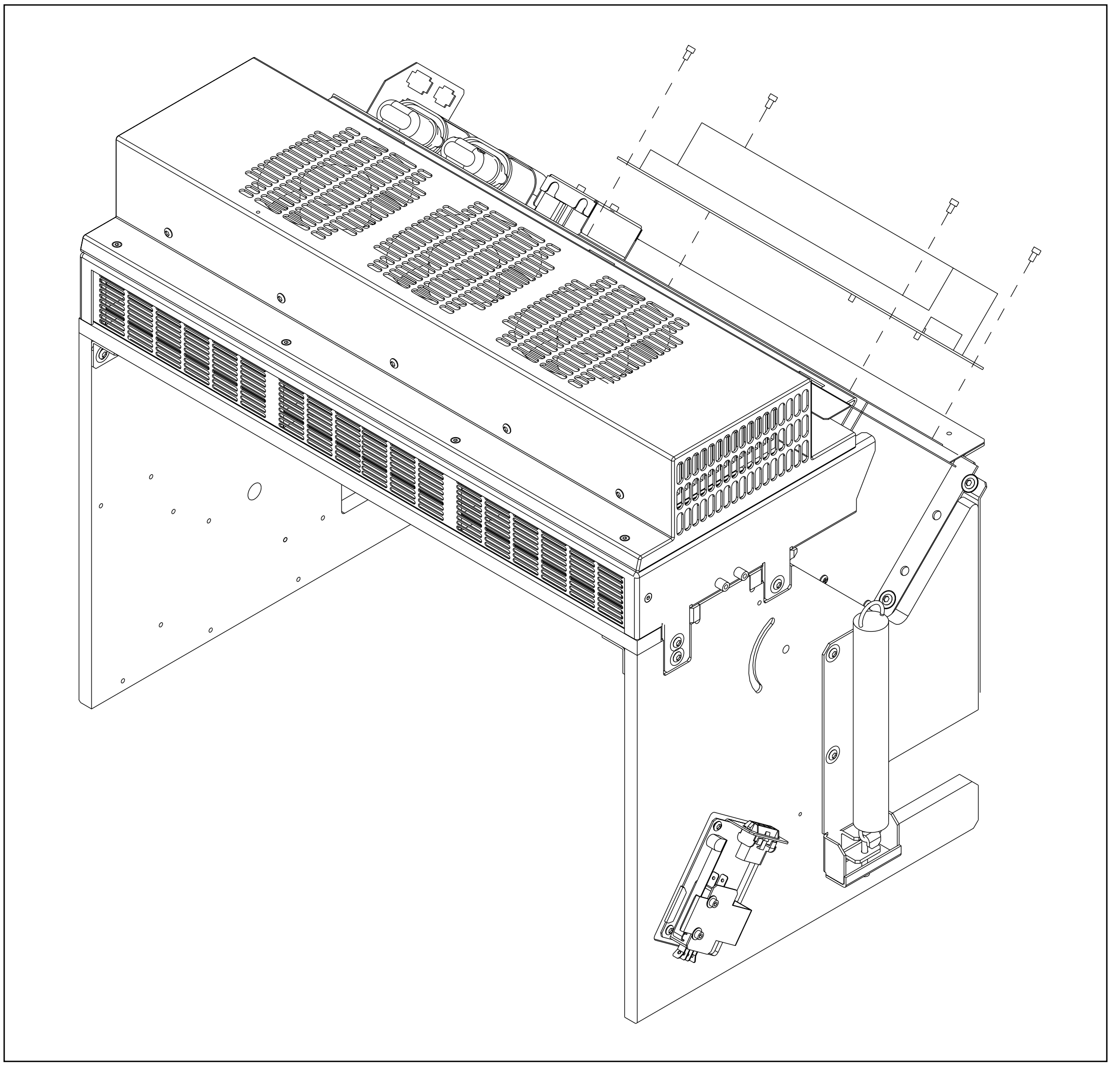


Figure 9-22. TMPR Board Mounting.

### 9.24.1 Removal Procedure

1. Remove the top cover (section 9.2.1).
2. Disconnect the cables from the TMPR board.
3. Remove the four screws that secure the TMPR board to the heater/cooler assembly.

### 9.24.2 Installation Procedure

1. Place the TMPR board in position, and install the four screws that secure the TMPR board to the heater/cooler assembly.
2. Reconnect the cables to the TMPR board.
3. Install the top cover (section 9.2.2).

## 9.25 TE Cooler Assembly

For the following procedures, see figure 9-23.

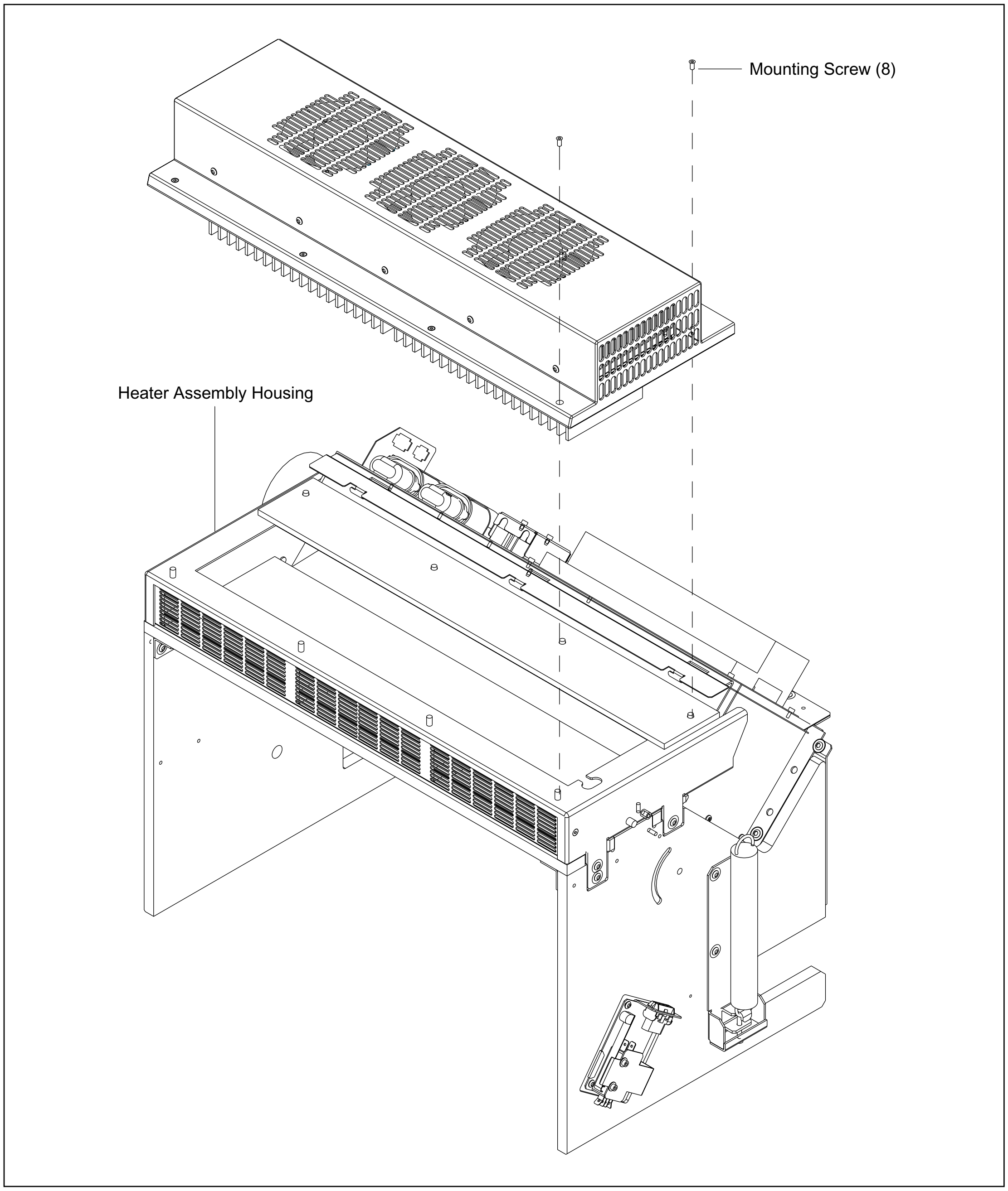



Figure 9-23. TE Cooler Assembly Mounting.

### 9.25.1 Removal Procedure

1. Remove the top cover (section 9.2.1).
2. Remove the left panel assembly (section 9.4.1).
3. Remove the midcover support (section 9.7.1).
4. Disconnect the cables from the TMPR board.
5. Remove the eight screws that secure the TE cooler assembly to the heater assembly housing.
6. Lift the TE cooler assembly from the instrument.

### 9.25.2 Installation Procedure

1. Place the TE cooler assembly in position on the heater assembly housing.
2. Install the eight screws that secure the TE cooler assembly to the heater assembly housing.
3. Reconnect the cables to the TMPR board.
4. Install the left panel assembly (section 9.4.2).
5. Install the midcover support (section 9.7.2).
6. Install the top cover (section 9.2.2).

## 9.26 Heater Assembly

For the following procedures, see figure 9-24.

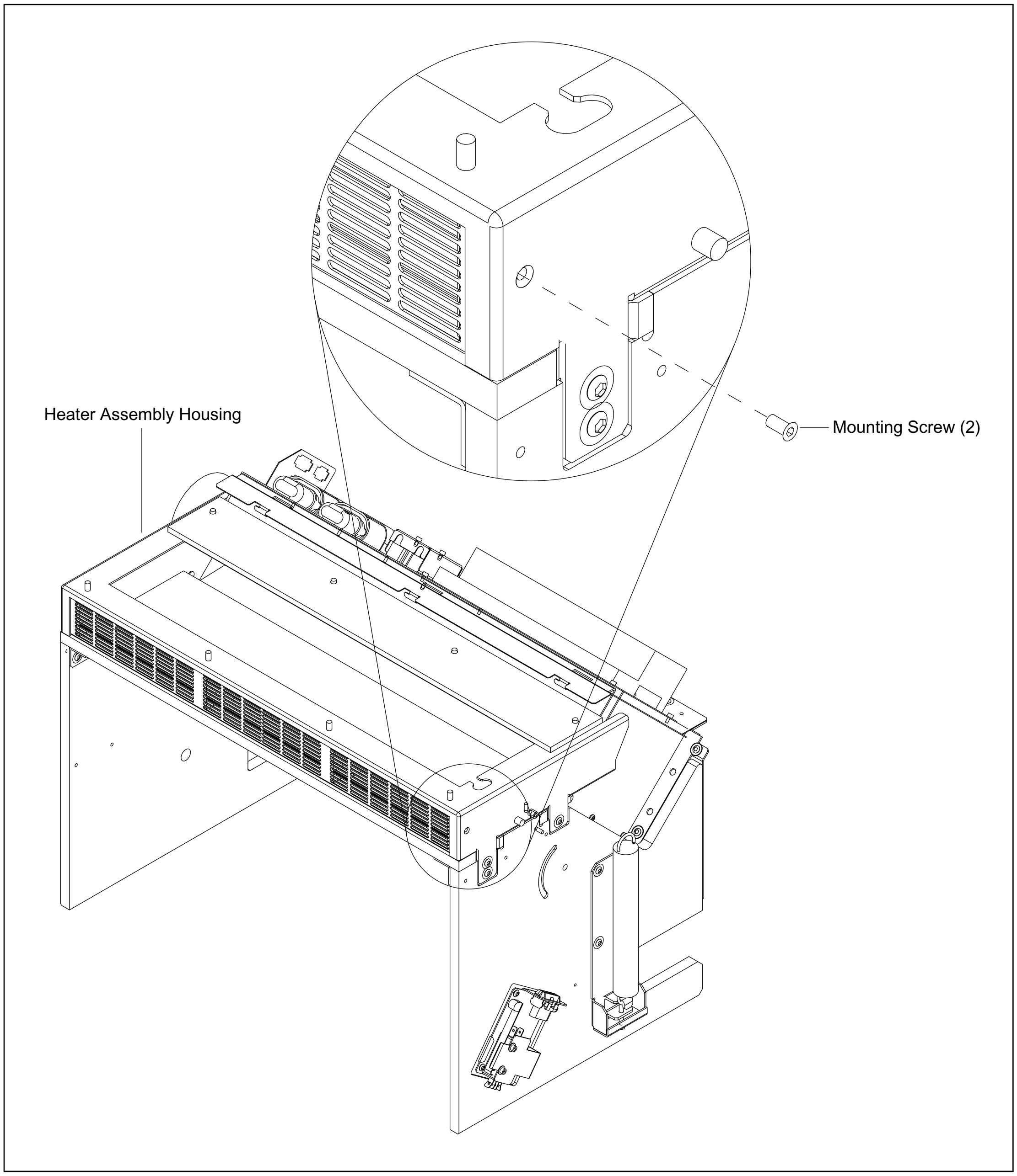



Figure 9-24. Heater Assembly Mounting.

### 9.26.1 Removal Procedure

1. Remove the TE cooler assembly (section 9.25.1).
2. Disconnect the heater cable from the TMPR board.
3. Remove the two screws that secure the heater assembly to the heater assembly mounting.
4. Remove the heater assembly from the instrument.

### 9.26.2 Installation Procedure

1. Place the heater assembly in position in the heater assembly mounting.
2. Install the two screws that secure the heater assembly to the heater assembly mounting.
3. Reconnect the heater cable to the TMPR board.
4. Install the TE cooler assembly (section 9.25.2).

## 9.27 Blower Assembly

For the following procedures, see figure 9-25.

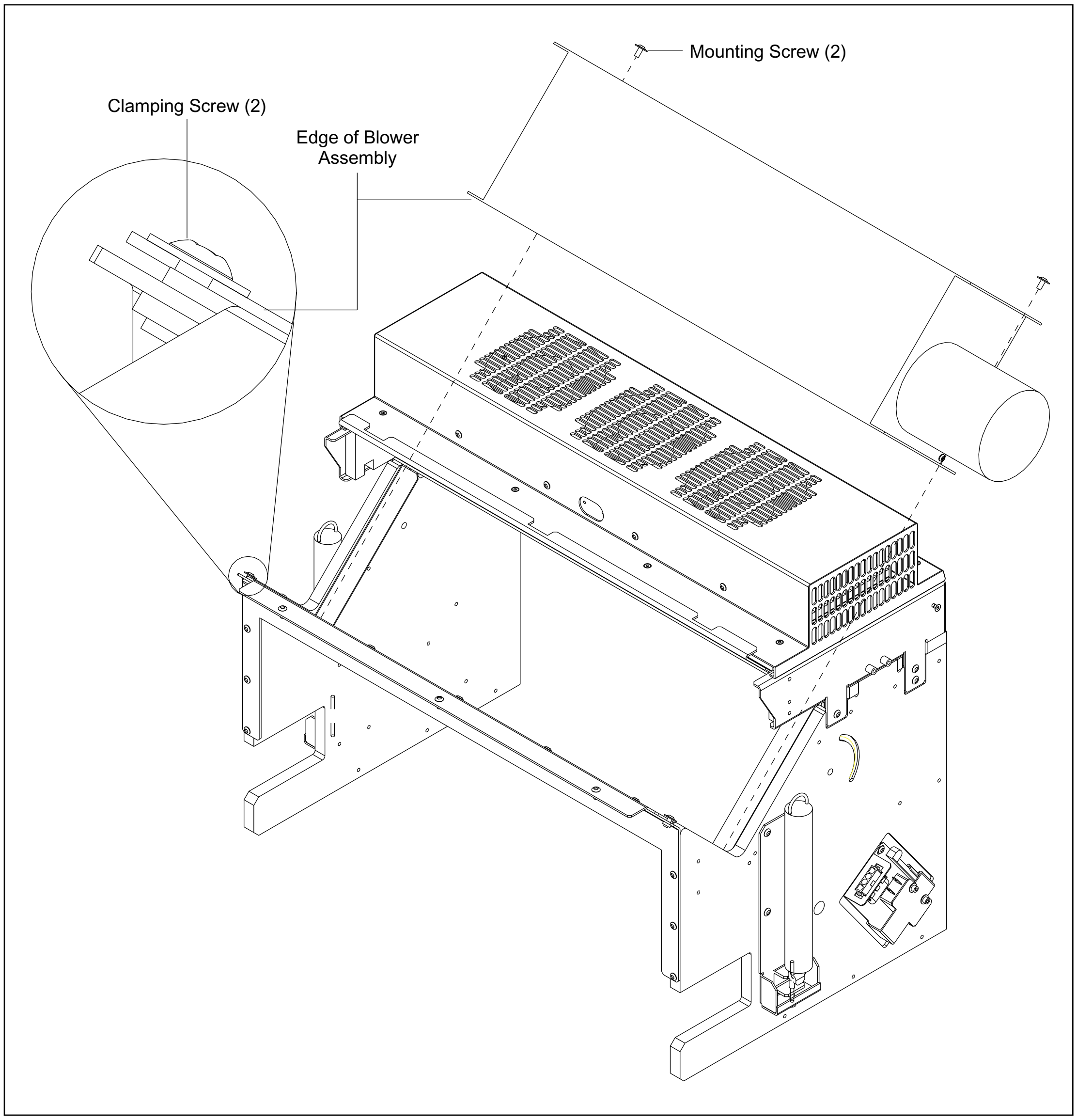



Figure 9-25. Blower Assembly Mounting.

### 9.27.1 Removal Procedure

1. Remove the top cover (section 9.2.1).
2. Remove the left panel assembly (section 9.4.1).
3. Remove the midcover support (section 9.7.1).
4. Disconnect the blower cable from the TMPR board.
5. Loosen the two clamping screws and remove the two mounting screws that secure the blower assembly to the electrophoresis chamber chassis.
6. Remove the blower assembly from the instrument.

### 9.27.2 Installation Procedure

1. Place the blower assembly in position on the heater/cooler assembly.
2. Tighten the two clamping screws and install the two mounting screws that secure the blower assembly to the electrophoresis chamber chassis.
3. Reconnect the blower cable to the TMPR board.
4. Install the left panel assembly (section 9.4.2).
5. Install the midcover support (section 9.7.2).
6. Install the top cover (section 9.2.2).

## 9.28 Service Door Interlock Switches

For the following procedures, see figure 9-26.

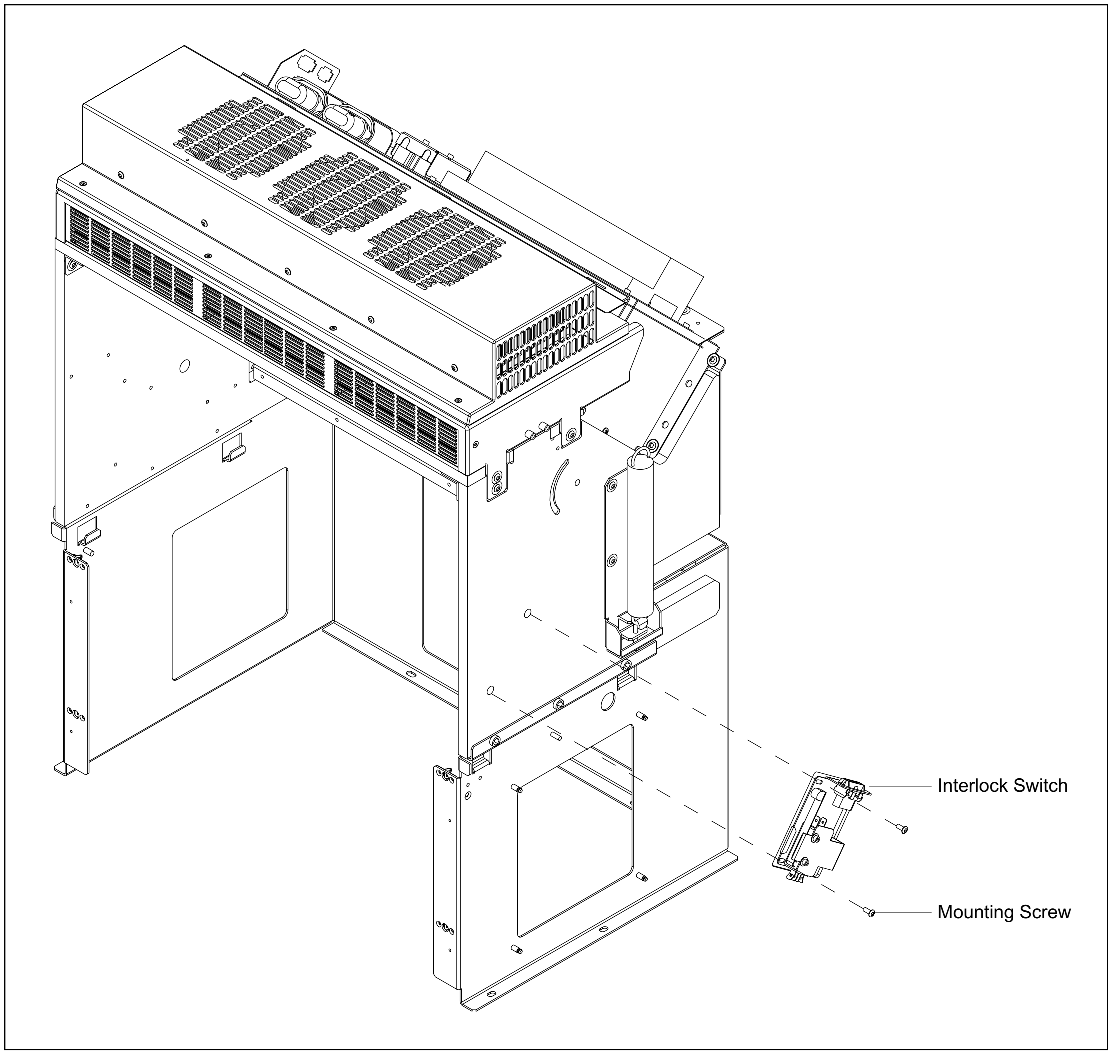



Figure 9-26. Service Door Interlock Switch Mounting.

### 9.28.1 Removal Procedure

1. Remove the top cover (section 9.2.1).
2. Remove the left panel assembly (section 9.4.1).
3. Remove the midcover support (section 9.7.1).
4. Disconnect the cable to the interlock switch on the left or right side of the heater/cooler assembly.
5. Remove the two screws that secure the interlock switch to the electrophoresis chamber chassis.

### 9.28.2 Installation Procedure

1. Install the two screws that secure the interlock switch to the electrophoresis chamber chassis.
2. Reconnect the cable to the interlock switch on the left or right side of the heater/cooler assembly.
3. Install the left panel assembly (section 9.4.2).
4. Install the midcover support (section 9.7.2).
5. Install the top cover (section 9.2.2).

## 9.29 ADAQ Board

For the following procedures, see figure 9-27.

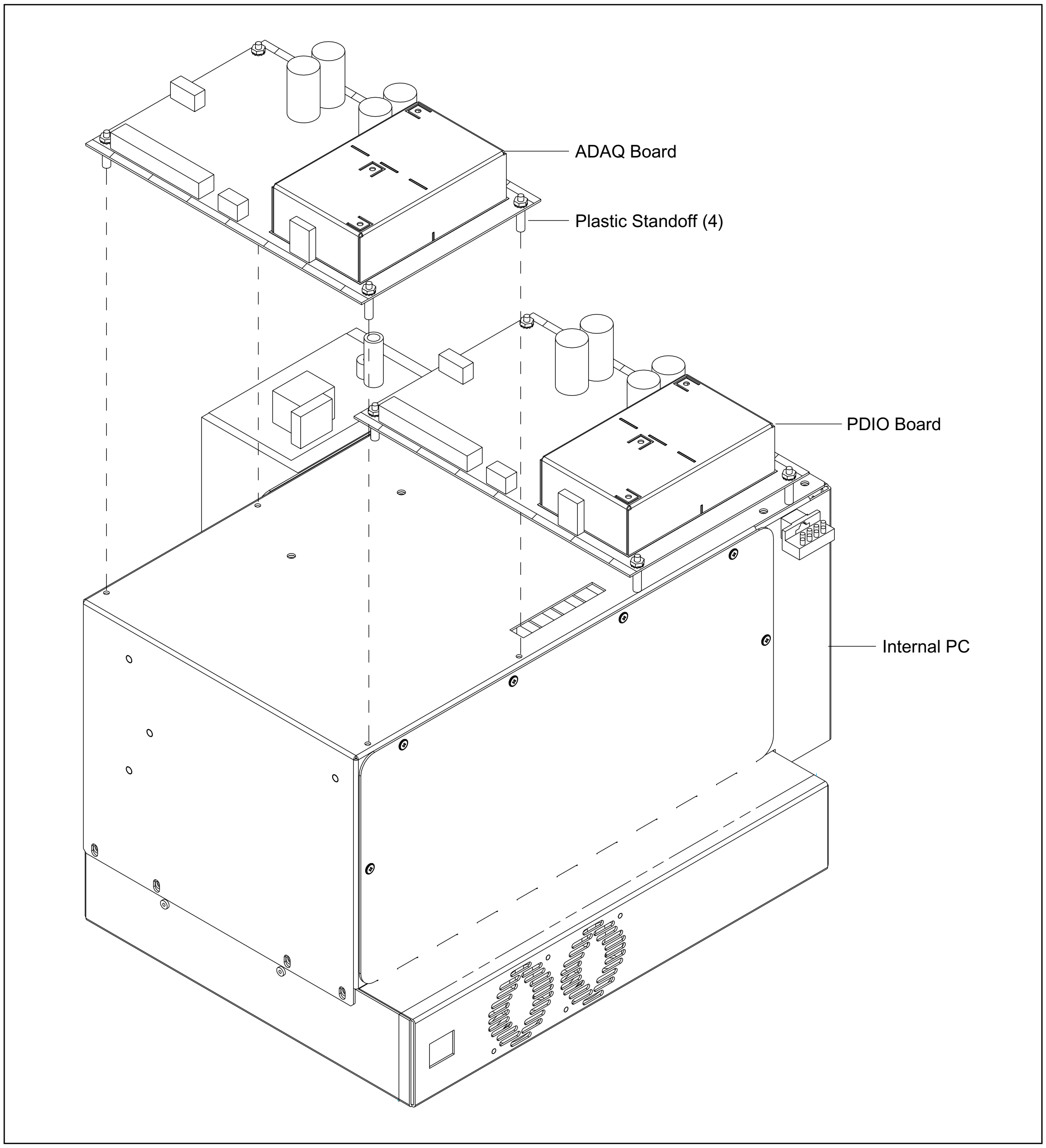



Figure 9-27. ADAQ Board Mounting.

### 9.29.1 Removal Procedure

1. Remove the lower-right cover (section 9.6.1).
2. From the right side of the instrument, remove the coax connectors from the ADAQ board.
3. Reach over the board and disconnect the Neuron network cables from the ADAQ board.
4. Gently pry up the ADAQ board until the plastic standoffs disengage from the holes in the top of the internal computer, and then remove the board from the instrument.
5. Disconnect the remaining cables from the board.
6. Remove the hex nuts and washers from the four plastic standoffs.

### 9.29.2 Installation Procedure

1. Using the hex nuts and washers, install the four plastic standoffs on the ADAQ board.
2. Reconnect the cables to the top of the board.
3. Position the ADAQ board so that the plastic standoffs are over the holes in the top of the internal computer. Press down gently on the ADAQ board until the plastic standoffs are firmly seated in their respective holes.
4. Reach over the board and reconnect the Neuron network cables to the ADAQ board.
5. From the right side of the instrument, reconnect the coax connectors to the ADAQ board.
6. Install the lower-right cover (section 9.6.2).

## 9.30 PDIO Board

For the following procedures, see figure 9-28.

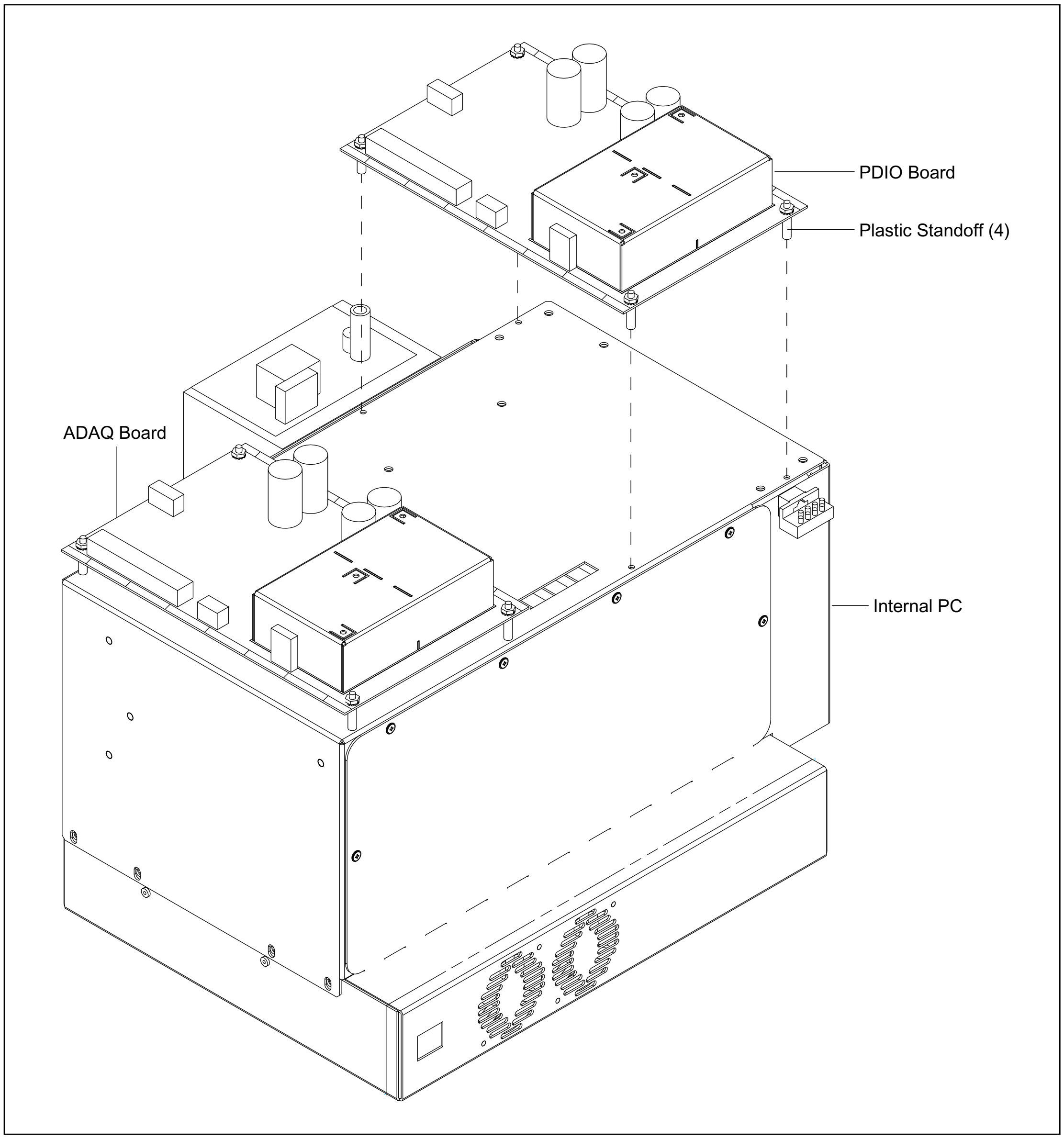



Figure 9-28. PDIO Board Mounting.

### 9.30.1 Removal Procedure

1. Remove the lower-right cover (section 9.6.1).
2. From the right side of the instrument, remove the coax connector from the PDIO board.
3. Reach over the board, and disconnect the Neuron network cables from the PDIO board.
4. Gently pry up the PDIO board until the plastic standoffs disengage from the holes in the top of the internal computer, and then remove the board from the instrument.
5. Disconnect the remaining cables from the board.
6. Remove the hex nuts and washers from the four plastic standoffs.

### 9.30.2 Installation Procedure

1. Using the hex nuts and washers, install the four plastic standoffs on the PDIO board.
2. Reconnect the cables to the top of the PDIO board.
3. Position the PDIO board so that the plastic standoffs are over the holes in the top of the internal computer. Press down gently on the PDIO board until the plastic standoffs are firmly seated in their respective holes.
4. Reach over the board, and reconnect the Neuron network cables to the PDIO board.
5. From the right side of the instrument, reconnect the coax connectors to the PDIO board.
6. Install the lower-right cover (section 9.6.2).

## 9.31 Internal Computer

For the following procedures, see figure 9-29.

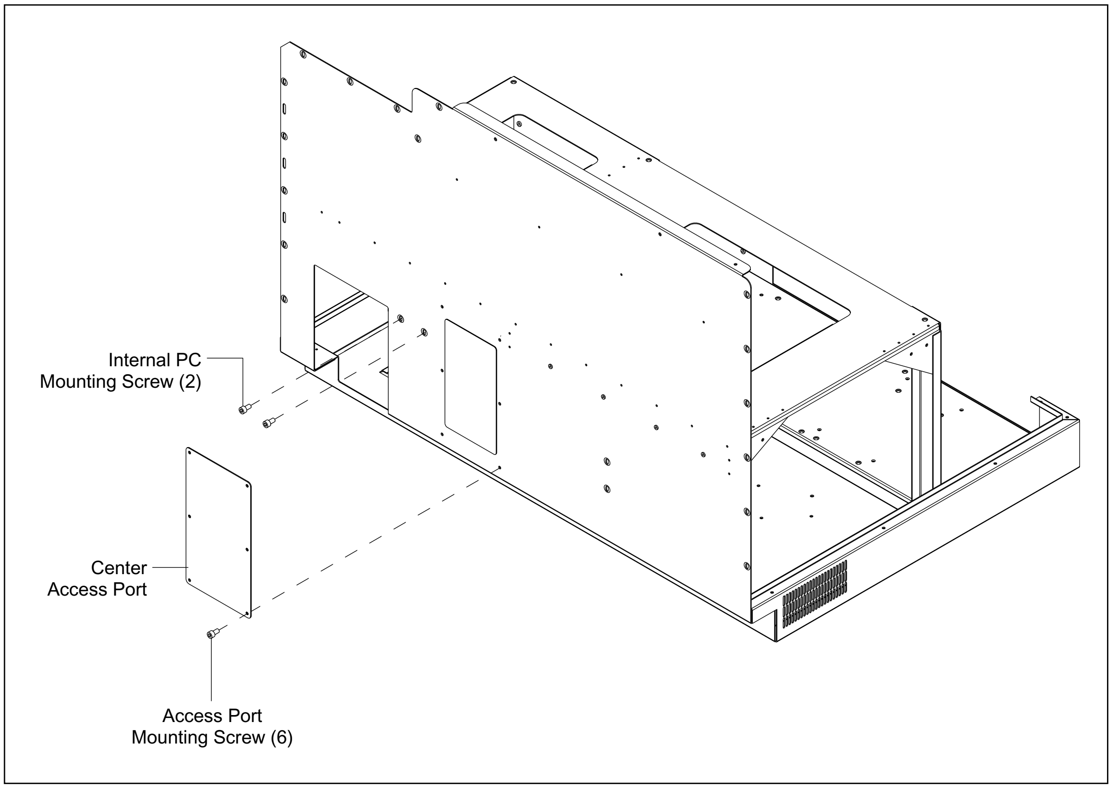



Figure 9-29. Internal Computer Mounting.

### 9.31.1 Removal Procedure

1. Remove the lower-right cover (section 9.6.1).
2. At the internal computer access port at the rear of the instrument, disconnect the cables from the internal computer.
3. Remove the ADAQ board (section 9.29.1).
4. Remove the PDIO board (section 9.30.1).
5. From the center access port, disconnect the cables from the internal computer and the HV power supply.
6. Remove the two screws that secure the internal computer to the sheet-metal chassis rear panel.
7. Lift the internal computer up and move it toward the center of the instrument until the tabs clear the sheet-metal chassis.
8. Slide the internal computer clear of the instrument.

### 9.31.2 Installation Procedure

1. Slide the internal computer into the instrument.
2. Replace the two screws that secure the internal computer to the sheet-metal chassis rear panel.
3. From the rear access port, reconnect the cables to the internal computer and the HV power supply.
4. At the internal computer access port at the rear of the instrument, reconnect the cables to the internal computer.
5. Replace the ADAQ board (section 9.29.2).
6. Replace the PDIO board (section 9.30.2).
7. Replace the lower-right cover (section 9.6.2).

## 9.32 HV Power Supply

For the following procedures, see figure 9-30.

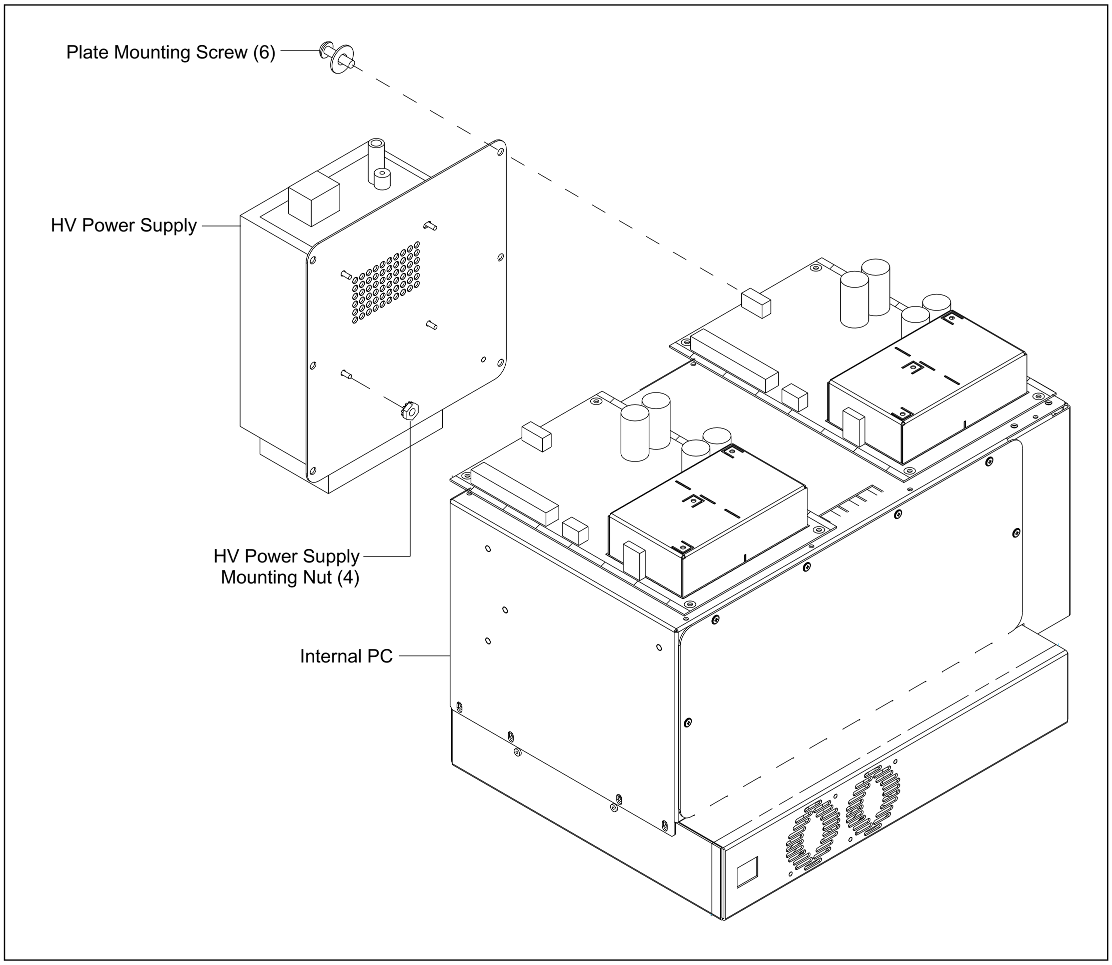



Figure 9-30. HV Power Supply Mounting.

### 9.32.1 Removal Procedure

1. Remove the internal computer (section 9.31.1).
2. Remove the six screws and washers that secure the HV power supply with its mounting plate to the side of the internal computer.
3. Remove the four hex nuts and washers that secure the mounting plate to the HV power supply.

### 9.32.2 Installation Procedure

1. Position the mounting plate on the HV power supply and install the four hex nuts and washers that secure the mounting plate to the HV power supply.
2. Position the HV power supply and install the six screws that secure the HV power supply to the side of the internal computer.
3. Install the internal computer (section 9.31.2).

## 9.33 Host SCSI Interface Board

For the following procedures, see figure 9-31.

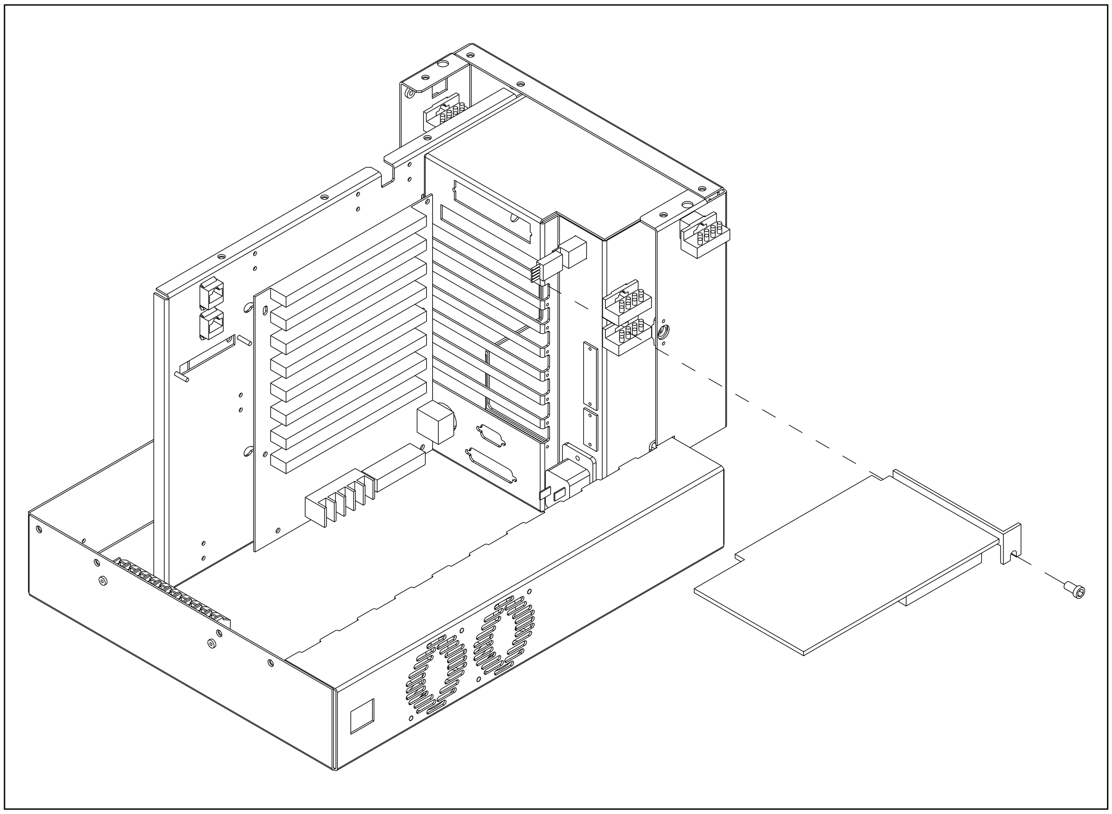


Figure 9-31. Host SCSI Interface Board Mounting.

### 9.33.1 Removal Procedure

1. At the internal computer access panel, remove the SCSI connector from the host SCSI interface board.
2. Remove the four screws that secure the right access port to the lower-right cover.
3. Loosen the six 1/4-turn studs that secure the front cover to the internal computer. Remove the front cover.
4. From inside the internal computer, disconnect the ribbon cable and the SCSI ID switch cable from the host SCSI interface board.
5. Remove the screw that secures the host SCSI interface board to the internal computer chassis.
6. Gently pull the host SCSI interface board from its slot on the passive motherboard.

### 9.33.2 Installation Procedure

1. Check the new SCSI interface and make sure that it is configured as shown in figure 9-32.
2. Position the host SCSI interface board over its slot on the passive motherboard, and firmly push down until the board is securely seated in the slot.

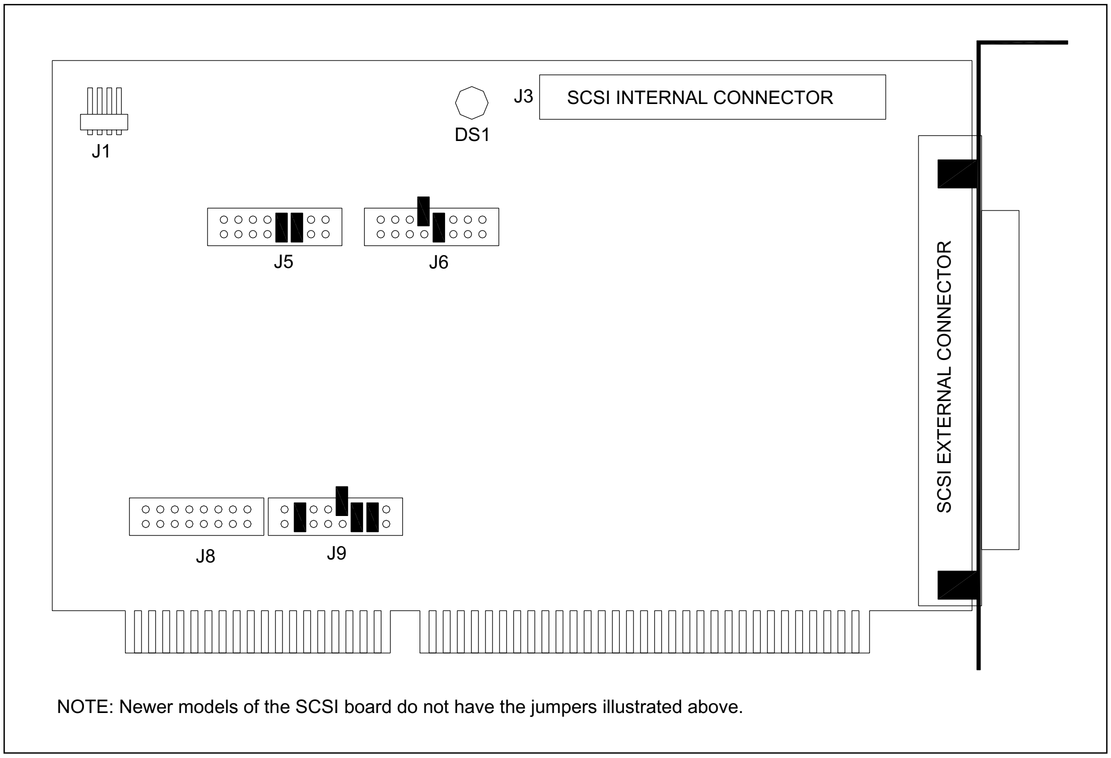



Figure 9-32.  SCSI Interface Board Jumper Configuration.

3. Install the screw that secures the host SCSI interface board to the internal computer chassis.
4. From inside the internal computer, reconnect the ribbon cable and the SCSI ID switch cable to the host SCSI interface board.
5. Position the front cover on the internal computer, and tighten the six 1/4-turn studs that secure the front cover to the internal computer.
6. Install the four screws that secure the right access port to the lower-right cover.

## 9.34 Analog Interface Board

For the following procedures, see figure 9-33. There are two analog interface boards that occupy two slots of the backplane motherboard. The two boards are identical except for the programming of the eight-segment address switch, S1. The address switches of the two boards are shown in figure 9-34.

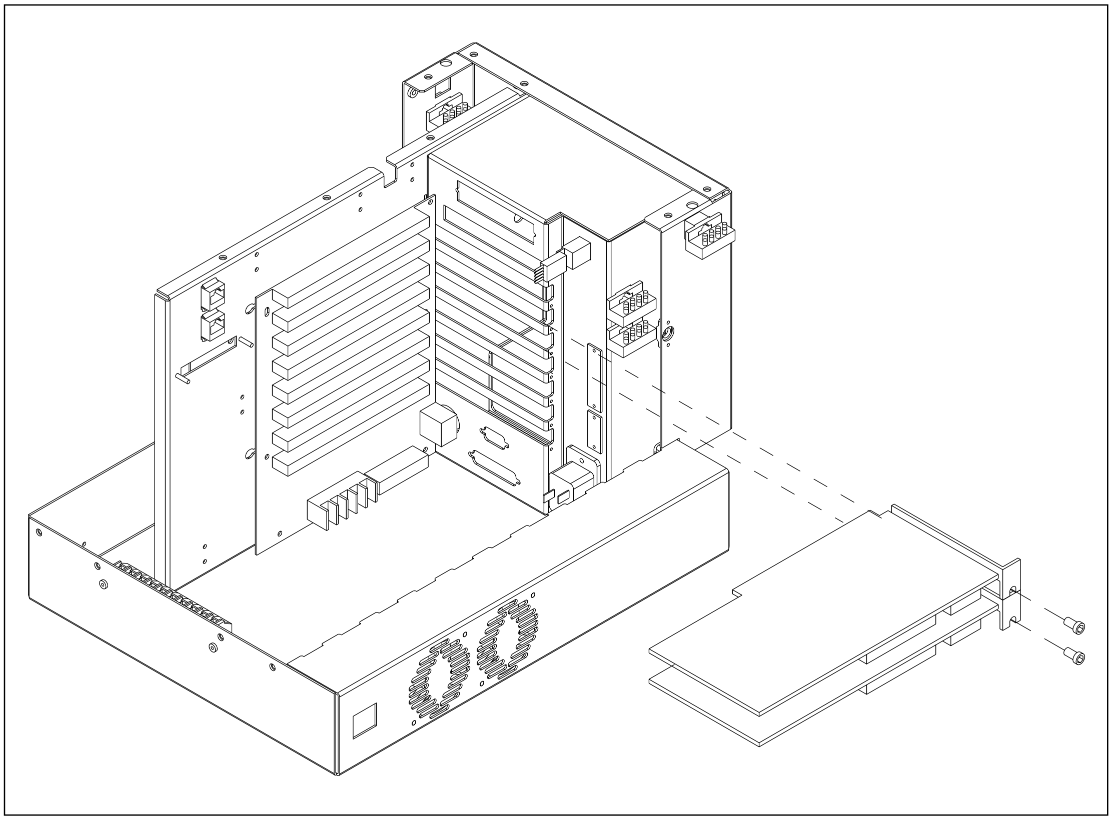


Figure 9-33. Analog Interface Board Mounting.

### 9.34.1 Removal Procedure

1. Remove the four screws that secure the right access port to the lower-right cover.
2. Loosen the six 1/4-turn studs that secure the front cover to the internal computer. Remove the front cover.
3. From inside the internal computer, disconnect the ribbon cable from the analog interface board.
4. Remove the screw that secures the analog interface board to the internal computer chassis.
5. Gently pull the analog interface board from its slot on the passive motherboard.

### 9.34.2 Installation Procedure

1. Program the I/O address switch on the analog interface board as shown in figure 9-34.

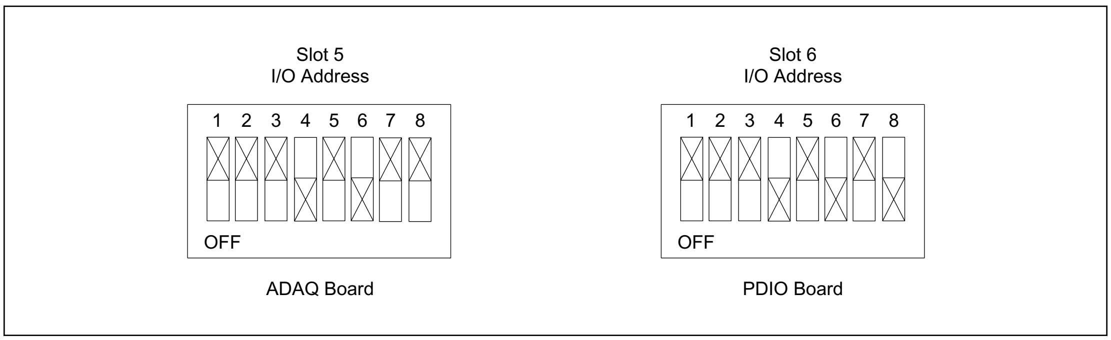



Figure 9-34. Analog Interface Board Address Programming.

2. Position the analog interface board over its slot on the passive motherboard and firmly push down until the board is securely seated in the slot.
3. Install the screw that secures the analog interface board to the internal computer chassis.
4. From inside the internal computer, reconnect the ribbon cable to the analog interface board.
5. Position the front cover on the internal computer and tighten the six 1/4-turn studs that secure the front cover to the internal computer.
6. Install the four screws that secure the right access port to the lower-right cover.

## 9.35 Echelon Network Interface Board

For the following procedures, see figure 9-35.

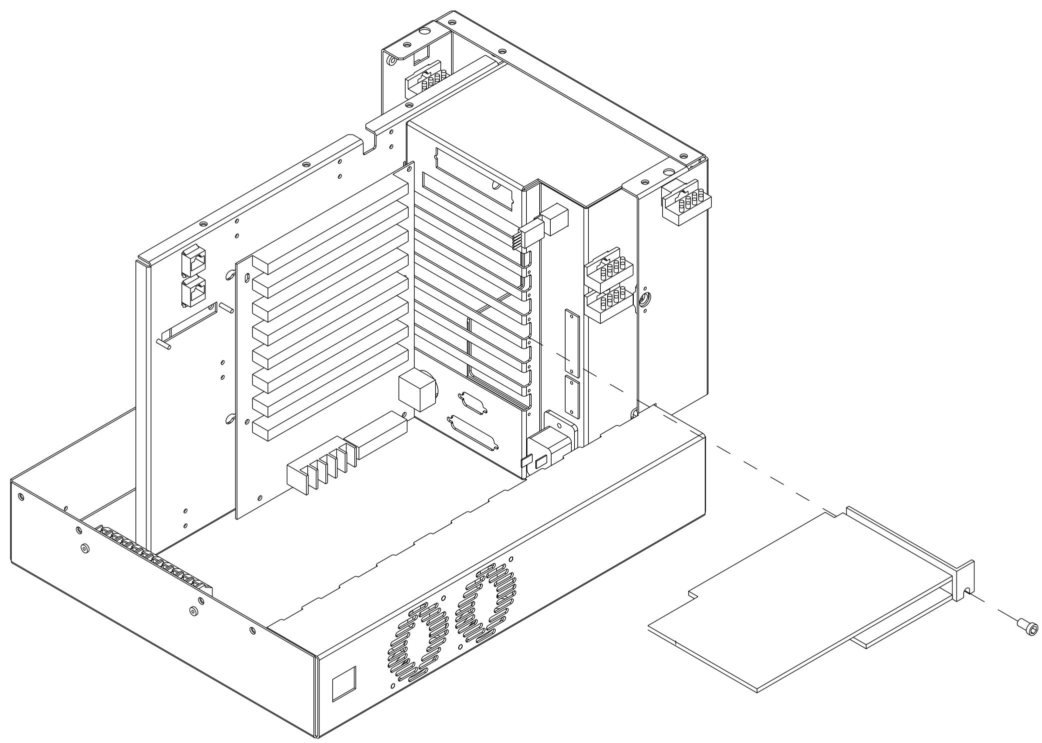


Figure 9-35. Echelon Network Interface Board Mounting.

### 9.35.1 Removal Procedure

1. At the internal computer access panel, remove the connectors from the Echelon network interface board.
2. Remove the four screws that secure the right access port to the lower-right cover.
3. Loosen the six 1/4-turn studs that secure the front cover to the internal computer. Remove the front cover.
4. Remove the screw that secures the Echelon network interface board to the internal computer chassis.
5. Gently pull the Echelon network interface board from its slot on the passive motherboard.

### 9.35.2 Installation Procedure

1. Position the Echelon network interface board over its slot on the passive motherboard and firmly push in until the board is securely seated in the slot.
2. Install the screw that secures the host Echelon network interface board to the internal computer chassis.
3. Position the front cover on the internal computer, and tighten the six 1/4-turn studs that secure the front cover to the internal computer.
4. Install the four screws that secure the right access port to the lower-right cover.

## 9.36 CPU Board

For the following procedures, see figure 9-36.

*NOTE* **The CPU is in the bottom slot of the backplane motherboard and is below the edge of the chassis.**

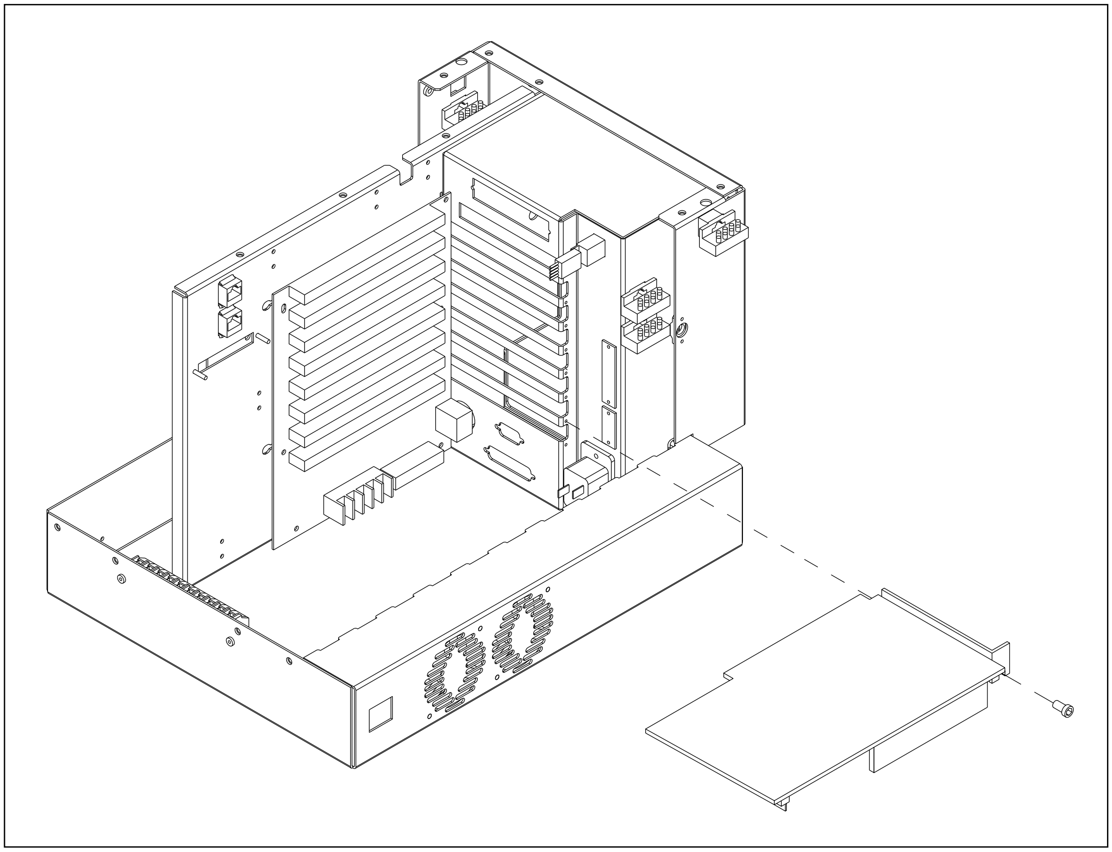


Figure 9-36. CPU Board Mounting.

### 9.36.1 Removal Procedure

1. Remove the four screws that secure the right access port to the lower-right cover.
2. Loosen the six 1/4-turn studs that secure the front cover to the internal computer. Remove the front cover.
3. Remove the screw that secures the CPU board to the internal computer chassis.
4. Gently pull the CPU board from its slot on the passive motherboard.

### 9.36.2 Installation Procedure

1. Position the CPU board over its slot on the passive motherboard, and firmly push down until the board is securely seated in the slot.
2. Install the screw that secures the CPU board to the internal computer chassis.
3. Position the front cover on the internal computer, and tighten the six 1/4-turn studs that secure the front cover to the internal computer.
4. Install the four screws that secure the right access port to the lower-right cover.

## 9.37 Backplane Motherboard Board

For the following procedures, see figure 9-37.

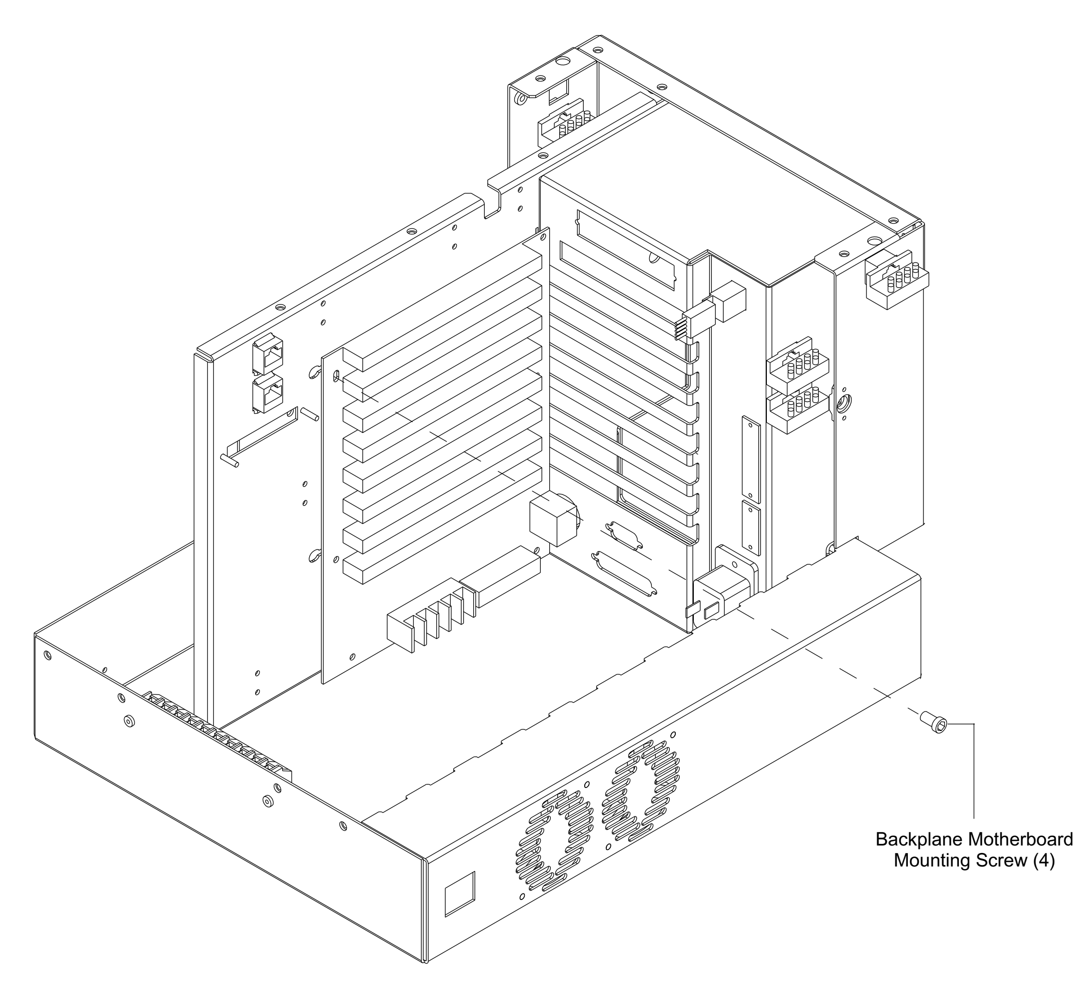



Figure 9-37. Backplane Motherboard Mounting.

### 9.37.1 Removal Procedure

1. Remove the internal computer (section 9.31.1).
2. Remove the six screws that secure the HV power supply with its mounting plate to the side of the internal computer.
3. Loosen the six 1/4-turn studs that secure the front cover to the internal computer. Remove the front cover.
4. Loosen the 12 screws that secure the top cover to the internal computer.
5. Disconnect the ribbon cables from the host SCSI interface board and the analog interface board.
6. Remove the screws that secure the host SCSI interface board, CPU board, analog interface boards, and Echelon network interface board to the internal computer chassis and remove the boards.
7. Remove the four screws that secure the backplane motherboard to the internal computer chassis.

### 9.37.2 Installation Procedure

1. Position the backplane motherboard and install the four screws that secure the backplane motherboard to the internal computer chassis.
2. Install the host SCSI interface board, CPU board, analog interface boards, and Echelon network interface board into their respective slots on the backplane motherboard board. Install the screws that secure the boards to the internal computer chassis.
3. Reconnect the ribbon cables to the host SCSI interface board and the analog interface board.
4. Install the top cover and tighten the 12 screws that secure the top cover to the internal computer.
5. Position the front cover on the internal computer and tighten the six 1/4-turn studs that secure the front cover to the internal computer.
6. Position the HV power supply and install the six screws that secure the HV power supply to the side of the internal computer.
7. Install the internal computer (section 9.31.2).

# 9.38 EPHV Board

For the following procedures, see figure 9-38.

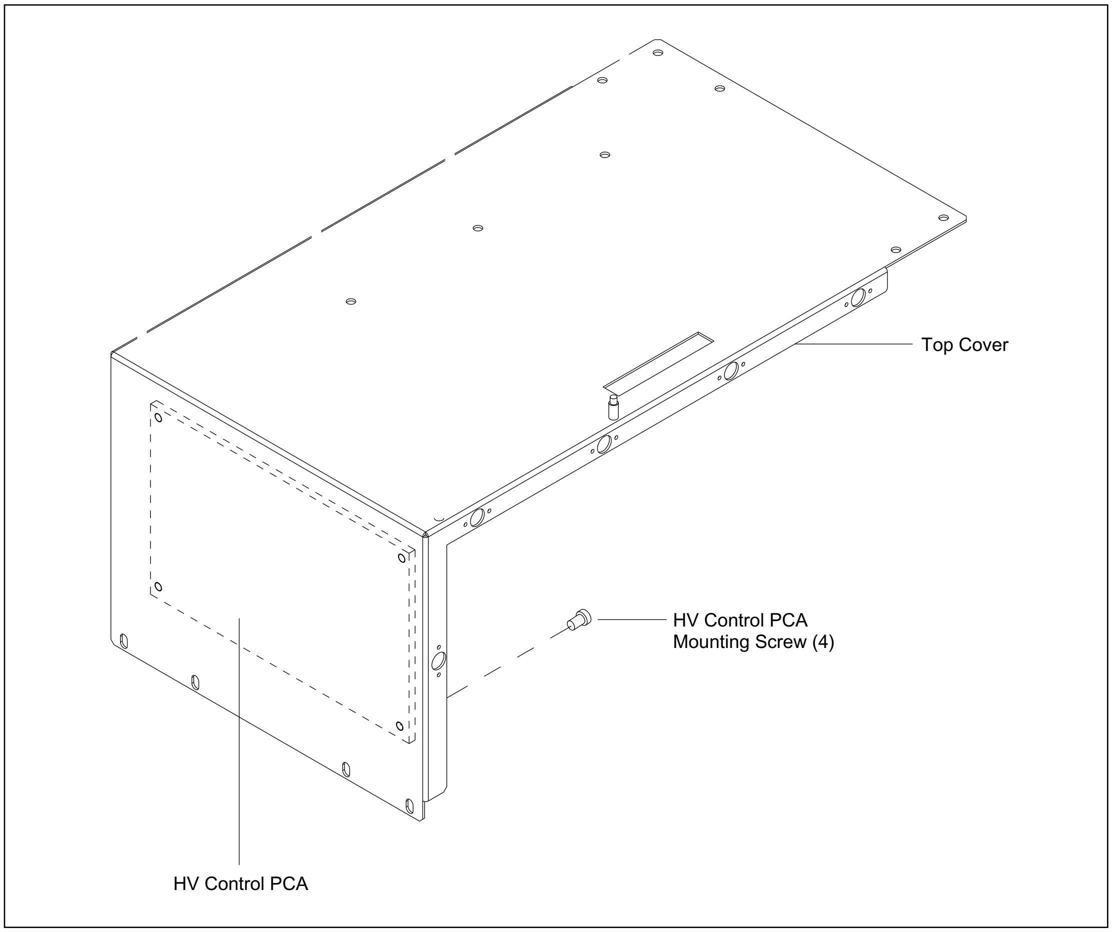



Figure 9-38. EPHV Board Mounting.

### 9.38.1 Removal Procedure

1. Remove the internal computer (section 9.31.1).
2. Remove the six screws that secure the HV power supply with its mounting plate to the side of the internal computer.
3. Loosen the six 1/4-turn studs that secure the front cover to the internal computer. Remove the front cover.
4. Loosen the 12 screws that secure the top cover to the internal computer.
5. Lift the top cover enough to gain access to the cables connected to the EPHV board. Disconnect all the cables from the EPHV board.
6. Remove the four screws that secure the EPHV board to the top cover of the internal computer.

### 9.38.2 Installation Procedure

1. Place the EPHV board in position and install the four screws that secure the EPHV board to the top cover of the internal computer.
2. Install the top cover and tighten the 12 screws that secure the top cover to the internal computer.
3. Position the front cover on the internal computer and tighten the six 1/4-turn studs that secure the front cover to the internal computer.
4. Position the HV power supply and install the six screws that secure the HV power supply to the side of the internal computer.
5. Install the internal computer (section 9.31.2).

## 9.39 BEAM Board

For the following procedures, see figure 9-39.

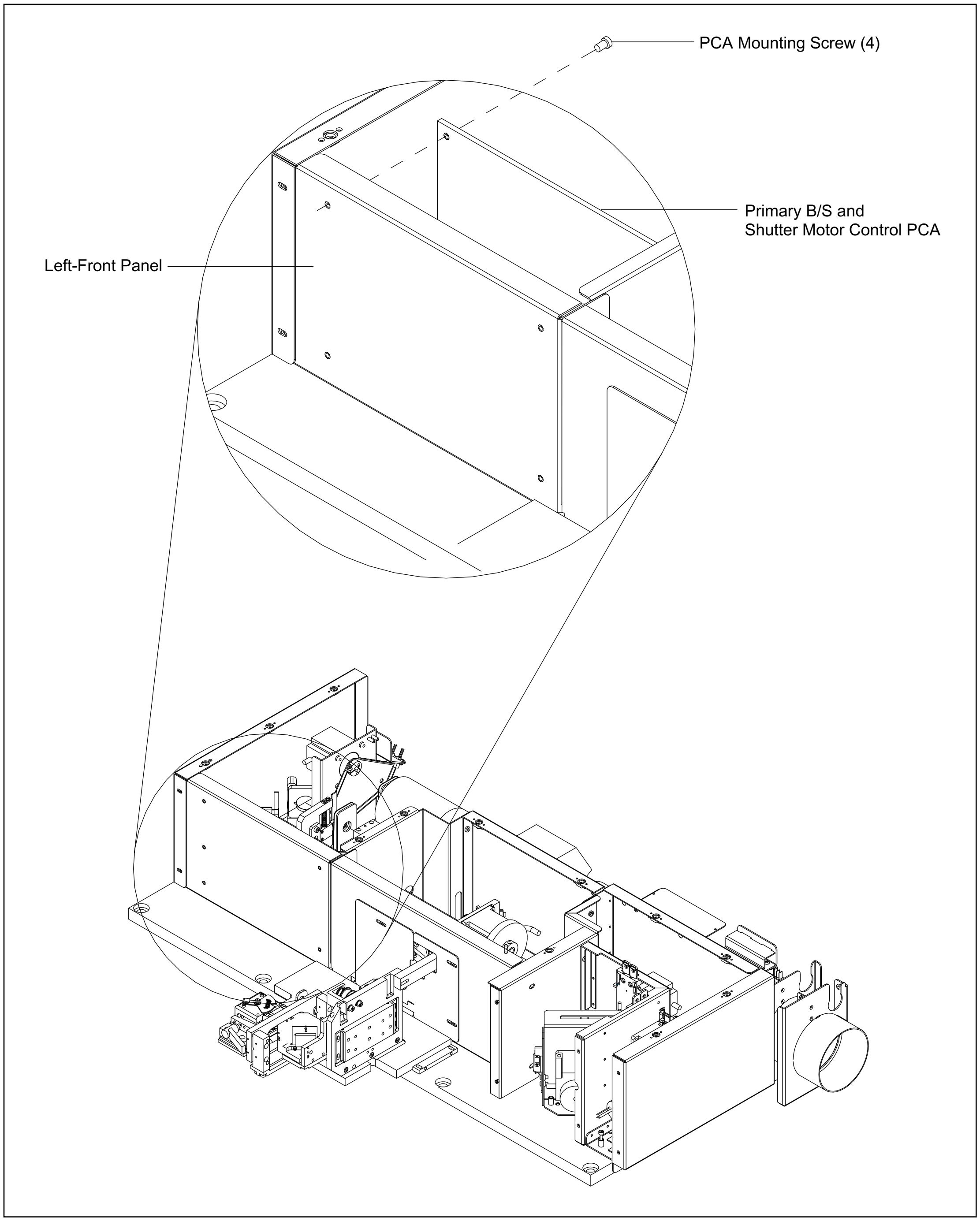



Figure 9-39. BEAM Board Mounting.

### 9.39.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the cables from the BEAM board.
4. Remove the four screws that secure the BEAM board to the left-front panel.

### 9.39.2 Installation Procedure

1. Hold the BEAM board in place, and install the four screws that secure the board to the left-front panel.
2. Reconnect the cables to the BEAM board.
3. Place the optics enclosure top cover in position, and tighten the eight 1/4-turn studs.
4. Install the left panel assembly (section 9.4.2).

## 9.40 SCAN Board

For the following procedures, see figure 9-40.

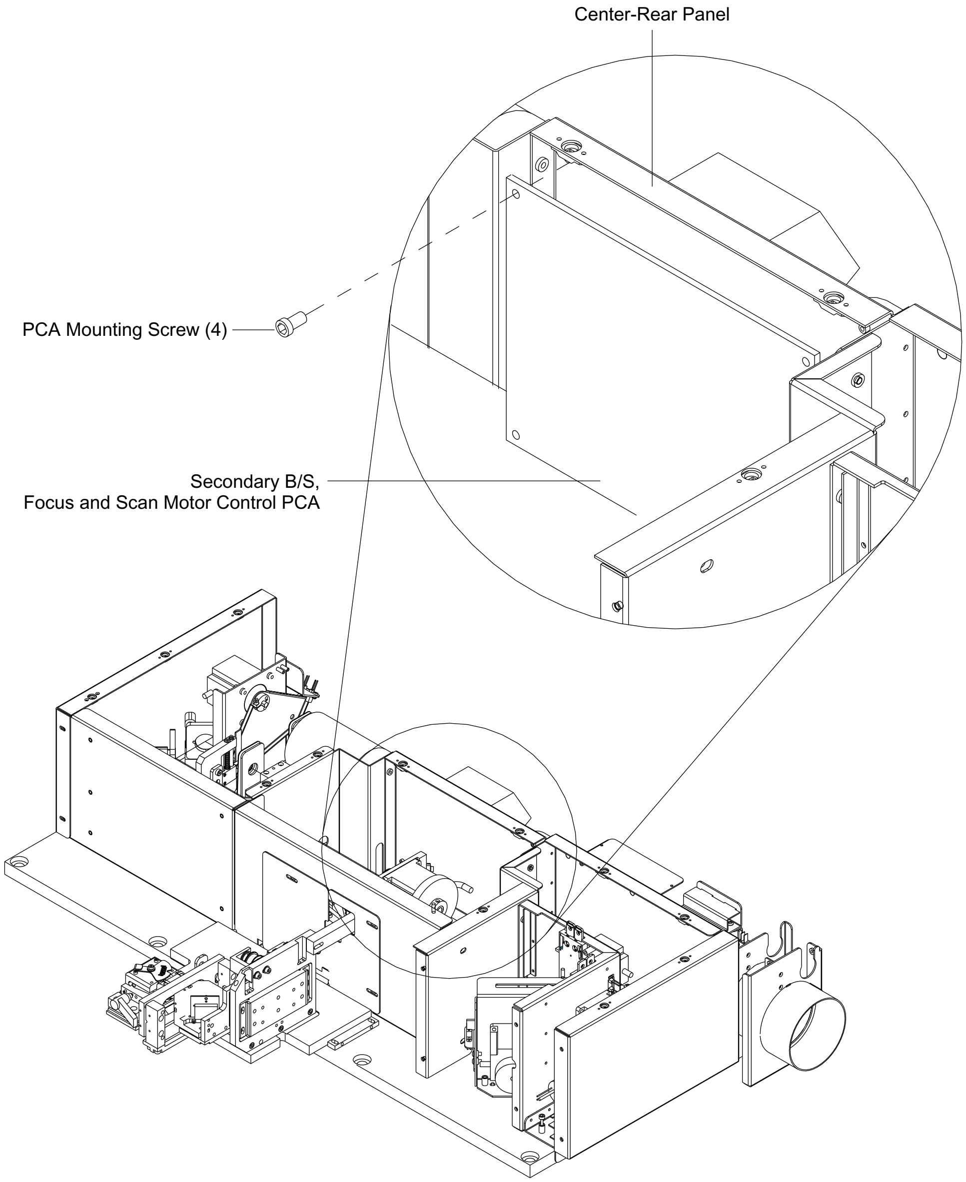



Figure 9-40. SCAN Board Mounting.

### 9.40.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the cables from the SCAN board.
4. Remove the four screws that secure the SCAN board to the center-rear panel.

### 9.40.2 Installation Procedure

1. Hold the SCAN board in place, and install the four screws that secure the board to the center-rear panel.
2. Reconnect the cables to the SCAN board.
3. Place the optics enclosure top cover in position, and tighten the eight 1/4-turn studs.
4. Install the left panel assembly (section 9.4.2).

## 9.41 Scan Motor Driver

For the following procedures, see figure 9-41.

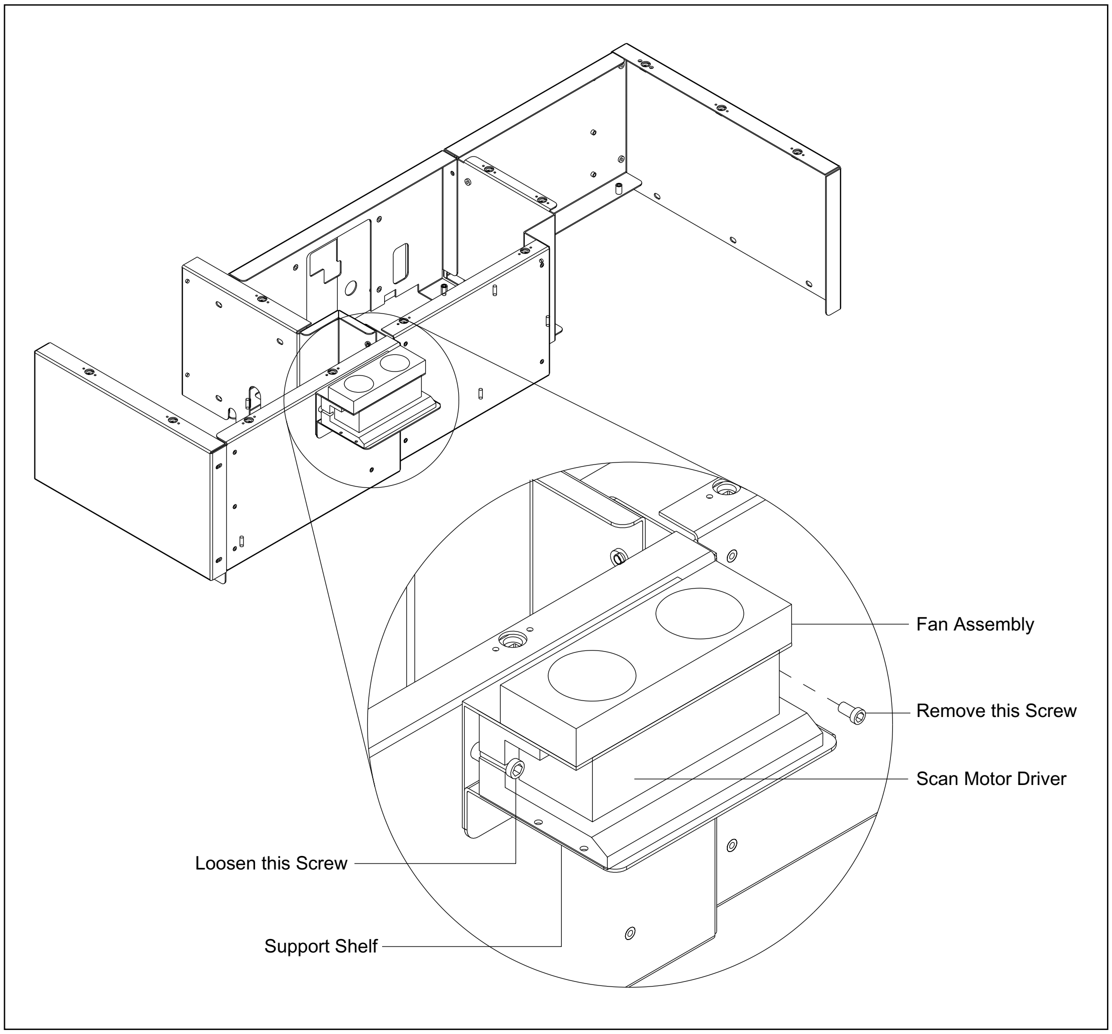



Figure 9-41. Scan Motor Driver Mounting.

### 9.41.1 Removal Procedure

1. Remove the top cover (section 9.2.1).
2. Remove the filter cover assembly (section 9.5.1).
3. Remove the midcover support (section 9.7.1).
4. There are two screws that secure the scan motor driver to the right-rear panel of the optics enclosure assembly. Loosen the right screw and remove the left screw.
5. Slide the scan motor driver from between the fan assembly and the support shelf.
6. Tag and disconnect the wires from the scan motor driver terminal strip.

### 9.41.2 Installation Procedure

1. Reconnect the wires to the scan motor driver terminal strip.
2. Position the scan motor driver on its support bracket and install the two screws that secure the scan motor driver to the right-rear panel of the optics enclosure assembly.
3. Install the midcover support (section 9.7.2).
4. Install the filter cover assembly (section 9.5.2).
5. Install the top cover (section 9.2.2).

## 9.42 FLTR Board

For the following procedures, see figure 9-42.

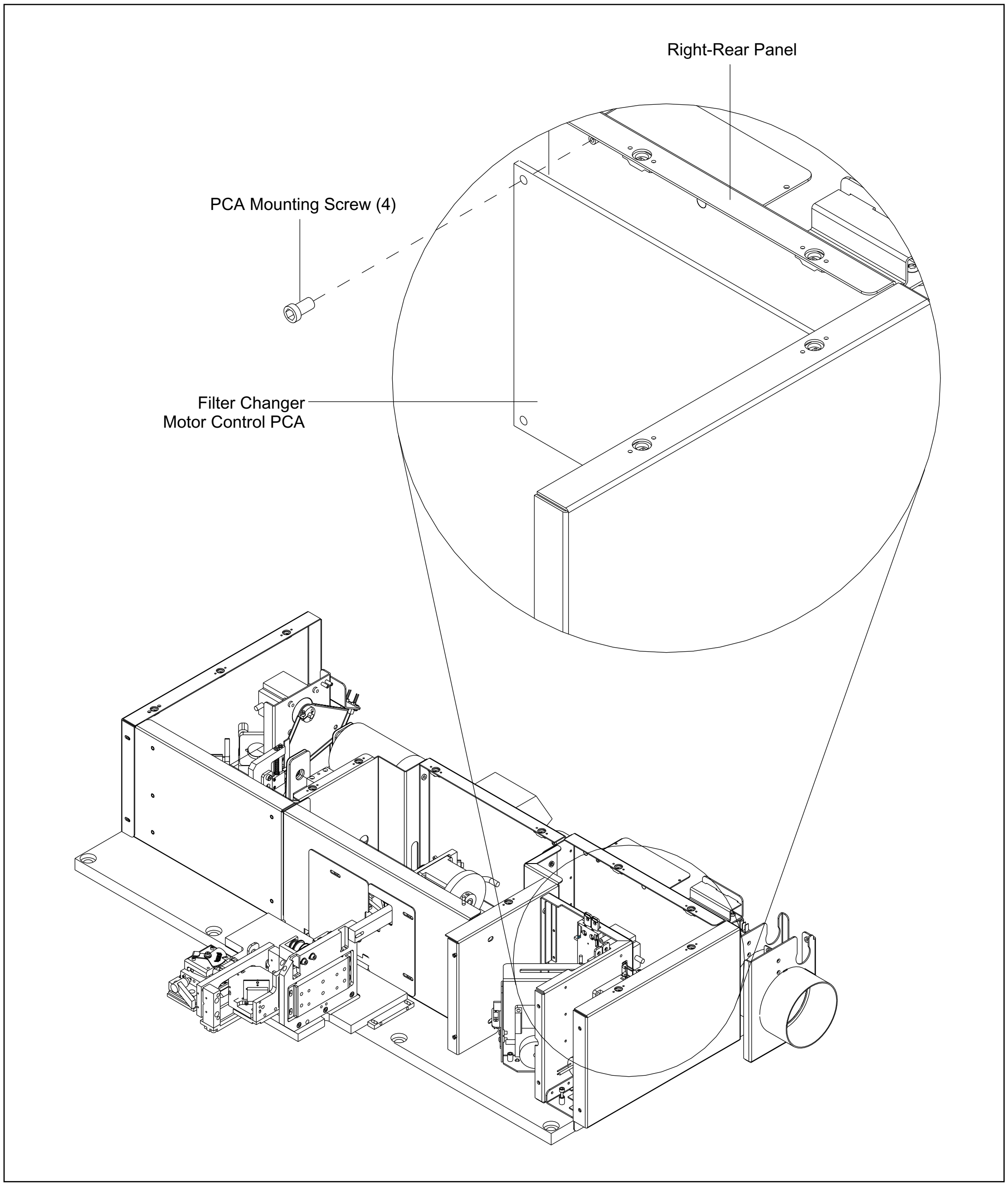



Figure 9-42. FLTR Board Mounting.

### 9.42.1 Removal Procedure

1. Remove the filter cover assembly (section 9.5.1).
2. Loosen the four 1/4-turn studs on the top of the filter changer cover, remove the four screws and washers from the front of the filter changer cover, and remove the cover.
3. Disconnect the cables from the FLTR board.
4. Remove the four screws that secure the FLTR board to the right-rear panel.

### 9.42.2 Installation Procedure

1. Hold the FLTR board in place and install the four screws that secure the board to the right-rear panel.
2. Reconnect the cables to the FLTR board.
3. Place the filter changer cover in position and tighten the four 1/4-turn studs on the top of the filter changer cover.
4. Install the four screws and washers on the front of the filter changer cover.
5. Install the filter cover assembly (section 9.5.2).

## 9.43 Blue Laser

For the following procedures, see figure 9-43.

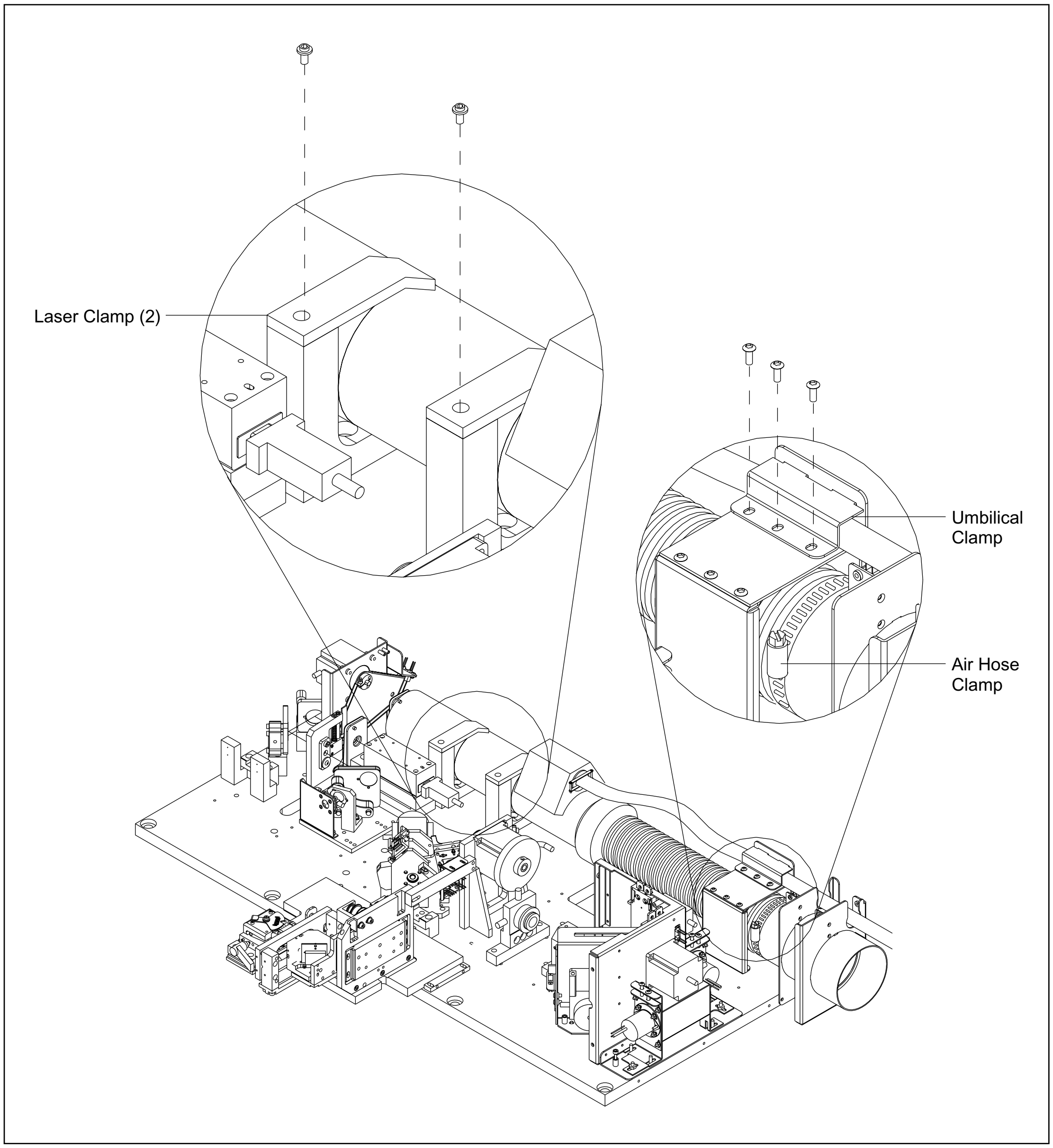



Figure 9-43. Blue Laser Mounting.

### 9.43.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Remove the midcover support (section 9.7.1).
3. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
4. Remove the three screws that secure the umbilical clamp.
5. Remove the two screws that secure the two laser clamps.
6. Loosen the air hose clamp and slide the air hose off the air hose bracket.
7. Disconnect the umbilical from the laser power supply unit.

### 9.43.2 Installation Procedure

1. Position the laser assembly in the cradle, and install the two screws that secure the two laser clamps.
2. Place the umbilical in position, and install the three screws that secure the umbilical clamp.
3. Perform the blue laser alignment procedure (section 8.4).
4. Place the optics enclosure top cover in position, and tighten the eight 1/4-turn studs on the optics enclosure top cover.
5. Install the midcover support (section 9.7.2).
6. Install the left panel assembly (section 9.4.2).

## 9.44 Green Laser and Power Supply

The green laser and its power supply are mounted together and are removed and/or installed as a unit. The green laser is mounted to the top of the optics plate, and the power supply is mounted to the underside of the optics plate. The cable connecting the green laser to the power supply is routed through a hole in the optics plate. A heat sink attached to the top of the green laser must be removed before the green laser can be passed through the hole.

For the following procedures, see figure 9-44.

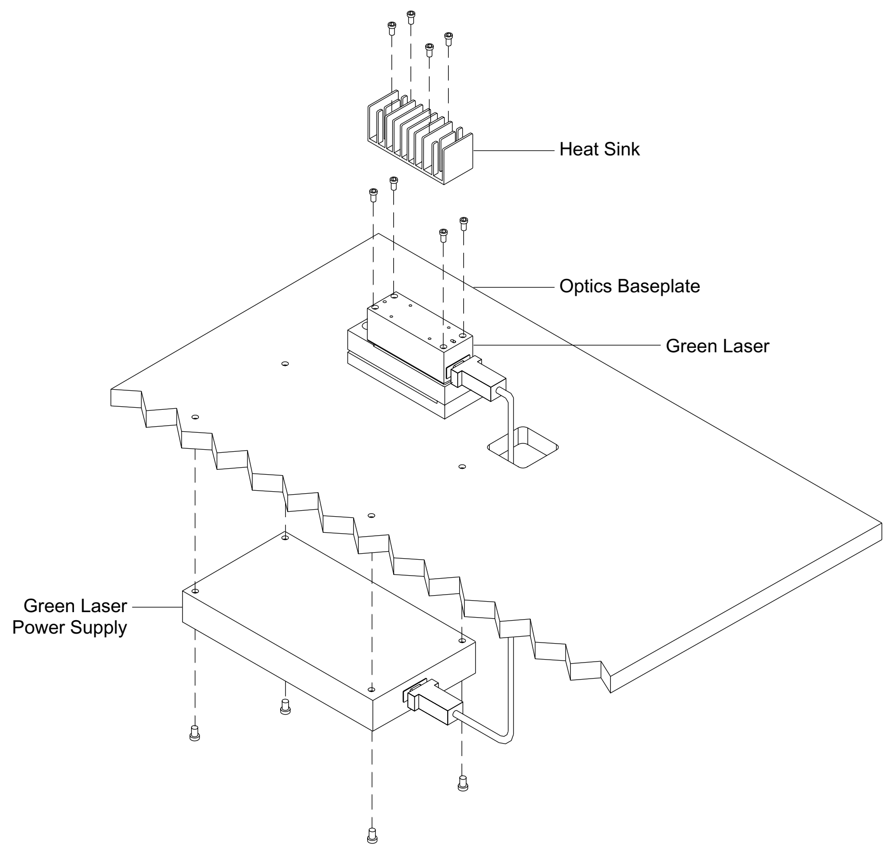



Figure 9-44. Green Laser and Power Supply Mounting.

### 9.44.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Remove the three screws that secure the left side panel to the optics baseplate.
4. Remove the two screws that secure the left side panel to the left front panel of the optics enclosure.
5. Remove the screw that secures the left partition to the center rear panel of the optics enclosure.

6. Loosen the captive screws that secure the left front panel and the left partition to the optics baseplate. Remove the left front panel and left partition.
7. Disconnect the cables from the motor control driver mounted to the center rear panel.
8. Remove the four screws that secure the heat sink to the top of the green laser.
9. Remove the four screws that secure the green laser to its mounting block.

*CAUTION* **To prevent static electric discharge damage to the green laser, *do not* disconnect the laser from its controller. The green laser is very susceptible to static electricity.**

10. Carefully move the green laser down through the square hole in the optics baseplate.
11. Disconnect the control cable attached to the left side of the green laser power supply.
12. Remove the four screws that secure the green laser power supply to the underside of the optics baseplate.
13. Remove the green laser and its power supply.

### 9.44.2 Installation Procedure

*CAUTION* **To prevent static electric discharge damage to the green laser, *do not* disconnect the laser from its controller. The green laser is very susceptible to static electricity.**

1. Wipe the optics baseplate and mounting block with a lint-free tissue to remove dust.
2. Position the green laser power supply against the underside of the optics baseplate and install the four screws that secure the green laser power supply to the optics baseplate. (Remove the plastic feet.)
3. Reconnect the control cable to the left side of the green laser power supply.
4. Feed the green laser up through the square hole in the optics baseplate and position it on its mounting block.
5. Install the four screws that secure the green laser to its mounting block. Torque the four screws to 1/5 ft.-lb. (= 40 ounce-in).
6. Wipe the top of the green laser and the bottom of the heat sink with lint-free tissue to remove dust.
7. Install the four screws that secure the heat sink to the top of the green laser. Torque the four screws to 4 ounce-in or less.
8. Reconnect the cables to the motor control driver mounted to the center rear panel.
9. Place the left front panel and left partition in place on the optics baseplate and tighten the captive screws.
10. Install the screw that secures the left partition to the center rear panel of the optics enclosure.
11. Place the left side panel in place, and install the two screws that secure the left side panel to the left front panel of the optics enclosure.
12. Install the three screws that secure the left side panel to the optics baseplate.
13. Place the optics enclosure top cover in position and tighten the eight 1/4-turn studs.
14. Install the left panel assembly (section 9.4.2).

## 9.45 Shutter Assembly

For the following procedures, see figure 9-45.

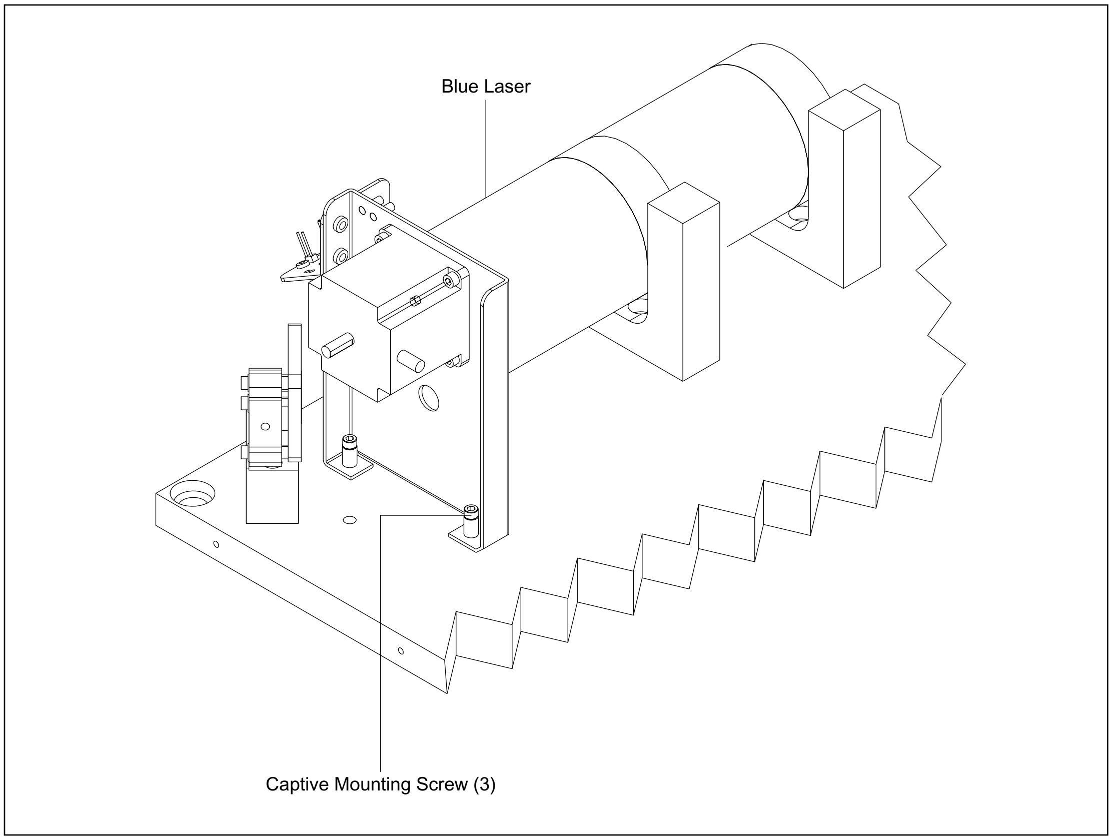



Figure 9-45. Shutter Assembly Mounting.

### 9.45.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the motor cable and sensor cable from the BEAM board.
4. Loosen the three captive screws that secure the three-position shutter assembly to the optics baseplate.

### 9.45.2 Installation Procedure

1. Place the three-position shutter assembly in position, and tighten the three captive screws that secure the assembly to the optics baseplate.
2. Reconnect the motor cable and sensor cable to the BEAM board.
3. Check and align the shutter as needed.
4. Place the optics enclosure top cover in position, and tighten the eight 1/4-turn studs.
5. Install the left panel assembly (section 9.4.2).

## 9.46 Shutter Drive Motor

For the following procedures, see figure 9-46.

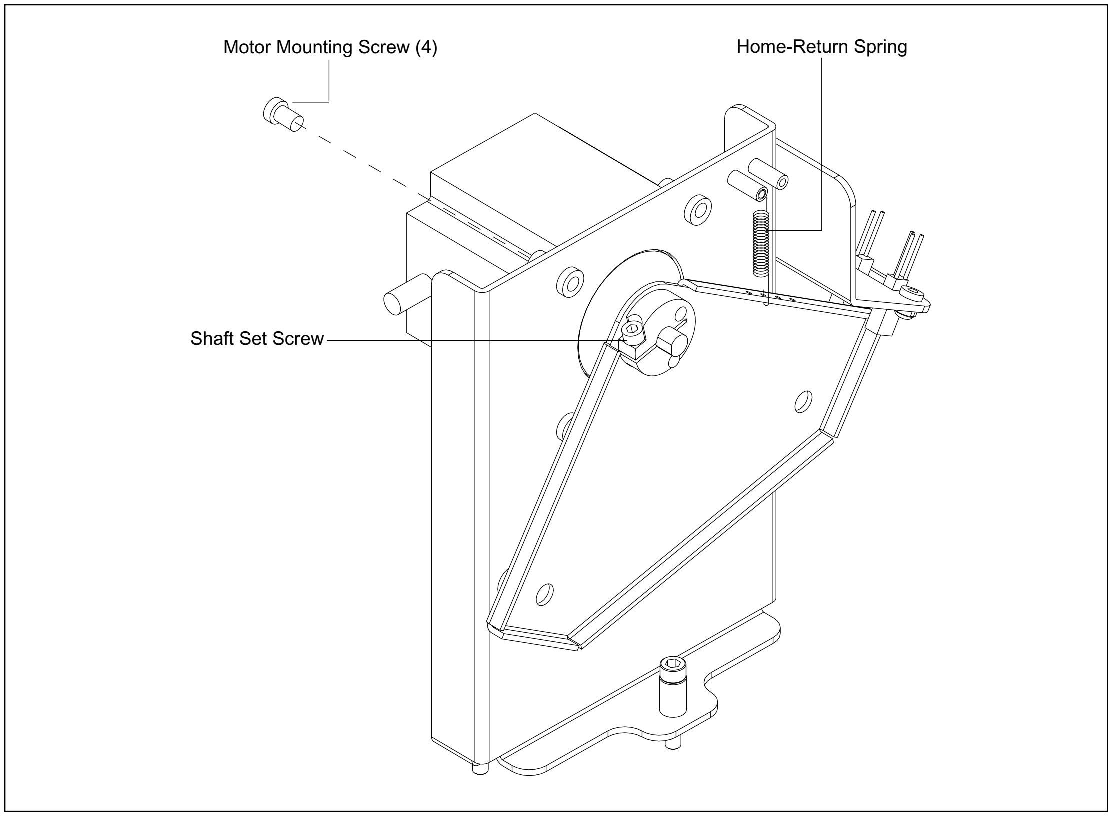



Figure 9-46. Shutter Drive Motor Mounting.

### 9.46.1 Removal Procedure

1. Remove the shutter (section 9.45.1).
2. Disconnect the home-return spring from the shutter.
3. Loosen the setscrew that secures the shutter to the motor shaft and remove the shutter from the shaft.
4. Remove the four screws that secure the shutter motor to the shutter assembly.

### 9.46.2 Installation Procedure

1. Install the four screws that secure the shutter motor to the shutter assembly.
2. Install the shutter onto the motor shaft and tighten the setscrew that secures the shutter to the motor shaft.
3. Reconnect the home-return spring from the shutter.
4. Install the shutter (section 9.45.2).

## 9.47 Shutter Home Sensor

For the following procedures, see figure 9-47.

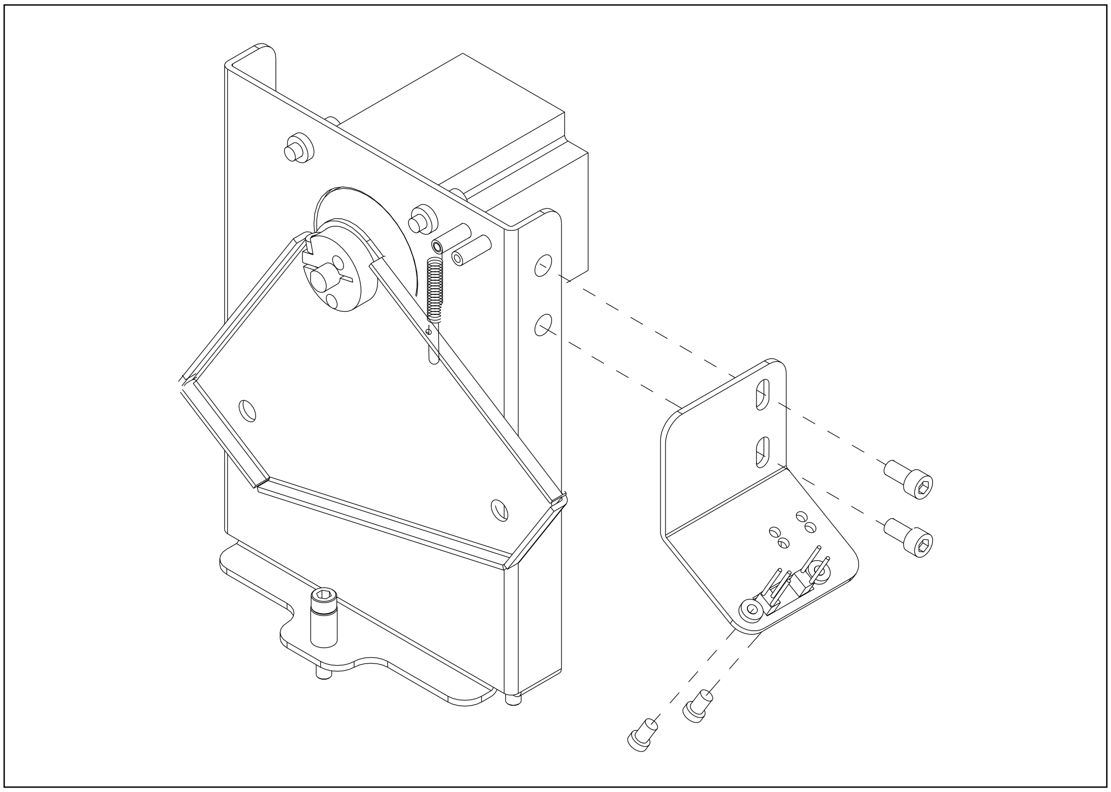


Figure 9-47. Shutter Home Sensor Mounting.

### 9.47.1 Removal Procedure

1. Remove the shutter (section 9.45.1).
2. Remove the two screws that secure the home sensor mounting bracket to the shutter assembly.
3. Remove the two screws that secure the home sensor to the home sensor mounting bracket.

### 9.47.2 Installation Procedure

1. Install the two screws that secure the home sensor to the home sensor mounting bracket.
2. Install the two screws that secure the home sensor mounting bracket to the shutter assembly.
3. Install the shutter (section 9.45.2).
4. Check and align the shutter home sensor.

## 9.48 Primary Beamsplitter Changer Assembly

For the following procedures, see figure 9-48.

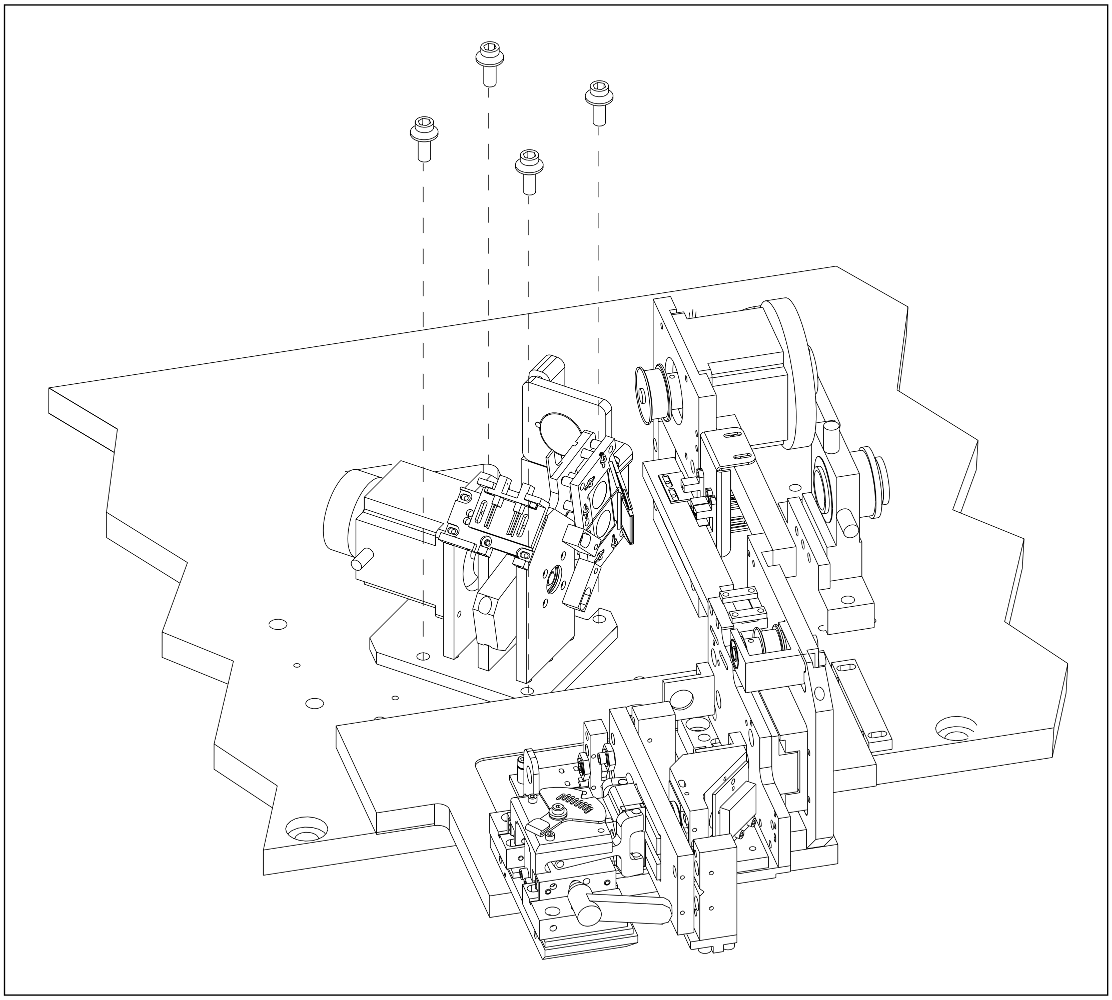


Figure 9-48. Primary Beamsplitter Changer Mounting.

### 9.48.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the motor cable and sensor cable from the BEAM board.
4. Remove the four screws and washers that secure the primary beamsplitter changer assembly to the optics baseplate.

### 9.48.2 Installation Procedure

1. Place the primary beamsplitter changer assembly in position, and install the four screws that secure the assembly to the optics baseplate.
2. Reconnect the motor cable and sensor cable to the BEAM board.
3. Realign the primary beamsplitter as needed (section 8.4.10).
4. Place the optics enclosure top cover in position, and tighten the eight 1/4-turn studs.
5. Install the left panel assembly (section 9.4.2).

## 9.49 Primary Beamsplitter Changer Drive Motor

For the following procedures, see figure 9-49. The shaft of the drive motor is coupled to the beamsplitter-arm shaft.

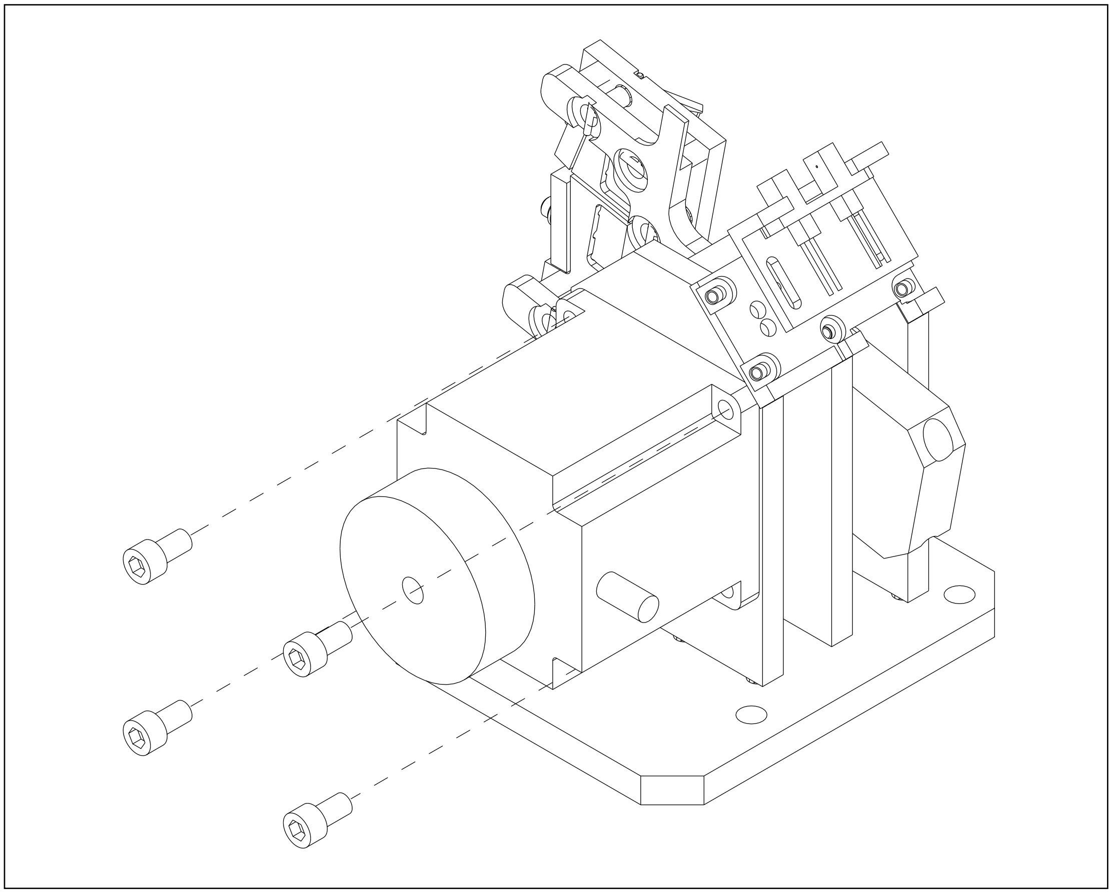


Figure 9-49. Primary Beamsplitter Changer Drive Motor Mounting.

### 9.49.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the motor cable from the BEAM board.
4. Loosen the screw on the coupler between the drive motor shaft and the beamsplitter arm shaft.
5. Remove the four screws that secure the drive motor to the primary beamsplitter changer assembly.
6. Remove the drive motor.

### 9.49.2 Installation Procedure

1. Place the primary beamsplitter changer drive motor in position, and install the four screws that secure the drive motor to the primary beamsplitter changer assembly.
2. Reconnect the motor cable home to the BEAM board.
3. Place the optics enclosure top cover in position, and tighten the eight 1/4-turn studs.
4. Install the left panel assembly (section 9.4.2).

## 9.50 Primary Beamsplitter Changer Home Sensor

For the following procedures, see figure 9-50.

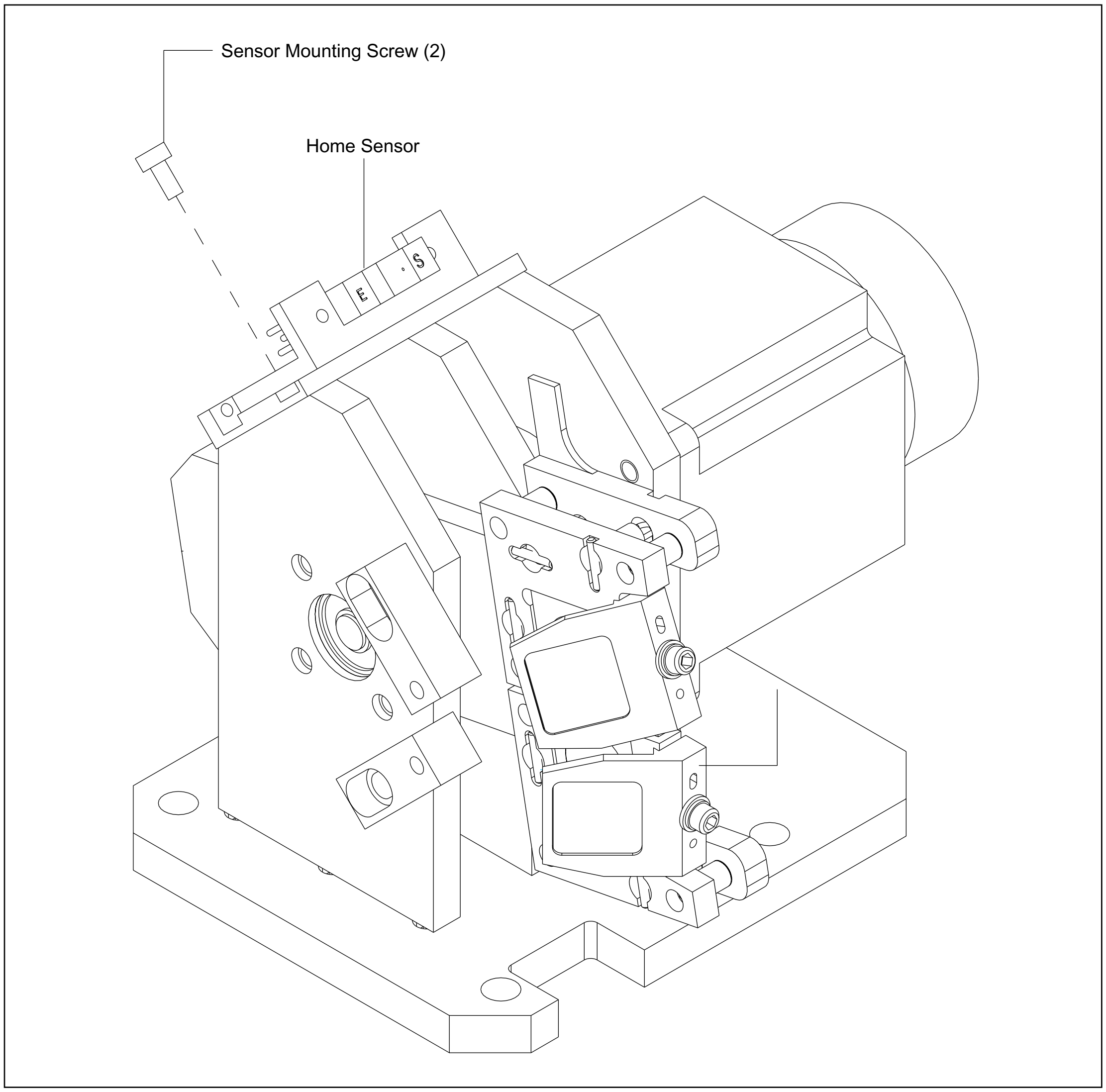



Figure 9-50. Primary Beamsplitter Changer Home Sensor Mounting.

### 9.50.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the home sensor cable from the BEAM board.
4. Remove the two screws that secure the home sensor to the primary beamsplitter changer assembly.

### 9.50.2 Installation Procedure

1. Place the home sensor in position and install the two screws that secure the home sensor to the primary beamsplitter changer assembly.
2. Reconnect the home sensor cable to the BEAM board.
3. Place the optics enclosure top cover in position and tighten the eight 1/4-turn studs.
4. Install the left panel assembly (section 9.4.2).

## 9.51 Scanning Stage Assembly

For the following procedures, see figure 9-51.

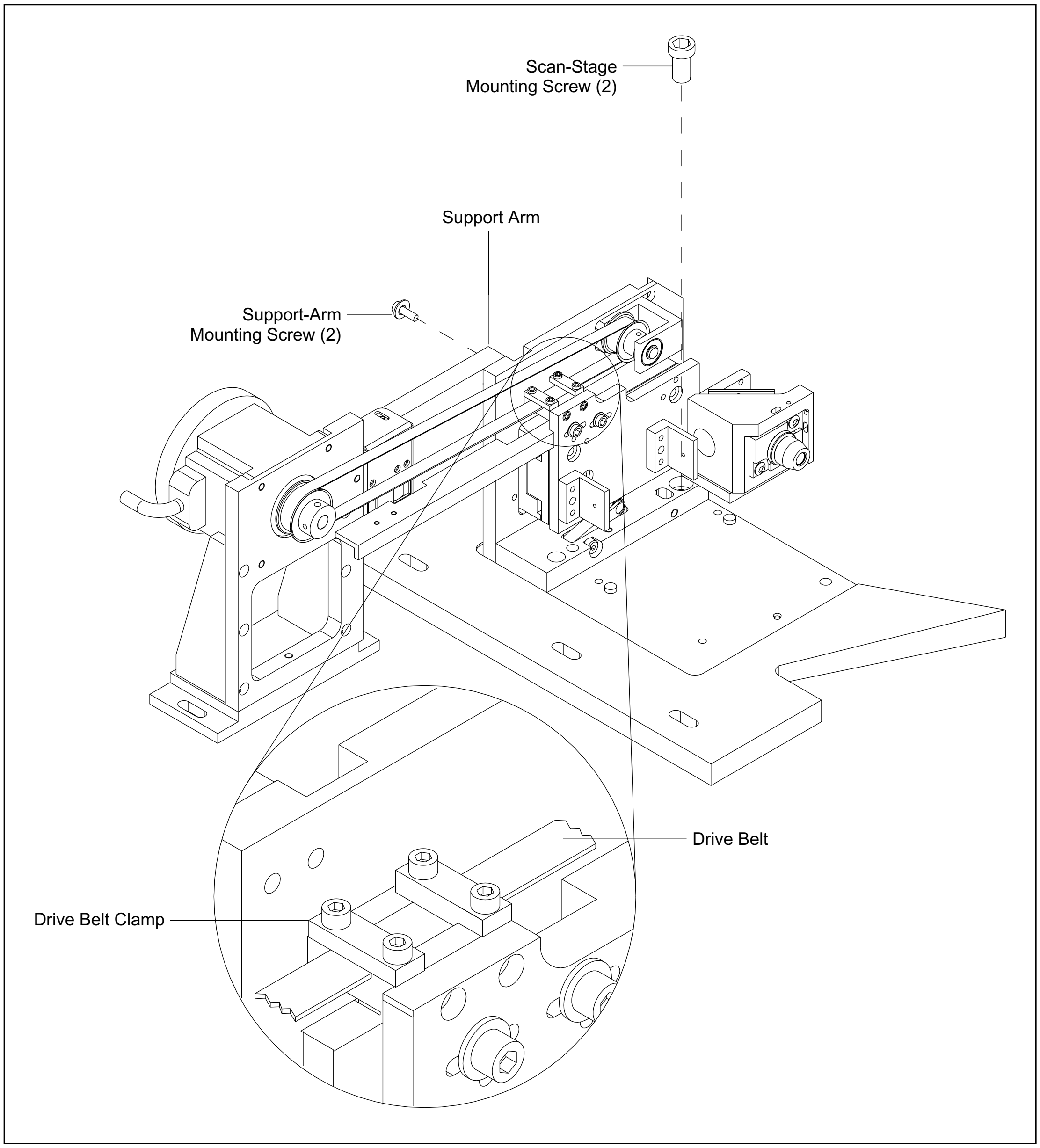



Figure 9-51. Scanning Stage Assembly Mounting.

### 9.51.1 Removal Procedure

1. Remove the focus assembly (section 9.55.1).
2. Loosen the four screws that secure the drive-belt clamp to the scanning stage assembly.
3. Remove the drive belt from the drive motor pulley.
4. Remove the two screws that secure the support arm to the scanning stage assembly.
5. Remove the two screws that secure the scanning stage assembly to the insulated mounting plate.

### 9.51.2 Installation Procedure

1. Place the scanning stage assembly in position on the insulated mounting plate, and install the two screws that secure the scanning stage assembly to the insulated mounting plate.
2. Install the two screws that secure the support arm to the scanning stage assembly.
3. Loop the drive belt over the drive motor pulley, tension the drive belt, and tighten the four screws that secure the drive belt to the drive-belt clamp.
4. Install the focus assembly (section 9.55.2).

## 9.52 Scan Head Drive Motor

For the following procedures, see figure 9-52.

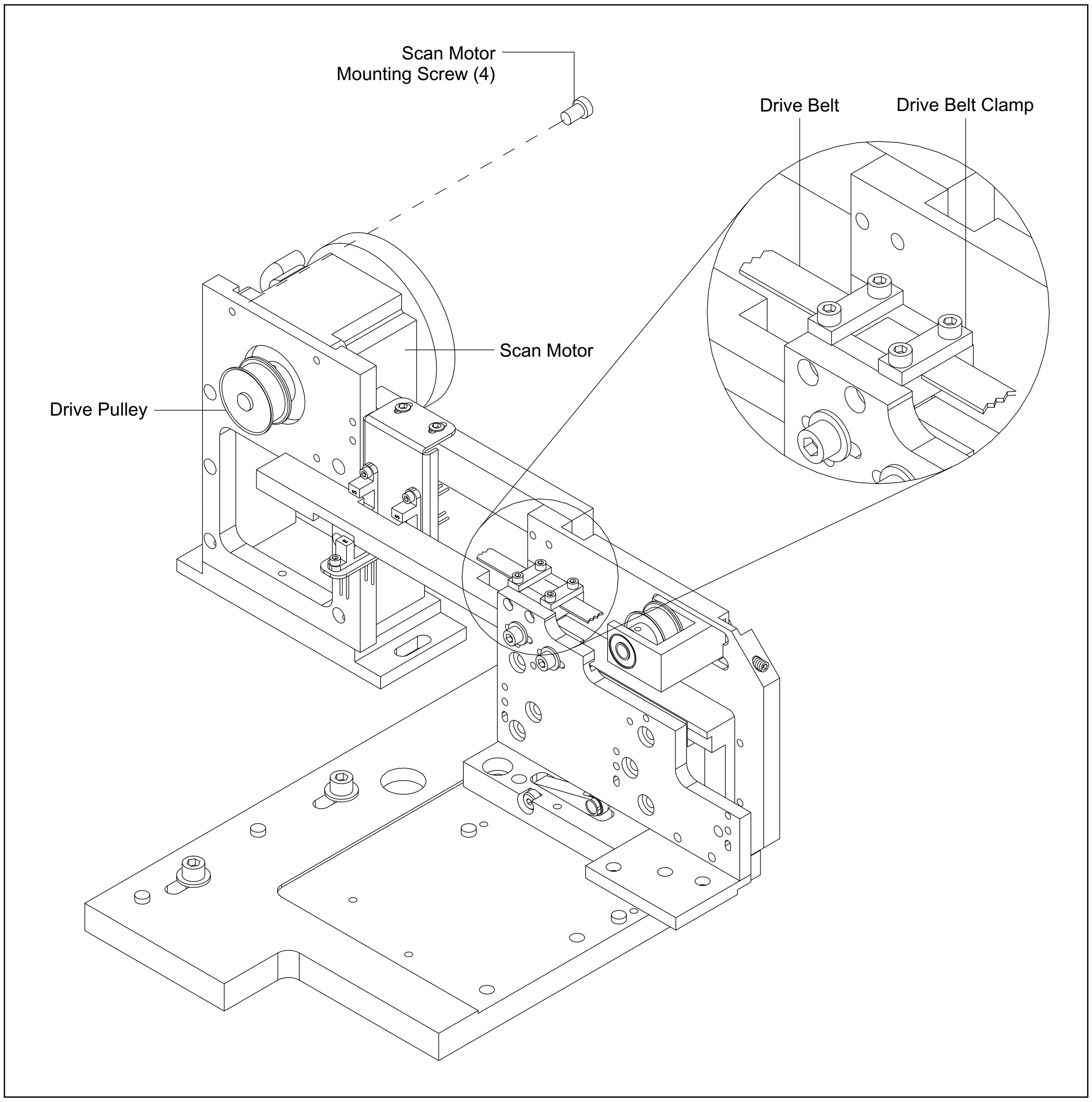



Figure 9-52. Scan Head Drive Motor Mounting.

### 9.52.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the wires of the scan motor cable from the scan motor control module.
4. Loosen the four screws that secure the drive belt tensioning loop, loosen the drive belt, and slip the drive belt off the drive motor pulley.
5. Remove the four screws that secure the drive motor to the drive motor bracket.
6. Remove the drive motor.

### 9.52.2 Installation Procedure

1. Place the scan head drive motor in position, and install the four screws that secure the drive motor to the drive motor bracket.
2. Slip the drive belt onto the drive motor pulley, adjust the drive belt tension, and tighten the four screws that secure the drive belt tensioning loop.
3. Reconnect the wires of the scan motor cable to the scan motor control module.
4. Place the optics enclosure top cover in position, and tighten the eight 1/4-turn studs.
5. Install the left panel assembly (section 9.4.2).

## 9.53 Scan Head Position Sensors

Three optical sensors are located on the scan head assembly. All three are mounted to the sensor bracket, and the sensor bracket is mounted to the insulating support bar. For the following procedures, see figure 9-53.

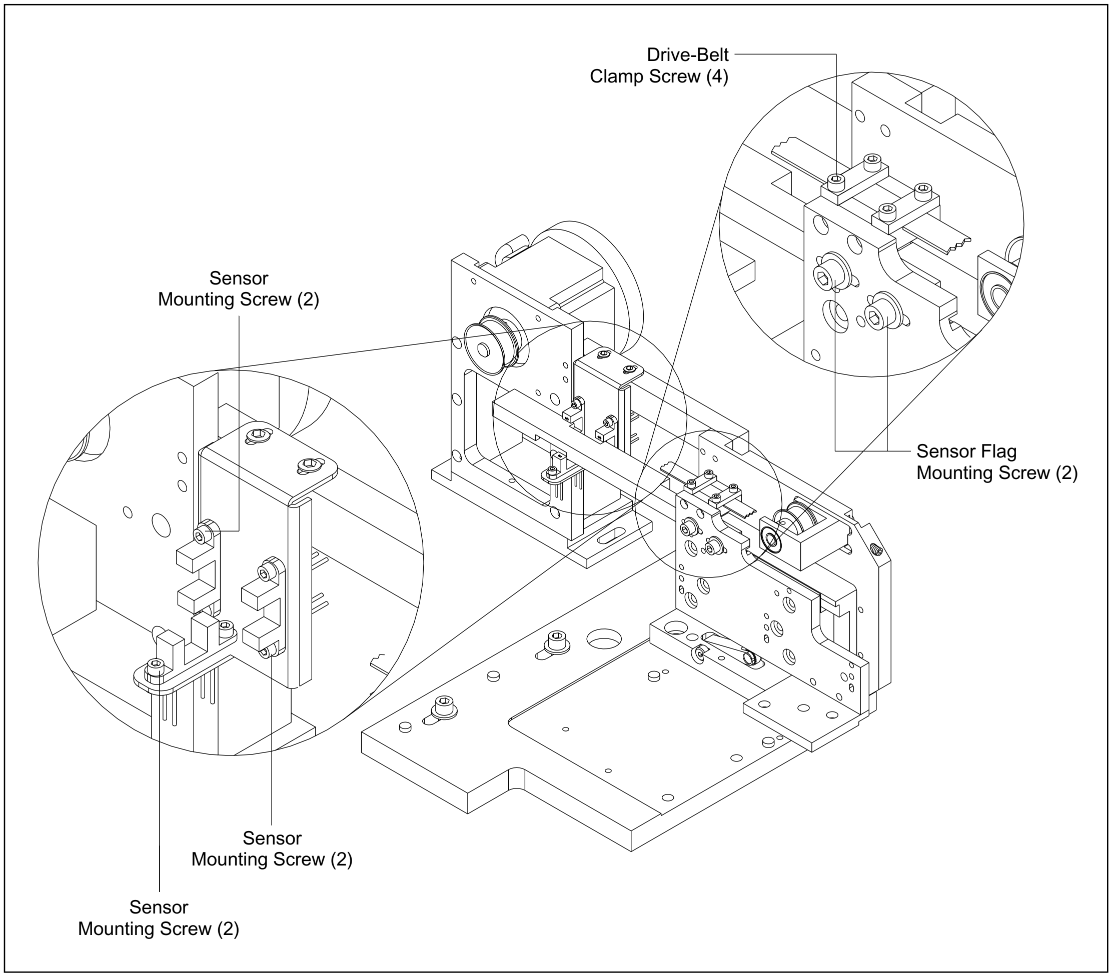



Figure 9-53. Scan Head Position Sensor Mounting.

### 9.53.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the sensor cables from the SCAN, ADAQ, and PDIO boards.
4. Loosen the four screws that secure the drive belt, loosen the drive belt, and slip the drive belt off the drive motor pulley.
5. Remove the two screws that secure the sensor flag to the scan head assembly and remove the sensor flag.
6. Remove the two screws that secure the sensor bracket to the insulating support bar.
7. Remove the two screws that secure the each sensor to the sensor bracket.

### 9.53.2 Installation Procedure

1. Place the sensor in position on the sensor bracket and install the two screws that secure the sensor to the sensor bracket.
2. Place the sensor bracket in position on the insulating support bar and install the two screws that secure the sensor bracket to the insulating support bar.
3. Slip the drive belt onto the drive motor pulley and tighten the four screws that secure the drive belt.
4. Reconnect the sensor cables to the SCAN, ADAQ, and PDIO boards.
5. Place the optics enclosure top cover in position and tighten the eight 1/4-turn studs.
6. Install the left panel assembly (section 9.4.2).

## 9.54 Scan Head Bearing Assembly

For the following procedures, see figure 9-54.

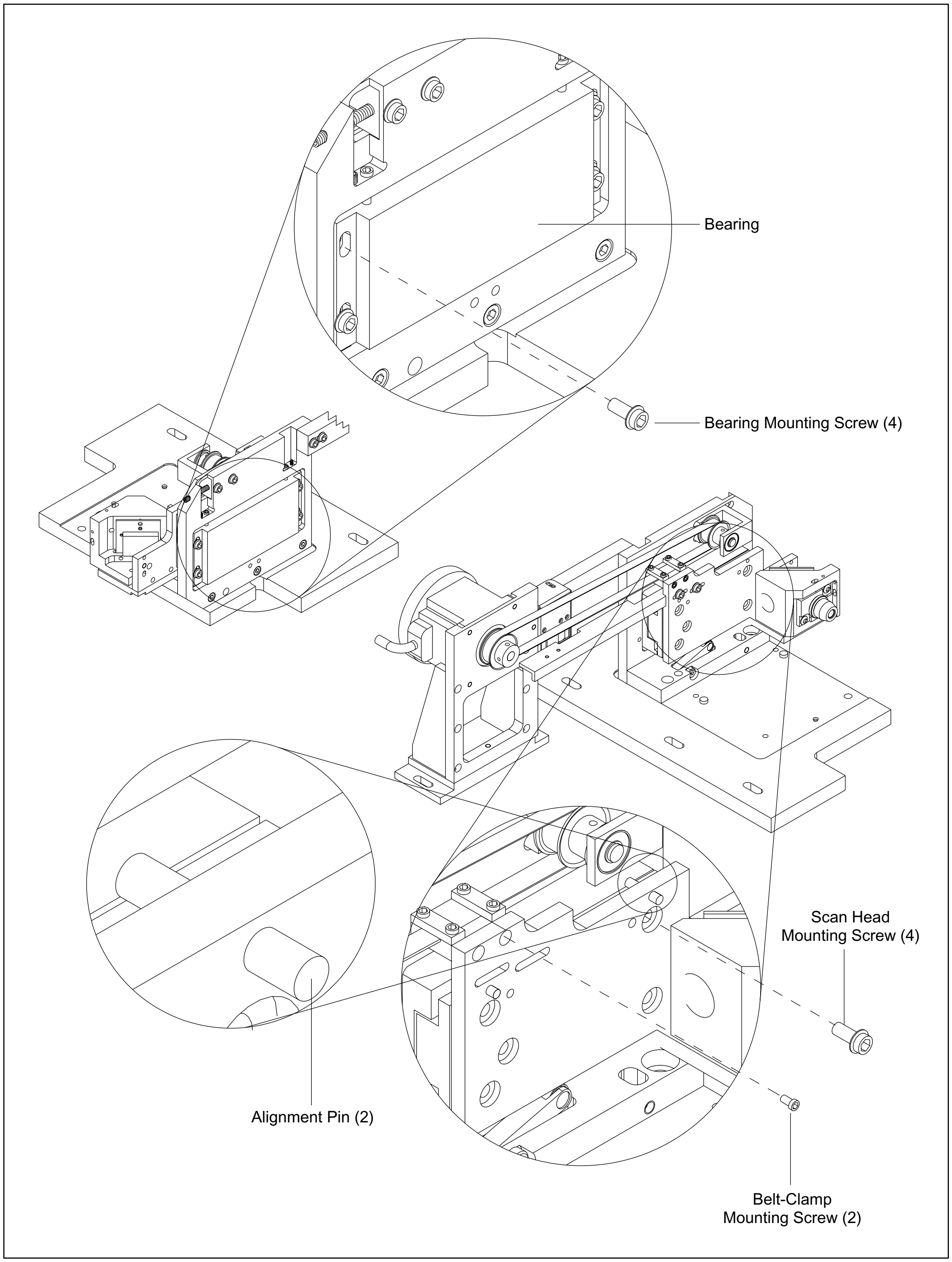



Figure 9-54. Scan Head Bearing Mounting.

### 9.54.1 Removal Procedure

1. Remove the focus assembly (figure 9.55.1).
2. Remove the two screws that secure the belt clamp to the scan head assembly.
3. Remove the four screws that secure the scan head assembly to the bearing assembly.
4. Remove the scan head assembly.
5. Remove the four screws that secure the bearing assembly to the bearing assembly mounting bracket.
6. Remove the bearing assembly.

### 9.54.2 Installation Procedure

1. Place the bearing assembly into position and install the four screws that secure the bearing to the bearing assembly mounting bracket.
2. Position the scan head assembly on the bearing assembly and loosely install the four screws that secure the scan head assembly to the bearing assembly.
3. Insert the two scan-head alignment pins and allow the alignment pins to rest on the movable part of the bearing assembly.
4. Tighten the four screws that secure the scan head assembly to the bearing assembly.
5. Install the two screws that secure the belt clamp to the scan head assembly.
6. Install the focus assembly (figure 9.55.2).

## 9.55 Focus Assembly

The focus assembly is secured to the insulated plate with three captive mounting screws and one removable mounting screw. For the following procedures, see figure 9-55.

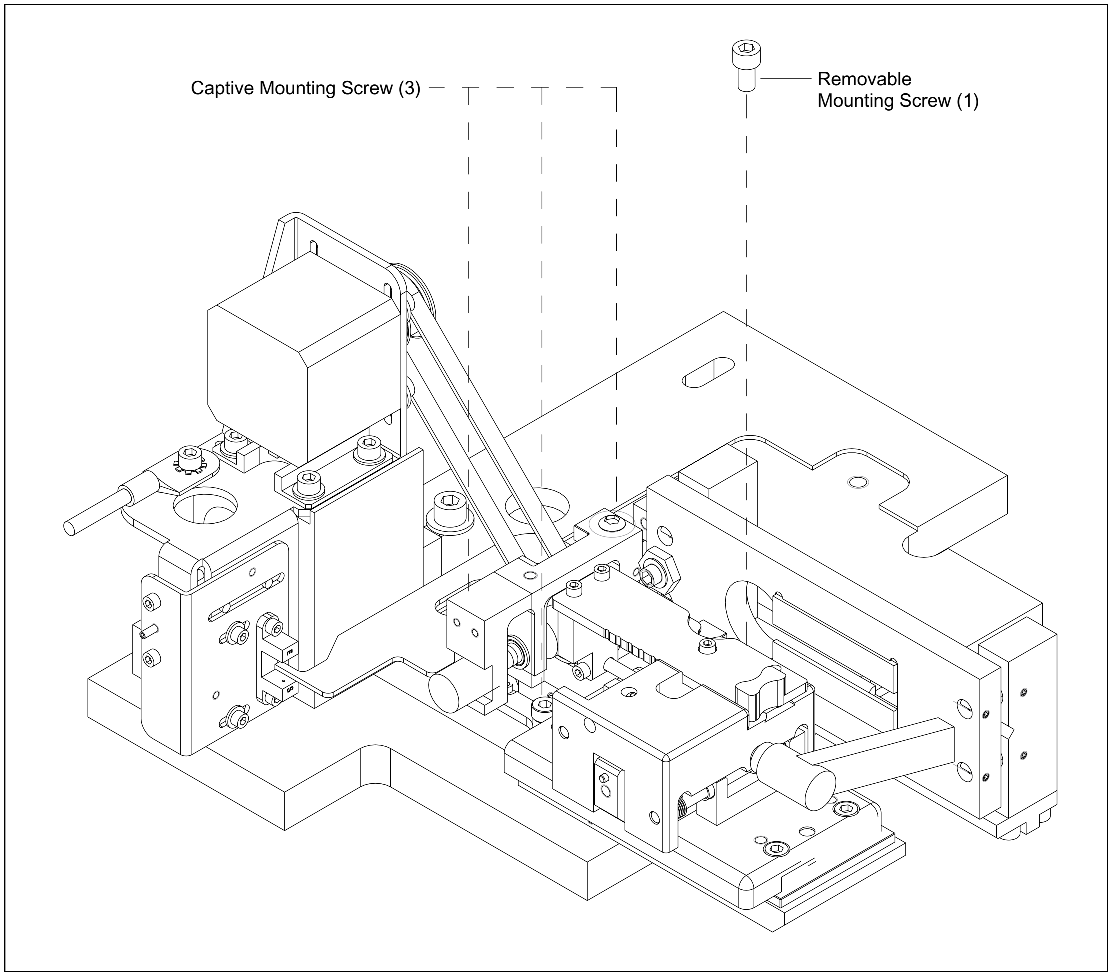



Figure 9-55. Focus Assembly Mounting.

### 9.55.1 Removal Procedure

1. Remove and properly store the six capillary arrays.
2. Loosen the three captive mounting screws that secure the focus assembly to the insulated plate.
3. Remove the single removable mounting screw that secures the focus assembly to the insulated plate.
4. Lift the focus assembly up to relieve the tension on the drive belt and slip the drive belt off the focus motor pulley.
5. Move the focus assembly to allow the sensor flag to clear the sensor.

### 9.55.2 Installation Procedure

1. Position the focus assembly to allow the sensor flag to clear the sensor.
2. Slip the drive belt over the focus motor pulley and position the focus assembly on the insulated plate.
3. Install the single removable mounting screw that secures the focus assembly to the insulated plate.
4. Tighten the three captive mounting screws that secure the focus assembly to the insulated plate.
5. Install the six capillary arrays.

## 9.56 Focus Drive Assembly

For the following procedures, see figure 9-56.

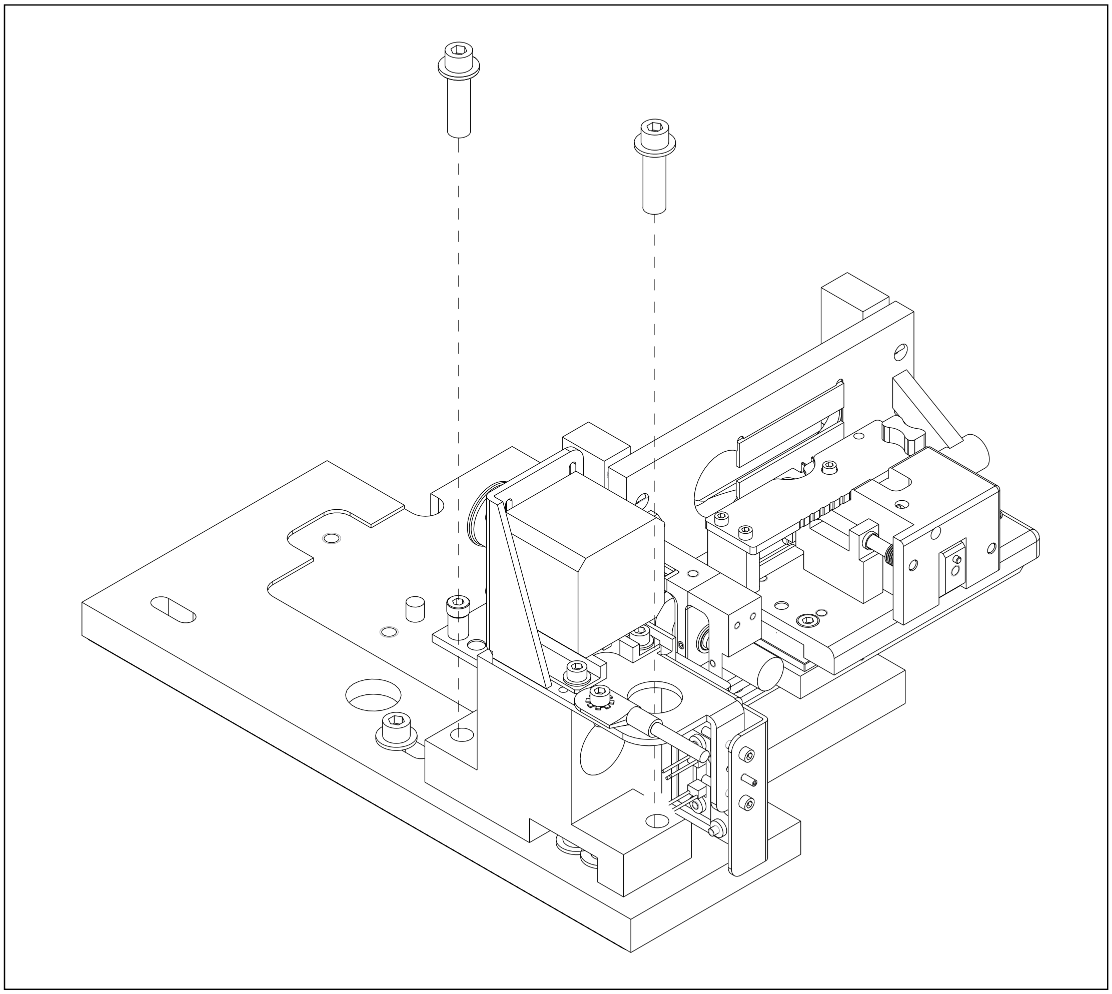


Figure 9-56. Focus Drive Assembly Mounting.

### 9.56.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the focus motor and sensor cables from the SCAN board.
4. Loosen the four screws that secure the drive motor to the drive motor bracket.
5. Remove the drive belt from the drive motor pulley.
6. Remove the two screws that secure the focus drive assembly to the insulated mounting plate.

### 9.56.2 Installation Procedure

1. Place the focus drive assembly in position on the insulated mounting plate and install the two screws that secure the focus drive assembly to the insulated mounting plate.
2. Loop the drive belt over the drive motor pulley, pull up on the drive motor to tension the drive belt, and tighten the four screws that secure the drive motor to the drive motor bracket.
3. Reconnect the motor and sensor cables to the SCAN board.
4. Place the optics enclosure top cover in position and tighten the eight 1/4-turn studs.
5. Install the left panel assembly (section 9.4.2).

## 9.57 Focus Assembly Drive Motor

For the following procedures, see figure 9-57.

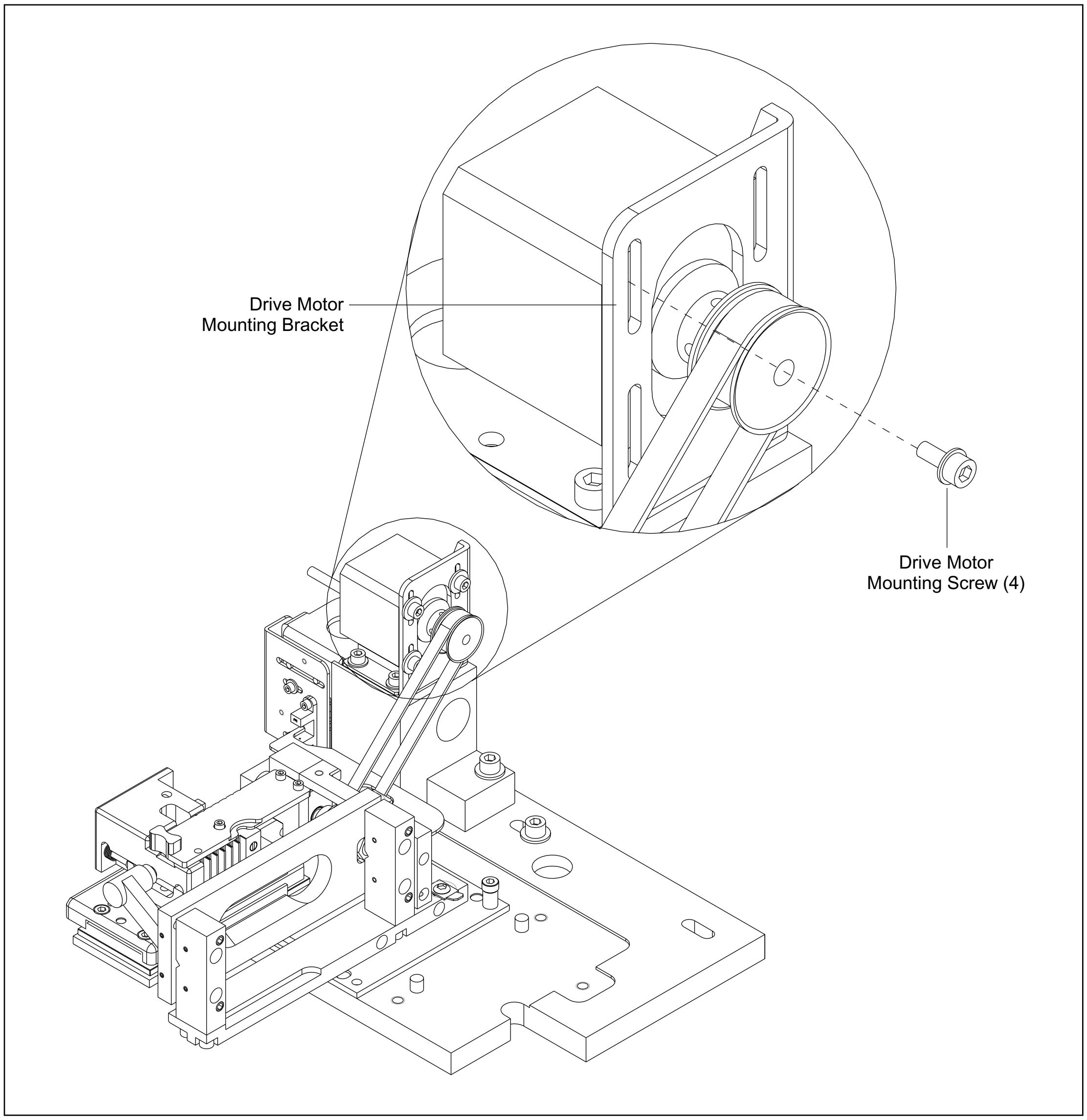



Figure 9-57. Focus Assembly Drive Motor Mounting.

### 9.57.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the motor cable from the SCAN board.
4. Remove the four screws that secure the drive motor to the drive motor bracket.
5. Remove the drive belt from the drive motor pulley.
6. Remove the drive motor.

### 9.57.2 Installation Procedure

1. Place the drive motor in position on the drive motor bracket and install the four screws that secure the drive motor to the drive motor bracket.
2. Loop the drive belt over the drive motor pulley, pull up on the drive motor to tension the drive belt, and tighten the four screws.
3. Reconnect the motor cable to the SCAN board.
4. Place the optics enclosure top cover in position, and tighten the eight 1/4-turn studs.
5. Install the left panel assembly (section 9.4.2).

## 9.58 Focus Assembly Position Sensor

For the following procedures, see figure 9-58.

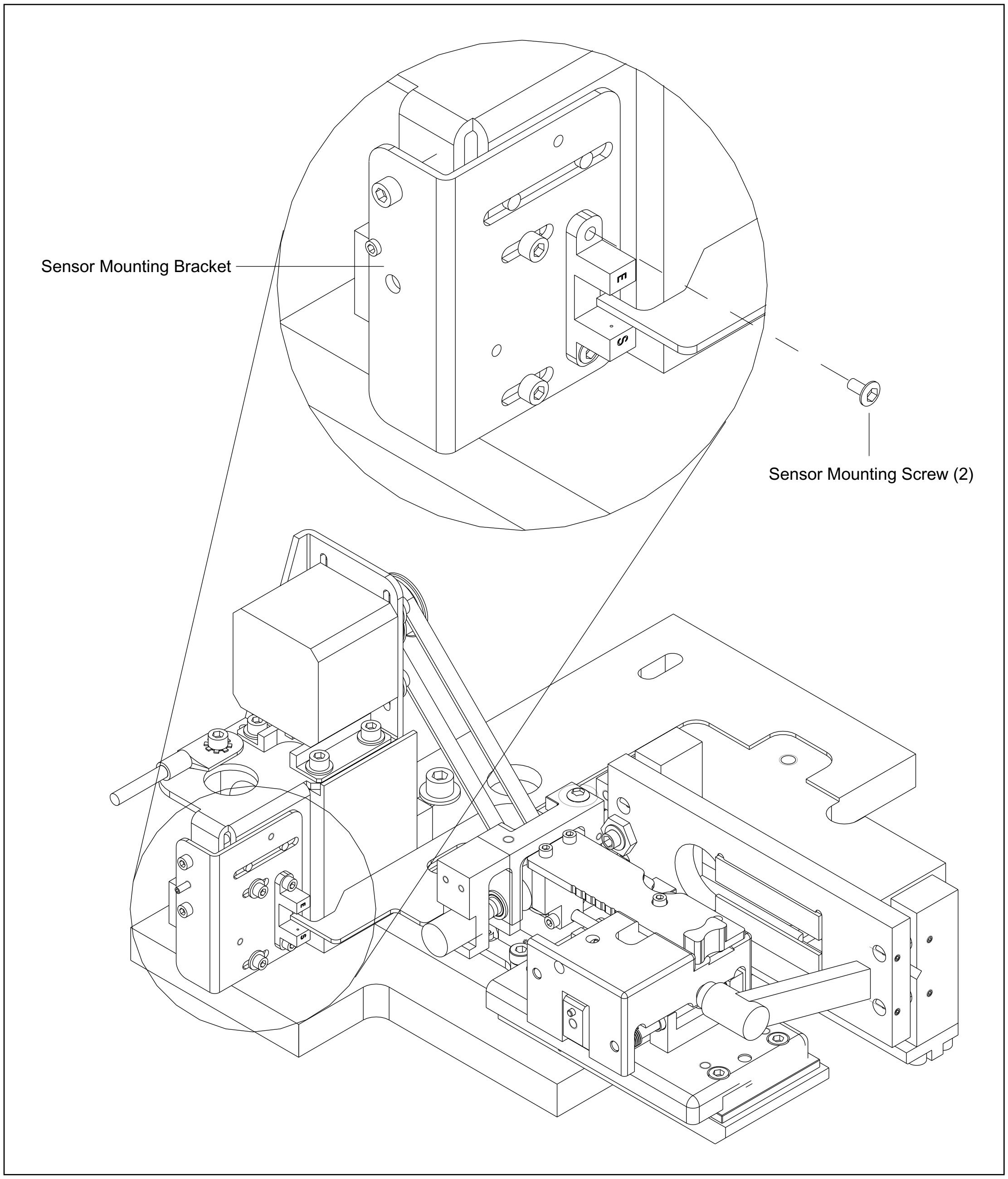



Figure 9-58. Focus Assembly Position Sensor Mounting.

### 9.58.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the sensor cable from the SCAN board.
4. Remove the two screws that secure the position sensor to the sensor mounting bracket.

### 9.58.2 Installation Procedure

1. Place the sensor in position on the sensor mounting bracket and install the two screws that secure the sensor to the sensor mounting bracket.
2. Reconnect the sensor cable to the SCAN board.
3. Place the optics enclosure top cover in position and tighten the eight 1/4-turn studs.
4. Install the left panel assembly (section 9.4.2).

## 9.59 Capillary Mount Assembly

For the following procedures, see figure 9-59.

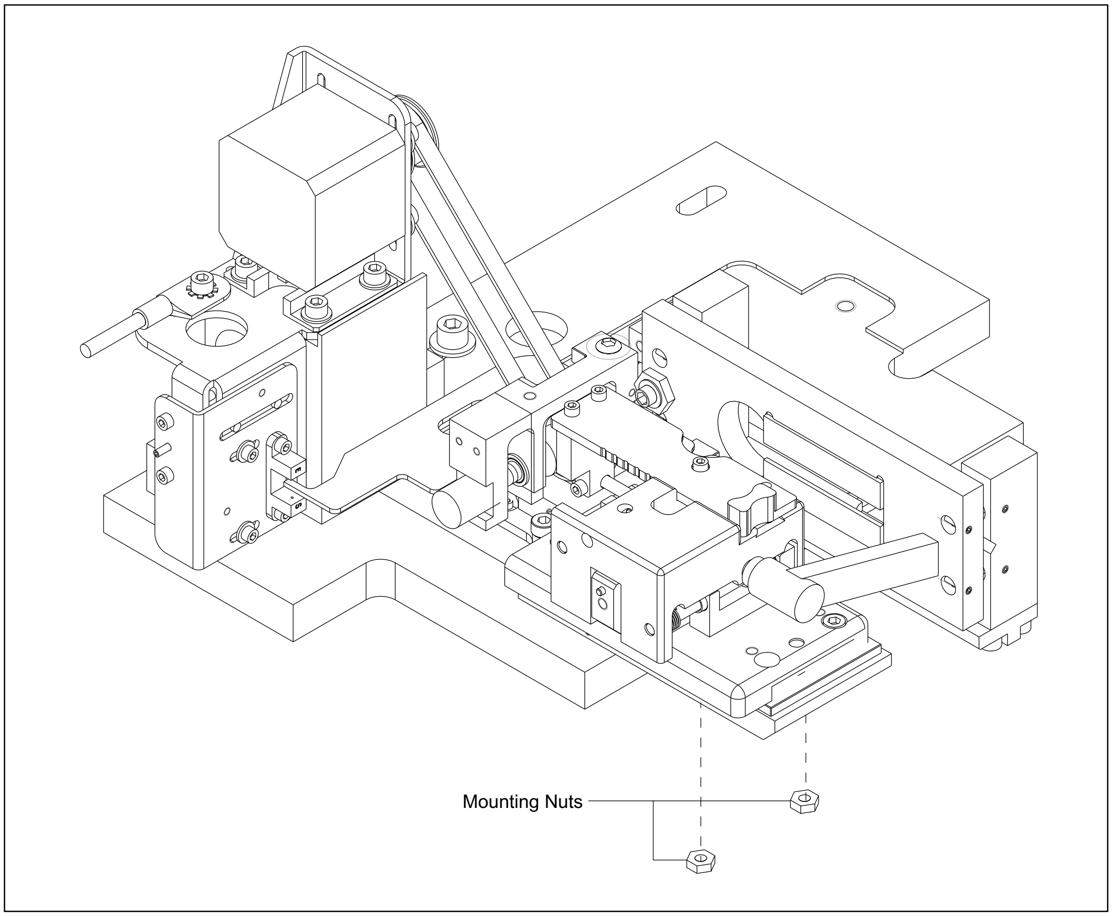



Figure 9-59. Capillary Mount Assembly Mounting.

### 9.59.1 Removal Procedure

1. Remove and properly store the six capillary arrays.
2. Remove the two mounting nuts that secure the capillary mount assembly to the focus assembly.

### 9.59.2 Installation Procedure

1. Position the capillary mount assembly on the focus assembly.
2. Install the two mounting nuts that secure the capillary mount assembly to the focus assembly.
3. Install the six capillary arrays.

## 9.60 Secondary Beamsplitter Changer Assembly

For the following procedures, see figure 9-60.

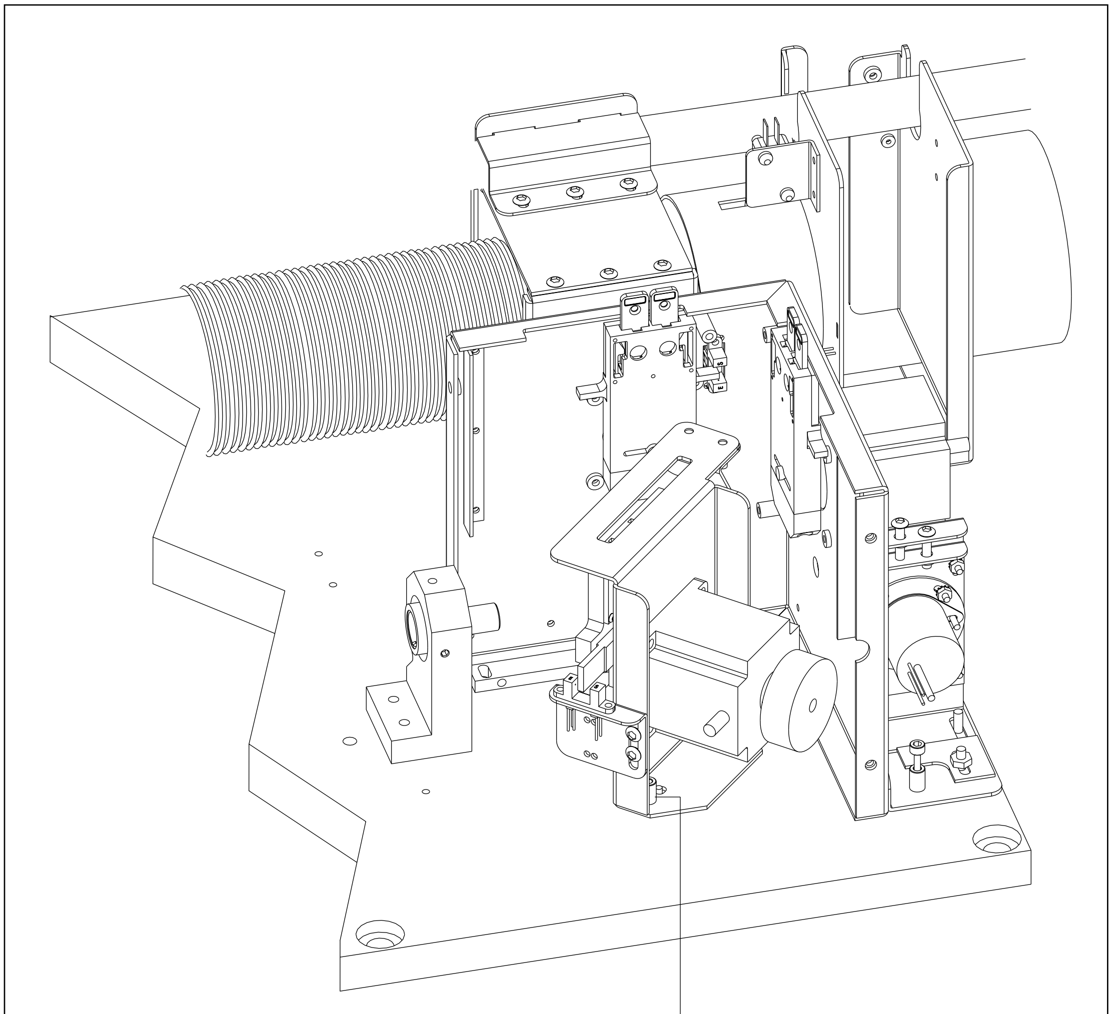



Figure 9-60. Secondary Beamsplitter Assembly Mounting.

### 9.60.1 Removal Procedure

1. Remove the filter cover assembly (section 9.5.1).
2. Loosen the four 1/4-turn studs on the top of the filter changer cover, remove the four screws on the front of the filter changer cover, and remove the cover.
3. Remove the four screws that secure the right partition to the center front panel and center rear panel.
4. Remove the top and left side panels and the main optics cover.
5. Disconnect the motor cable and sensor cable from the SCAN board.
6. Loosen the two captive screws that secure the secondary beamsplitter changer assembly to the optics baseplate.

### 9.60.2 Installation Procedure

1. Place the secondary beamsplitter changer assembly in position and tighten the two captive screws that secure the assembly to the optics baseplate.
2. Reconnect the motor cable and sensor cable to the SCAN board.
3. Install the top and left side panels and the main optics cover.
4. Install the four screws that secure the right partition to the center front panel and center rear panel.
5. Place the filter changer cover in position, tighten the four 1/4-turn studs on the top of the filter changer cover, and install the four screws on the front of the filter changer cover.
6. Install the filter cover assembly (section 9.5.2).

## 9.61 Secondary Beamsplitter Changer Drive Motor

For the following procedures, see figure 9-61.

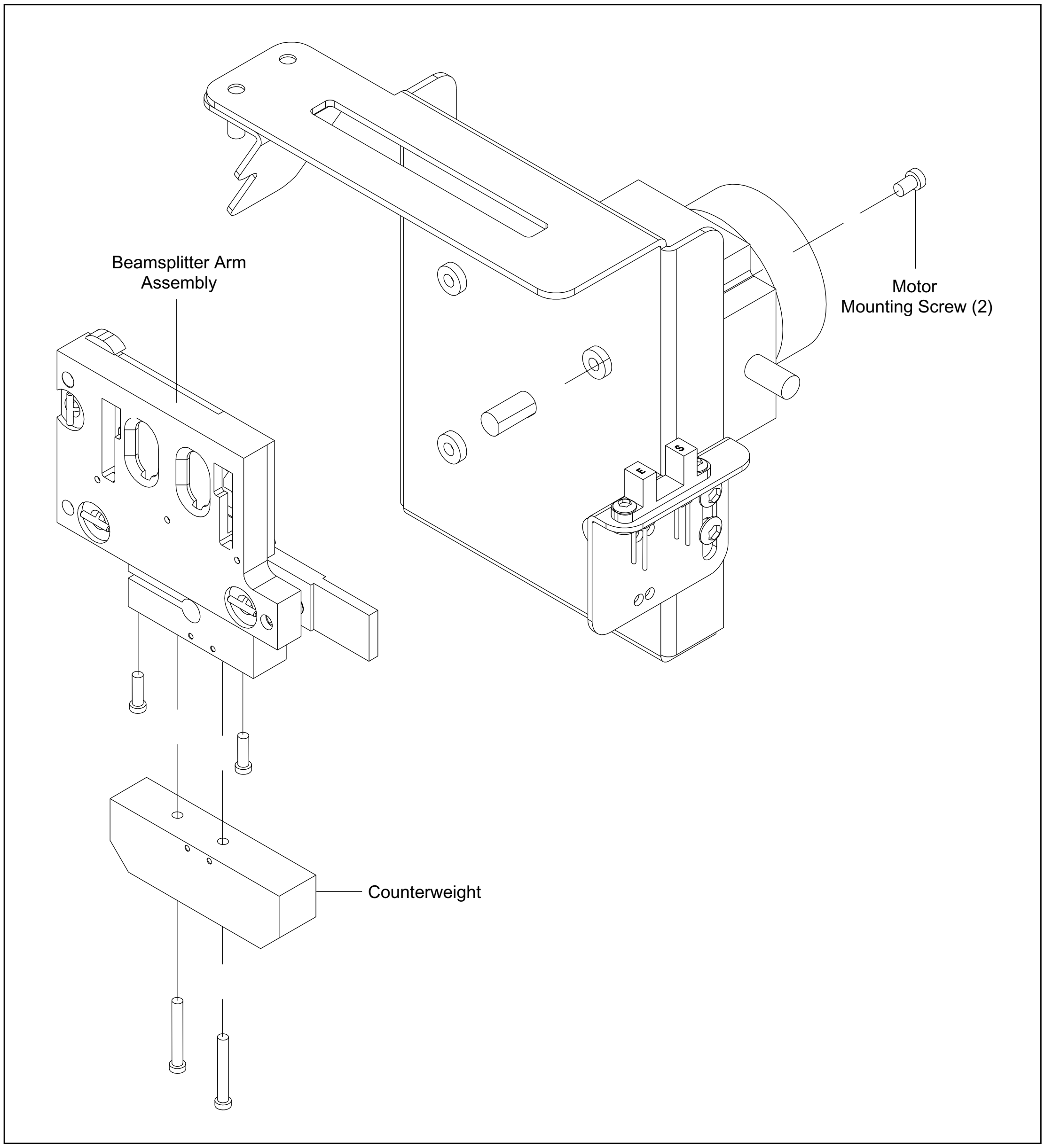



Figure 9-61. Secondary Beamsplitter Arm Assembly Mounting.

### 9.61.1 Removal Procedure

1. Remove the secondary beamsplitter changer (section 9.60.1).
2. Remove the beamsplitters from the beamsplitter arm.
3. Remove the two screws that secure the counterweight to the beamsplitter arm.
4. Loosen the two screws that secure the beamsplitter arm to the shaft.
5. Slide the beamsplitter arm off the shaft.
6. Disconnect the motor cable from the SCAN board.
7. Remove the four screws that secure the motor to the secondary beamsplitter changer assembly.

### 9.61.2 Installation Procedure

1. Install the four screws that secure the motor to the secondary beamsplitter changer assembly.
2. Reconnect the motor cable to the SCAN board.
3. Slide the beamsplitter arm onto the shaft.
4. Tighten the two screws that secure the beamsplitter arm to the shaft.
5. Install the two screws that secure the counterweight to the beamsplitter arm.
6. Install the beamsplitters into the beamsplitter arm.
7. Install the secondary beamsplitter changer (section 9.60.2).

## 9.62 Secondary Beamsplitter Changer Home Sensor

For the following procedures, see figure 9-62.

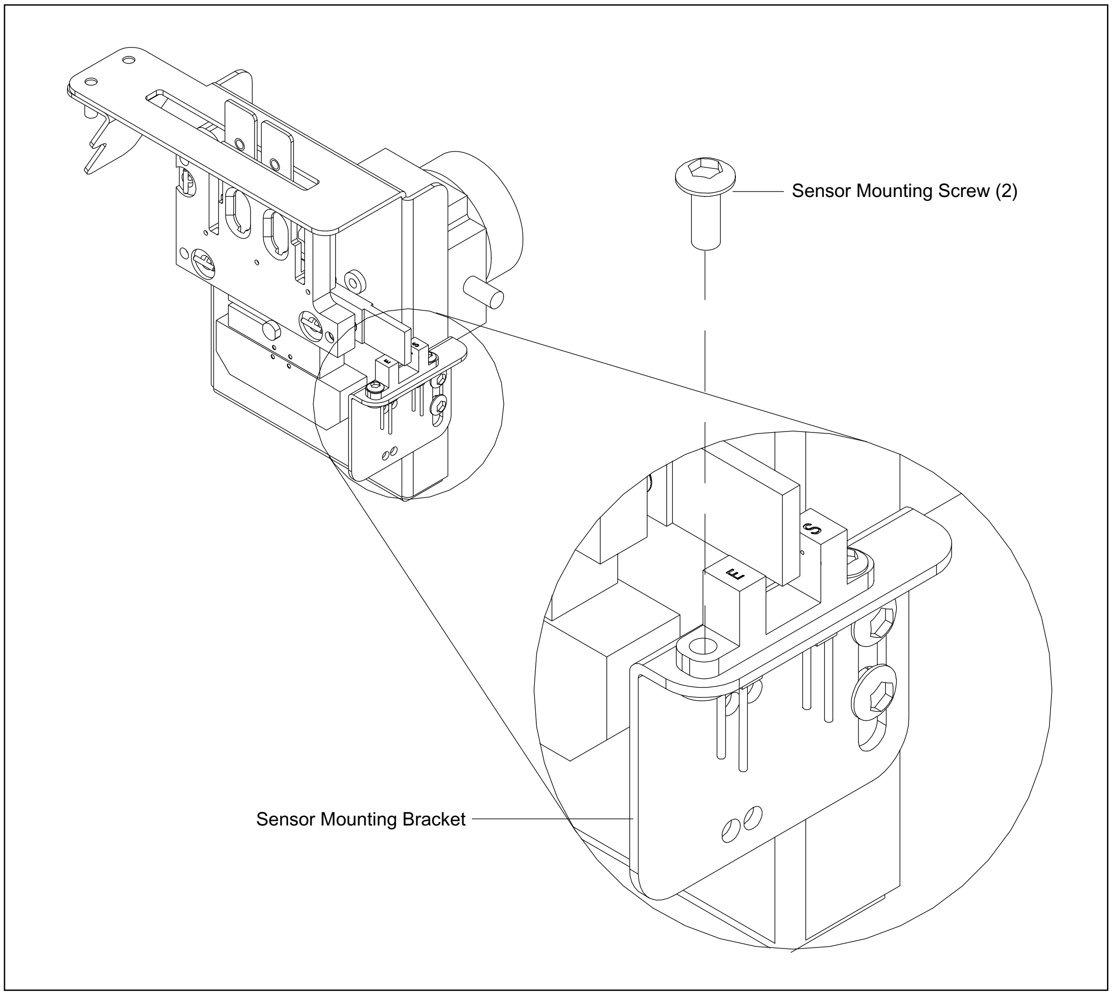



Figure 9-62. Secondary Beamsplitter Changer Home Sensor Mounting.

### 9.62.1 Removal Procedure

1. Remove the left panel assembly (section 9.4.1).
2. Remove the PMT cover.
3. Loosen the eight 1/4-turn studs on the optics enclosure top cover and remove the cover.
4. Disconnect the home sensor cable from the SCAN board.
5. Remove the two screws that secure the home sensor to the sensor mounting bracket.

### 9.62.2 Installation Procedure

1. Place the home sensor in position on the sensor mounting bracket and install the two screws that secure the sensor to the sensor mounting bracket.
2. Reconnect the home sensor cable to the SCAN board.
3. Place the optics enclosure top cover in position, and tighten the eight 1/4-turn studs.
4. Install the PMT cover.
5. Install the left panel assembly (section 9.4.2).

## 9.63 Filter Changer Assembly

For the following procedures, see figure 9-63.

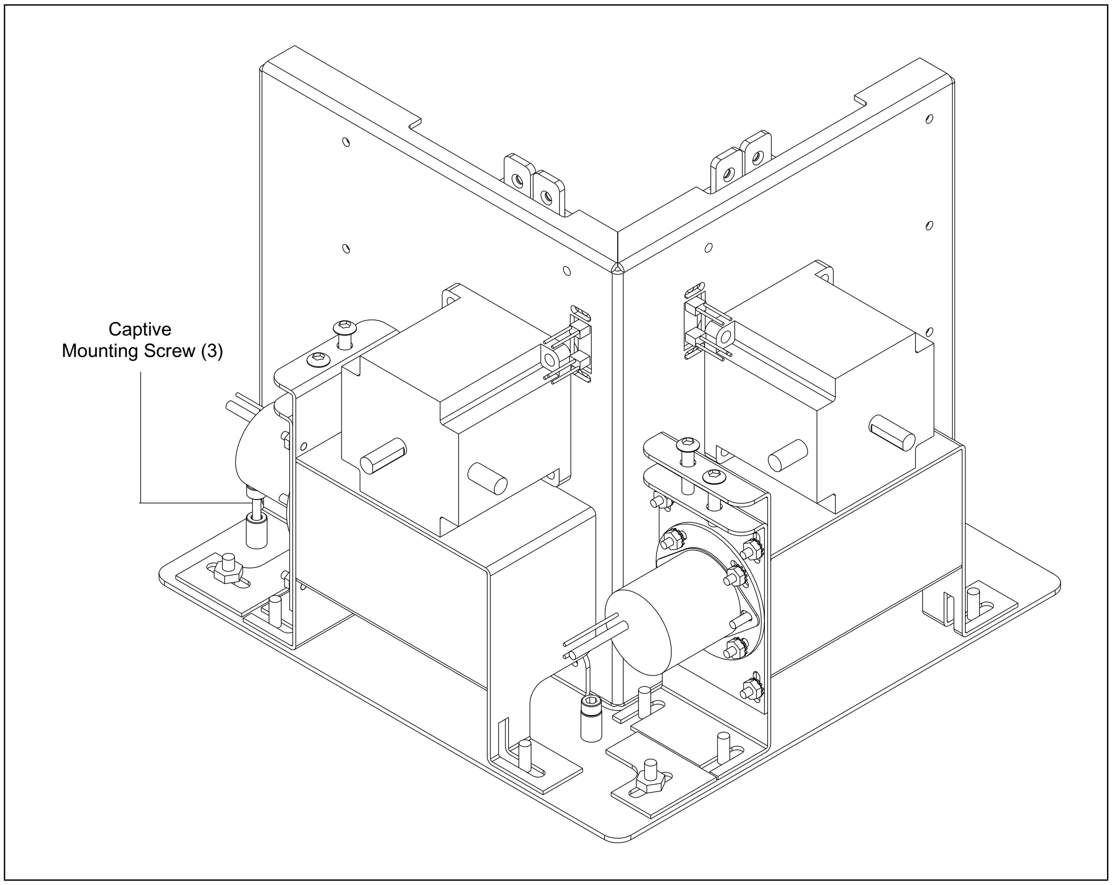



Figure 9-63. Filter Changer Assembly Mounting.

### 9.63.1 Removal Procedure

1. Remove the filter cover assembly (section 9.5.1).
2. Loosen the four 1/4-turn studs on the top of the filter changer cover, remove the four screws on the front of the filter changer cover, and remove the cover.
3. Remove the three screws that secure the right side panel to the optics baseplate.
4. Disconnect the motor cables and sensor cables from the FLTR board.
5. At the ADAQ board, disconnect the coax cables from the PMTs.
6. At the ADAQ board, disconnect the power cables from the PMTs.
7. Loosen the three captive screws that secure the filter changer assembly to the optics baseplate.

### 9.63.2 Installation Procedure

1. Place the filter changer assembly in position and tighten the three captive screws that secure the assembly to the optics baseplate.
2. At the ADAQ board, reconnect the coax cables from the PMTs.
3. At the ADAQ board, reconnect the power cables from the PMTs.
4. Reconnect the motor cables and sensor cables to the FLTR board.
5. Install the three screws that secure the right side panel to the optics baseplate.
6. Place the filter changer cover in position, tighten the four 1/4-turn studs on the top of the filter changer cover, and install the four screws on the front of the filter changer cover.
7. Install the filter cover assembly (section 9.5.2).

## 9.64 Filter Changer Drive Motors

The removal and installation procedures for each of the two filter changer drive motors are identical. For the following procedures, see figure 9-64.

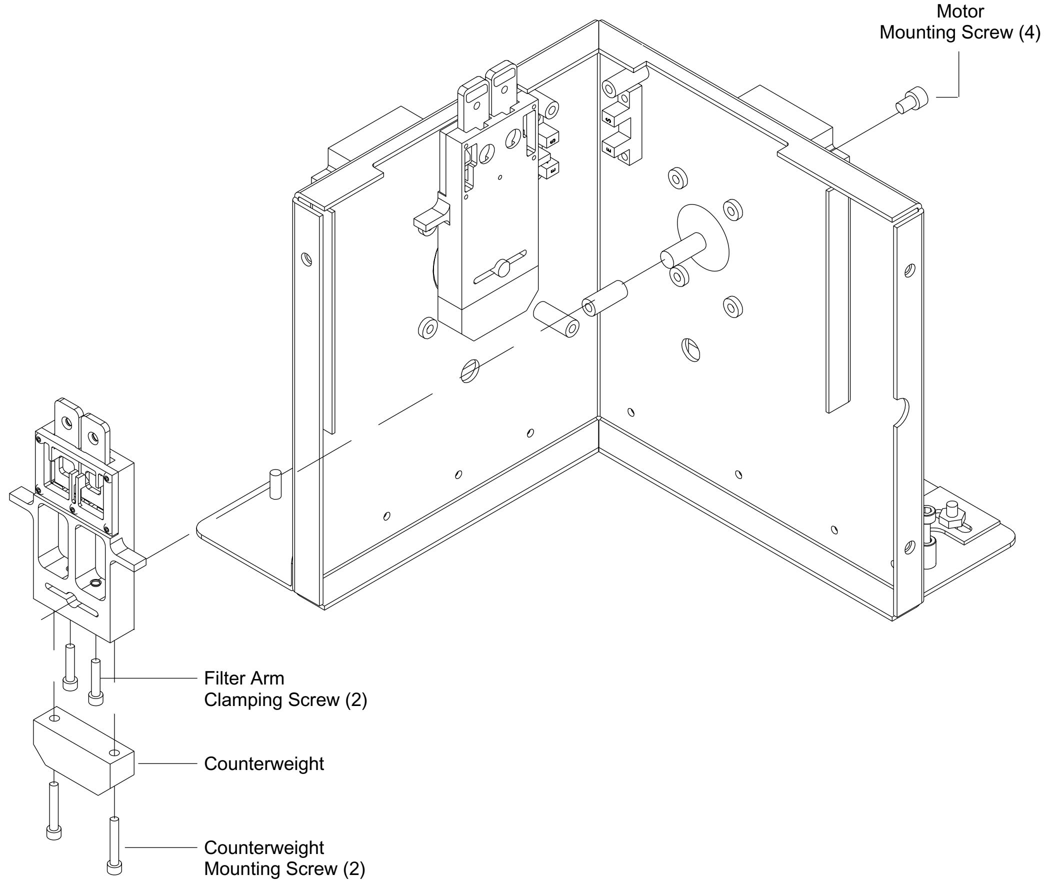



Figure 9-64. Filter Changer Arm Assembly Mounting.

### 9.64.1 Removal Procedure

1. Remove the filter changer assembly (section 9.63.1).
2. Remove the two screws that secure the counterweight to the filter arm.
3. Loosen the two screws that secure the filter arm to the motor shaft.
4. Slide the filter arm off the shaft.
5. Disconnect the motor cable from the FLTR board.
6. Remove the four screws that secure the motor to the filter changer assembly.

### 9.64.2 Installation Procedure

1. Install the four screws that secure the motor to the filter changer assembly.
2. Reconnect the motor cable to the FLTR board.
3. Slide the filter arm onto the shaft.
4. Tighten the two screws that secure the filter arm to the motor shaft.
5. Install the two screws that secure the counterweight to the filter arm.
6. Install the filter changer assembly (section 9.63.2).

## 9.65 Filter Changer Home Sensor

For the following procedures, see figure 9-65.

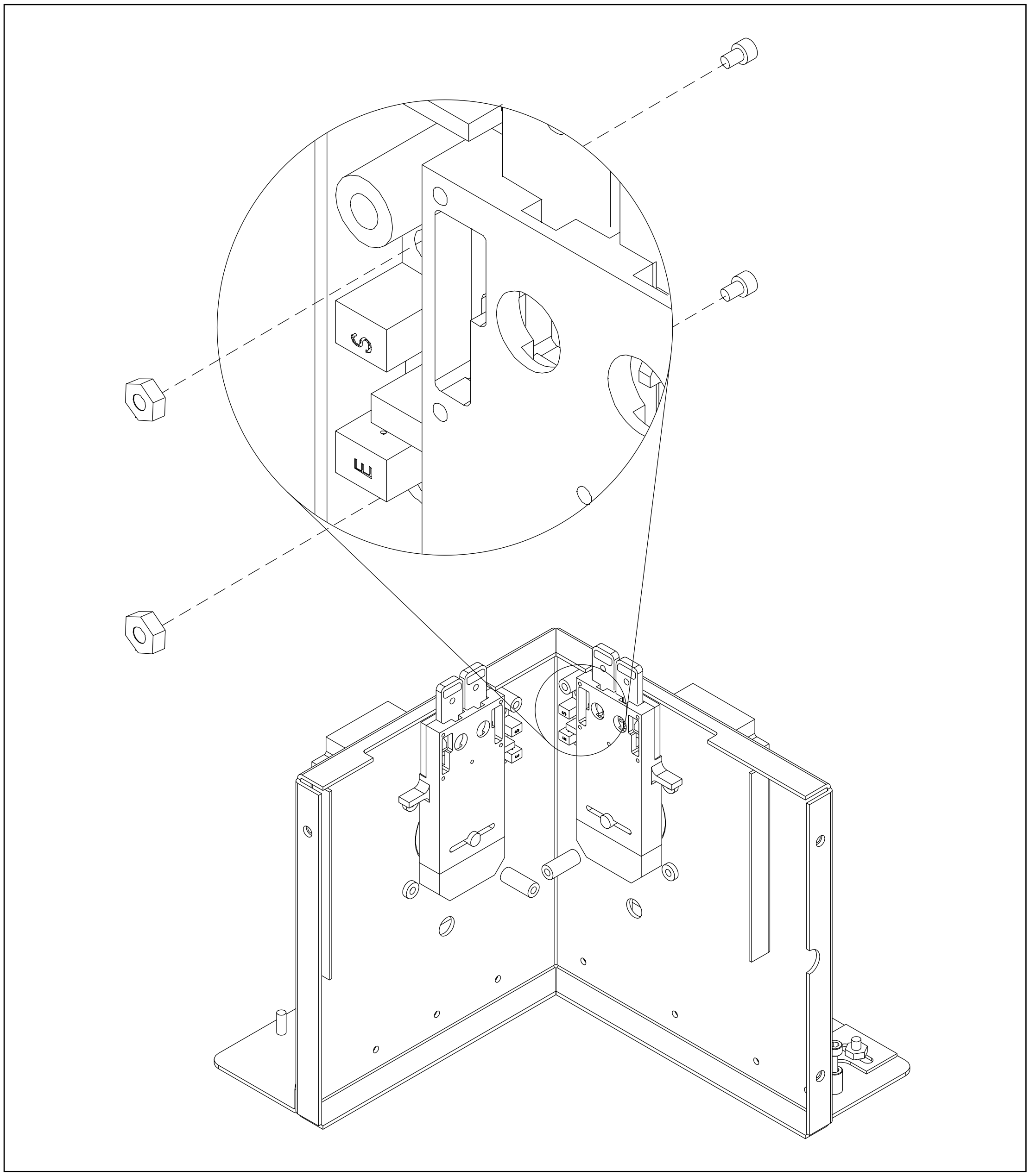


Figure 9-65. Filter Changer Home Sensor Mounting.

### 9.65.1 Removal Procedure

1. Remove the filter cover assembly (section 9.5.1).
2. Loosen the four 1/4-turn studs on the optics enclosure top cover and remove the cover.
3. Disconnect the home sensor cable from the FLTR board.
4. Remove the two screws, two nuts, and two washers that secure the home sensor to the sensor mounting bracket.

### 9.65.2 Installation Procedure

1. Place the home sensor in position on the sensor mounting bracket and install the two screws, two nuts, and two washers that secure the home sensor to the sensor mounting bracket.
2. Reconnect the home sensor cable to the FLTR board.
3. Place the optics enclosure top cover in position and tighten the four 1/4-turn studs.
4. Install the filter cover assembly (section 9.5.2).

# 9.66 PMT Assembly

For the following procedures, see figure 9-66.

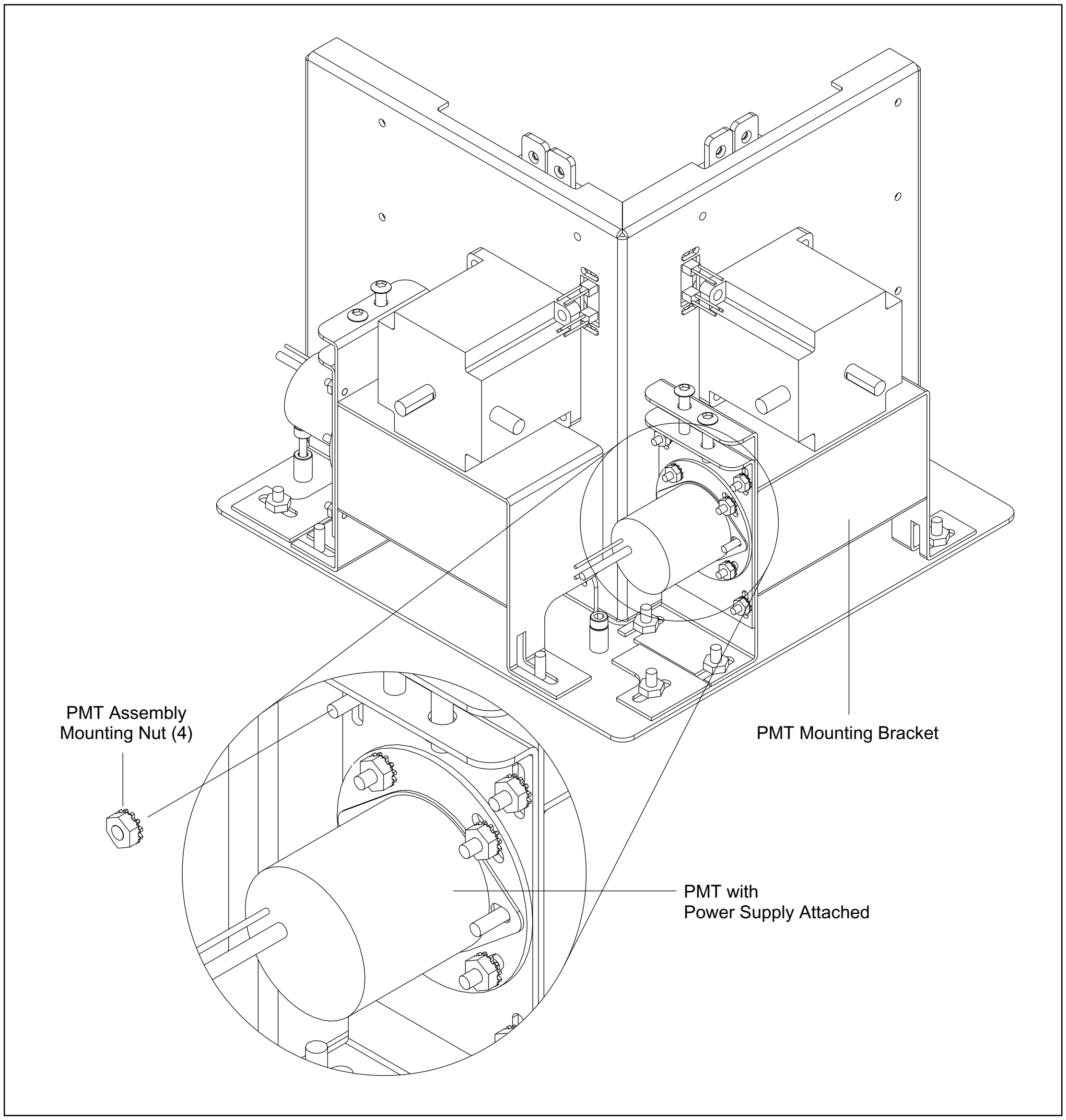



Figure 9-66. PMT Assembly Mounting.

### 9.66.1 Removal Procedure

1. Remove the filter cover assembly (section 9.5.1).
2. Loosen the four 1/4-turn studs on the top of the filter changer cover, remove the four screws on the front of the filter changer cover, and remove the cover.
3. Remove the three screws that secure the right side panel to the optics baseplate.
4. At the ADAQ board, disconnect the coax cables from the PMT.
5. At the ADAQ board, disconnect the power cables from the PMT.
6. Remove the four nuts that secure the PMT assembly to the PMT mounting bracket and pull the PMT assembly out of the PMT housing.
7. Unplug the PMT from the PMT socket.

### 9.66.2 Installation Procedure

1. Plug the new PMT into the PMT socket.
2. Place the PMT assembly in position and inside the housing and install the four nuts that secure the PMT assembly to the PMT mounting bracket.
3. At the ADAQ board, reconnect the coax cables from the PMTs.
4. At the ADAQ board, reconnect the power cables from the PMTs.
5. Install the three screws that secure the right side panel to the optics baseplate.
6. Place the filter changer cover in position, tighten the four 1/4-turn studs on the top of the filter changer cover, and install the four screws on the front of the filter changer cover.
7. Install the filter cover assembly (section 9.5.2).

## 9.67 Cathode Assembly

For the following procedures, see figure 9-67.

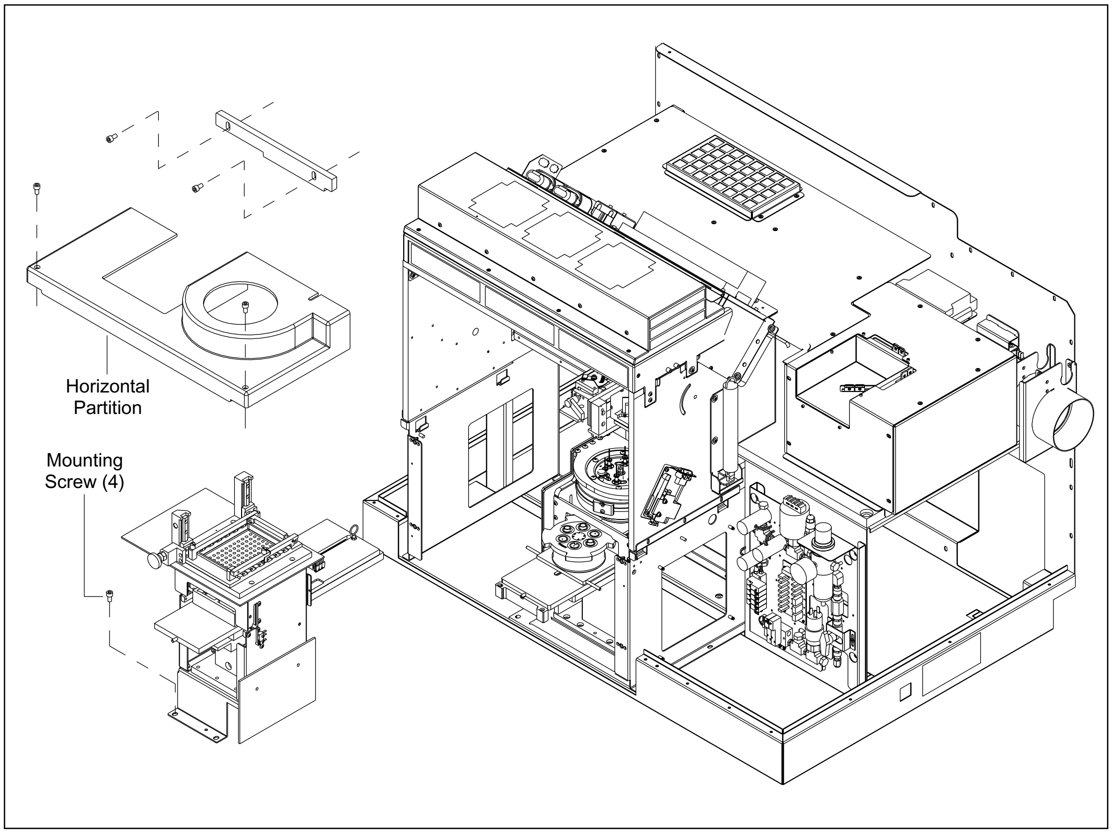



Figure 9-67. Cathode Assembly Mounting.

### 9.67.1 Removal Procedure

1. Open the service door.
2. Remove and properly store the capillary arrays.
3. Remove the front panel assembly (section 9.9.1).
4. Remove the two screws that secure the horizontal partition to the front of the electrophoresis chamber assembly and remove the horizontal partition.
5. Disconnect the ribbon cable from the cathode interface board.
6. From the left side of the cathode assembly, remove the pneumatic connections.
7. Disconnect the two Echelon cables from the CMON board.
8. Remove the four screws that secure the cathode assembly to the sheet-metal chassis.
9. Carefully slide the cathode assembly forward out of the electrophoresis chamber assembly.

### 9.67.2 Installation Procedure

1. Place the cathode assembly in position and install the four screws that secure the cathode assembly to the sheet-metal chassis.
2. Reconnect the two Echelon cables to the CMON board.
3. From the rear of the cathode assembly, install the pneumatic connections.
4. Reconnect the ribbon cable to the cathode interface board.
5. Place the horizontal partition in position and install the two screws that secure the horizontal partition to the front of the electrophoresis chamber assembly.
6. Install the front panel assembly (section 9.9.2).
7. Install the capillary arrays.
8. Close the service door.

## 9.68 Array Stage and CMON Board (MB 1000)

For the following procedures, see figure 9-68.

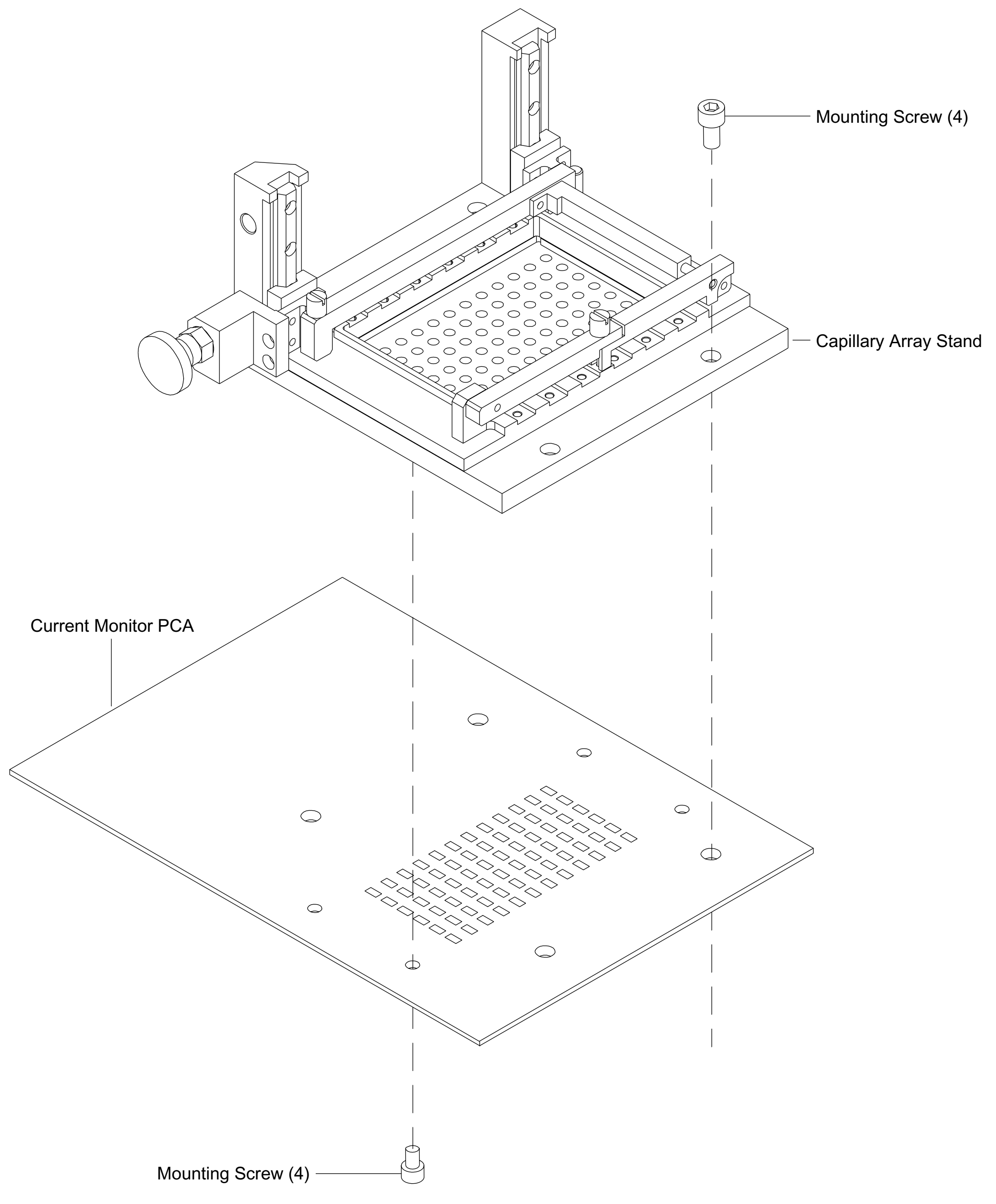



Figure 9-68. Array Stage and CMON Board Mounting.

### 9.68.1 Removal Procedure

1. Remove the two screws that secure the horizontal partition and remove the partition.
2. Remove the four screws that secure the capillary array stand and CMON board assembly to the cathode assembly.
3. Remove the four screws that secure the CMON board to the capillary array stand.

### 9.68.2 Installation Procedure

1. Put the alignment pins in place on the cathode assembly and align the capillary array stand and CMON board.
2. Install the four screws that secure the CMON board to the capillary array stand and remove the alignment pins.
3. Install the four screws that secure the capillary array stand and CMON board assembly to the cathode assembly.
4. Put the horizontal partition in place, and install the two screws that secure the horizontal partition.

## 9.69 Cathode Slide-In Sensor Switches

There is a slide-in sensor switch on each side of the cathode assembly. The procedures are the same for both switches. For the following procedures, see figure 9-69.

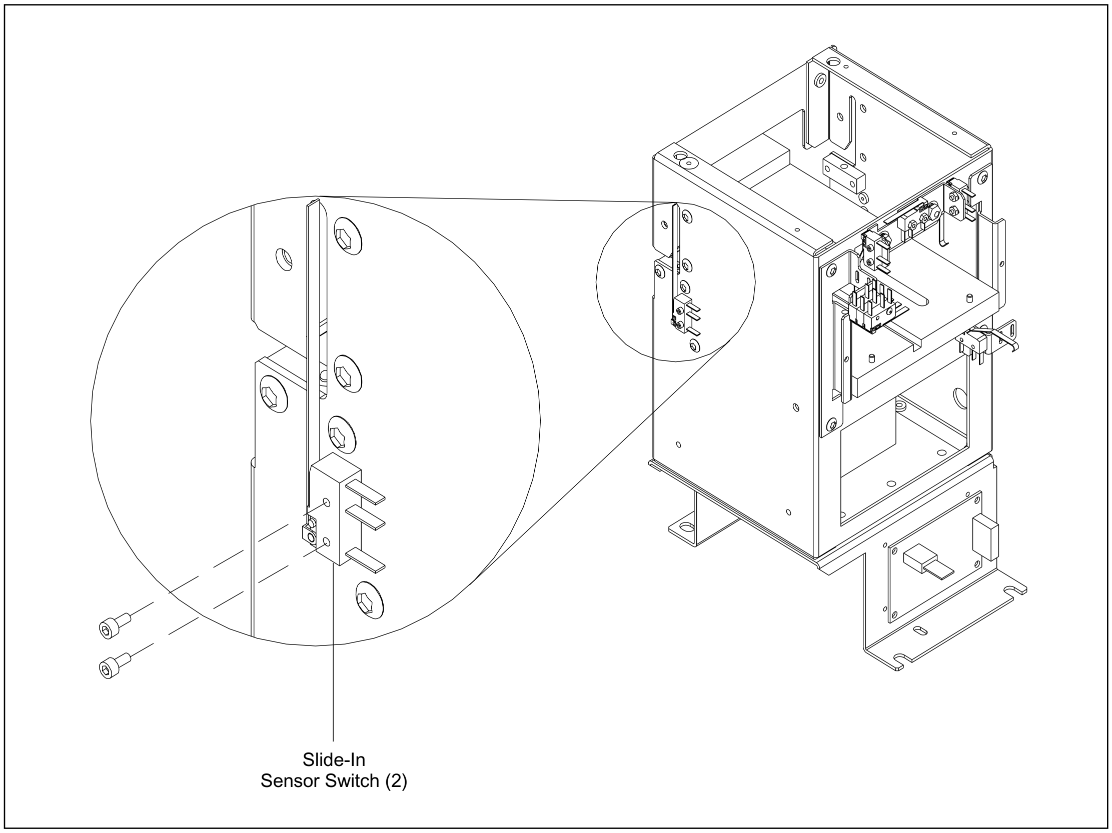



Figure 9-69. Cathode Slide-In Sensor Mounting.

### 9.69.1 Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Disconnect the slide-in sensor cable from the cathode connector board.
3. Remove the two screws that secure the slide-in sensor to the side of the cathode assembly.
4. Remove the slide-in sensor.

### 9.69.2 Installation Procedure

1. Place the slide-in sensor in position on the side of the cathode assembly.
2. Install the two screws that secure the slide-in sensor to the side of the cathode assembly.
3. Reconnect the slide-in sensor cable to the cathode connector board.
4. Install the cathode assembly (section 9.67.2).

## 9.70 Cathode Stage-Up Interlock and Sensor Switches

For the following procedures, see figure 9-70.

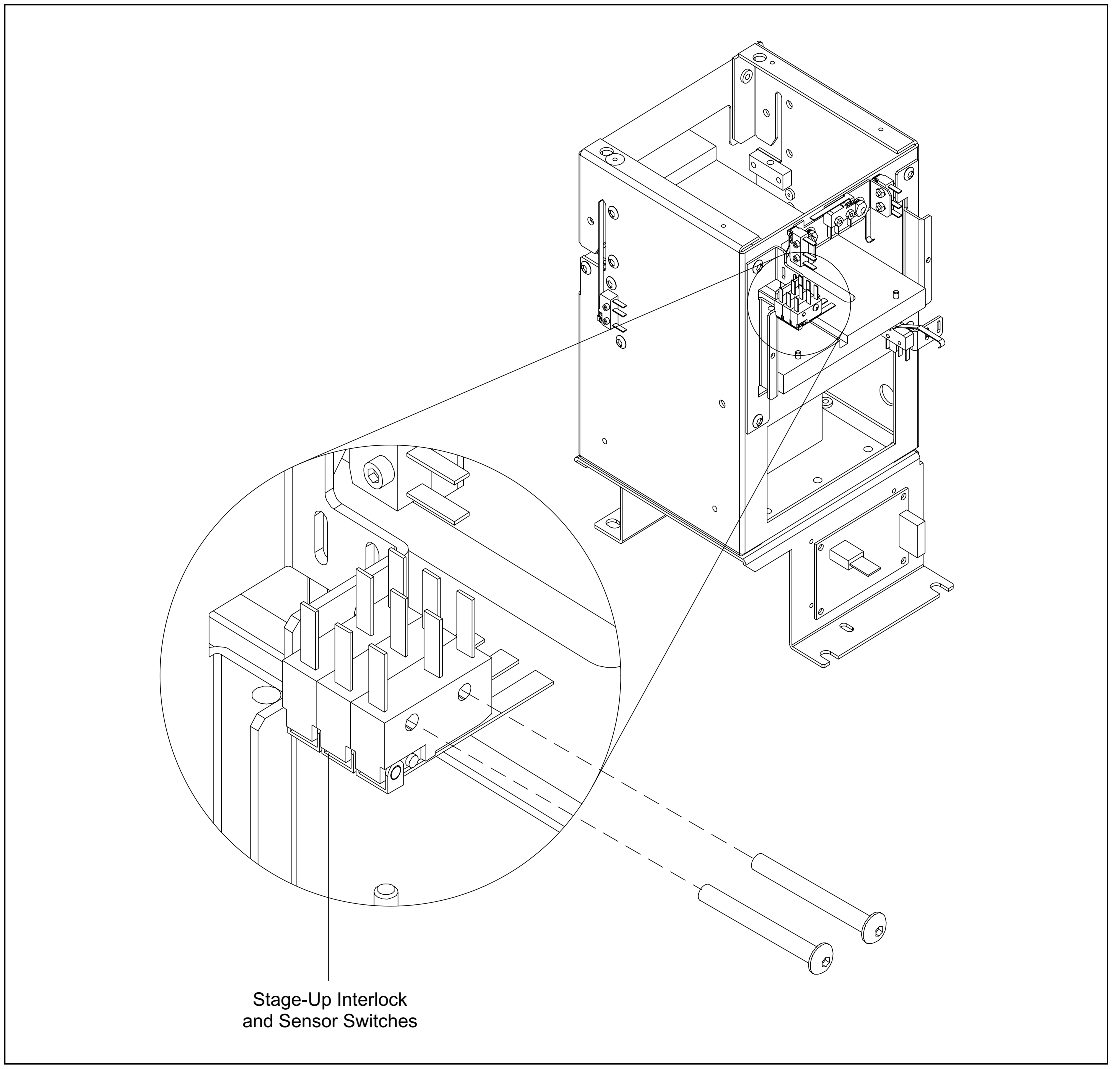



Figure 9-70. Cathode Stage-Up Interlock and Sensor Switch Mounting.

### 9.70.1 Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Disconnect the stage-up interlock and sensor switch cable from the cathode connector board.
3. Remove the two screws that secure the stage-up interlock and sensor switches to the rear of the cathode assembly.
4. Remove the stage-up interlock and sensor switches.

### 9.70.2 Installation Procedure

1. Place the stage-up interlock and sensor switches in position on the rear of the cathode assembly.
2. Install the two screws that secure the stage-up interlock and sensor switches to the rear of the cathode assembly.
3. Reconnect the stage-up interlock and sensor switch cable to the cathode connector board.
4. Install the cathode assembly (section 9.67.2).

## 9.71 Cathode Plate or Tank ID Sensor Switches

For the following procedures, see figure 9-71.

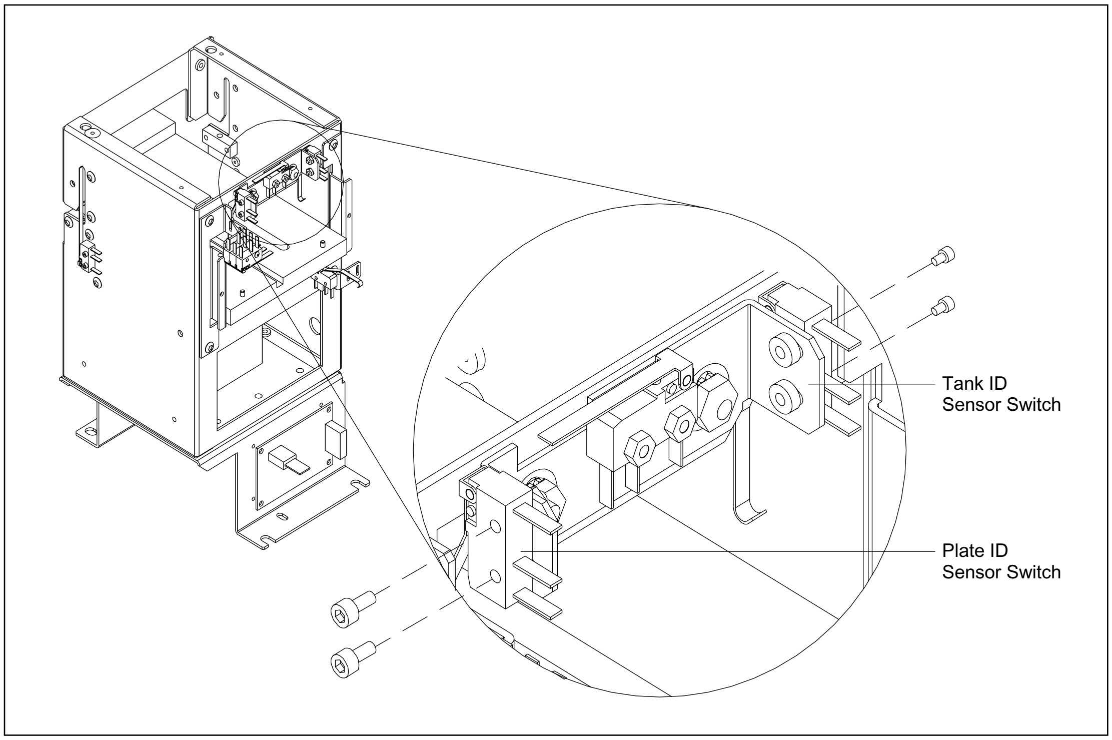



Figure 9-71. Cathode Plate and Tank ID Sensor Switches Mounting.

### 9.71.1  Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Disconnect the plate or tank ID sensor cable from the cathode connector board.
3. Remove the two screws, two nuts, and two washers that secure the plate or tank ID sensor to the rear of the cathode assembly.
4. Remove the plate or tank ID sensor.

### 9.71.2  Installation Procedure

1. Place the plate or tank ID sensor in position on the rear of the cathode assembly.
2. Install the two screws, two nuts, and two washers that secure the plate or tank ID sensor to the rear of the cathode assembly.
3. Reconnect the plate or tank ID sensor cable to the cathode connector board.
4. Install the cathode assembly (section 9.67.2).

## 9.72 Array Stage Position Sensor Switch

For the following procedures, see figure 9-74.

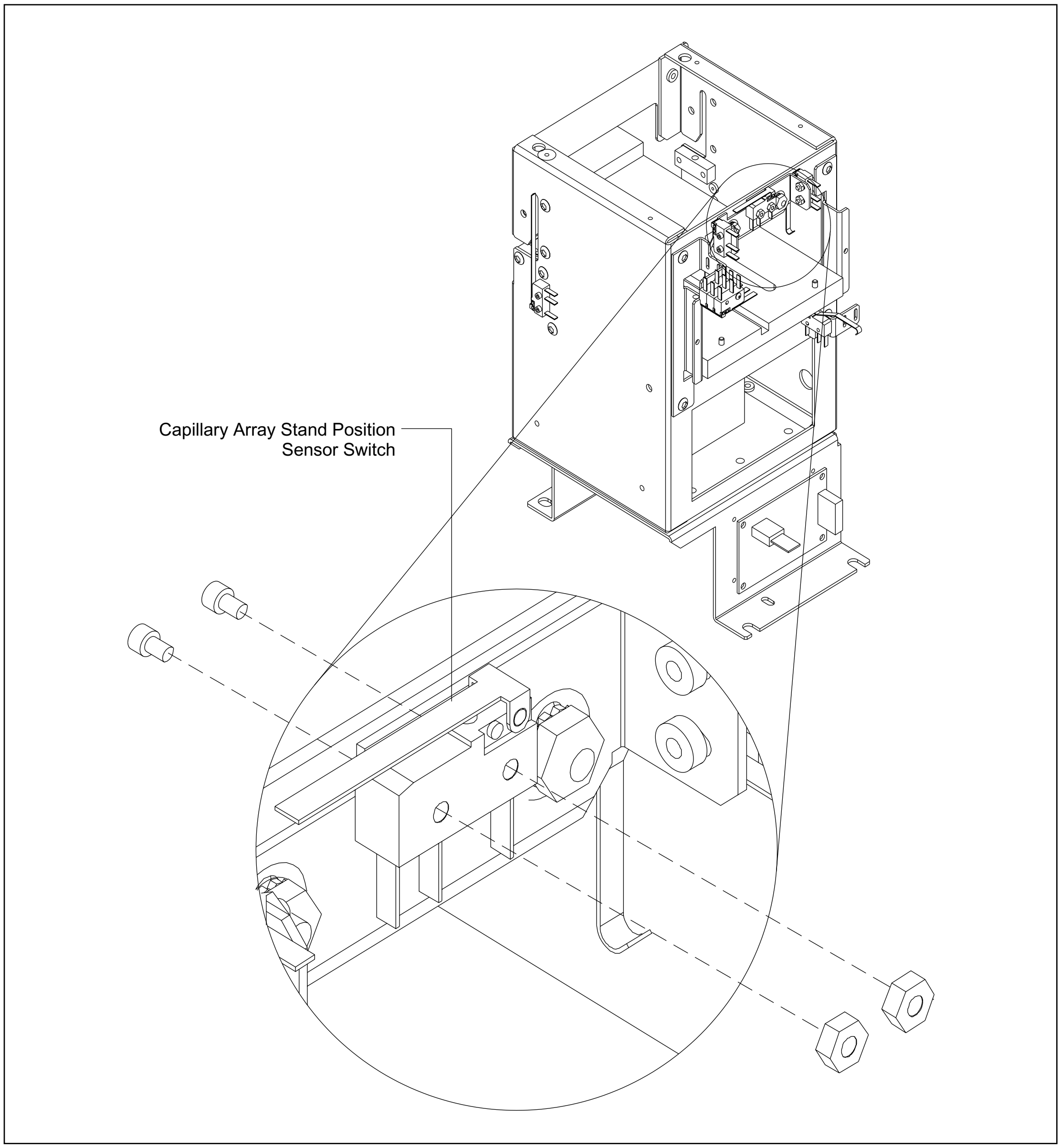



Figure 9-72. Array Stage Position Sensor Mounting.

### 9.72.1 Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Disconnect the capillary array stand position sensor cable from the cathode connector board.
3. Remove the two screws that secure the capillary array stand position sensor to the rear of the cathode assembly.
4. Remove the capillary array stand position sensor.

### 9.72.2 Installation Procedure

1. Place the capillary array stand position sensor in position on the rear of the cathode assembly.
2. Install the two screws that secure the capillary array stand position sensor to the rear of the cathode assembly.
3. Reconnect the capillary array stand position sensor cable to the cathode connector board.
4. Install the cathode assembly (section 9.67.2).

## 9.73 Cathode Stage-Down Sensor Switch

For the following procedures, see figure 9-73.

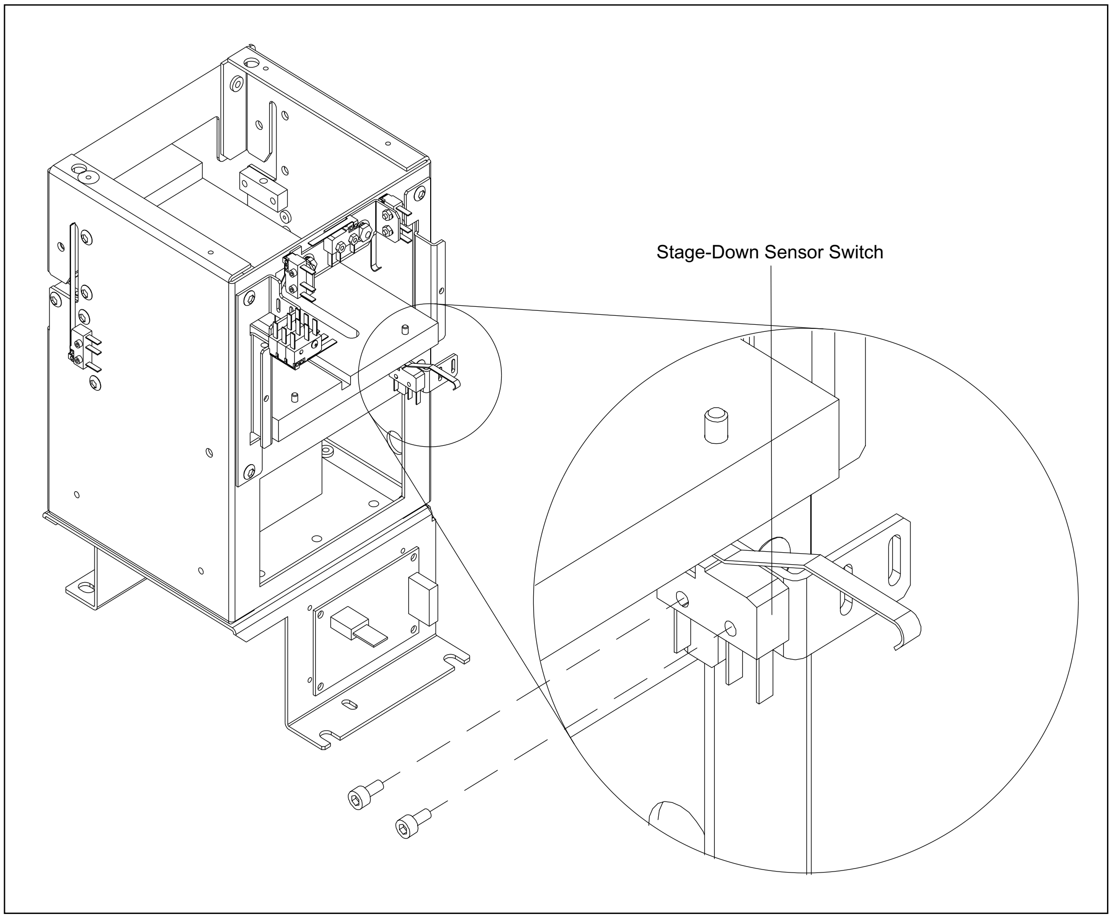



Figure 9-73. Cathode Stage-Down Sensor Switch Mounting.

### 9.73.1 Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Disconnect the stage-down sensor cable from the cathode connector board.
3. Remove the two screws that secure the stage-down sensor switch to the rear of the cathode assembly.
4. Remove the stage-down sensor switch.

### 9.73.2 Installation Procedure

1. Place the stage-down sensor switch in position on the rear of the anode assembly.
2. Install the two screws that secure the stage-down sensor switch to the rear of the cathode assembly.
3. Reconnect the stage-down sensor cable to the cathode connector board.
4. Install the cathode assembly  (figure 9.67.2).

## 9.74 Capillary Array Stage Actuator (MB 2000)

For the following procedures, see figure 9-74.

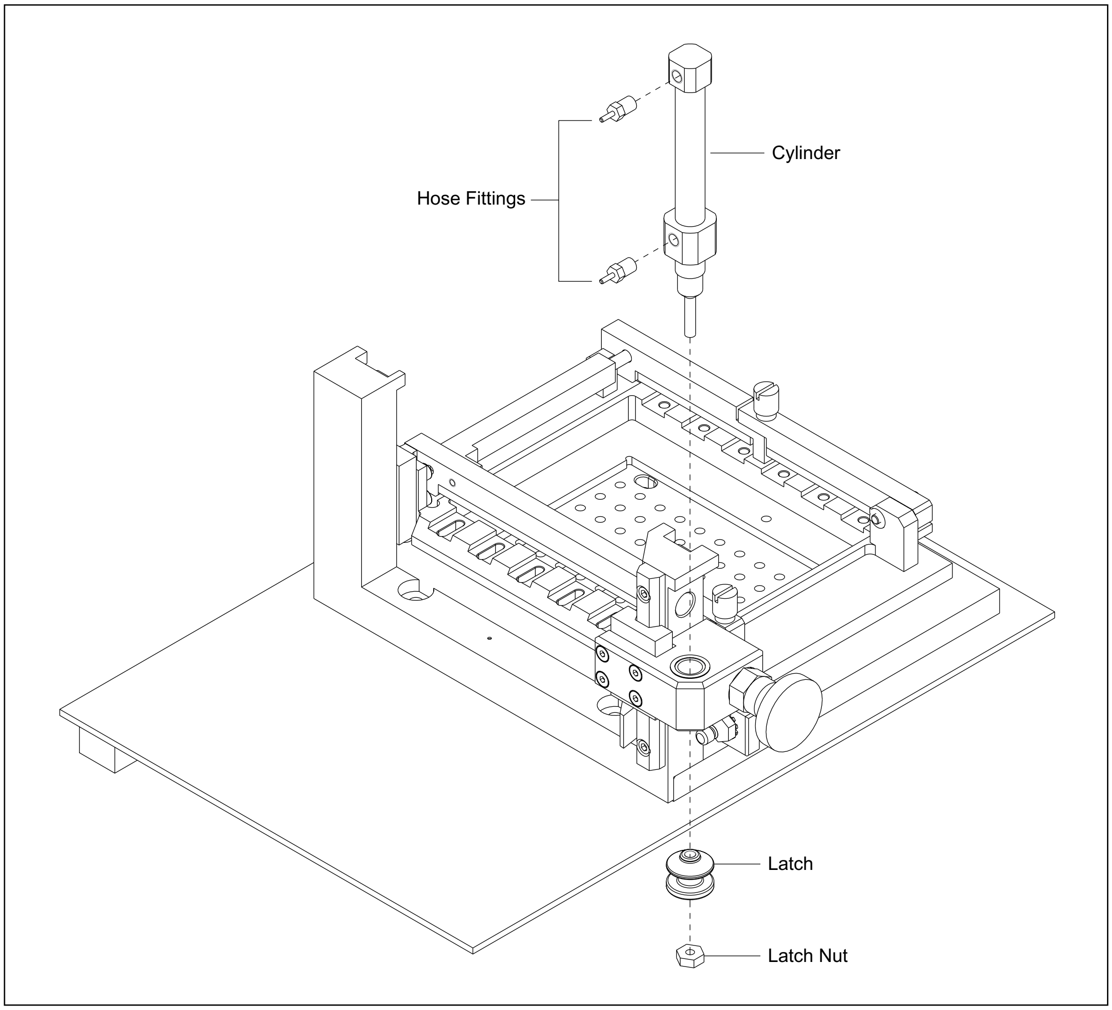



Figure 9-74. Capillary Array Stage Actuator Mounting (MB 2000).

### 9.74.1 Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Remove the two plastic hoses from the hose fittings on the cylinder.
3. Remove the latch nut from the end of the actuating piston.
4. Loosen the cylinder and unscrew the cylinder from the mounting bracket at the same time that you unscrew the latch from the actuating piston.
5. Unscrew the two hose fittings from the cylinder.

### 9.74.2 Installation Procedure

1. Screw the two hose fittings into the new cylinder.
2. Screw the cylinder into the mounting bracket at the same time that you screw the latch onto the actuating piston.
3. Install the latch nut on the end of the actuating piston.
4. Install the two small clear hoses onto the rear cylinder hose fitting.
5. Install the cathode assembly (section 9.67.2).

## 9.75 Indexer Y-Position Sensors (MB 2000)

For the following procedures, see figure 9-75.

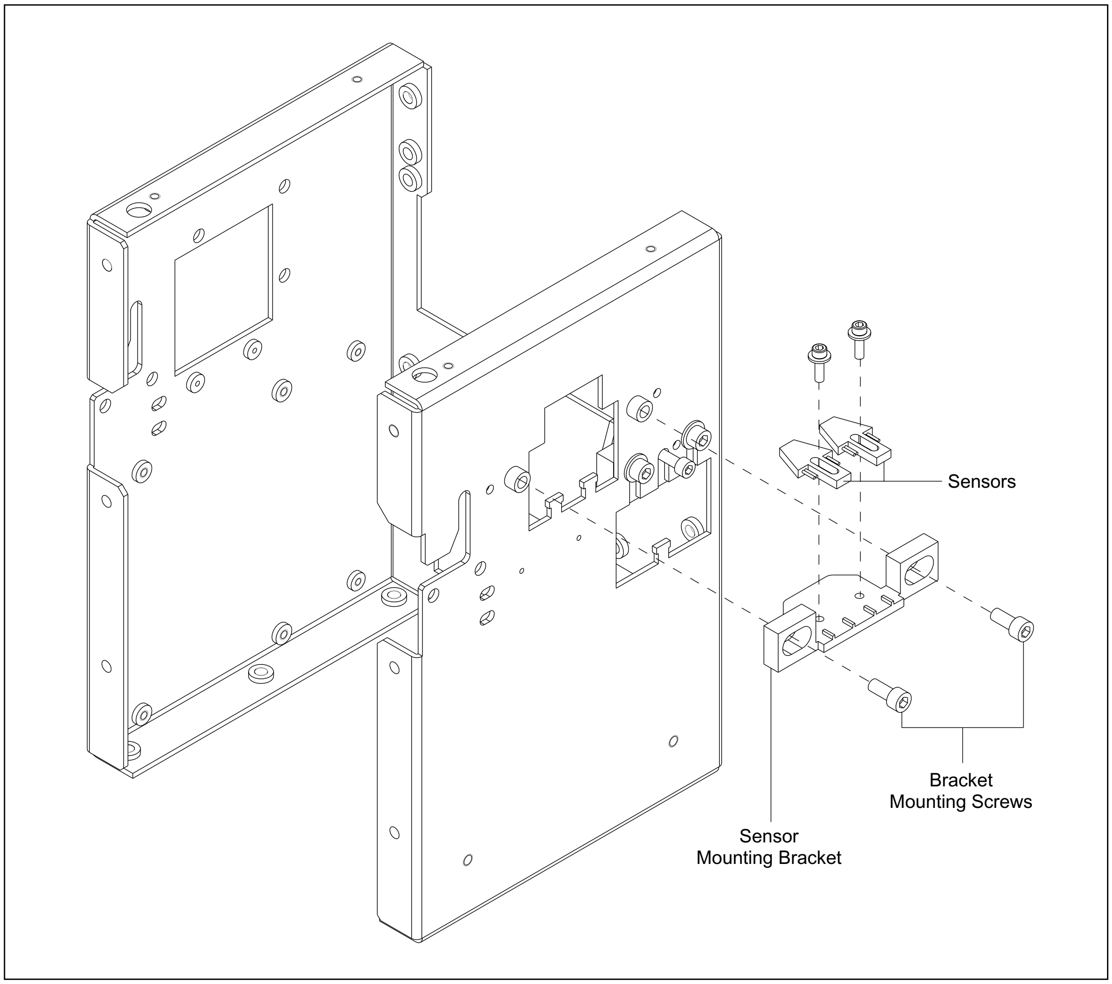



Figure 9-75. Indexer Y-Position Sensor Mounting (MB 2000).

### 9.75.1 Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Disconnect the y-position sensor cables from the cathode connector board.
3. Remove the two screws that secure the sensor mounting bracket to the side of the cathode assembly.
4. Remove the screws that secure the sensors to the sensor mounting bracket.

### 9.75.2 Installation Procedure

1. Place the sensors in position on the sensor mounting bracket.
2. Install the two screws that secure the sensor mounting bracket to the side of the cathode assembly.
3. Reconnect the y-position sensor cables to the cathode connector board.
4. Adjust the sensors for proper operation (section 8.8).
5. Install the cathode assembly (section 9.67.2).

## 9.76 Indexer X-Position Sensors (MB 2000)

For the following procedures, see figure 9-76.

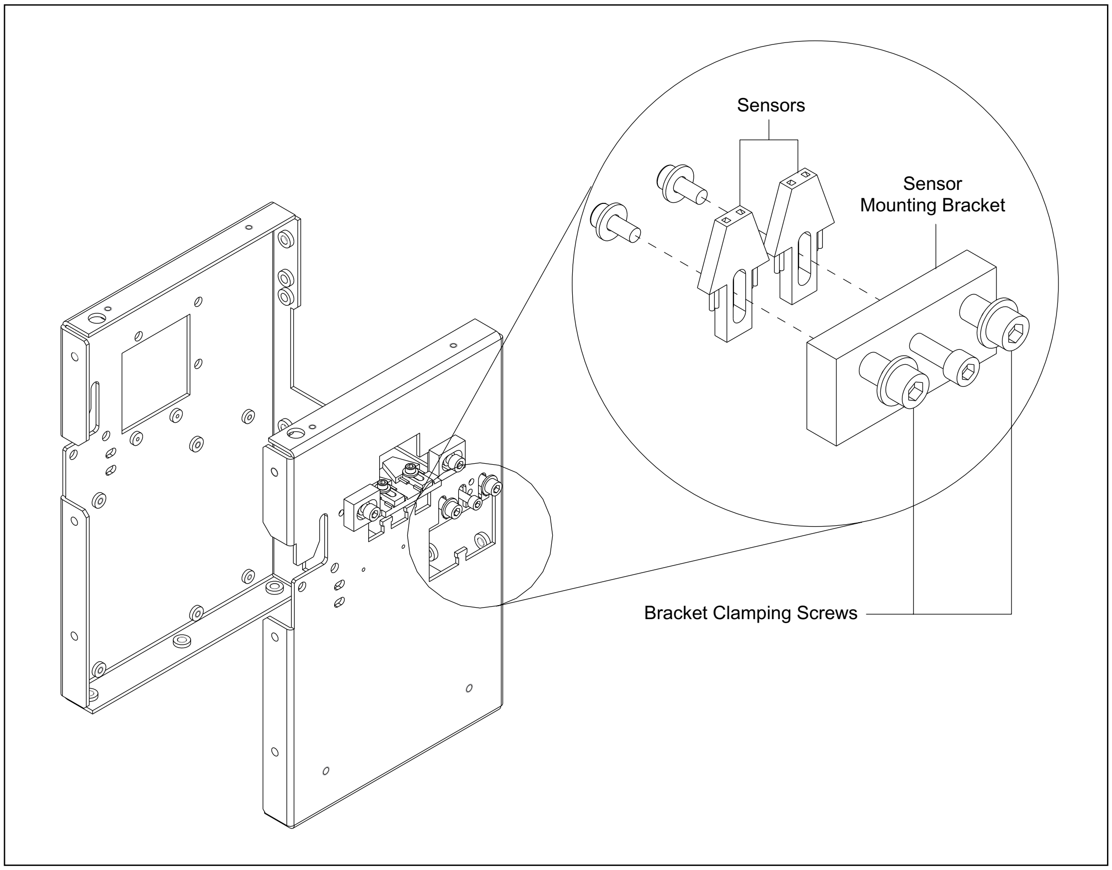



Figure 9-76. Indexer X-Position Sensor Mounting (MB 2000).

### 9.76.1 Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Disconnect the x-position sensor cables from the cathode connector board.
3. Loosen the two bracket clamping screws that secure the bracket to the side of the cathode assembly.
4. Grasp the sensor mounting bracket by the single screw in the center of the bracket and lower the bracket and sensors until they clear the access hole and pull the sensor bracket clear.
5. Remove the screws that secure the sensors to the sensor mounting bracket.

### 9.76.2 Installation Procedure

1. Place the sensors in position on the sensor mounting bracket and install the screws that secure the sensors to the bracket.
2. Grasp the sensor mounting bracket by the single screw in the center of the bracket and maneuver the bracket and sensors into position.
3. Tighten the two screws that secure the sensor mounting bracket to the side of the cathode assembly.
4. Reconnect the x-position sensor cables to the cathode connector board.
5. Adjust the sensors for proper operation (section 8.8).
6. Install the cathode assembly (section 9.67.2).

## 9.77 Indexer Y-Position Actuator (MB 2000)

For the following procedures, see figure 9-77.

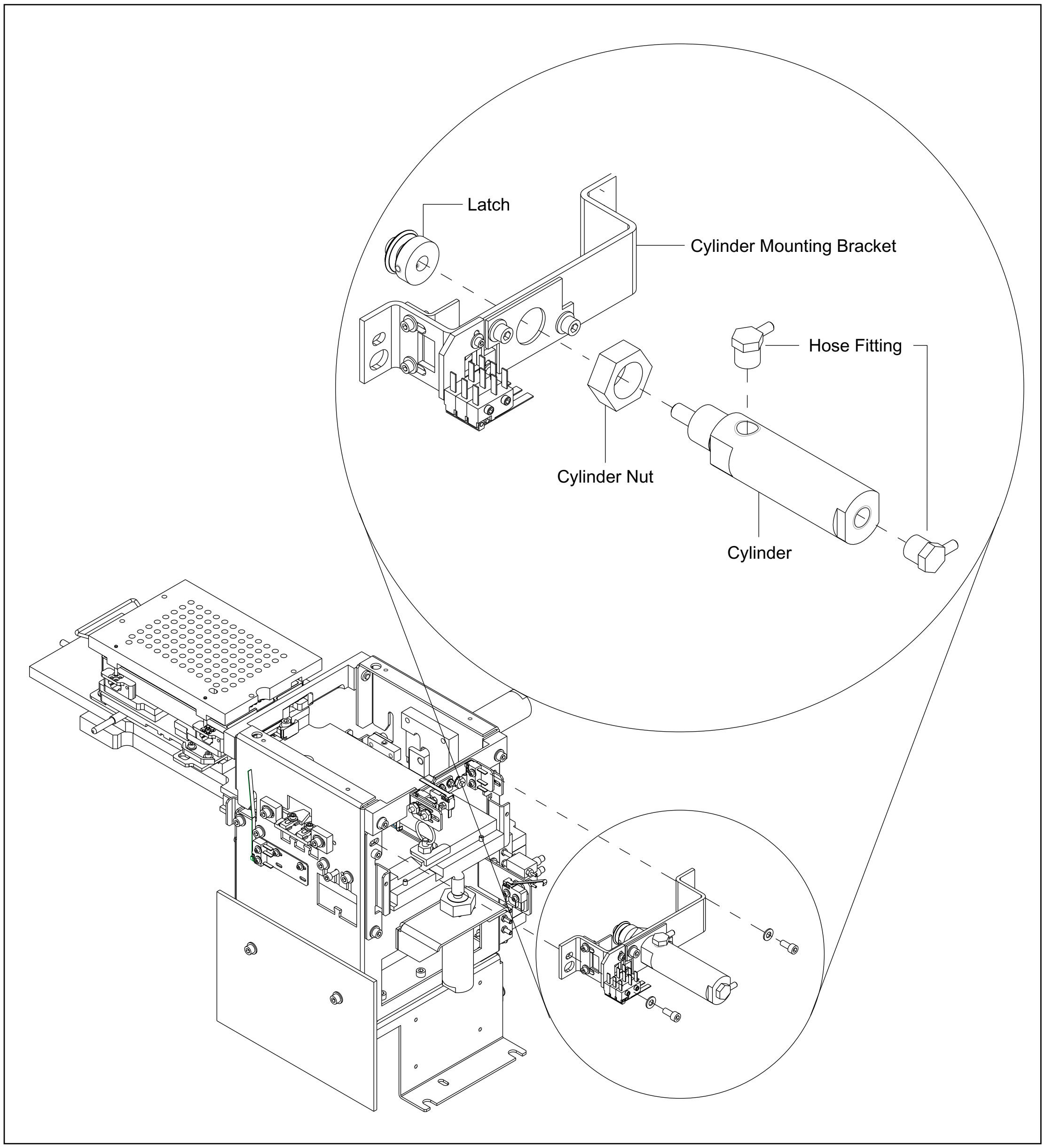



Figure 9-77. Indexer Y-Position Actuator Mounting (MB 2000).

### 9.77.1 Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Remove the two plastic hoses from the hose fittings on the cylinder.
3. Remove the two screws that secure the cylinder mounting bracket to the rear of the cathode assembly.
4. Loosen the two setscrews that secure the latch to the actuating piston and unscrew the latch.
5. Loosen the cylinder nut from the cylinder and pull the cylinder from the mounting bracket.
6. Unscrew the two hose fittings from the cylinder and strip the old Teflon™ tape from the fittings.

### 9.77.2 Installation Procedure

1. Wrap the threads of the two hose fittings with Teflon tape and screw the fittings into the new cylinder.
2. Place the end of the cylinder through the bracket access hole and install the cylinder nut and tighten the cylinder nut against the bracket.
3. Install the yellow hose onto the rear cylinder hose fitting.
4. Install the pink hose onto the front cylinder hose fitting.
5. Screw the latch onto the end of the actuating piston and tighten the two setscrews.
6. Install the two screws that secure the cylinder mounting bracket to the rear of the cathode assembly.
7. Install the cathode assembly (section 9.67.2).

## 9.78  Indexer Y-Position Lock Sensor (MB 2000)

For the following procedures, see figure 9-78.

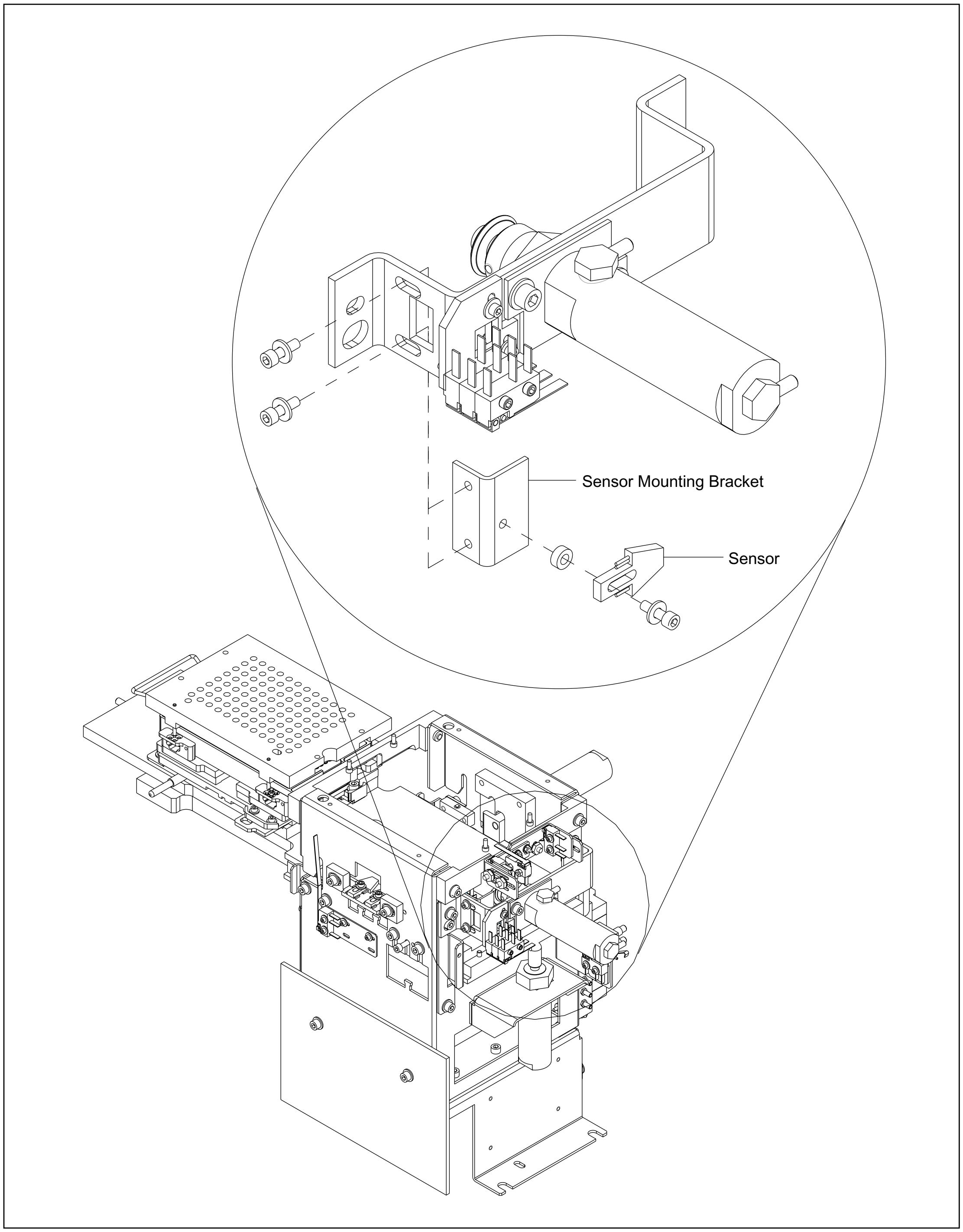



Figure 9-78.  Indexer Y-Position Lock Sensor Mounting (MB 2000).

### 9.78.1 Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Remove the two screws that secure the cylinder mounting bracket to the rear of the cathode assembly.
3. Remove the two screws that secure the sensor mounting bracket to the cylinder mounting bracket.
4. Remove the single screw that secures the sensor to the sensor mounting bracket.

### 9.78.2 Installation Procedure

1. Place the new sensor in position and install the single screw that secures the sensor to the sensor mounting bracket.
2. Place the sensor mounting bracket in position on the cylinder mounting bracket and install the two screws that secure the sensor mounting bracket.
3. Install the two screws that secure the cylinder mounting bracket to the rear of the cathode assembly.
4. Adjust the sensor for proper operation.
5. Install the cathode assembly (section 9.67.2).

## 9.79 Indexer X-Position Actuator (MB 2000)

For the following procedures, see figure 9-79.

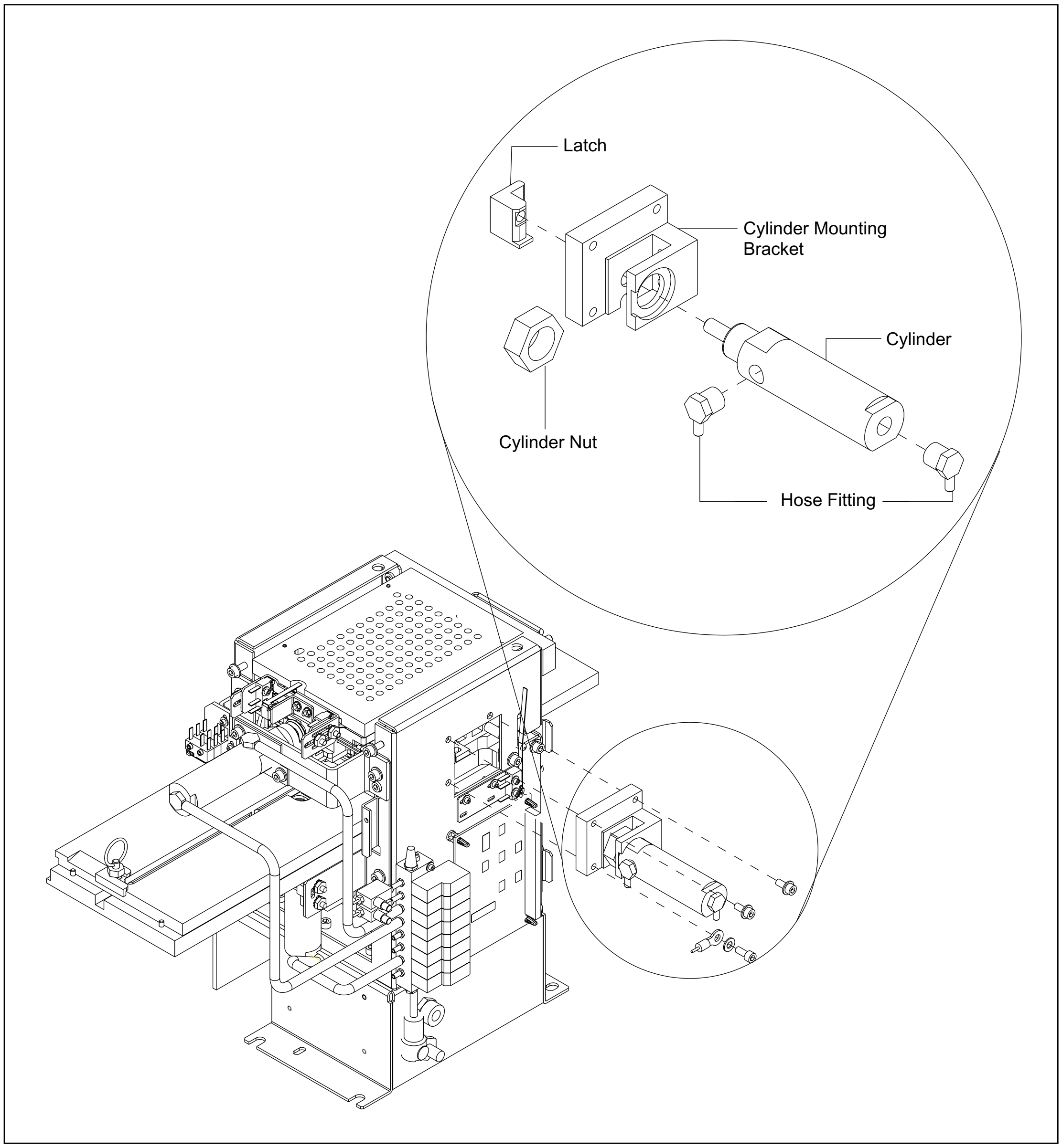



Figure 9-79. Indexer X-Position Actuator Mounting (MB 2000).

### 9.79.1 Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Remove the two plastic hoses from the hose fittings on the cylinder.
3. Remove the three screws that secure the cylinder mounting bracket to the side of the cathode assembly and remove the cylinder and mounting bracket.
4. Loosen the cylinder nut and turn the cylinder counterclockwise to unscrew the actuating piston from the latch and cylinder nut and pull the cylinder from the mounting bracket.
5. Unscrew the two hose fittings from the cylinder and strip the old Teflon tape from the fittings.

### 9.79.2 Installation Procedure

1. Wrap the threads of the two hose fittings with Teflon tape and screw the fittings into the new cylinder.
2. Place the end of the cylinder through the bracket access hole and install the cylinder nut. Put the latch in position on the end of the actuating piston and turn the cylinder clockwise to tighten the latch and cylinder nut.
3. Install the green hose onto the rear cylinder hose fitting.
4. Install the purple hose onto the front cylinder hose fitting.
5. Position the cylinder mounting bracket through the access hole in the side of the cathode and install the three screws that secure the bracket.
6. Install the cathode assembly (section 9.67.2).

## 9.80 Slide Assembly Lock Actuator (MB 2000)

For the following procedures, see figure 9-80.

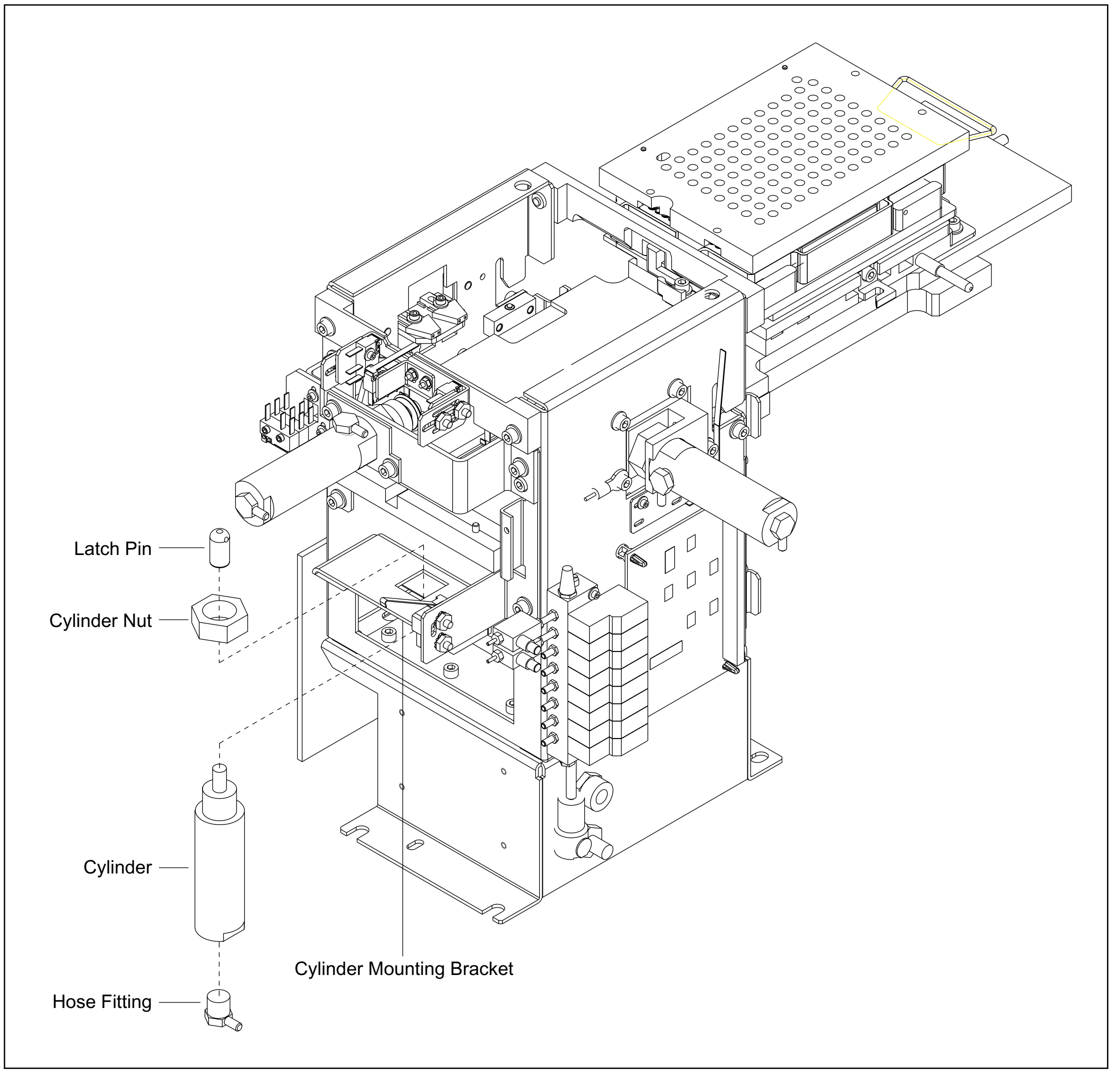



Figure 9-80. Slide Assembly Lock Actuator Mounting (MB 2000).

### 9.80.1 Removal Procedure

1. Remove the cathode assembly (section 9.67.1).
2. Remove the plastic hose from the hose fitting on the cylinder.
3. Loosen and remove the cylinder nut and remove the cylinder from the mounting bracket.
4. Unscrew the latch pin from the end of the actuating piston.
5. Unscrew the hose fitting from the cylinder and strip the old Teflon tape from the fitting.

### 9.80.2 Installation Procedure

1. Wrap the threads of the hose fitting with Teflon tape and screw the fitting into the new cylinder.
2. Screw the latch pin onto the end of the actuating piston.
3. Place the end of the cylinder through the bracket access hole and install the cylinder nut. Use a wrench to secure the cylinder nut against the mounting bracket.
4. Install the orange hose onto the cylinder hose fitting.
5. Install the cathode assembly (section 9.67.2).

## 9.81 Anode Assembly

For the following procedures, see figure 9-81.

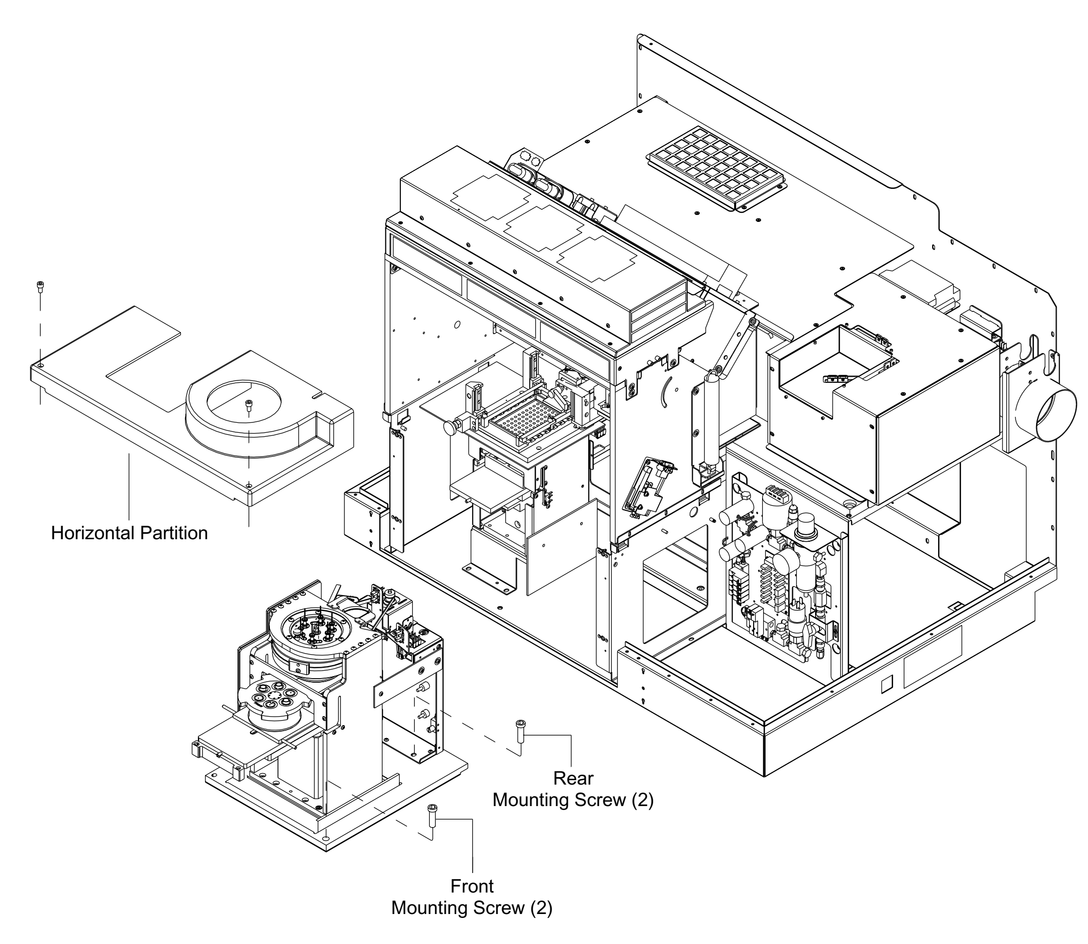



Figure 9-81. Anode Assembly Mounting.

### 9.81.1 Removal Procedure

1. Open the service door.
2. Remove and properly store the capillary arrays.
3. Remove the front panel assembly (section 9.9.1).
4. Remove the two screws that secure the horizontal partition and remove the partition.
5. Disconnect the high-voltage cables from the anode assembly.
6. At the pneumatic manifold assembly, remove the anode high-pressure connection.
7. From the rear of the anode assembly, remove the pneumatic connections.
8. Remove the four screws that secure the anode assembly to the sheet-metal chassis.
9. Carefully slide the anode assembly forward out of the electrophoresis chamber assembly.

### 9.81.2 Installation Procedure

1. Place the anode assembly in position and install the four screws that secure the anode assembly to the sheet-metal chassis.
2. From the rear of the anode assembly, install the pneumatic connections.
3. Reconnect the high-voltage cables to the anode assembly.
4. Place the horizontal partition in position and install the two screws that secure the horizontal partition to the front of the electrophoresis chamber assembly.
5. Install the front panel assembly (section 9.9.2).
6. Install the capillary arrays.
7. Close the service door.

## 9.82 Anode Cover

For the following procedure, see figure 9-82.

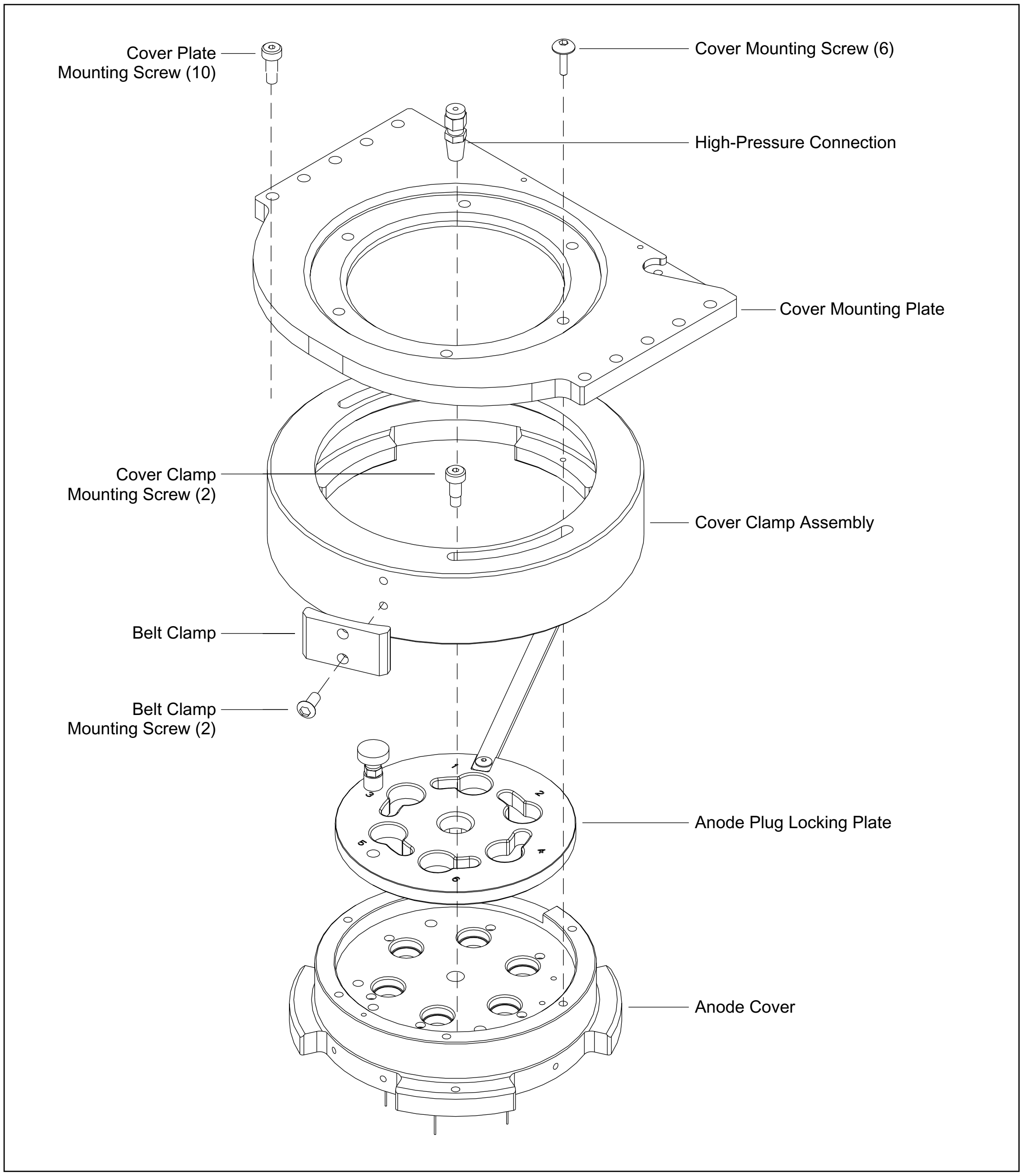



Figure 9-82. Anode Cover Mounting.

### 9.82.1 Removal Procedure

1. Remove the two screws that secure the horizontal partition and remove the partition.
2. Remove the high-pressure connector from the top of the anode cover assembly.
3. Remove the two screws that secure the belt clamp to the cover clamp assembly.
4. Remove the ten screws that secure the cover mounting plate to the anode assembly.

*CAUTION* **When lifting the cover assembly from the anode assembly, be very careful not to damage the platinum electrodes that extend from the bottom of the cover assembly.**

5. Carefully lift the cover assembly with attached mounting plate and place on a flat surface.
6. Remove the six screws that secure the cover assembly to the cover mounting plate.
7. Remove the two shouldered screws that secure the cover clamp assembly and plug locking plate to the anode cover.

### 9.82.2 Installation Procedure

1. Assemble the anode cover, plug locking plate, and cover clamp, and install the two shouldered screws that secure the cover clamp assembly and plug locking plate to the anode cover.
2. Install the six screws that secure the cover assembly to the cover mounting plate.

*CAUTION* **When positioning the cover assembly onto the anode assembly, be very careful not to damage the platinum electrodes that extend from the bottom of the cover assembly.**

3. Carefully lift the cover assembly with attached mounting plate and put into position on the anode assembly.
4. Install the ten screws that secure the cover mounting plate to the anode assembly.
5. Position the cover clamp drive belt and install the two screws that secure the belt clamp to the cover clamp assembly.
6. Install the high-pressure connector to the top of the anode cover assembly.
7. Position the horizontal partition and install the two screws that secure the horizontal partition.

## 9.83 Anode Left Slide-In Optical Sensor

For the following procedures, see figure 9-83.

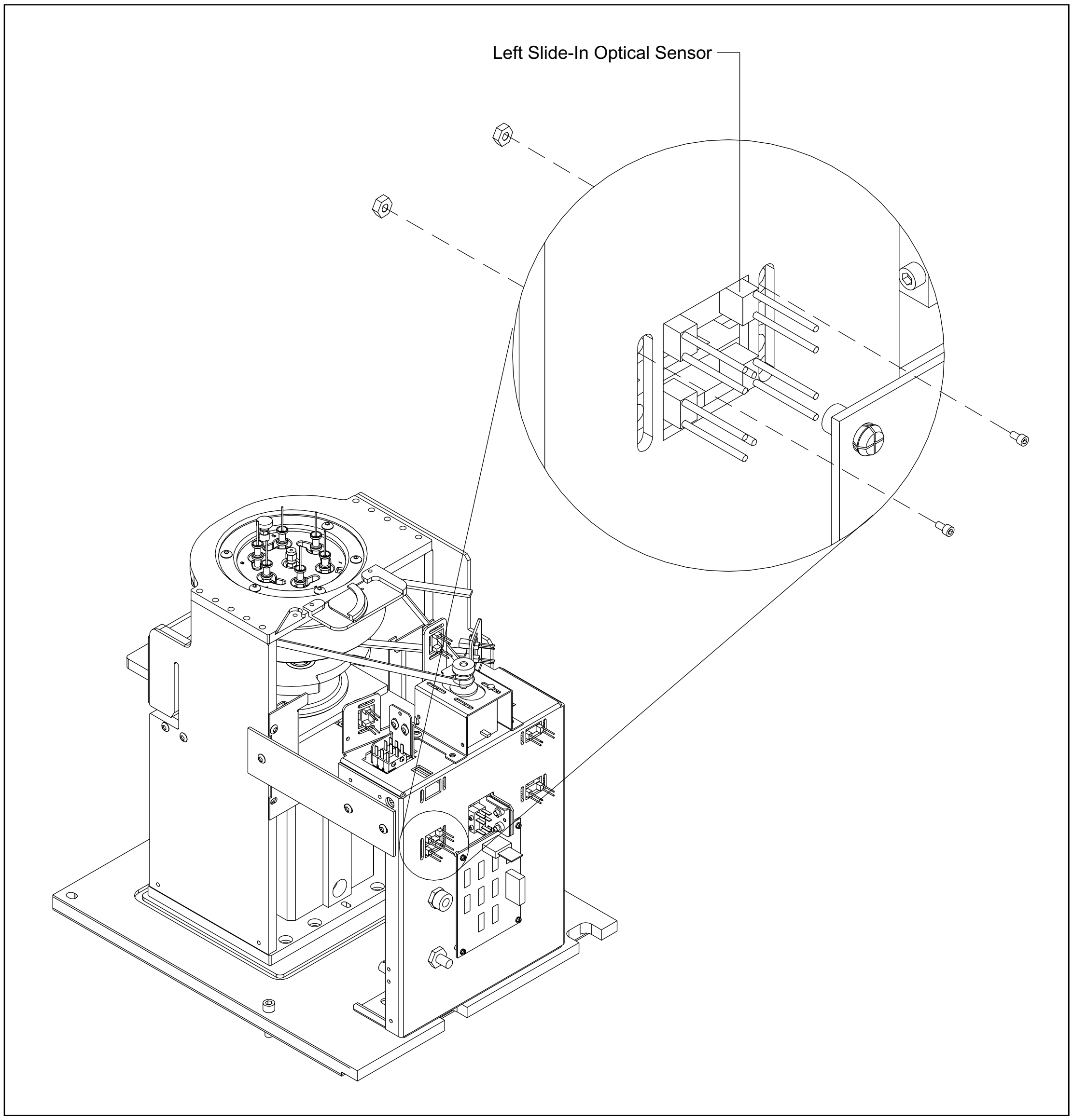



Figure 9-83. Anode Left Slide-In Sensor Mounting.

### 9.83.1 Removal Procedure

1. Remove the anode assembly (section 9.81.1).
2. Disconnect the left slide-in optical sensor cable from the anode connector board.
3. Remove the two screws that secure the left slide-in optical sensor to the rear of the anode assembly.
4. Remove the left slide-in optical sensor.

### 9.83.2 Installation Procedure

1. Place the left slide-in optical sensor in position on the rear of the anode assembly.
2. Install the two screws that secure the left slide-in optical sensor to the rear of the anode assembly.
3. Reconnect the left slide-in optical sensor cable to the anode connector board.
4. Install the anode assembly (section 9.81.2).

## 9.84 Anode Right Slide-In Optical Sensor

For the following procedures, see figure 9-84.

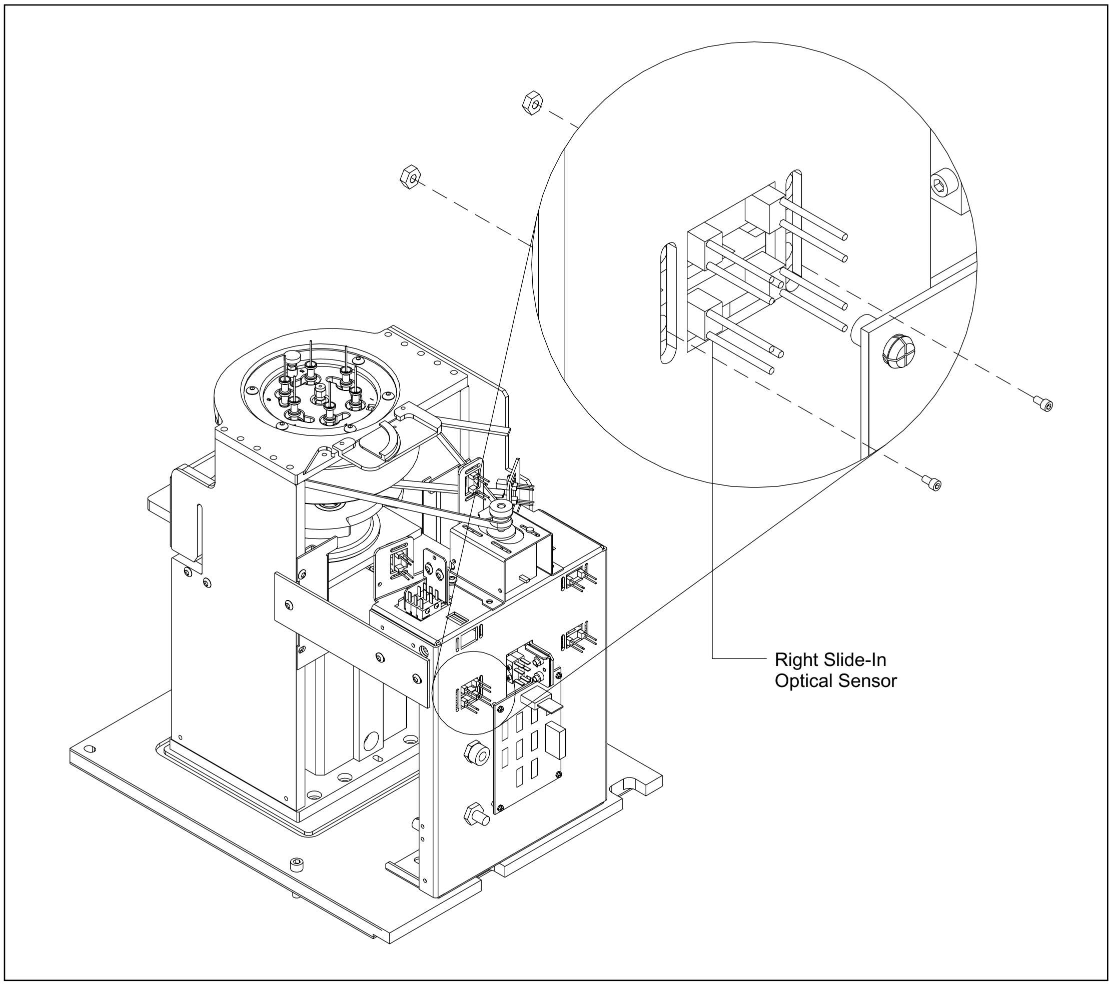



Figure 9-84. Anode Right Slide-In Optical Sensor Mounting.

### 9.84.1 Removal Procedure

1. Remove the anode assembly (section 9.81.1).
2. Disconnect the right slide-in optical sensor cable from the anode connector board.
3. Remove the two screws, two nuts, and two washers that secure the right slide-in optical sensor to the rear of the anode assembly.
4. Remove the right slide-in optical sensor.

### 9.84.2 Installation Procedure

1. Place the right slide-in optical sensor in position on the rear of the anode assembly.
2. Install the two screws, two nuts, and two washers that secure the right slide-in optical sensor to the rear of the anode assembly.
3. Reconnect the right slide-in optical sensor cable to the anode connector board.
4. Install the anode assembly (section 9.81.2).

## 9.85 Anode Stage-Up Interlock and Sensor Switches

For the following procedures, see figure 9-85.

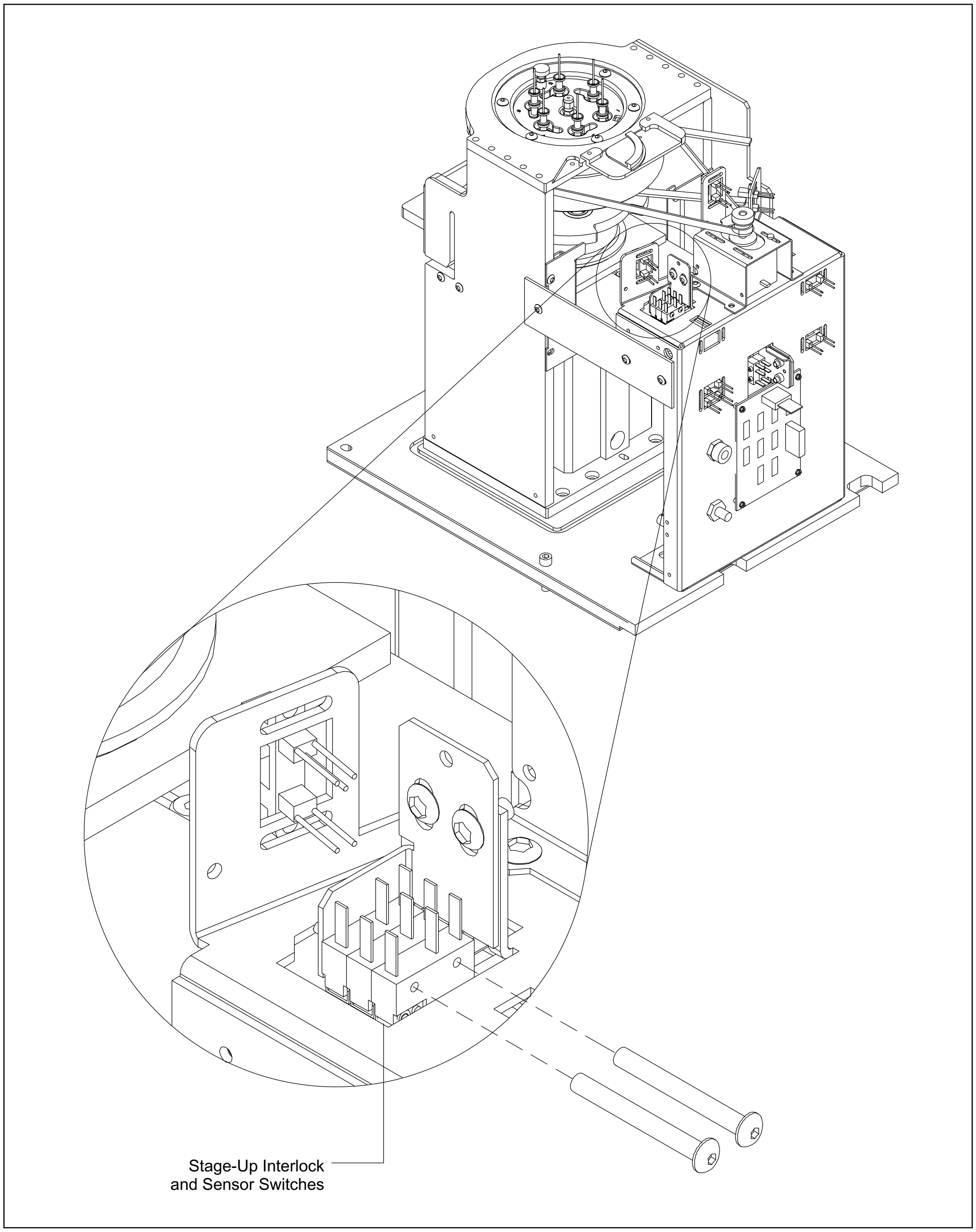



Figure 9-85. Anode Stage-Up Interlock and Sensor Switch Mounting.

### 9.85.1 Removal Procedure

1. Remove the anode assembly (section 9.81.1).
2. Disconnect the stage-up interlock and sensor switch cable from the anode connector board.
3. Remove the two screws that secure the stage-up interlock and sensor switches to the rear of the anode assembly.
4. Remove the stage-up interlock and sensor switches.

### 9.85.2 Installation Procedure

1. Place the stage-up interlock and sensor switches in position on the rear of the anode assembly.
2. Install the two screws that secure the stage-up interlock and sensor switches to the rear of the anode assembly.
3. Reconnect the stage-up interlock and sensor switch cable to the anode connector board.
4. Install the anode assembly (section 9.81.2).

## 9.86 Cover Clamp-Locked Optical Sensor

For the following procedures, see figure 9-86.

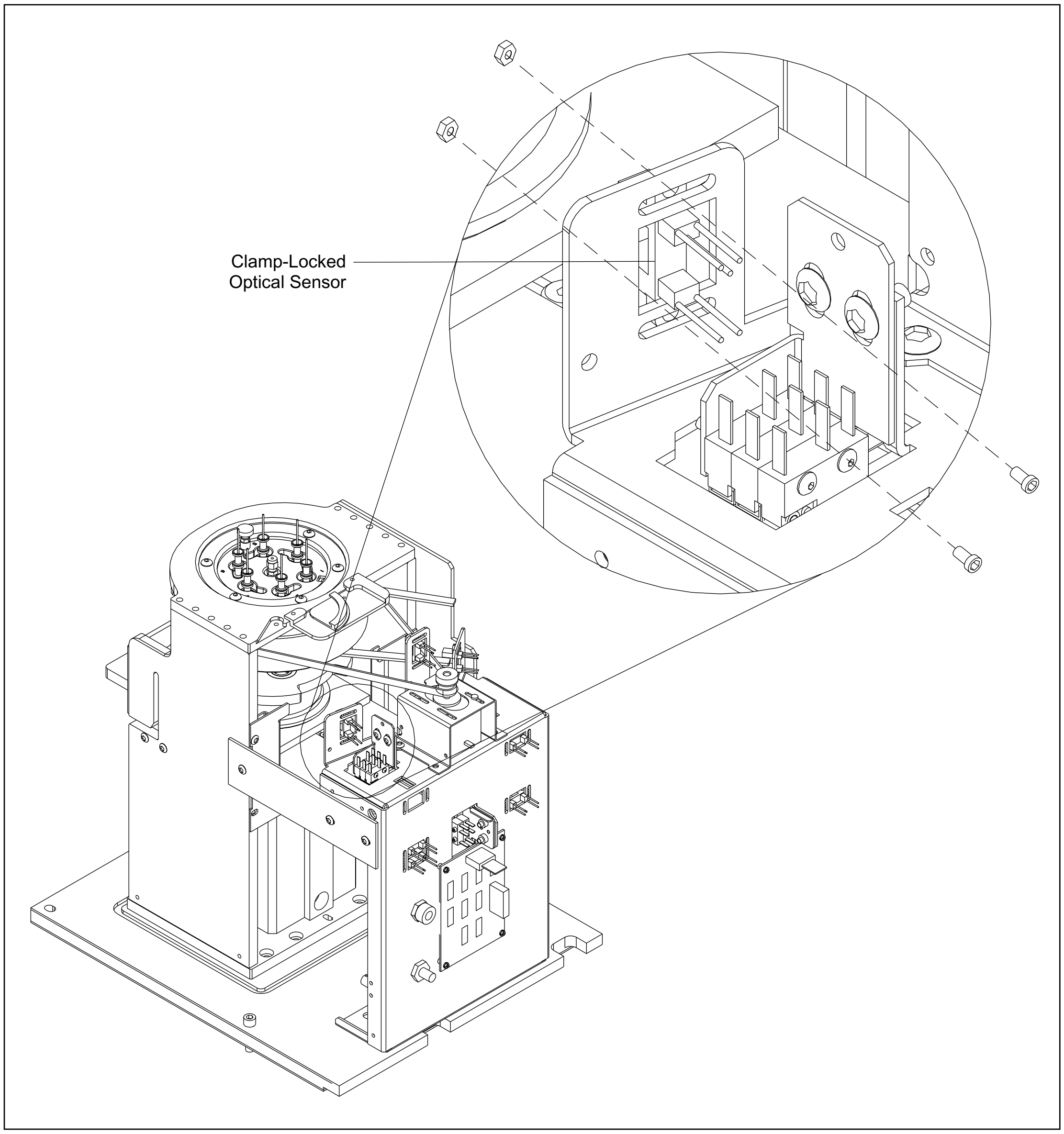



Figure 9-86. Anode Cover Clamp-Locked Optical Sensor Mounting.

### 9.86.1 Removal Procedure

1. Remove the anode assembly (section 9.81.1).
2. Disconnect the cover clamp-locked optical sensor cable from the anode connector board.
3. Remove the two screws, two nuts, and two washers that secure the cover clamp-locked optical sensor to the rear of the anode assembly.
4. Remove the cover clamp-locked optical sensor.

### 9.86.2 Installation Procedure

1. Place the cover clamp-locked optical sensor in position on the rear of the anode assembly.
2. Install the two screws, two nuts, and two washers that secure the cover clamp-locked optical sensor to the rear of the anode assembly.
3. Reconnect the cover clamp-locked optical sensor cable to the anode connector board.
4. Install the anode assembly (section 9.81.2).

## 9.87 Cover Clamp-Unlocked Optical Sensor

For the following procedures, see figure 9-87.

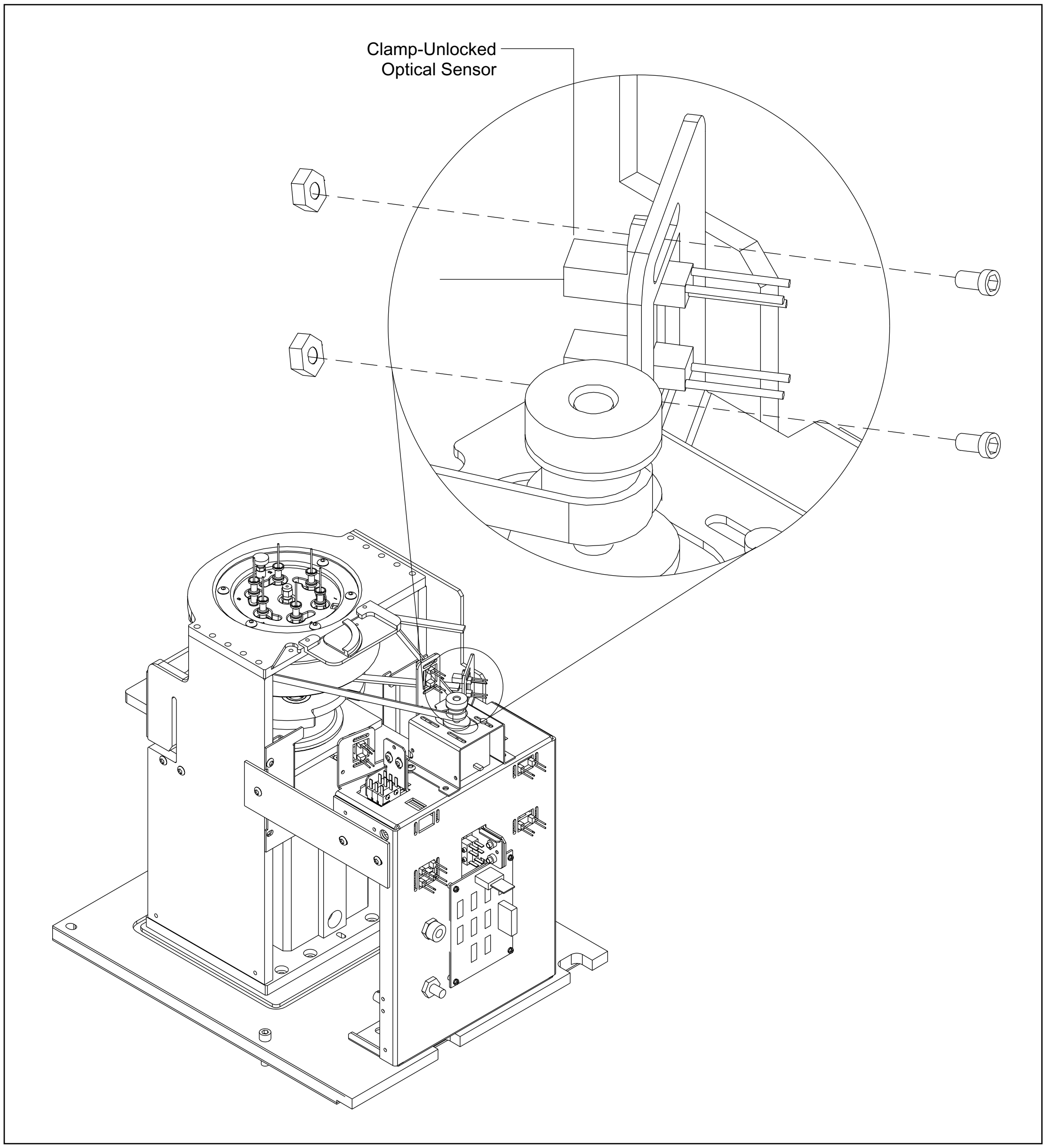



Figure 9-87. Anode Cover Clamp-Unlocked Optical Sensor Mounting.

### 9.87.1 Removal Procedure

1. Remove the anode assembly (section 9.81.1).
2. Disconnect the cover clamp-unlocked optical sensor cable from the anode connector board.
3. Remove the two screws, two nuts, and two washers that secure the cover clamp-unlocked optical sensor to the rear of the anode assembly.
4. Remove the cover clamp-unlocked optical sensor.

### 9.87.2 Installation Procedure

1. Place the cover clamp-unlocked optical sensor in position on the rear of the anode assembly.
2. Install the two screws, two nuts, and two washers that secure the cover clamp-unlocked optical sensor to the rear of the anode assembly.
3. Reconnect the cover clamp-unlocked optical sensor cable to the anode connector board.
4. Install the anode assembly (section 9.81.2).

## 9.88 Anode Plug-Lock Optical Sensor

For the following procedures, see figure 9-88.

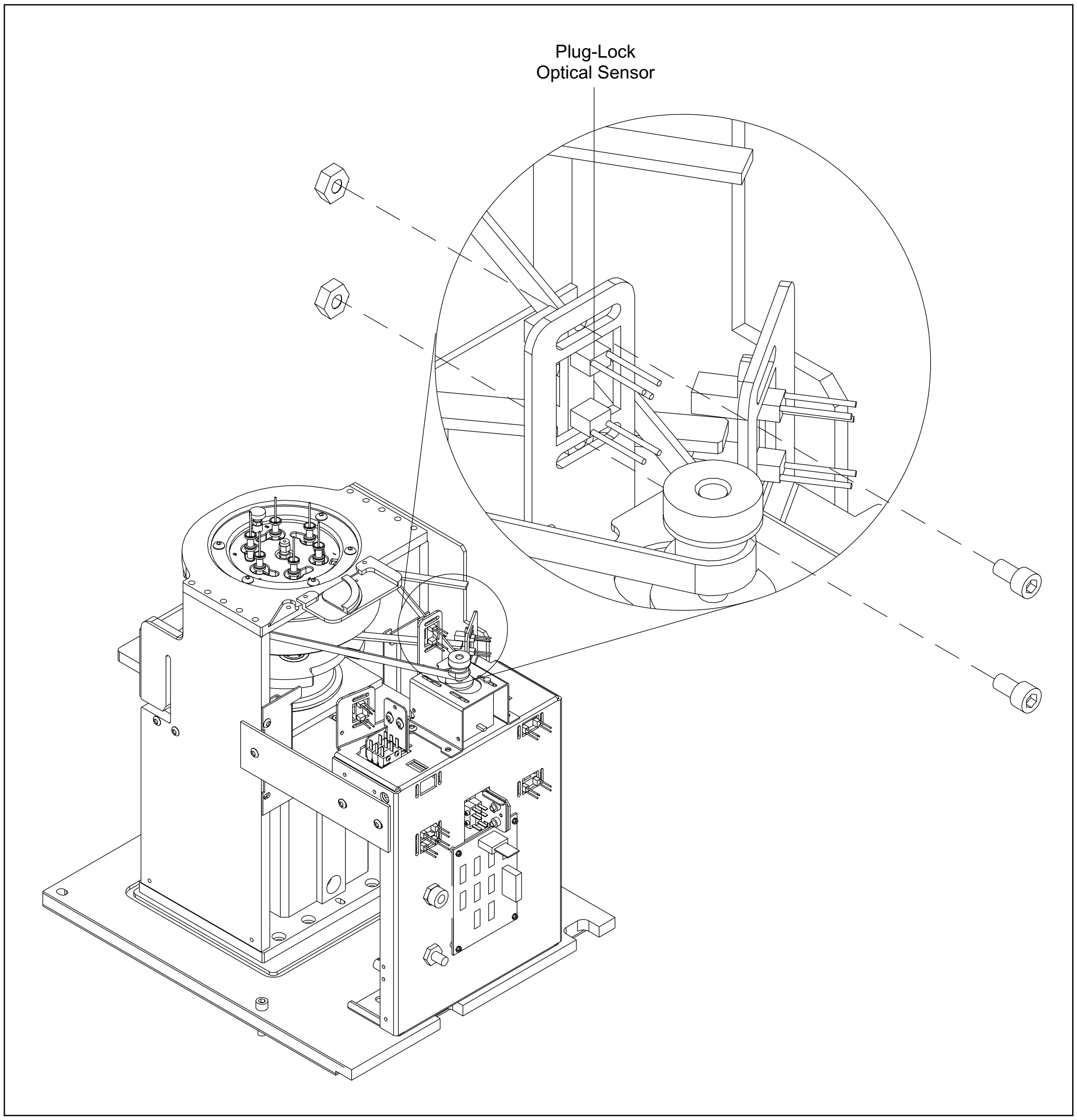



Figure 9-88. Anode Plug-Lock Optical Sensor Mounting.

### 9.88.1 Removal Procedure

1. Remove the anode assembly (section 9.81.1).
2. Disconnect the plug-lock optical sensor cable from the anode connector board.
3. Remove the two screws, two nuts, and two washers that secure the plug-lock optical sensor to the rear of the anode assembly.
4. Remove the plug-lock optical sensor.

### 9.88.2 Installation Procedure

1. Place the plug-lock optical sensor in position on the rear of the anode assembly.
2. Install the two screws, two nuts, and two washers that secure the plug-lock optical sensor to the rear of the anode assembly.
3. Reconnect the plug-lock optical sensor cable to the anode connector board.
4. Install the anode assembly (section 9.81.2).

## 9.89 Anode Slide-In Interlock and Sensor Switches

For the following procedures, see figure 9-89.

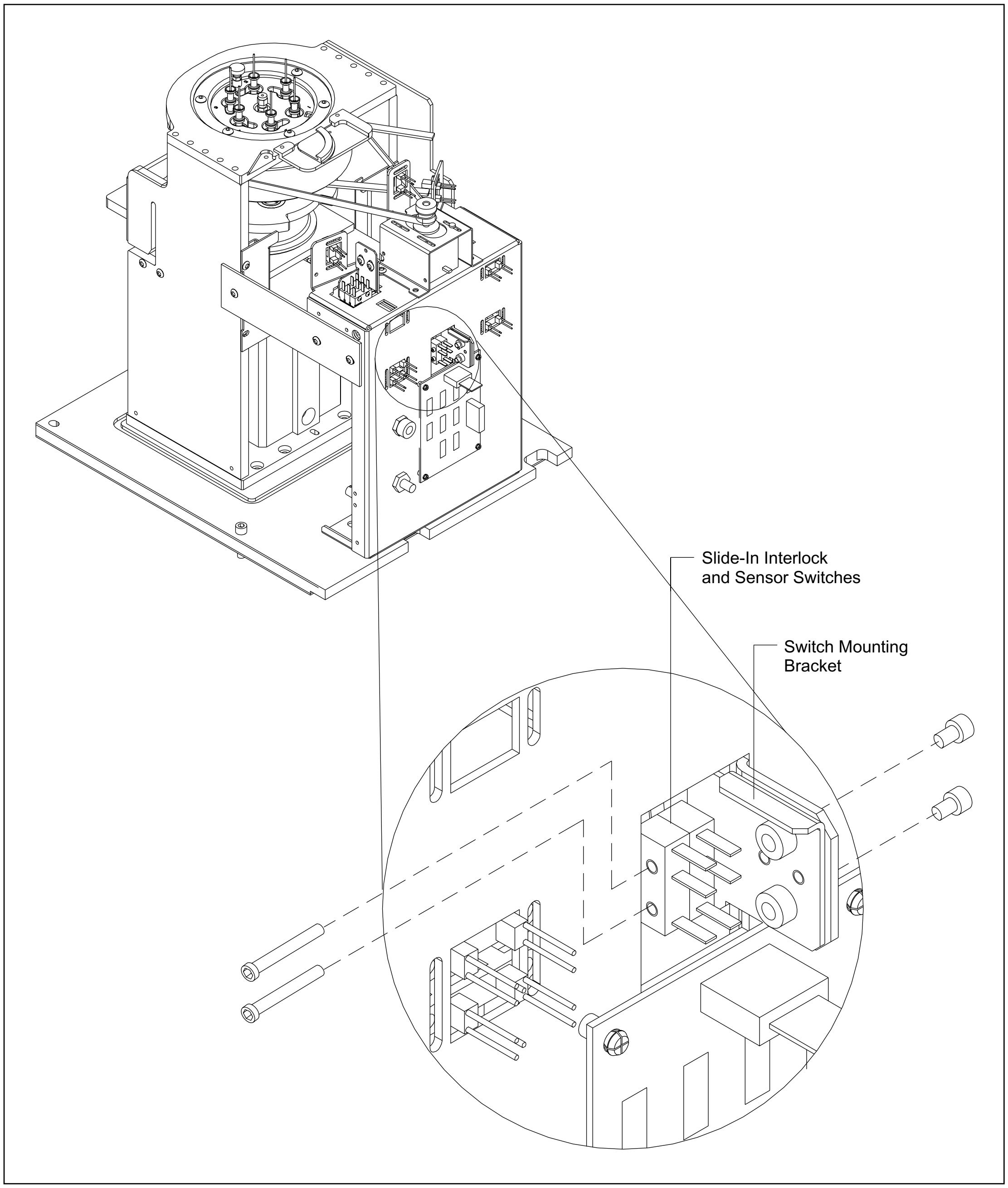



Figure 9-89. Anode Slide-In Interlock and Sensor Switch Mounting.

### 9.89.1 Removal Procedure

1. Remove the anode assembly (section 9.81.1).
2. Disconnect the slide-in interlock and sensor switch cable from the anode connector board.
3. Remove the two screws that secure the switch mounting bracket to the rear of the anode assembly.
4. Remove the two screws that secure the slide-in interlock and sensor switches to the switch mounting bracket.
5. Remove the slide-in interlock and sensor switches.

### 9.89.2 Installation Procedure

1. Place the slide-in interlock and sensor switches in position on the rear of the anode assembly.
2. Install the two screws that secure the slide-in interlock and sensor switches to the switch mounting bracket.
3. Install the two screws that secure the switch mounting bracket to the rear of the anode assembly.
4. Reconnect the slide-in interlock and sensor switch cable to the anode connector board.
5. Install the anode assembly (section 9.81.2).

## 9.90 Anode Stage-Moving-Up Optical Sensor

For the following procedures, see figure 9-90.

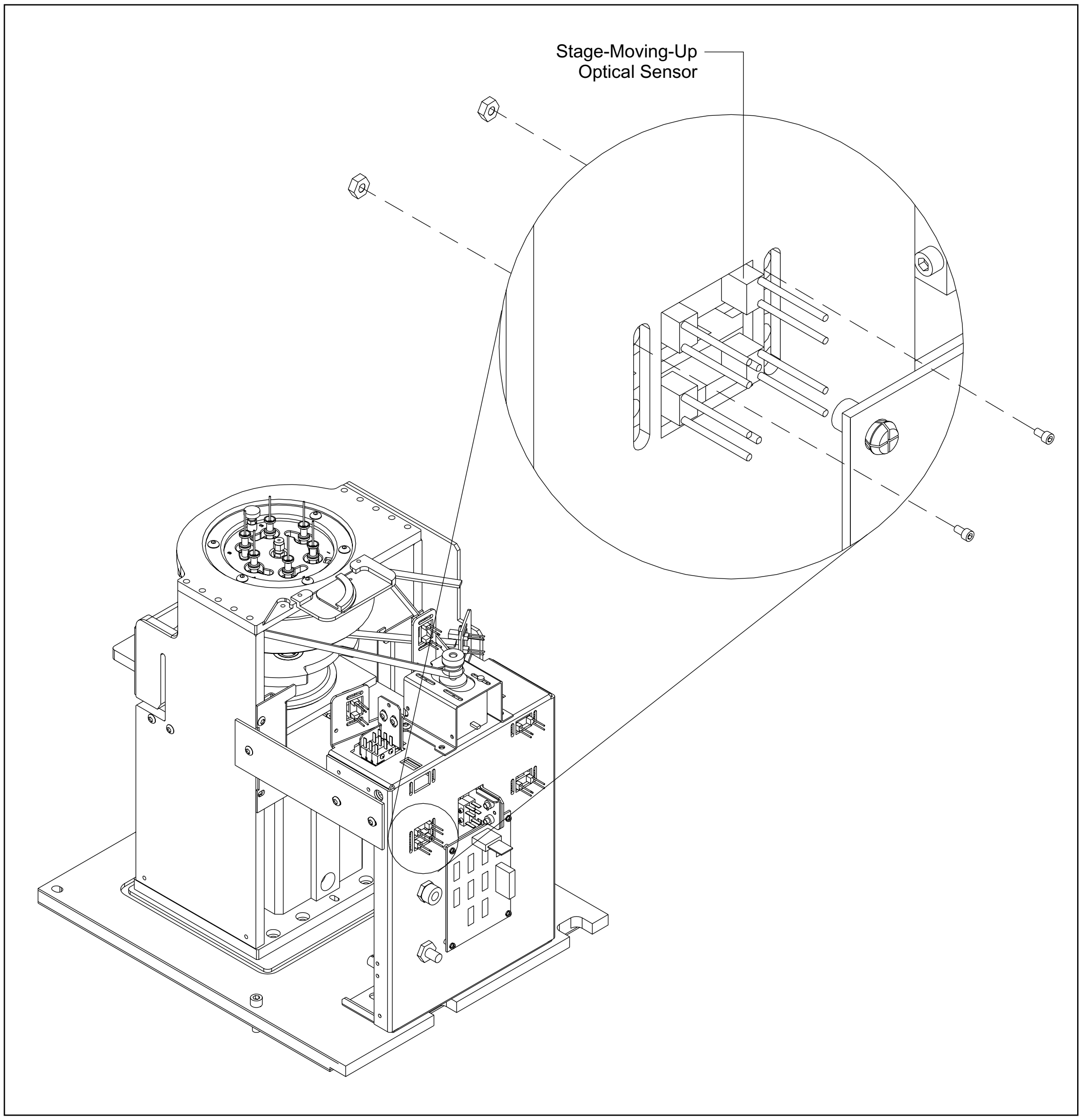



Figure 9-90. Anode Stage-Moving-Up Optical Sensor Mounting.

### 9.90.1 Removal Procedure

1. Remove the anode assembly (section 9.81.1).
2. Disconnect the stage-moving-up optical sensor cable from the anode connector board.
3. Remove the two screws, two nuts, and two washers that secure the stage-moving-up optical sensor to the rear of the anode assembly.
4. Remove the stage-moving-up optical sensor.

### 9.90.2 Installation Procedure

1. Place the stage-moving-up optical sensor in position on the rear of the anode assembly.
2. Install the two screws, two nuts, and two washers that secure the stage-moving-up optical sensor to the rear of the anode assembly.
3. Reconnect the stage-moving-up optical sensor cable to the anode connector board.
4. Install the anode assembly (section 9.81.2).

## 9.91 Anode Stage-Up Optical Sensor

For the following procedures, see figure 9-91.

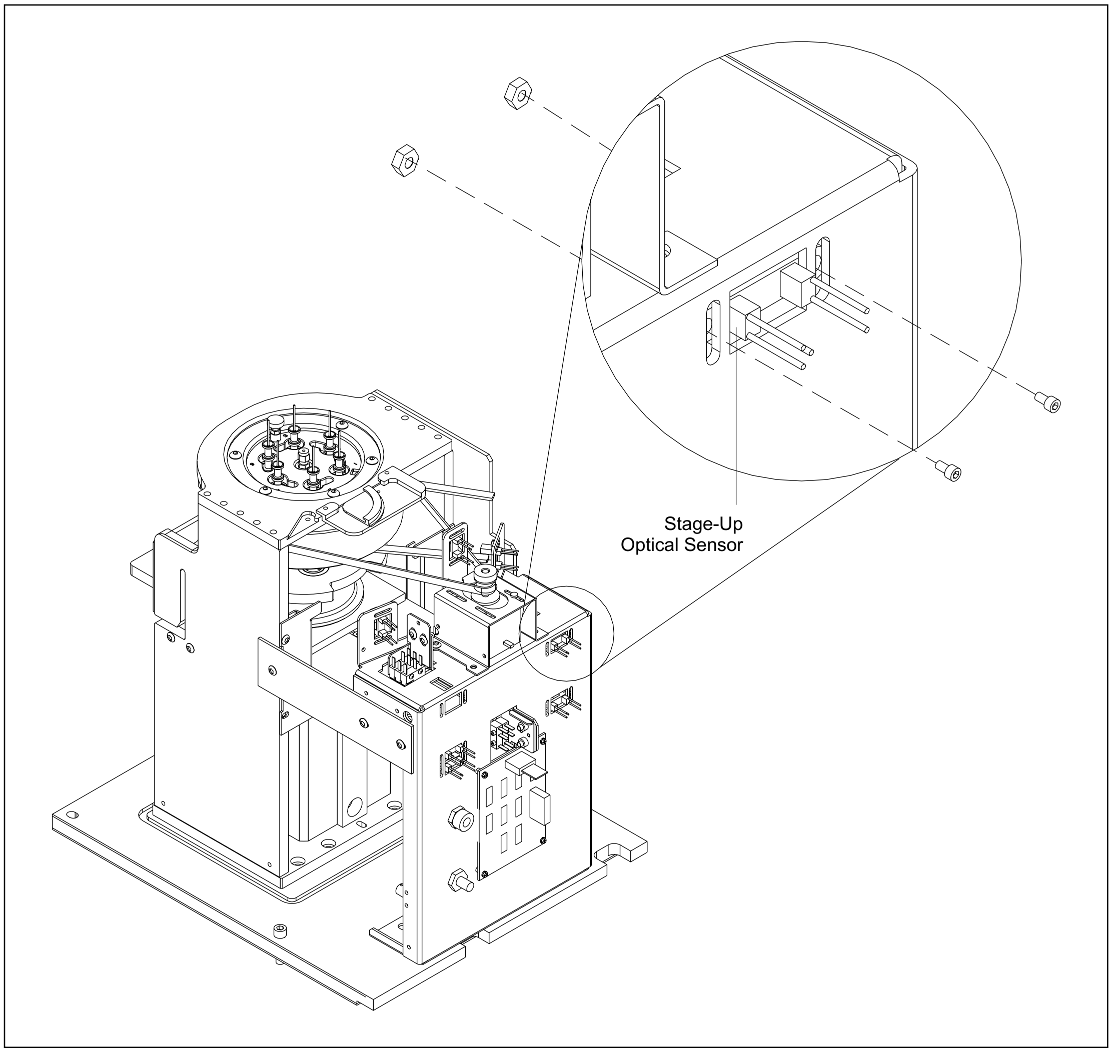



Figure 9-91. Anode Stage-Up Optical Sensor Mounting.

### 9.91.1 Removal Procedure

1. Remove the anode assembly (section 9.81.1).
2. Disconnect the stage-up optical sensor cable from the anode connector board.
3. Remove the two screws, two nuts, and two washers that secure the stage-up optical sensor to the rear of the anode assembly.
4. Remove the slide-up optical sensor.

### 9.91.2 Installation Procedure

1. Place the stage-up optical sensor in position on the rear of the anode assembly.
2. Install the two screws, two nuts, and two washers that secure the stage-up optical sensor to the rear of the anode assembly.
3. Reconnect the stage-up optical sensor cable to the anode connector board.
4. Install the anode assembly (section 9.81.2).

## 9.92 Anode Cover Locking Motor

For the following procedures, see figure 9-92.

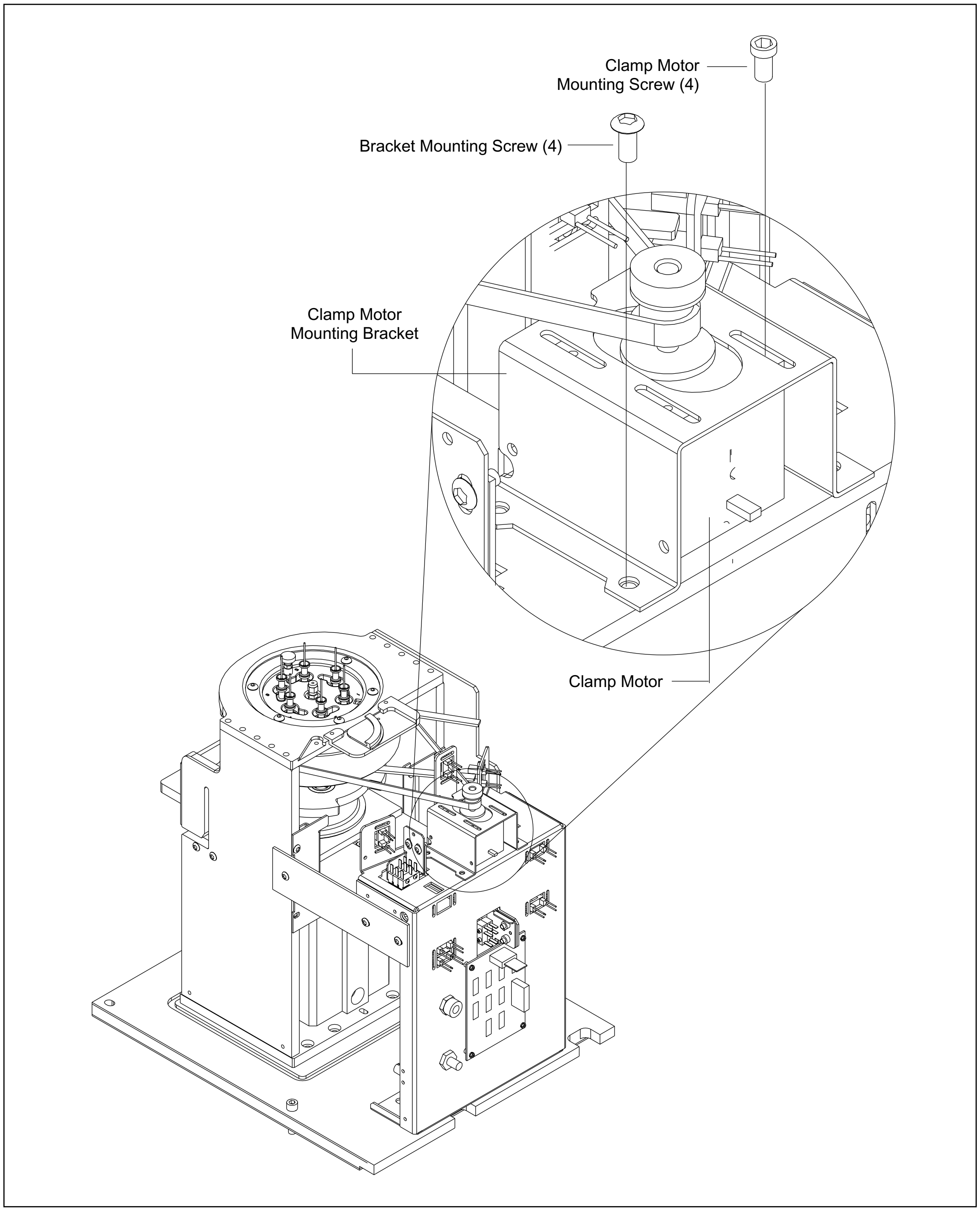



Figure 9-92. Anode Cover Locking Motor Mounting.

### 9.92.1 Removal Procedure

1. Remove the anode assembly (section 9.81.1).
2. Disconnect the motor cable from the anode connector board.
3. Loosen the four screws that secure the clamp motor to the clamp-motor mounting bracket.
4. Remove the drive belt from the motor pulley.
5. Remove the four screws that secure the clamp-motor mounting bracket to the rear of the anode assembly.
6. Remove the four screws that secure the clamp motor to the clamp-motor mounting bracket.
7. Remove the motor pulley from the motor shaft.

### 9.92.2 Installation Procedure

1. Install the motor pulley onto the motor shaft.
2. Install the four screws that secure the clamp motor to the clamp-motor mounting bracket. Do not tighten the screws.
3. Install the drive belt on the motor pulley.
4. Install the four screws that secure the clamp-motor mounting bracket to the rear of the anode assembly.
5. Adjust the drive-belt tension and tighten the four screws that secure the clamp motor to the clamp-motor mounting bracket.
6. Reconnect the motor cable to the anode connector board.
7. Install the anode assembly (section 9.81.2).

## 9.93 Nitrogen Pressure Manifold

For the following procedures, see figure 9-93.

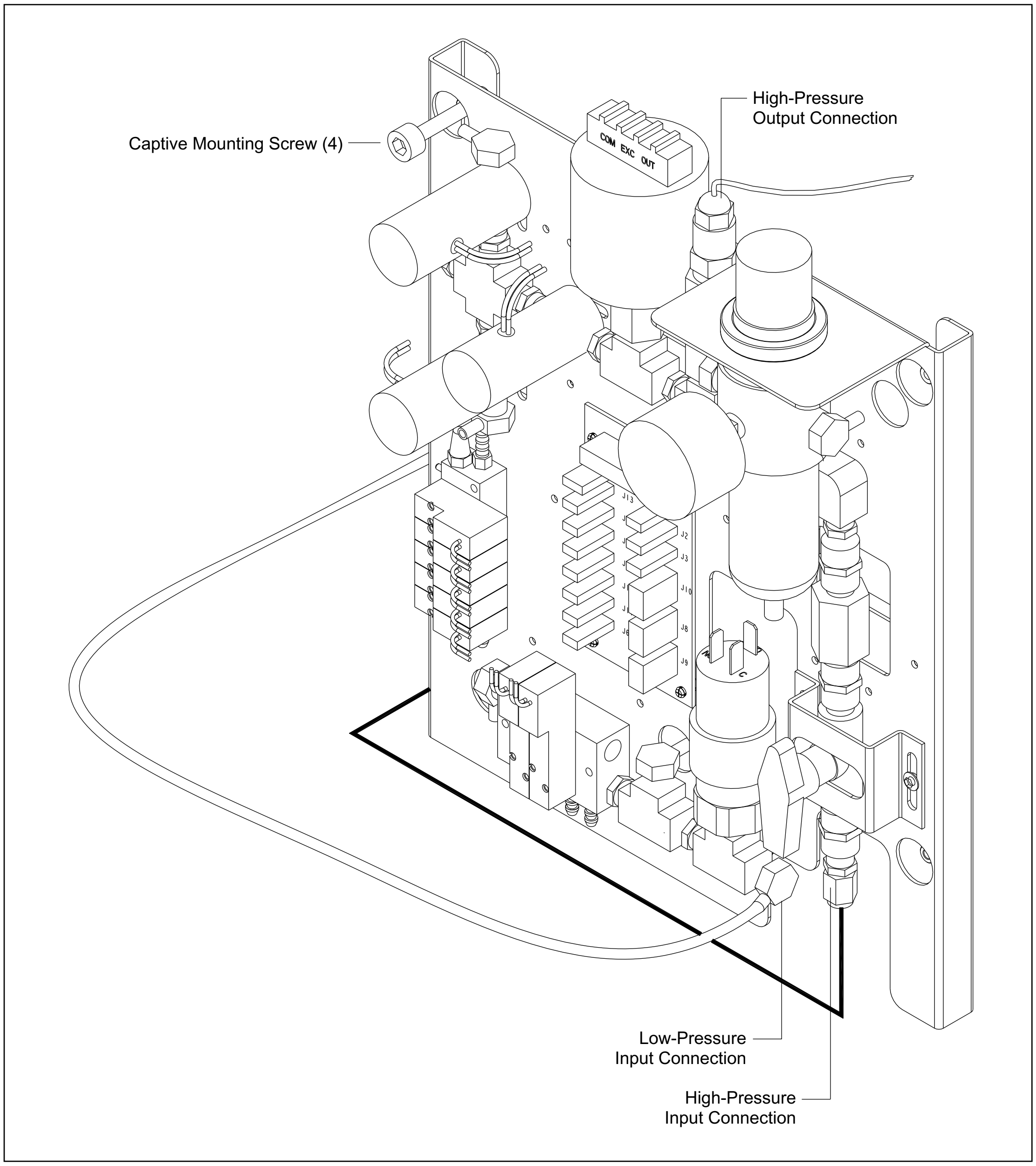



Figure 9-93. Nitrogen Pressure Manifold.

### 9.93.1 Removal Procedure

1. Turn off the nitrogen supply.
2. Using the ICS or Scan software, vent the high pressure and lower both stages.
3. Open the service door.
4. Power down the instrument.
5. Remove the lower-right cover assembly (section 9.6.1).
6. Disconnect the high-pressure output connection to the anode.
7. Disconnect the two nitrogen input connections to the manifold.
8. Disconnect the interconnect cable from the pressure connector board.
9. Remove the four screws that secure the pressure manifold to the sheet-metal chassis and remove the pressure manifold.

### 9.93.2 Installation Procedure

1. Put the pressure manifold in position and install the four screws that secure the pressure manifold to the sheet-metal chassis.
2. Reconnect the interconnect cable to the pressure connector board.
3. Reconnect the two nitrogen input connections to the manifold.
4. Reconnect the high-pressure output connection to the anode.
5. Install the lower-right cover assembly (section 9.6.2).
6. Close the service door.
7. Turn on the nitrogen and test the pressure manifold system.

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