7800 Ventilator

Service Manual

Product Group Codes CAT and CBA

7800 Ventilator

Service Manual

Product Group Codes CAT and CBA

Important

The information contained in this service manual pertains only to those models of products which are marketed by Ohmeda as of the effective date of this manual or the latest revision thereof. This service manual was prepared for exclusive use by Ohmeda service personnel in light of their training and experience as well as the availability to them of parts, proper tools and test equipment. Consequently, Ohmeda provides this service manual to its customers purely as a business convenience and for the customer's general information only without warranty of the results with respect to any application of such information. Furthermore, because of the wide variety of circumstances under which maintenance and repair activities may be performed and the unique nature of each individual's own experience, capacity, and qualifications, the fact that customer has received such information from Ohmeda does not imply in any way that Ohmeda deems said individual to be qualified to perform any such maintenance or repair service. Moreover, it should not be assumed that every acceptable test and safety procedure or method, precaution, tool, equipment or device is referred to within, or that abnormal or unusual circumstances, may not warrant or suggest different or additional procedures or requirements.

This manual is subject to periodic review, update and revision. Customers are cautioned to obtain and consult the latest revision before undertaking any service of the equipment. Comments and suggestions on this manual are invited from our customers. Send your comments and suggestions to the Manager of Service Education, Ohmeda, Ohmeda Drive, Madison, Wisconsin 53707.

⚠CAUTION: Servicing of this product should never be undertaken in the absence of proper tools, test equipment and the most recent revision to this service manual which is clearly and thoroughly understood.

Technical Competence

The procedures described in this service manual should be performed by trained and authorized personnel only. Maintenance should only be undertaken by competent individuals who have a general knowledge of and experience with devices of this nature. No repairs should ever be undertaken or attempted by anyone not having such qualifications.

It is strongly recommended that genuine replacement parts manufactured or sold by Ohmeda be used for all maintenance, service and repair involving this product.

Read completely through each step in every procedure before starting the procedure; any exceptions may result in a failure to properly and safely complete the attempted procedure.

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Notes:

1/Introduction

1.1 Note, Important, Caution and Warning

Throughout this manual, note, important, caution and warning have special meaning:

Note: Is used to stress a point.

Important: Is similar to a note but used for greater emphasis

No matter which part of the manual you are using, always be familiar with the ⚠ **CAUTIONS** and ⚠ **WARNINGS** that appear. **WARNINGS** alert you to conditions or actions that may cause harm to humans. **CAUTIONS** alert you to conditions or actions that may result in damage to equipment.

Pay special attention to the **WARNINGS** and **CAUTIONS** as they appear in this manual and on the equipment.

Read the statements under the IMPORTANT heading; they describe what is expected of you to service, repair and maintain the ventilator.

1.2 Symbols

We have also used—both in the manual and on the device itself—symbols to represent some common terms. No one product or manual has every symbol listed. Refer to this listing concerning symbols found on various products and manuals. These symbols include:


On (power)


Off (power)


Standby


Standby or preparatory state for a part of the equipment


"ON" only for part of the equipment


"OFF" only for part of the equipment

Direct Current


Alternating Current


Protective earth ground


Earth Ground


Frame or chassis ground


Alarm silence button


Equipotential


Variability


Variability in steps

Plus, positive polarity

Minus, negative polarity

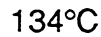

Lamp, lighting, illumination


Movement in one direction


Movement in both directions


Lock


Unlock


Autoclavable


Non-autoclavable


Type B equipment


Type BF equipment


Type CF equipment


Caution, ISO 7000-0434


Attention, consult accompanying documents, IEC 601-1


This way up


Dangerous Voltage


Input


Output

REF Stock Number

SN Serial Number

1.3 Standard Service Procedures

Operation and Service Manuals

You must have, and be familiar with, the Operation and Maintenance manuals for this product. Study the Anesthesia System Operation and Maintenance manuals if you need further information about the operation of the system. You must determine where a problem is located before you can determine which manual to use. Refer to the various service manuals or accessory manuals if you require more information.

Bellows Assembly

This manual covers both the Autoclavable Bellows Assembly (ABA) and the non-autoclavable bellows assembly (non-ABA).

The Autoclavable Bellows Assembly is operator maintainable. For more information see the ventilator Operation and Maintenance manual, or the Autoclavable Bellows Assembly, Operation and Maintenance supplement.

Stock Numbers for Replacement Parts

Stock Numbers can be identified in the "8/Illustrated Parts List" section of this manual. Parts can be obtained through Ohmeda offices/distributors.

Ventilator tests

Normal operational tests can be performed while the ventilator is installed in, or attached to, an anesthesia system. Calibration, troubleshooting or repair may require removing the ventilator from the anesthesia system.

⚠WARNING: Section "4/Tests and Calibration" must be performed whenever you remove a ventilator cover, to ensure that the ventilator is still operational and within specification. Failure to do so may result in patient injury.

⚠WARNING: You must perform section "3/Post-Service Checkout" for the entire anesthesia system before returning the system to clinical use. Failure to do so may result in patient injury.

⚠WARNING: Do not perform testing or maintenance on medical equipment while they are being used on a patient; patient injury may result.

1.4 7800 Ventilator Configuration

The 7800 Ventilator (hereafter called ventilator) is available in significantly different product packages. This manual is exclusively for ventilators with product group codes CAT and CBA. Check the product group code before you proceed.

The Ventilator is composed of two basic units:

- the **Bellows Assembly** which contains the bellows and bellows housing, and
- the **Control Module** containing the control valves, processing circuits, controls, monitors and display screen.

The Ventilator is available in three configurations:

- **Excel Mount,** as an integrated ventilator in an Ohmeda Excel anesthesia system or
- **Stand-alone,** for use with other anesthesia systems or
- **Modulus® II Upgrade,** as an integrated ventilator in an Ohmeda Modulus II Anesthesia System.

Differences in these configurations include:

- How the control module and bellows assembly are mounted.
- Connections between the control module, bellows assembly and anesthesia system.
- Connection of the oxygen and volume sensors.

Modulus®, registered trademark, BOC Health Care Inc

A. Excel Mount

The control module can be mounted on an optional arm, or from a system shelf.

On systems with flowmeters extending all the way to the top shelf, the control Module can hang, by a bracket, from the shelf to the right side of the flowmeters.

On systems with the lower shelf extending over the flowmeters, the control module can hang directly from the shelf over the flowmeters.

The bellows assembly can be mounted on top of the control module, on an optional arm, or directly to an Ohmeda GMS absorber (using an interface manifold).

The anesthesia system ON/OFF switch, controls ventilator power up.

Oxygen and volume sensor connections are located on the front left or right side of the Excel, below the table top.

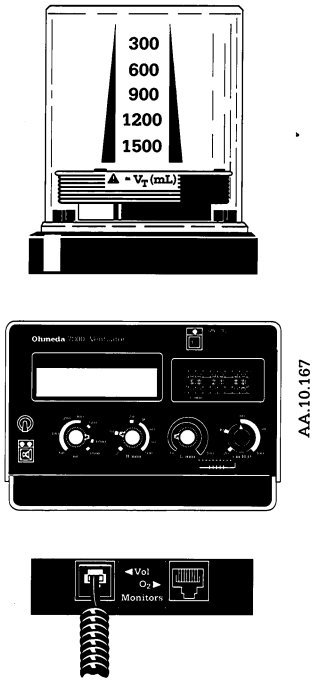


Figure 1-1 Excel Mount

B. Stand-alone

The control module can be mounted on an optional arm, or stand.

The bellows assembly can be mounted on top of the control module, or directly to an Ohmeda GMS absorber (using an interface manifold).

A power switch on the lower front panel, controls ventilator power up.

Oxygen and volume sensors connect directly to the lower front panel of the control module.

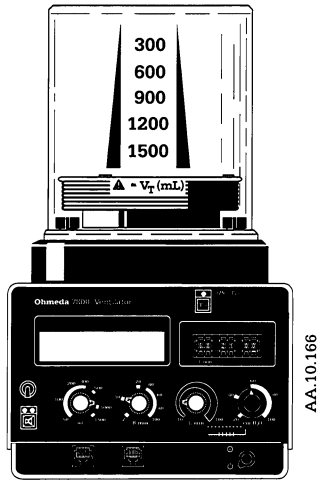


Figure 1-2 Stand-alone

C. Modulus II Upgrade

The control module is mounted above the flowmeters inside the Modulus II.

The bellows assembly can be mounted on an optional arm, or directly to an Ohmeda GMS absorber (using an interface manifold).

The anesthesia system ON/OFF switch, controls ventilator power up.

Oxygen and volume sensor connections are located on the front left side of the Modulus II, below the table top.

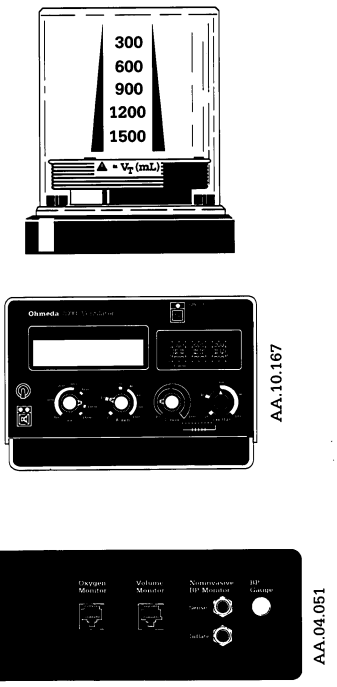


Figure 1-3 Modulus II Upgrade

Product Group Code

Ventilators with serial numbers starting with CAT were manufactured without a piggyback watchdog board and other EMC enhancements.

Ventilators with serial numbers starting with CBA were manufactured with a piggyback watchdog board, Universal pressure transducer board, the newer EMC/Interface board (International), 4.xx or greater software, and other EMC enhancements.

Piggyback Watchdog Board

The piggyback watchdog board provides enhanced monitoring of correct microcontroller operation.

Note: The piggyback watchdog board is not installed on some units.

Software Versions

This manual includes test and calibration procedures for versions 4.xx and 1.xx software.

EMC/Interface Board

The EMC/Interface board attenuates electrical noise from electro-surgical units or other electrical noise generators in the operating room environment. This board is mounted behind the lower front panel (Excel Mount and stand-alone) or below the control module, inside the Modulus II Anesthesia system.

The EMC/Interface board is available in two versions the original and international EMC/Interface boards. They are not directly interchangeable and require different cabling.

Pressure Transducer Board

A newer style "Universal" pressure transducer board is now available as a replacement for the original pressure transducer board.

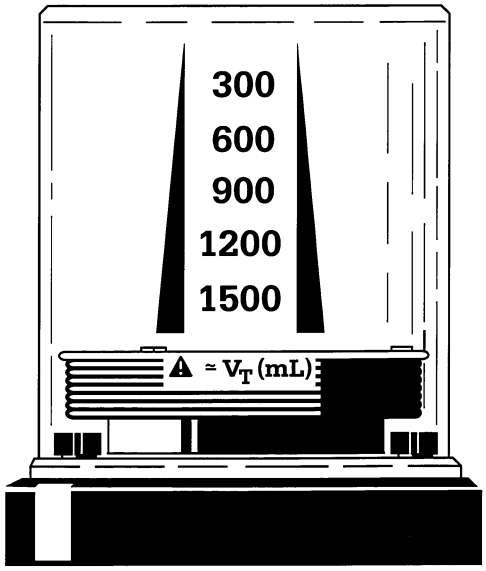
Notes:

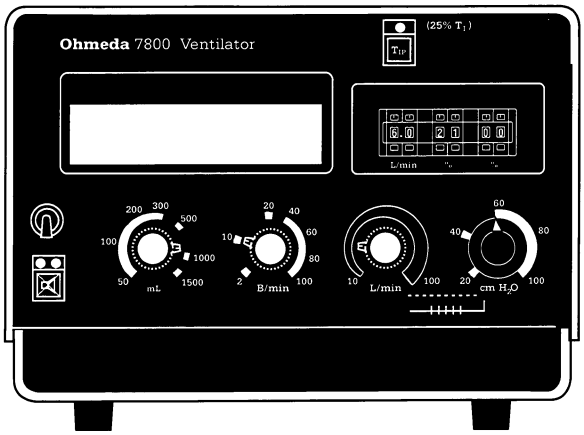
2/Theory of Operation

2.1 Ventilator Overview

The ventilator provides mechanical ventilation of patients during surgery. It is a microprocessor controlled pneumatic device. The ventilator consists of two major parts:

- **bellows assembly**, which isolates the driving gas from the breathing gas
- **control module**, which drives the bellows assembly; and monitors oxygen, pressures, and volumes.





AA.32.044

2/Theory of Operation

The Control Module

Knobs and switches on the front of the control module are used to select operational parameters. A LCD (Liquid Crystal Display) shows current parameter information, alarms and error messages. The front panel also has an alarm silence button  with red and yellow alarm lights LEDs (Light Emitting Diodes).

The control module uses a compressed gas source (typically compressed oxygen) to pneumatically control patient ventilation. The gas is supplied by the anesthesia system from either attached cylinders or a pipeline gas supply.

A microprocessor controls the operation of the control module. The microprocessor performs all of the timing, monitoring and sequencing involved in applying positive pressure to the bellows.

The main program memory is an EPROM (Erasable Programmable Read Only Memory). This memory retains its contents when the power is turned OFF. The EPROM holds the permanent preprogrammed application software package. The software revision number can be displayed in a special subroutine called the "Setup Page."

Certain user set parameters are stored in an EEPROM (Electrically Erasable Programmable Read Only Memory) that can be altered under program control. These include operator selected parameters that may vary between sites, such as speaker volume or altitude setting, and are not likely to be changed during a case. The EEPROM also contains the factory set calibration parameters for the flow control valve (part of the pneumatic manifold assembly). The calibration parameters cannot be programmed in the field.

Ventilator data can be communicated to another device through an RS232 connection.

The Bellows Assembly

The drive gas output of the control module is used to impress breathing gas on the patient. The drive gas is on the outside of the bellows and is isolated from the breathing gas on the inside. There is no direct connection between the two gas volumes. The ventilator moves breathing gas to the patient by applying positive pressure on the breathing circuit. Exhalation occurs when the ventilator releases the positive drive gas pressure to atmosphere.

The ventilator drive gas output is connected to the bellows assembly by a flexible hose. A small diameter pressure sensing tube connects the patient breathing circuit to the control module which monitors pressure in the breathing circuit. The operator can select an adjustable inspiratory pressure limit which limits the inspiration phase of ventilation if excess pressure is detected.

An independent pressure relief valve is located inside the bellows. If excess gas accumulates during exhalation, this valve will open and exhaust the excess breathing gas.

2.2 Pneumatic Description

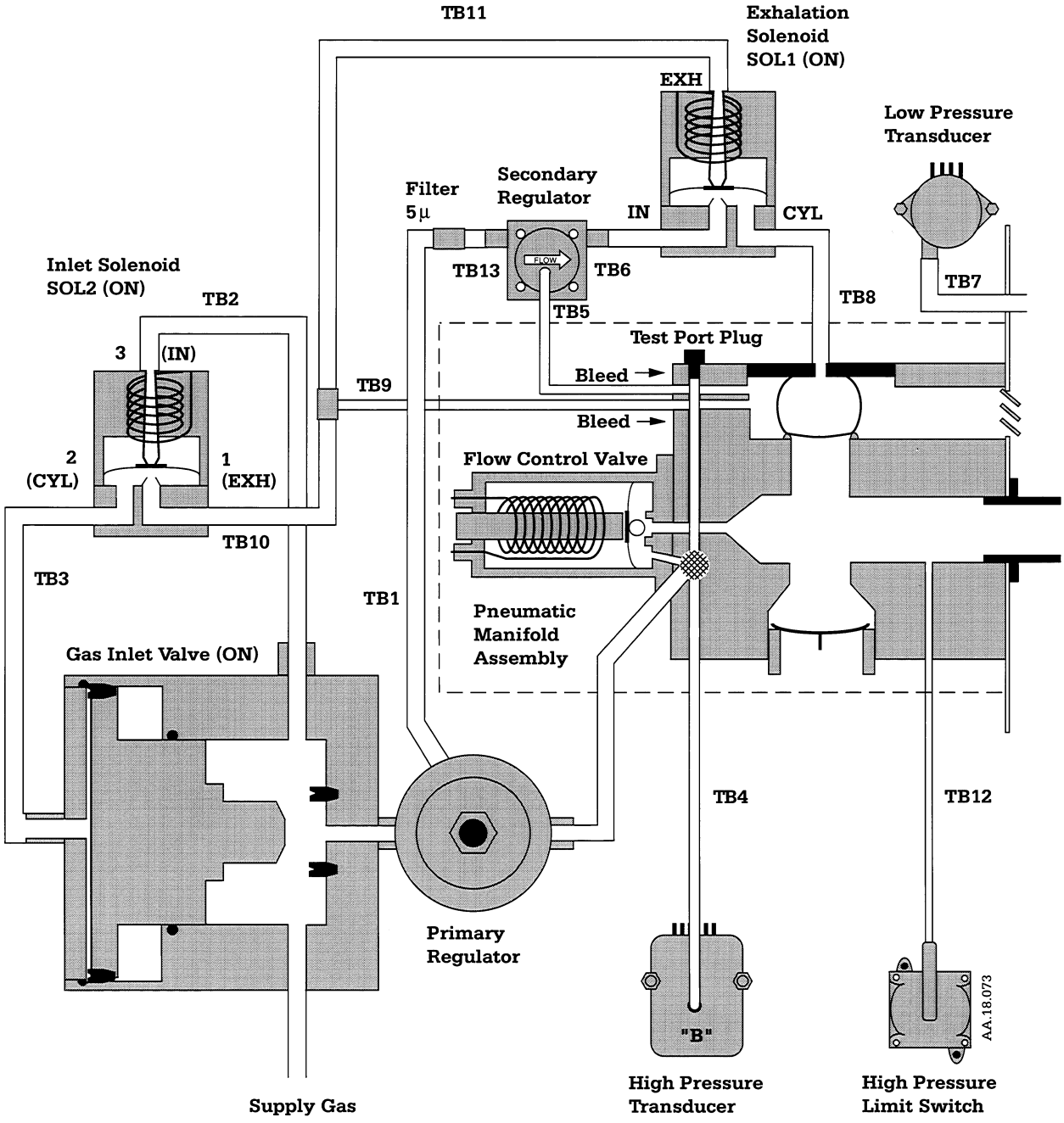


Figure 2-1 Block Diagram Pneumatic Circuit

A. Gas Inlet Valve

The gas inlet valve switches the supply gas entering the control module. The gas inlet valve and inlet solenoid together form a valve that is normally OFF. The supply gas is turned ON by the microprocessor at power up. If the electrical power ever fails, the gas inlet valve shuts OFF.

Inside the gas inlet valve is a shuttle (spoppet). The shuttle has a small control stop on one end which blocks or allows the flow of supply gas to the primary regulator.

When the inlet solenoid is OFF, a pressure differential holds the shuttle in the closed position.

The inlet solenoid must be activated (have current flow) in order for the gas inlet valve to allow supply gas into the control module.

When the inlet solenoid is turned ON, the energized coil attracts a plug that blocks the inlet orifice. At the same time the exhaust orifice is opened,. the compressed gas at the large side of the shuttle is vented through the inlet solenoid. The pressure on the small side of the shuttle moves it, opening the gas inlet valve.

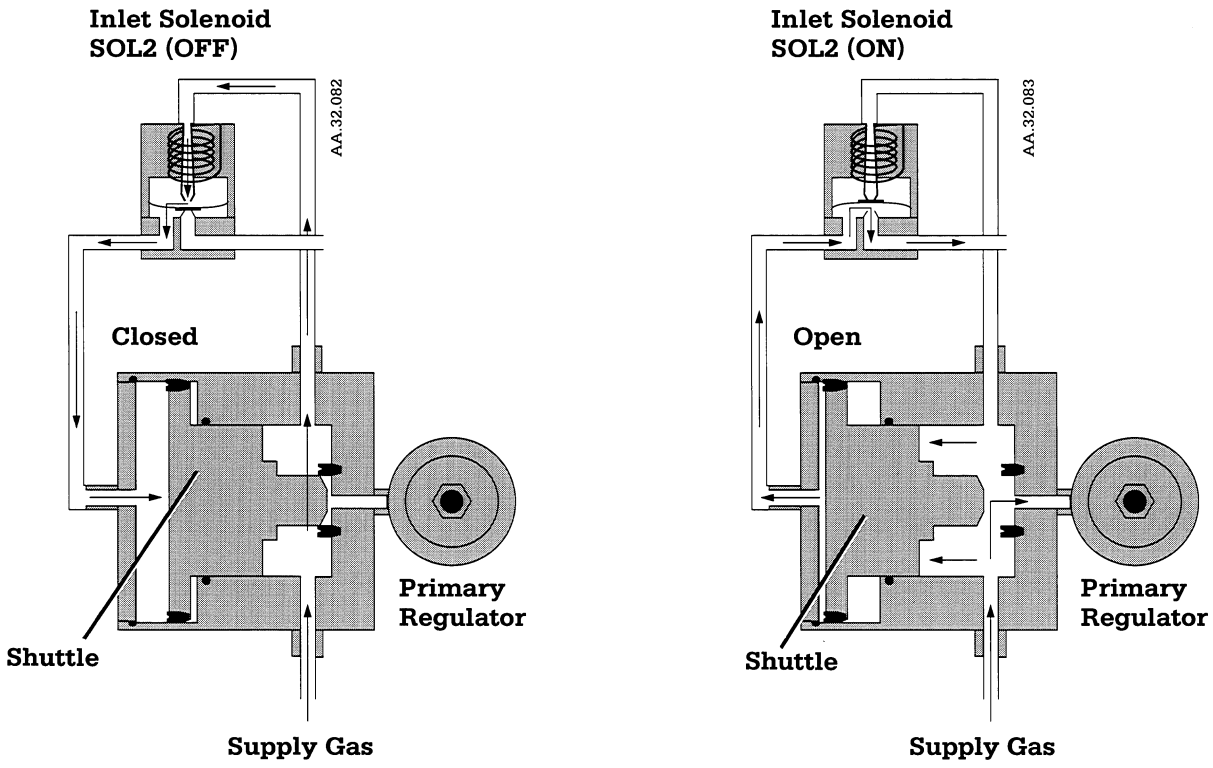


Figure 2-2 Inlet Solenoid and Gas Inlet Valve, OFF and ON

B. Pressure Regulation

The ventilator has a primary regulator and a secondary regulator. The primary regulator is mounted next to the gas inlet valve. Supply gas enters the primary regulator directly from the gas inlet valve. The primary regulator output connects to the pneumatic manifold assembly which contains the flow control valve. The output of the primary regulator also goes to a secondary regulator that further reduces the pressure. The output of the secondary regulator is used to inflate the exhalation valve.

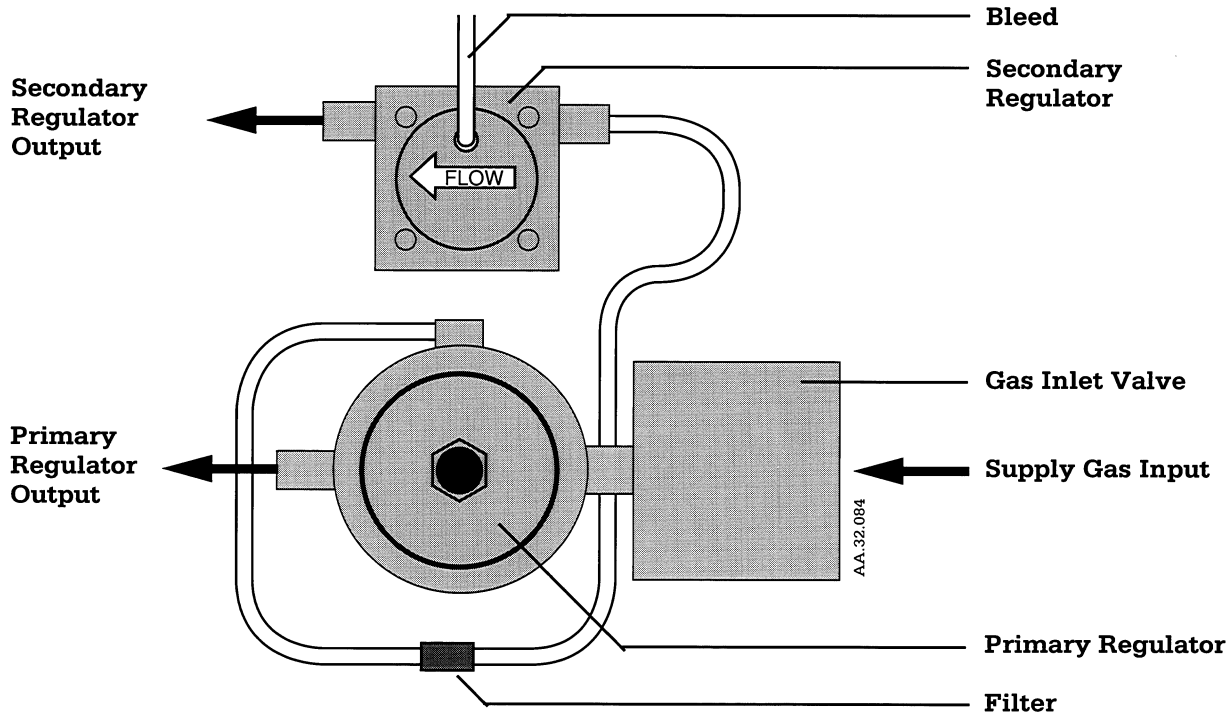


Figure 2-3 Primary Regulator and Secondary Regulator

C. Flow Control Valve

The drive for inspiration is an increase in pressure applied to the breathing circuit. Ventilation drive gas flow is supplied by the flow control valve. The precise amount and rate of inspiration is accurately controlled by the microprocessor through a digital to analog converter. The microprocessor proportionally changes the drive gas flow by changing the current applied to the flow control valve. If the power is removed the flow control valve shuts OFF.

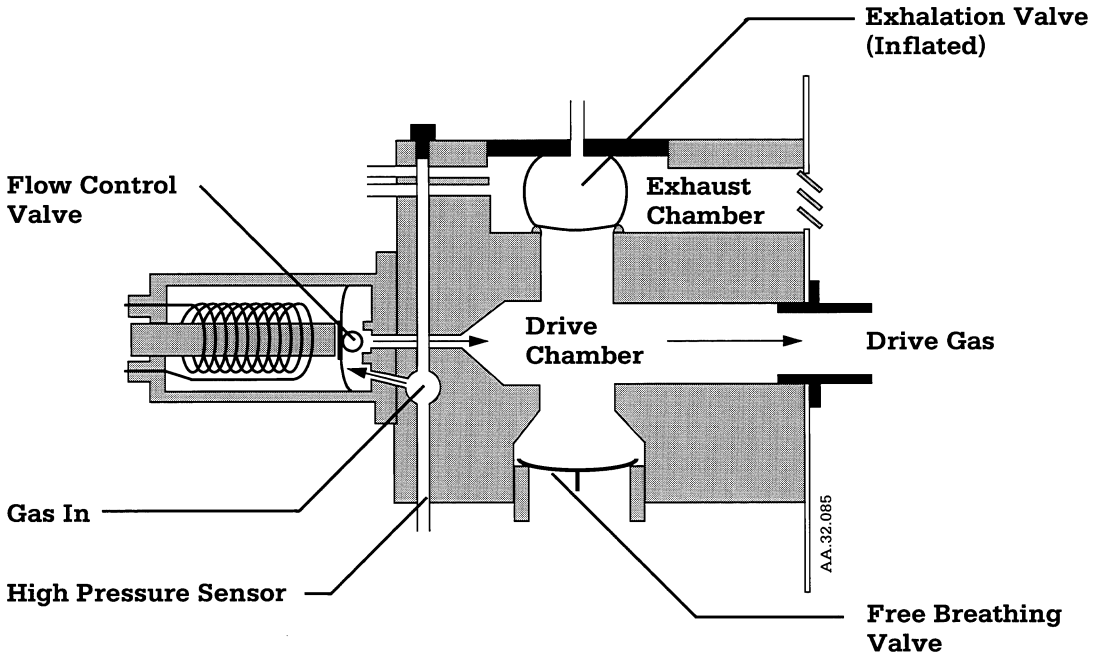


Figure 2-4 Pneumatic Manifold Assembly Inspiration

The flow control valve releases positive pressure into the drive chamber. As gas enters, the drive gas pressure builds up in the drive chamber, through the flexible hose, and increases the pressure in the bellows assembly.

During the inspiratory phase of ventilation the drive gas increases the patient circuit pressure and, in combination with the duration, determines the tidal volume.

D. Exhalation Valve

The pneumatic manifold assembly has an internal exhaust chamber. The exhaust chamber is open to atmosphere through the back of the control module. Note the louvers above the drive gas output on the rear panel. Exhaust gas from the two solenoids and the secondary regulator, is connected to the exhaust chamber and relieve directly to the atmosphere.

During the exhalation phase, the exhalation valve is deflated and drive gas pressure is released to the atmosphere through the exhaust chamber.

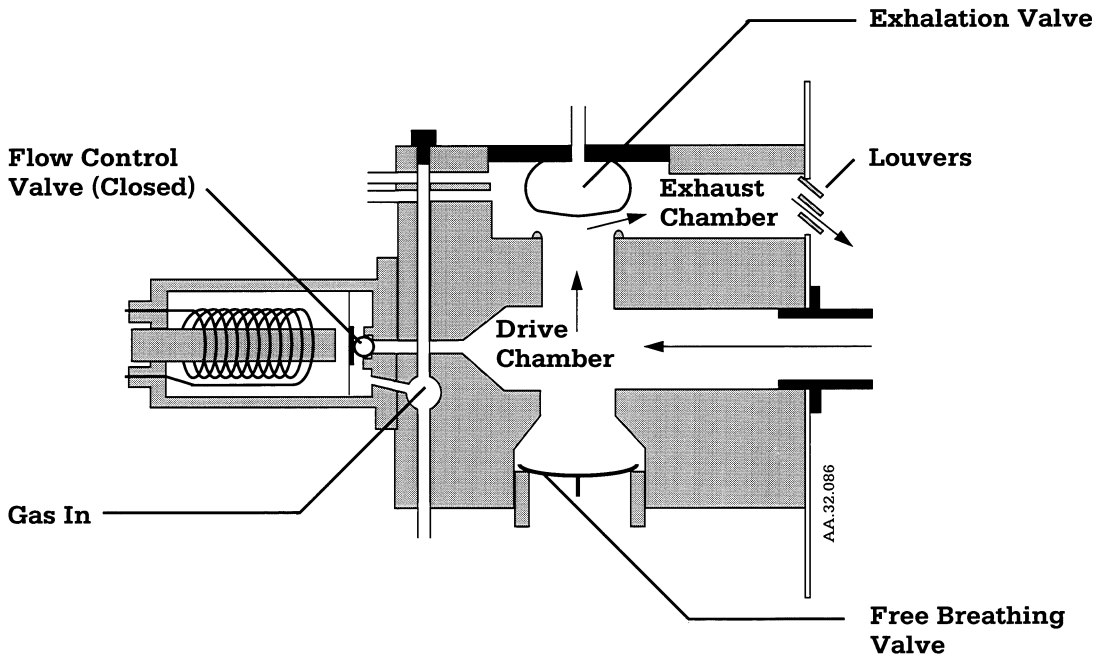


Figure 2-5 Pneumatic Manifold Assembly Exhalation

The drive chamber and exhaust chamber are separated by the exhalation valve. The exhalation valve inflates, like a balloon, to seal off the opening.

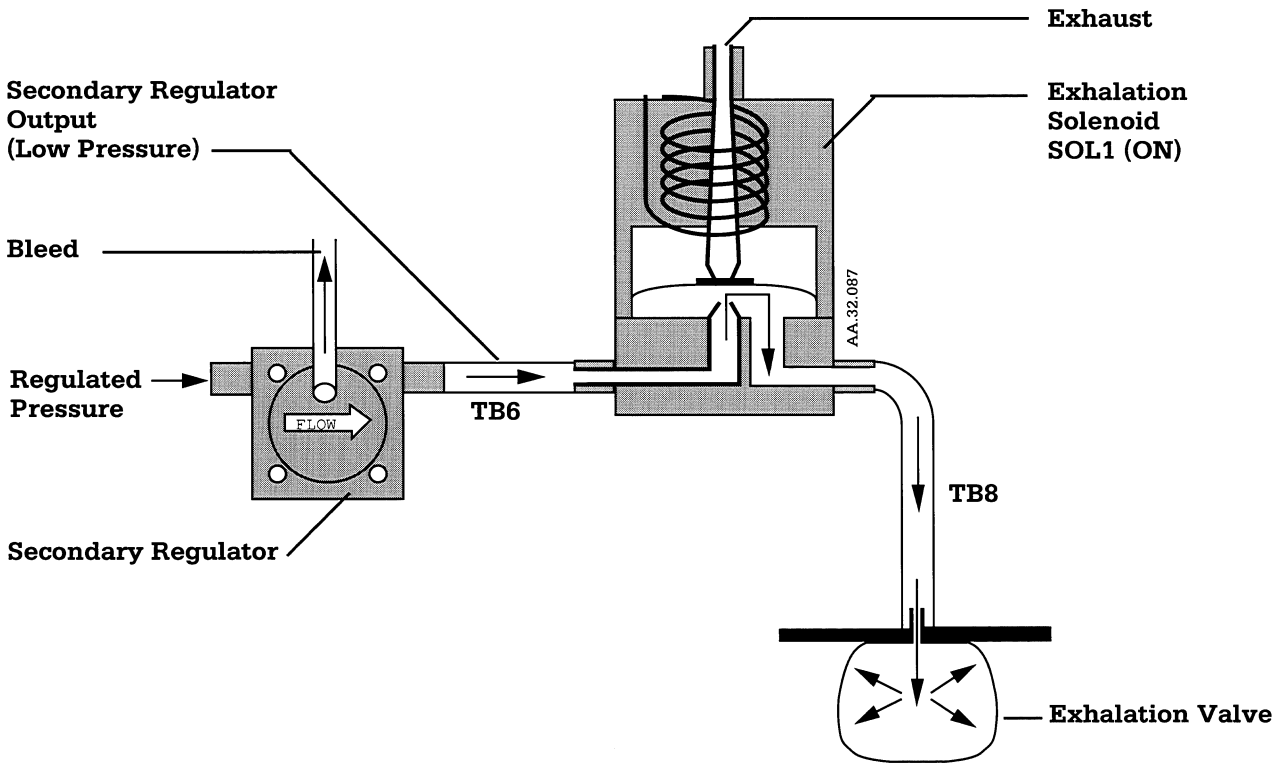


Figure 2-6 Exhalation Valve Inflating

During inspiration, positive pressure is held in the drive chamber by inflating the exhalation valve. Positive pressure builds in the drive chamber, drive gas hose and the outside chamber of the bellows assembly. The flow control valve allows gas flow for the desired inspiratory time.

Approaching the end of inspiration the flow control valve is turned OFF. If inspiratory pause (T_{IP}) is ON, the exhalation valve will remain inflated for an additional 25% of the set inspiratory time. The exhalation valve is deflated at the end of inspiration. This relieves the positive pressure in the drive chamber and allows the drive gas in the bellows assembly to be vented through the exhaust chamber to the atmosphere.

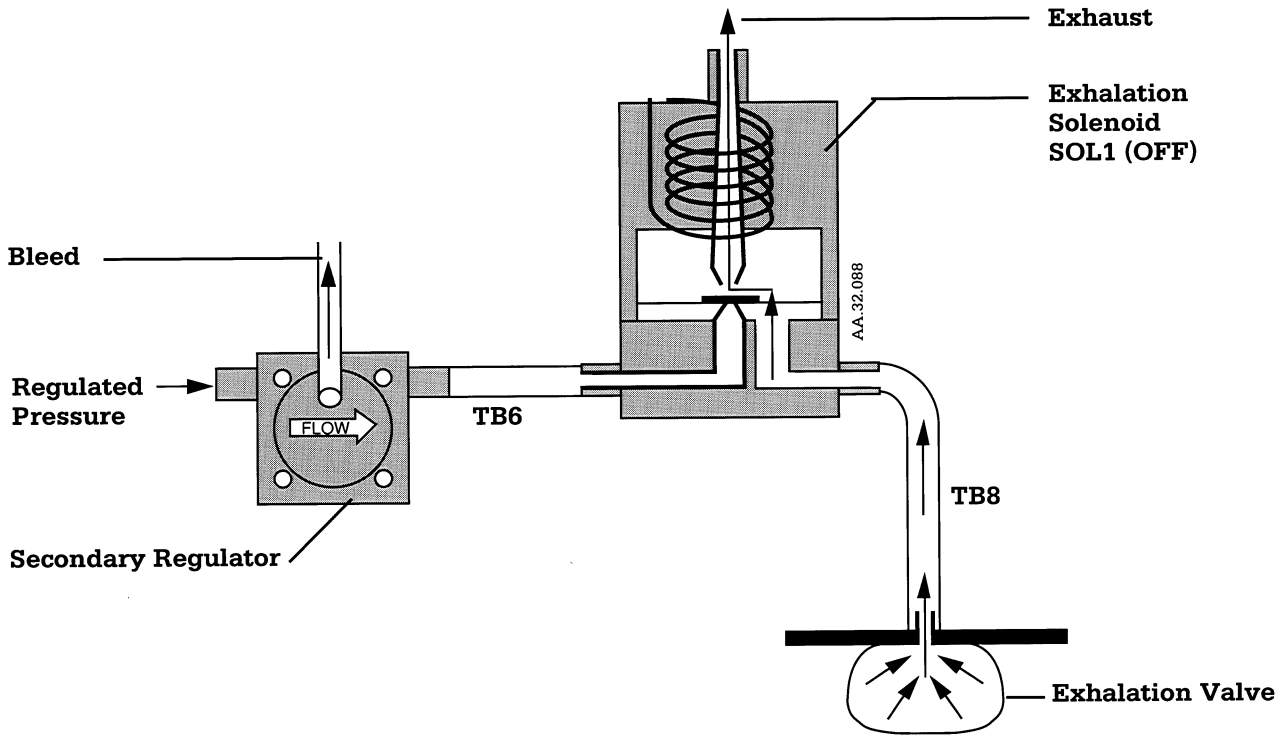


Figure 2-7 Exhalation Valve Deflating

E. Bellows

The bellows isolates the drive gas from the breathing gas supplied by the anesthesia system. At no time does the drive gas enter the patient breathing circuit.

During the inspiratory phase, the control module delivers drive gas into the area between the bellows and the bellows housing. As the volume of gas increases, pressure is exerted on the bellows which compresses. The bellows in turn exerts pressure on the patient breathing circuit and the patient's lungs.

During the exhalation phase, the drive circuit pressure is vented to the atmosphere. This reduction in pressure allows gas to flow from the patient breathing circuit into the bellows. The bellows rises within the bellows housing.

F. Pressure Relief Valve

The pressure relief valve is located within the bellows. This valve remains closed during inspiration. When the bellows cannot extend any further during exhalation, the pressure relief valve opens and the excess gas is vented through the exhaust tube. This will happen when the pressure in the patient circuit during exhalation exceeds the vented driving gas circuit pressure by approximately 2.5 cm H_2O.

G. Free Breathing

The free breathing valve acts as a check valve. Normally the pressure within the drive chamber and corresponding bellows and breathing circuit is controlled by the ventilator. If the patient attempts to inhale, a sudden drop in breathing circuit pressure occurs. If the drive gas flow is less than the demand, pressure within the drive chamber will drop, the free breathing valve will open making up the additional volume with ambient air. This allows the patient to breathe spontaneously.

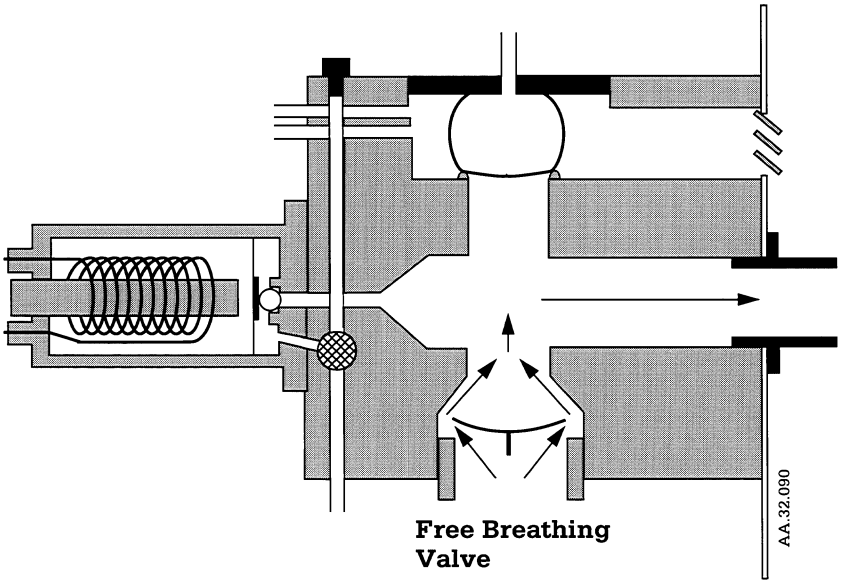


Figure 2-8 Free Breathing Valve

H. Pressure Sensing

The output of the primary regulator is monitored by a high pressure transducer. If the pressure is greater than about 207 kPa (30 psi), the microprocessor will not allow ventilation and an error message is displayed.

The pressure within the drive chamber is monitored by a pressure switch. This circuit is independent of the microprocessor to maintain operational integrity in the event of a microprocessor failure. If excessive pressure (approximately 105 cm H_2O) is detected, the switch closes and causes the exhalation valve to deflate relieving the drive circuit pressure.

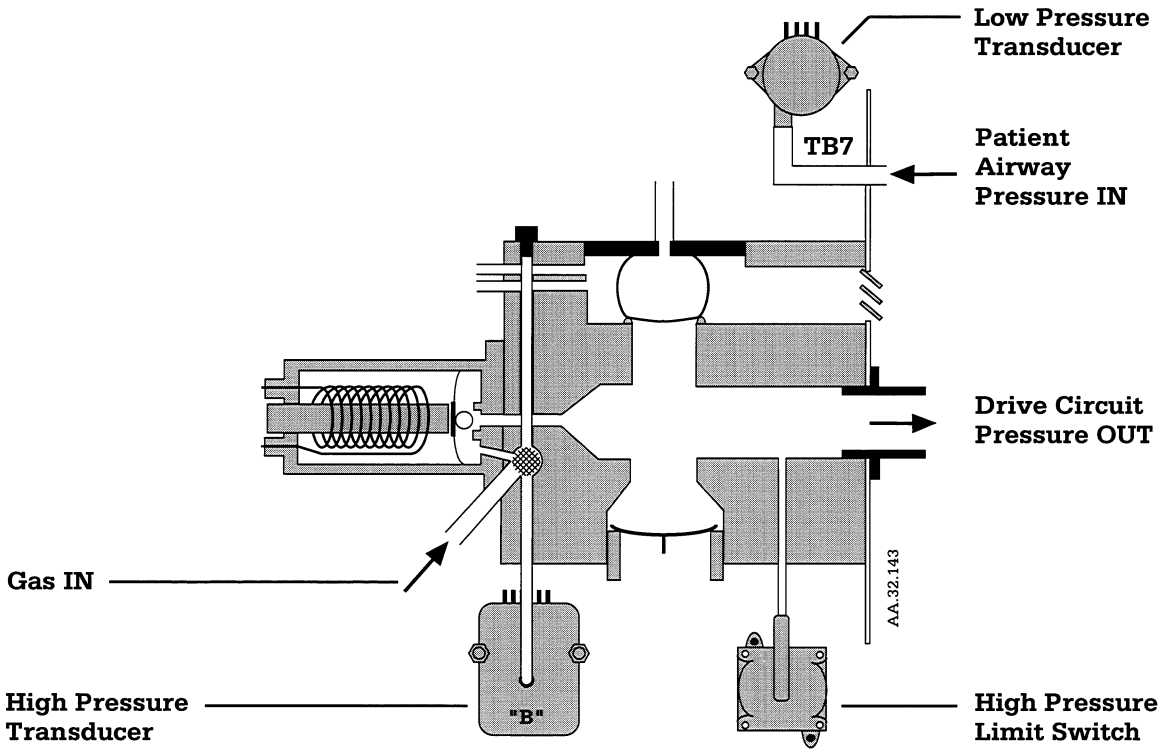


Figure 2-9 Pressure Sensing

A pressure sensing point is located in the breathing circuit. This pressure is fed back to the control module though a clear pressure sensing tube. The tube is connected to the low pressure transducer, located on the pressure transducer board. This pressure monitor allows the microprocessor to respond to pressure in the breathing circuit.

I. Filtering

A replaceable five (5) micron particulate filter is located between the primary regulator and secondary regulator.

A permanent coarse (150 mesh) screen filter is located where the gas enters the pneumatic manifold assembly.

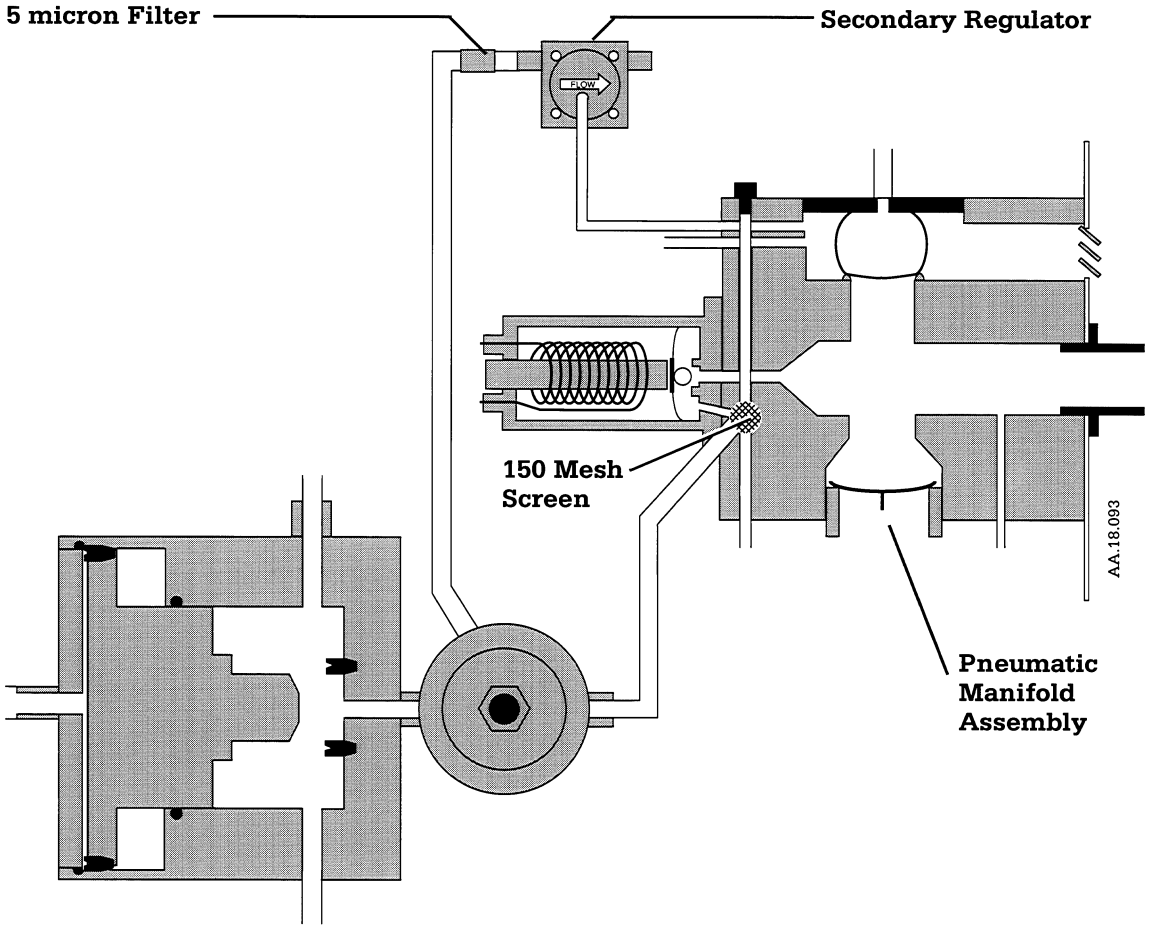


Figure 2-10 Filter

2.3 Electronic Descriptions

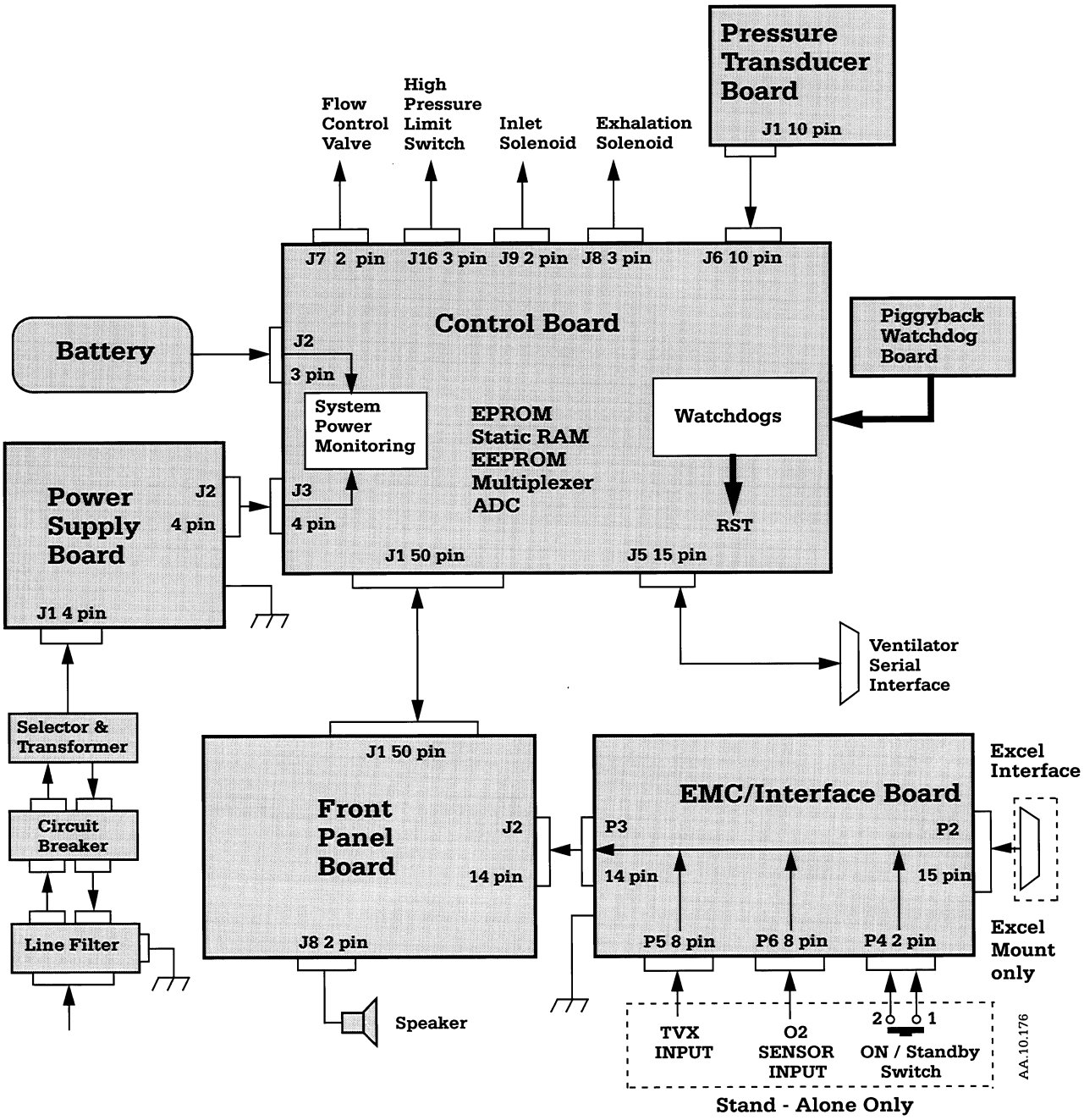


Figure 2-11 Block Diagram Electrical

Notation Within this Text

Unless otherwise noted, all voltages are positive with respect to signal and supply common (DGND and AGND).

A "/" indicates that for this signal, active (true) is at a logic level of zero (0). Some examples are: /CS2, /RD, or /WR. This is often referred to as a "negative logic" or "active low" signal.

All voltages are designated as direct current "V dc" or alternating current "V ac." Voltages are also designated as positive "+" or negative "minus (-)." Some examples are: "+ 4.37 V dc," or "minus (-) 4.37 V dc." Tolerances are expressed with an additional number: "5.25 ±0.01 V dc."

Current values are designated as Ampere "A dc", milliampere "mA dc" or microampere as " µA dc."

Component Designations

Component numbers are separated from pin numbers by a "–." Like this: "U124-2" or "J2-15." Additional pins are separated by a comma "U8-2,3" or "J10-7,8."

Typical Notation	Part
C178	Capacitor
CR124	Diode
F2	Fuse
FL1	Filter
J1, J15	Connector jumper, jack or plug
K102	Relay
L103	Inductor
P1	Connector jack or plug
R102	Resistor fixed or adjustable
SW101	Switch
U124	Integrated circuit

A. Power Cord

The line cord is permanently attached to the control module.

B. Filter, Breaker, Selector, Transformer

The power cord connects directly to the electromagnetic interference line filter, FLTR. The device filters interference going to and coming from the control module.

The output of the filter goes to a 0.5 A double pole circuit breaker, BKR. Excess line current, or neutral current, can cause this circuit breaker to open, disconnecting both inputs.

The transformer windings are selected by a multiple pole voltage selector switch (VSC). The combinations of windings provide for different selectable primary voltages (100, 120, 220, 240 V ac).

The transformer has internal thermal protection and will open the primary winding if the temperature reaches 150° C. The secondary of the transformer steps down to a center tapped 32 V ac.

C. Power Supply Board (Original)

The power supply board converts an ac or dc input to +5 V, 3 A dc using a step-down switching regulator configuration.

CR1, CR2 and J1-1 form a full-wave center-tap rectifier circuit which is filtered by C1. Alternatively, a dc input voltage (8.5 to 35 V dc) can be input at J1-4.

U1 converts the dc input by chopping the voltage with an internal transistor switch. The resultant square wave is filtered through a low-pass filter, T1 and C2.

R1 programs the output voltage of the regulator.

U2 is for over-voltage protection in the event of regulator failure.

D. Power Supply Board (Universal)

The power supply board converts an ac or dc input to +5 V, 3 A dc using a step-down switching regulator configuration.

The ac input is supplied by a transformer secondary with a center tap connection.

The input voltage range is from 28.8 V ac (center tapped) minimum, to 48.0 V ac (center tapped) maximum, for a transformer rated at 42 VA.

Fuses F1, F2, and F3 provide fault protection in the event of a component failure on the power supply board.

U1 is an adjustable output, 3A dc step-down switching voltage regulator.

The combination of resistors R6 and R8 and potentiometer R7 provide a typical output voltage adjustment range of from +4.3 to +5.8 V dc.

U2 is a power supply supervisory circuit, used to monitor over and under voltage fault conditions. When a dc output voltage exceeding +6.17 V dc (typical) is detected for a period exceeding 125 microseconds (typical), U2-1 will go to logic 1, and cause crowbar SCR CR5 to conduct. Once SCR CR5 is turned ON, it will remain ON as long as input power is applied to connector J1; the voltage at J2-1 and J2-2 will be reduced to the forward drop of CR5 (0.8 V dc typical). When an unregulated voltage exceeding +36.6 V dc (typical) is detected for a period exceeding 1.25 milliseconds (typical), the open collector output U2-6 will turn OFF, and be pulled to a logic 1 by R11.

Resistors R3 and R4 provide a high impedance path from dc ground, to chassis ground. Capacitor C6, provides a high frequency path from dc ground to chassis ground, for electrical noise and electrostatic discharge. Chassis ground is tied to this circuit board through the heat sink on U1.

E. Two Layer Control Board

1. Power Source Selection [Sheet 3 of schematic, section 9]

The + 5 V dc power supply voltage is connected to the control board via J3-1,2 (+) and J3-3,4 (-). Fuse F101 limits current to 4 A dc.

2. Battery [Sheet 3]

The 7800 Ventilator backup battery is connected to J2-1 (+) and J2-3 (-). J2-2 is used for 7800 model identification. Headers J14 and J15 (jumpered for 7810 and 7850 only) provide the capability of using the ventilator without an internal battery.

3. System Power Up Relay [Sheet 3]

System power up relay K102 switches the VCC power source selected by K101 to the rest of the ventilator system. K102 can be energized by shorting jumper J4 on the control board or by connecting REMOTE+ to REMOTE- with a remotely located switch. Power is routed to the flow control valve circuits, gas inlet valve circuits, exhalation valve circuits and the dc-dc converters.

4. Plus (+) 7.5 V dc and Minus (-) 7.5 V dc [Sheet 3]

U115 is a step-up switching-regulator that generates plus (+) 7.5 V dc. U110 is a inverting switching-regulator that generates minus (-) 7.5 ± 0.60 V dc. Both voltages are supplied to the pressure transducer board through connector J6.

5. E.L. Panel Driver [Sheet 3]

L108 is a dc-to-ac converter which develops 80 ±20 V ac at 700 ±100 Hz with an electro-luminescent panel connected to its output. R114 provides a means for adjusting the output voltage to the EL panel, affecting its brightness. J11 is for de-energizing the EL panel.

6. Power Up RESET and Program Flow Watchdog Timer [Sheet 1]

The watchdog timer circuit is based upon a dual retriggerable monostable multivibrater, U122. During power up, the clear inputs are held low for approximately 0.3 seconds. Then a 0.5 sec low pulse is generated at the output (U122-12) which becomes the power up reset pulse (RST).

U122 monitors the power supply voltage level and forces a system reset if a low VCC voltage error or out of limit condition is detected. The voltage trip point is set at 4.5 V dc maximum (4.37 V dc typical).

After power up reset, the microcontroller (U117-8) will output a 50 Hz, 50% duty cycle square wave (WDOG). If the WDOG pulses should stop, a 0.5 second RST pulse is delivered by the timer every 1.5 seconds. The RST pulses will continue as long as there is no WDOG pulse and the system remains powered.

7. 16 x 16 EEPROM [Sheet 1]

U114 is a 16 register by 16-bit EEPROM. All data transfer to and from the device is done serially.

8. Microcontroller Oscillator [Sheet 1]

Y101, C57-C60, and the oscillator circuit in U117 (microcontroller) form a 12 MHz oscillator which provides the master clock for the 80C31 microcontroller.

9. RS-232 Interface [Sheet 1]

U116 is a dual RS-232 receiver/transmitter. It contains two voltage converters which generate +10 V dc and (minus) -10 V dc from +5 V dc.

U116 contains four level translators. Two of the level translators are RS-232 transmitters and convert TTL/CMOS input levels into plus (+) 9 V dc and minus (-) 9 V dc RS-232 outputs. The other two level translators are RS-232 receivers which convert RS-232 inputs to +5 V dc TTL/CMOS output levels. A single transmitter and receiver are used. The output of the transmitter and the input of the receiver are connected to J5.

10. Microcontroller [Sheet 1]

U117 is a 80C31 CMOS 8-bit microcontroller running at 12 MHz with:

- 128 x 8-bit RAM,
- 32 programmable I/O lines,
- two 16-bit timer/counters,
- 64K program memory space,
- 64K external data memory space,
- programmable serial port, and
- 5 interrupt sources.

Eight of the I/O lines are used for the multiplexed lower address/data bus and eight additional lines are used for the upper address bus.

The remaining port lines are used to:

- receive the TVX transducer interrupt,
- read the TVX transducer direction input,
- control the 24-channel multiplexer,
- send and receive data from the EEPROM,
- maintain the watchdog timer,
- send and receive serial communication,
- determine when an A/D conversion is complete,
- provide read and write signals for external data memory and mapped devices.

11. Memory Address Decoder [Sheet 1]

The 80C31 microcontroller has separate address spaces for program memory and external data memory. /RD and /WR control access to external data memory. /PSEN controls access to program memory. U123 determines which circuits will be accessed by the microcontroller by decoding address lines A11 through A15 and generating the individual chip select signals (/CS1 through /CS7).

12. 64K Program Memory [Sheet 1]

U112 is a socket for 64K program memory (socketed to assist software replacement).

The program memory is an Erasable Programmable Read Only Memory (EPROM).

A piggyback watchdog board may be inserted into the socket (U112). In this case, the EPROM is installed into the socket (U112) of the piggyback watchdog board.

13. BUS TRANSCEIVER [Sheet 1]

U118 is an octal bus transceiver. It provides buffering and direction control.

14. 8K Static RAM [Sheet 1]

U113 is an 8K static Random Access Memory (RAM).

15. Address Latch [Sheet 1]

U119 is an 8-bit address latch used to de-multiplex the lower address lines from the address/data bus.

16. 8-BIT Output Port [Sheet 1]

U120 is an 8-bit output port.

Pin	Signal	Function
U120-12	EE_CLK	Clock for EEPROM
U120-13	EEPCS	Select line for EEPROM
U120-15	SUP_VAL	Inlet Solenoid, control line
U120-16	YELLED	Front Panel, Yellow LED, control line
U120-17	REDLED	Front Panel, Red LED, control line
U120-18	EX_VAL	Exhalation Solenoid, control line
U120-19	CHRG	Battery Charger, control line

17. 8-BIT Input Port [Sheet 1]

U111 is an 8-bit input port. One input is used for an external alarm silence signal (/AL_RST). The remaining seven inputs are from miniature DIP switches (SW101).

18. +4.5 Voltage Reference [Sheet 2]

The +2.5 V dc reference is amplified by U102 to generate a +4.5 V dc reference. This output can be adjusted to +4.5 V dc with potentiometer R105.

19. Patient Pressure Analog Output [Sheet 2]

One half of dual 8-bit latched multiplying DAC U105 (DAC A) along with U102-1,2,3 and U101-12,13,14 generates a voltage which can be controlled by the microcontroller. The circuit is designed so that a 00H code latched into DAC A will generate 0 V dc, while an 8CH code (140 decimal) will generate +1 V dc (One LSB = 1 cm H_2O) at U101-14.

20. Flow Control Valve [Sheet 2]

The second half of DAC U105 (DAC B) along with U102-5,6,7 and related components generates another voltage which can be controlled by the microcontroller. The signal at U102-8 (DAC_FLOW) can be varied between minus (-) 40.2 mV dc and 0.0 mV dc with a 00H code input to DAC U105 (DAC B), and varied between +222 mV dc and +370 mV dc with a 0FFH code input to DAC U105 (DAC B).

21. Flow Control Valve Drive / Sense [Sheet 2]

U102-8 (DAC_FLOW) is tied to the U103 and Q102, a voltage to current converter with feedback. The current to pass 100 L/min. through the flow control valve is nominally 1200 mA dc.

The output of U103-8 is connected to front panel switch SW108. This interlocks the flow control valve drive circuit with the mechanical ventilation switch. If the switch is open, the flow control valve is shut OFF regardless of the voltage at U103-8.

U103-5,6,7 amplifies the sense voltage. This voltage is connected to one channel of the A/D converter for sensing correct drive circuit operation.

Q1 and R1 provide an additional interlock which keeps the flow control valve OFF if the exhalation valve is OFF.

22. Oxygen Analog Output [Sheet 2]

One half of dual 8-bit latched multiplying DAC U104 (DAC A) generates a voltage which can be varied by the microcontroller. A 00H code latched into DAC A will generate 0 V dc, while a 0C8H code (200 decimal) will generate +1 V dc on U101-1 (One LSB = 0.5% O_2).

23. LCD Contrast Driver [Sheet 2]

One half of dual 8-bit latched multiplying DAC U104 (DAC B) generates a voltage which can be varied by the microcontroller. The circuit is designed to generate 0 V dc to (minus) - 4.5 V dc, depending on the value latched into DAC B. This output is connected to the front panel board and is used to vary the contrast of the LCD.

24. A/D Converter [Sheet 2]

U106 is a CMOS l0-bit Analog-to-Digital converter with a conversion time of 50 µS (typical). The full scale input voltage is set to +4.500 V dc at U106-9.

25. 24-Channel Multiplexer [Sheet 2]

U107, U108 and U109 are CMOS single 8-channel analog multiplexers. Together they form a 24-channel multiplexer. The microcontroller uses signals /MUXl, /MUX2, and /MUX3 to select a specific multiplexer channel.

26. System OK / Valve Interlock [Sheet 2]

Gates from U124 and U125 form an interlock for the exhalation valve (which also interlocks the flow control valve). RST (the watchdog circuit reset) must be low, and PS_OK or BAT_OK from the power source selection circuit must be high, in order for SYS_OK to be high. SYS_OK is also ANDed with EX_VAL, and if SYS_OK is low, the exhalation valve will not turn ON. SYS_OK is also sent to the front panel board to force a system fail response if it goes low.

27. Exhalation Valve Drive and Sense [Sheet 2]

Power FET Q101 provides drive power for operation of the exhalation valve. A feedback sense signal is amplified by U103 and input to multiplexer U109.

A normally open (NO) pressure sense switch is connected between J16-1,3. If the pressure sensed by the switch rises to 105 ±5 cm H_2O, the switch closes. This de-energizes K103, disconnecting the exhalation solenoid valve. K103 will latch itself OFF until EX VAL is driven low. This provides a high pressure safety relief in the event that the patient pressure sensing circuit of the ventilator is inoperative.

28. Gas Inlet Valve Drive and Sense [Sheet 1 and 2]

The gas inlet valve signal (SUP_VAL) is decoded by U120 and connected to power FET Q103. Q103 controls operation of the gas inlet valve. The gas inlet valve is normally ON throughout ventilator operation. A feedback sense signal is amplified by U103 and input to multiplexer U109.

F. Front Panel Board

1. System Fail Logic [Sheet 1 of Schematic, Section 9]

SYSOK is generated by the control board and is high if the power supply and watchdog circuits are functioning correctly. If a failure occurs, SYSOK turns OFF the red LED and turns ON the yellow LED. The LCD also goes blank and the audio alarm section activates.

2. LED Alarm Indicators [Sheet 1]

The red LED (CR31) and the yellow LED (CR32) located on SW109 are driven by transistors Q6 and Q5 respectively. Transistor Q6 is controlled by REDLED and Q5 is controlled by YELLED from the control board.

3. Liquid Crystal Display [Sheet 1]

The LCD module is connected to the front panel board at J5. It is an intelligent device that receives commands and data from the microprocessor on the control board.

VEE is the display drive voltage which is controlled by V_DISP, generated on the control board. LCD contrast is related to the voltage difference between VCC (J5-2) and VEE (J5-3). Diodes CR1-CR4 and CR23-CR25 provide a voltage change with temperature of about minus (-)9.5 mV dc/°C. This closely matches and balances the temperature sensitivity of the LCD.

An electro-luminescent panel is contained in the LCD. An ac voltage of 80 ± 20 V ac rms. at 700 Hz ±100 Hz, powers the EL panel. The ac voltage comes from the control board (J1) and goes to the LCD.

4. Front Panel board Input [Sheet 1]

U110 functions as an 8 bit input port. The front panel switch matrix, touch detection circuit, and variable frequency audio alarm are input to the processor through this port.

5. Front Panel Switches [Sheet 1]

The following switches are wired in a 4 x 7 matrix:

- Pushwheel Assembly
  (Low MV, Low O_2, High O_2) SW102-SW107
- Alarm Reset Switch SW109
- Mechanical Ventilation Switch SW108
- Inspiratory Pause Switch SW110
- Future Switch Expansion .....(J9)

The pushwheel format is BCD (Binary Coded Decimal).

6. TVX (Volume Transducer) Input [Sheet 1]

The TVX (volume transducer), connected at J2, provides two input signals in the form of pulse trains PULSE A and PULSE B. The frequency of each signal is proportional to the amount of gas passing through the transducer.

When flow is in the expiratory direction (direction indicated on the label on the transducer clip), PULSE B leads PULSE A. When flow is in the opposite direction, PULSE B lags PULSE A.

R106 is connected in the return line of the TVX clip heater when the clip is plugged into J2. The voltage generated across R106 is used to sense if the TVX clip is plugged in.

7. Oxygen Sensor Input [Sheet 1]

The oxygen sensor (connected at J2) generates a current which is proportional to the partial pressure of oxygen in the sample gas. Two cells may be present in the sensor but only a single cell, SENSOR_A input, is used. The load presented to this cell is 617 ohms at 25 °C. The other cell, SENSOR_B input, is shunted to ground.

Note: The oxygen sensor should be shunted to ground through a load resistor at all times for proper operation. Leaving a sensor open-circuited causes oxide to develop on the cells. When the cell is later reconnected it may take several hours before normal operation of the cell resumes.

Calibration of this circuit is done via software using a gain value derived from the oxygen calibration potentiometer (R80).

8. Control Potentiometers [Sheet 1]

R101, R102, R103 and R105 are the front panel potentiometers used to set values for tidal volume, respiratory rate, inspiratory flow, and inspiratory pressure limit used by the ventilator. Each potentiometer has 270 degrees of mechanical travel range. Appropriate scaling is done in the software.

9. Audio Alarm [Sheet 2]

Two sections of the quad op amp U112 are used to generate +0.95 V dc and minus (–) 0.95 V dc voltages from the reference +4.500 V dc supply. These voltages are used in the audio alarm circuit.

One half of the dual 8 bit DAC U111 controls the frequency of a square wave oscillator. The other half of DAC U111 controls the gain of the square wave signal. If /SYSOK is low, this signal drives the speaker connected to J8.

A 555 oscillator generates an approximate 1 kHz wave form. If /SYSOK is high, this wave form drives the speaker, instead of the microprocessor generated signal (U111).

10. Touch Detection Circuit [Sheet 2]

There are three identical touch detection circuits, one each for the tidal volume, rate and inspiratory flow setting knobs on the front panel.

The knobs have a conductive front surface which is electrically connected to the front panel circuit board. Capacitors dc isolate the knob from the rest of the circuit.

A 500 kHz oscillator is connected to the detection circuit. The circuit operates by using body capacitance (about 30-100 pF) to lower the impedance to ground and reduce the amplitude of the 500 kHz signal. The signal is fed to a peak detector which outputs a signal equal to the difference at its inputs as the knob is touched. This signal is amplified for maximum gain without false triggering from noise. The output signal is low when the knob is not being touched. The output signal is high when the knob is first touched. The signal falls low again after about 1 second, as the low pass filters respond.

11. Flow Control Valve Interlock [Sheet 1]

One half of the mechanical ventilation ON/OFF switch (SW108) is connected so as to interrupt the control loop on the control board which drives the flow control valve. If SW108 is OFF (open), the control signal is disconnected, forcing the flow control valve OFF.

G. Pressure Transducer Board (Original)

1. Power Supply

Power is supplied to the board via connector J1-6 (+7.5 V dc), J1-5 minus (-) 7.5 V dc], and J1-7,8 (analog ground).

A precision +4.50 V dc from the control board is connected to J1-1.

2. Voltage References

U104 uses the +4.50 V dc to generate a minus (-) 3.00 ± 0.06 V dc voltage reference used on the pressure transducer board.

3. Patient Pressure Circuit

U105 is a temperature compensated silicon piezoresistive gauge pressure transducer.

The offset adjustment R102 is used to set a positive zero pressure output voltage. This positive offset allows the circuit to measure negative pressures.

The gain adjustment R101 is used to set the full scale output voltage.

4. Temperature

U107 is a temperature transducer used to generate TEMP (output, J1-4). TEMP is used by the system software to provide temperature compensation of the patient pressure signal.

5. Supply Pressure Circuit

U106 is a temperature compensated silicon gauge pressure transducer (output, J1-3).

Potentiometer R103 provides an adjustment to compensate for circuit offsets.

H. Pressure Transducer Board (Universal)

1. Power Supply [Sheet 2]

Power is supplied to the board via connector J1-6 (+7.50 ±0.60 V dc), J1-5 [minus (-) 7.50 ±0.60 V dc], J1-7,8 (analog ground) and J2-1 (chassis ground).

2. Voltage References [Sheet 2]

U7 is a +2.500 ±0.005 V dc voltage reference with a 25 ppm/°C maximum temperature coefficient.

The +2.5 V dc reference drives amplifiers U6A and U6B which generate the +5 V dc and minus (-) 5 V dc references. These references are used as power supplies for pressure transducers U4 and U5 and their offset adjustment circuits.

The +2.5 V dc reference is also used to generate a fixed +0.872 ±0.030 V dc temperature output reference at J1-4.

3. Patient Pressure Circuit [Sheet 3]

U5 is a temperature compensated silicon piezoresistive gauge pressure transducer.

The offset adjustment R102 is used to set a positive zero pressure output voltage. This positive offset allows the circuit to measure negative pressures.

The gain adjustment R101 is used to set the full scale output voltage.

4. Supply Pressure Circuit [Sheet 1]

U4 is a temperature compensated silicon gauge pressure transducer (output, J1-3).

Potentiometer R103, R18 and R19 provide an offset adjustment to compensate for circuit offsets.

I. Piggyback Watchdog Board

The piggyback watchdog board plugs into the control board. This circuit is designed to detect errant program execution as well as provide a watchdog time-out function.

A positive reset pulse will occur (J1-4 and P2-4) if the watchdog circuit is not toggled in an appropriate time or if incorrect program execution is detected. The watchdog audio alarm (LS1) will then sound if multiple reset pulses fail to restore the ventilator to correct operation (typically within 30 seconds). Fuse F1 limits the current to 1 A dc.

Note: The piggyback watchdog board is not installed on some units.

J. EMC/Interface Board

The EMC/Interface circuit includes EMI filters and bipolar transient voltage suppressers. The EMI filters attenuate electrical noise from electro-surgical units or other electrical noise generators in the operating room environment. The transient voltage suppressers protect the EMI filters and the signal input circuitry on the control board. The filters and transient voltage suppressers use the chassis ground as common. High frequency noise is shunted away from the signal lines.

Notes:

3/Post-Service Checkout

After servicing the ventilator, you must complete section "4/Tests and Calibration" and then the following "Post-Service Checkout." You must complete the checkout procedure for the entire system; the ventilator, the anesthesia system, and all the accessories and options.

⚠WARNING: You must perform all post-service checks after maintenance or service of the ventilator. Failure to do so may result in patient injury.

⚠WARNING: All components and accessories must be connected correctly. All hoses and cables must be properly connected before returning the anesthesia system to clinical use. Failure to do so may result in patient injury.

Test the Ventilator.

Perform section "4/Preoperative checkout procedure" found in the 7800 Ventilator Operation and Maintenance Manual.

Test the Anesthesia System.

The ventilator is an integral part of a complete anesthesia system. To be certain the ventilator is functioning correctly it is necessary to test the entire system. Please refer to the anesthesia system manuals.

Important: If you have an Ohmeda Excel Anesthesia System, complete the system checkout procedure in the Excel Service Manual. If you have an Ohmeda Modulus® II Anesthesia System, complete the system checkout procedure in the Modulus® II Service Manual.

Test all Options and Accessories.

Complete the checkout procedures for all options and accessories included with the anesthesia system.

Notes:

4/Tests and Calibration

4.1 Overview

⚠WARNING: Do not perform testing or maintenance on medical instruments while they are being used on a patient; patient injury may result.

This section includes failure identification tests and calibration procedures for the bellows assembly and the control module.

Testing Requirements

The 7800 Ventilator can be an integral part of the Ohmeda Excel Anesthesia System, or attached to various other anesthesia systems. In some configurations it is possible to test and repair the control module while attached to the anesthesia system. You must determine if it is necessary to remove the control module to gain access for service and/or maintenance.

The 7800 Ventilator can be an integral part of the Ohmeda Modulus II Anesthesia System (Modulus II Upgrade). The ventilator must be removed from the anesthesia system and placed on a special service shelf in order to gain access for service or maintenance. This service shelf and stand-off allows you to mount the ventilator behind the anesthesia system and connect required hoses and cables.

If you service only the bellows assembly, and do not remove the control module cover, it is not necessary to perform the control module tests. Or, if you service only the control module, and do not disassemble the bellows assembly, it is not necessary to perform the bellows assembly tests. If you are performing routine maintenance it is necessary to complete the entire section. It is always necessary to perform section "3/Post-Service Checkout" after this section.

⚠WARNING: Post-Service Checkout is required after you complete this section. You must perform section " 3/Post-Service Checkout" after performing any maintenance, service or repair. Failure to do so may result in patient injury.

⚠CAUTION: Do not short pins when measuring voltages. Shorting pins could cause damage to the control board.

Viewing Displays in Another Language
This manual illustrates ventilator displays in English. The ventilator language selection will determine which language you will actually see. In most cases the displays will be in the local language. You may choose to view the displays in English (by changing the language selection) or you can view the displays in your own language. Change the language setting back to the original language after testing is complete.

Note: The altitude and language selections are described in the Operation and Maintenance manual.

4.2 Bellows Assembly Tests

These tests can be used to test both the Autoclavable Bellows Assembly (ABA) and the Non-Autoclavable Bellows Assembly (Non-ABA). Autoclavable parts are identified with the "**134°C**" marking.

A. Visual Inspection

1. Disassemble the bellows assembly. On the ABA, do not remove the seat from the diaphragm. On the Non-ABA, do not disassemble the pressure relief valve.

⚠WARNING: Do not remove the seat from the diaphragm (ABA) or disassemble the pressure relief valve (Non-ABA). Patient injury may result.

2. Carefully inspect each component for proper fit, signs of wear, deterioration or damage such as cracks, warpage, swelling or other physical changes, and replace as necessary. The U-cup seal, pressure relief valve, base and tubing are the most likely to require replacement. It is normal for the ABA Bellows and other rubber goods to change color somewhat from steam autoclaving.

⚠WARNING: Non-ABA components cannot be autoclaved. Non-ABA components that have been autoclaved must be replaced. Patient injury may result.

3. Reassemble the bellows assembly.

B. Bellows Assembly Leak Tests

Tools Required:

- Ohmeda approved test plugs, two (2)
- Anesthesia O_2 flowmeter
- Breathing circuit pressure gauge
- Breathing circuit, complete

Bellows Retention Test

1. Occlude the patient connection port ("Y" piece), and exhaust outlet (19 mm or 30 mm).

2. Set the breathing circuit to ventilator mode. If you have an Ohmeda GMS Absorber, move the Bag/APL-Ventilator selector to "Ventilator."

3. Inflate the bellows to the top of the housing by pressing the oxygen flush button. Using the oxygen flowmeter, increase the pressure to 15 cm H_2O as read on the breathing circuit pressure gauge. The bellows must remain fully on the securing rim.

4. Remove the occlusion from the exhaust outlet.

Pressure Relief Valve Test

5. Ensure the bellows is still at the top of the housing. Adjust the oxygen flow from 200 mL/min. to 10 L/min. and back. The breathing circuit pressure must remain between 1 cm H_2O and 5 cm H_2O.

Bellows Drop Test

6. Ensure the bellows is still at the top of the housing. Power OFF the anesthesia system. The bellows must not drop more than 100 mL/min.

7. Remove all occlusions.

Pressure Leak Test

Leakage (without Bellows Assembly)

First, the entire breathing circuit leakage will be determined with the bellows assembly removed from the circuit. Then the test will be repeated with the bellows assembly included. The difference between the readings will be the bellows assembly leakage.

8. Set the breathing circuit to bag mode, which bypasses the bellows assembly. If you have an Ohmeda GMS Absorber, move the Bag/APL-Ventilator selector to "Bag/APL".

9. Remove the breathing bag and occlude the port with a test plug. Remove and occlude any gas sampling connections.

10. Close the APL valve. Turn OFF any other device that may cause this circuit to relieve at 60 cm H_2O. If necessary consult your breathing circuit operation manuals.

11. Turn ON the anesthesia system and adjust the O_2 to minimum flow. All other gasses OFF.

12. Watch the pressure gauge and occlude the patient connection port ("Y" piece) with a second test plug. Quickly unplug the port if the pressure approaches 100 cm H_2O. Ignore or silence alarms.

13. Slowly increase the O_2 flow until the pressure approaches 60 cm H_2O. Quickly reduce the flow until the pressure stabilizes. If the pressure continues to increase with the lowest flowmeter setting, the breathing circuit leak rate is less than the minimum deliverable O_2 flow.

Record the O_2 flowmeter reading. This flow is the breathing circuit leak rate without the bellows assembly. For most circuits this reading should be less than 300 mL/min. If the reading is greater, refer to the relevant breathing circuit manual for guidance and repair the circuit as necessary.

14. Return the O_2 flowmeter to minimum setting. Remove the patient connection port occlusion. Ensure the bellows is empty and at the bottom of the housing. Remove the breathing bag port occlusion and attach the breathing bag.

Leakage (with Bellows Assembly)

15. Set the breathing circuit to ventilator mode. If you have an Ohmeda GMS Absorber, move the Bag/APL-Ventilator selector to "Ventilator." Disconnect the 17 mm drive gas hose, at the back of the control module, and occlude the hose.

16. Watch the pressure gauge and occlude the patient connection port ("Y" piece). Quickly unplug the port if the pressure approaches 100 cm H_2O. Ignore or silence alarms.

17. Slowly increase the O_2 flow until the pressure approaches 60 cm H_2O. Quickly reduce the flow until the pressure stabilizes.

Note the O_2 flowmeter reading. This flow is the breathing circuit leak rate with the bellows assembly. For the ABA, this reading must not be more than 250 mL/min. above the previously recorded breathing circuit leak rate, or for Non-ABA 300 mL/min. above the previously recorded breathing circuit leak rate.

18. Remove all occlusions and connect the drive gas hose to the control module.

C. Additional Bellows Assembly Tests

If you have not removed the control module cover, it is not necessary to perform the control module tests. Go directly to section "3/Post-Service Checkout" if you have NOT serviced the control module.

⚠WARNING: Section "4/Tests and Calibration" must be performed whenever a ventilator cover is removed, to ensure the ventilator are still operational and within specifications. Failure to do so may result in patient injury.

⚠WARNING: You must perform section "3/Post-Service Checkout" for the entire system before returning the system to clinical use. Failure to do so may result in patient injury.

4.3 Control Module Tests

A. Power Supply Test

Tools Required:

- Multimeter (4-½ digit)

1. Power ON the ventilator.

2. Locate J10, the "TEST" connector, on the control board.

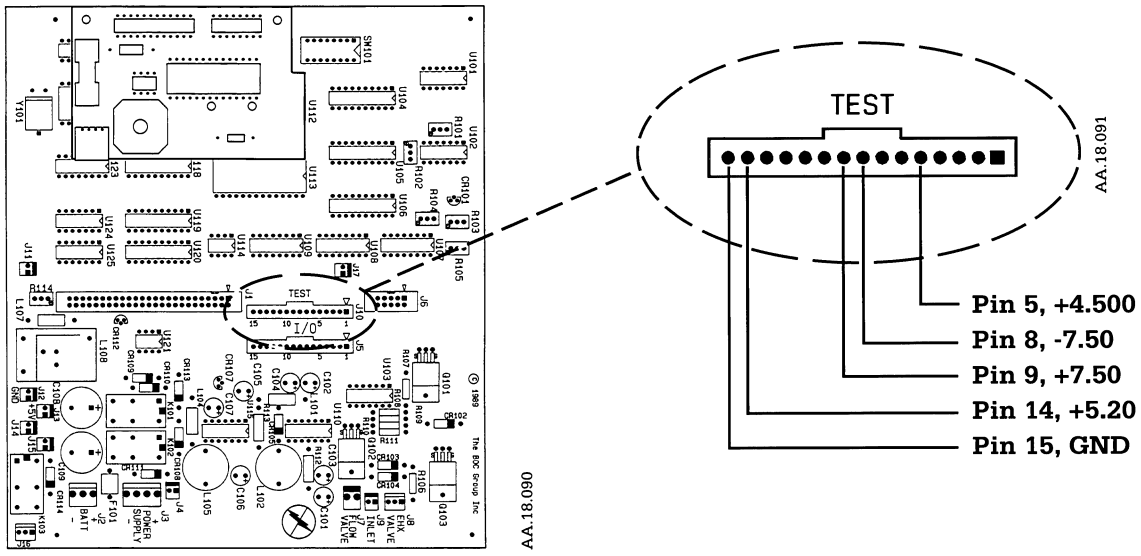


Figure 4-1 Control Board, TEST Connector J10

3. Measure the voltage between J10, pin 14 and pin 15 (AGND) on the control board (+5.20 V dc, + 0.00, -0.20 V dc).
   If out of range:

   a. Remove the lower shroud and adjust the voltage through the small hole in the power supply board box.

   b. If not adjustable, replace the power supply board.

Note: The original power supply boards are not adjustable.

4. Measure the voltage between J10, pin 9 and pin 15 (AGND) on the control board (+7.50 ± 0.60 V dc).

If out of range:

a. Disconnect the ribbon cable to J6 (on the control board) and check the voltage again.
b. If now correct, replace the pressure transducer board.
c. If still NOT correct, replace the control board.

5. Measure the voltage between J10, pin 8 and pin 15 (AGND) on the control board (-7.50 ± 0.60 V dc).

If out of range:

a. Add a jumper to J4 and disconnect the ribbon cable to J1 (on the control board) and check the voltage again.
b. If now correct, replace the front panel board and remove the jumper from J4 on the control board.
c. If still NOT correct, replace the control board.

6. Measure the voltage between J10, pin 5 and pin 15 (AGND) on the control board (+4.500 ± 0.005 V dc).

If out of range:

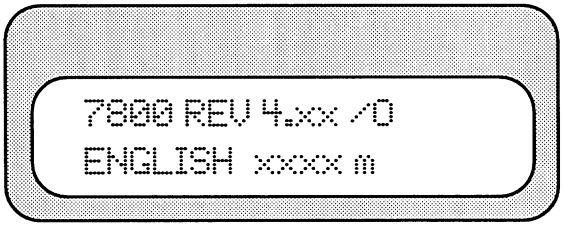
Adjust R105 on the control board, or replace the control board or the pressure transducer board.

B. Checking User Parameters, 4.xx Software

Important: The different versions of software require different calibration procedures. Be certain you are using the correct procedure before you proceed.

To Check User Parameters

1. Move the mechanical ventilation switch to OFF.
2. Electrically power ON the ventilator.
3. Hold down the alarm silence button, and press the inspiratory pause button.



If you do not see this screen: check the control board DIP switch SW101 (1 ON, 2 OFF, 3 OFF and 4 OFF). This is the setting for operational mode.

This screen includes the following information:

The Ventilator Model: 7800

If 7800 is not displayed, check the battery connector. The battery is not being recognized

The Software Revision Number: REV 4.xx

The Supply Gas: /O

/O = Oxygen Supply Gas, /A = Air Supply Gas, and /E indicates an Error or no supply gas selection has been made.

The Language Selection: ENGLISH

The Altitude: xxxx m

The language selection and altitude selection are described in the Operation and Maintenance manual.

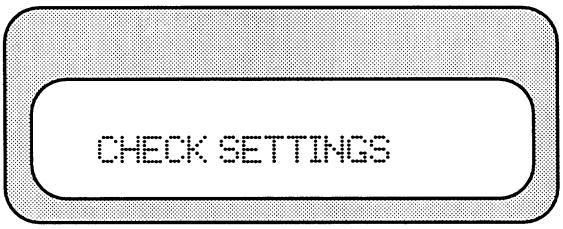
Record for future reference:

- Ventilator Model — 7800
- Software Revision Number — 4.xx
- Supply Gas Selection — O_2 or AIR
- Language — _____
- Altitude — xxxx meters.

Repeatedly press the alarm silence button and record for future reference:

- Reverse Flow Alarm — ON or OFF
- SIGH — ON or OFF
- Contrast — number xx
- Audio Volume — number xx.

Press the alarm silence button.



The ventilator will return to operational mode.

C. Service Calibration Mode, 4.xx Software

Important: The different versions of software require different calibration procedures. Be certain you are using the correct procedure before you proceed.

Tools Required:

- Pressure Gauge, 0-400 kPa (0-58 psi)
- Pressure Gauge, 0-150 cm H_2O
- Squeeze bulb and valve
- Digital Multi-Meter, 4 1/2 digit
- Stopwatch
- Flowmeter, 0-100 L/min. (or Respirometer)
- Pressure Source, 276 kPa (40 psi)
- Pressure Source, 90-135 cm H_2O adjustable

The service calibration routines perform electronic and pneumatic checks on the control module. Each check begins with a special display screen. Not all screens require action.

You must step through the checks sequentially. After completing each check, press the alarm silence button  to enter the next check in the sequence.

Do not turn OFF the ventilator during these routines. Service calibration can only be started from step 1.

1. Check the Watchdog Timer

a. Power ON the ventilator if not already powered ON.

b. Move the control board DIP switches (SW101) 1 OFF, 2 ON, 3 ON, 4 OFF.

c. This reset sequence occurs:
- You will hear a long (1 kHz) beep, followed by repeating short and long (1 kHz) beeps.
- The yellow LED also flashes this sequence.

d. If not:
- Check the ribbon cable between J1 (control board) and J1 (front panel board).
- Replace the control board or the front panel board.

e. Press and hold the alarm silence button  .

2. Check the Contrast

a. Note the initial "CONTRAST (xx)" number.

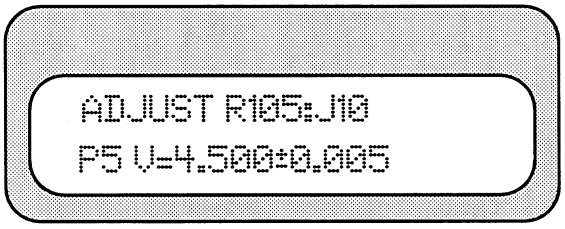
b. Turn the inspiratory flow knob. The display contrast should change.

c. Reset to the initial value "(xx)."

d. If no change:

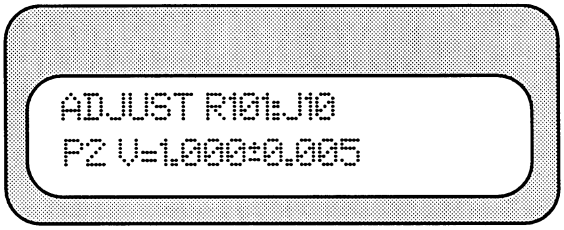
- Check the ribbon cable between J1 (control board) and J1 (front panel board).
- Replace the LCD, the front panel board, or the control board.

3. Check the 4.500 Volt Reference



The 4.500 V dc was checked during the power supply tests.

4. Measure the Oxygen Output Reference

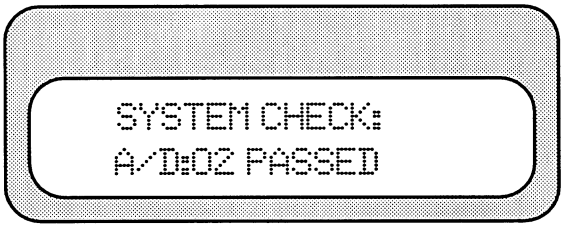


a. Measure between J10, pin 2 and pin 15 (AGND) on the control board (+1.000 ± 0.005 V dc).

b. If out of range, adjust R101 (control board).

c. If not adjustable, replace the control board.

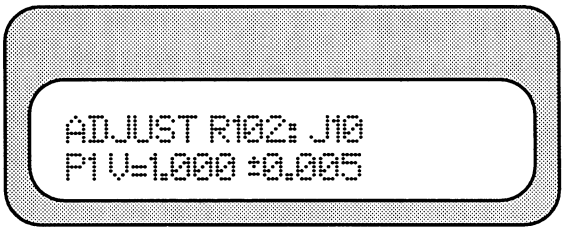
5. Check the Analog to Digital Conversion of the Oxygen Output



"PASSED" = correct

If "FAILED" appears, replace the control board.

6. Measure the Patient Pressure Output Reference

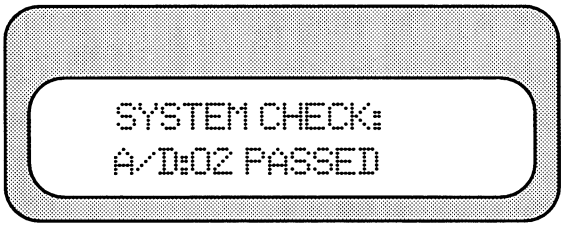


a. Measure between J10, pin 1 and pin 15 (AGND) on the control board (+1.000 ± 0.005 V dc).

b. If out of range, adjust R102 (control board).

c. If not adjustable, replace the control board.

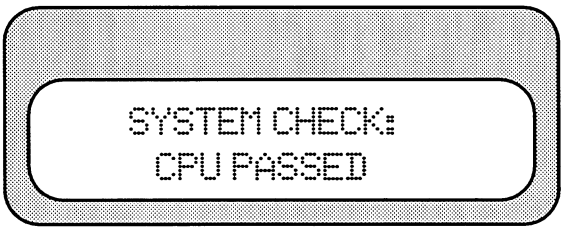
7. Check the Analog to Digital Conversion of the Patient Pressure Output



"PASSED" = correct

If "FAILED" appears, replace the control board.

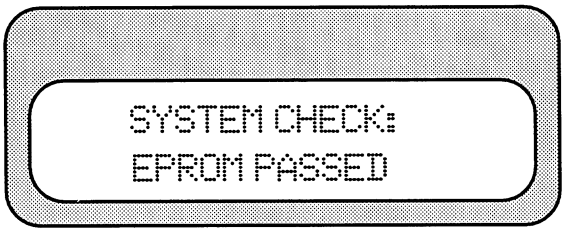
8. Check the CPU



"PASSED" = correct

If "FAILED" appears, replace the control board.

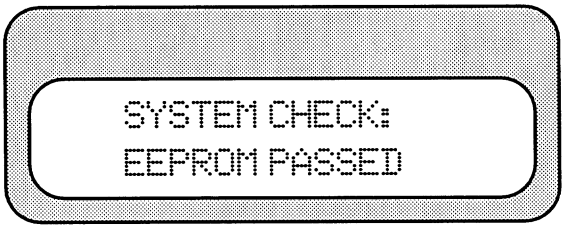
9. Check the EPROM



"PASSED" = correct

If "FAILED" appears, replace the EPROM or control board.

10. Check the EEPROM

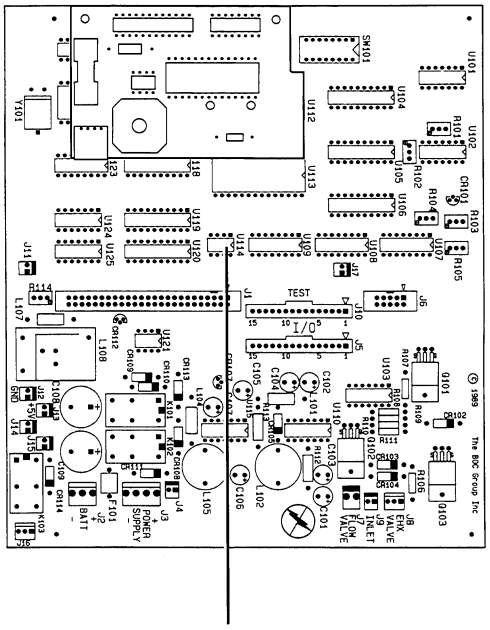


"PASSED" = correct

If "FAILED" appears,

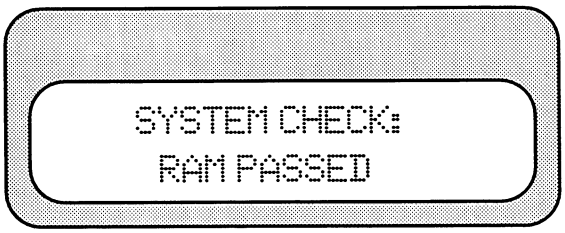
a. Check the EEPROM (U114) for correct installation.

b. Replace the EEPROM (U114) and pneumatic manifold assembly, or the control board.



Important: The EEPROM and the pneumatic manifold assembly must be replaced together.

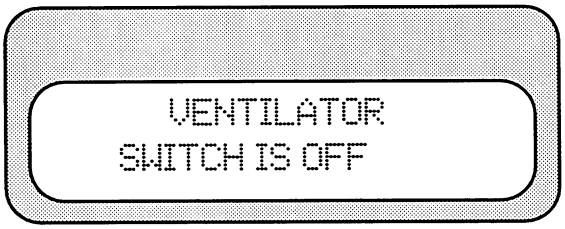
11. Check the RAM



"PASSED" = correct

If "FAILED" appears, replace the control board.

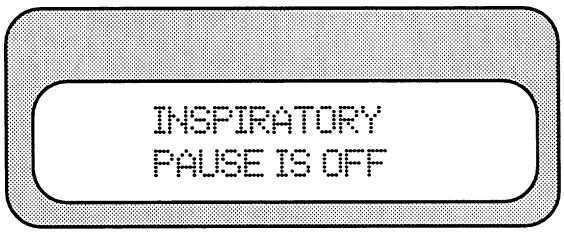
12. Check the Mechanical Ventilation Switch



a. Move the mechanical ventilation switch ON and OFF. The screen should correspond to the switch position.

b. If not:
   - Check the 50 pin ribbon cable.
   - Replace the front panel board or the switch.

13. Check the Inspiratory Pause Button



a. Toggle the inspiratory pause button between ON and OFF. The screen should read "ON" when the green LED is ON. "OFF" when the green LED is OFF.

b. If not:
- Replace the switch.
- Check the 50 pin ribbon cable.
- Replace the front panel board.

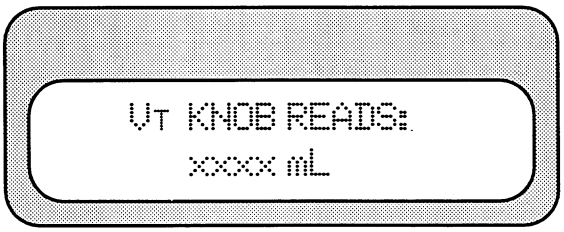
14. Check the DIP Switches

Important: Do not change the position of the switches while in service calibration mode.

a. The display should match the switch bank (SW101).

b. If not, replace the control board.

15. Check the Tidal Volume Knob



a. Rotate the tidal volume knob through its range.

Resolution Table

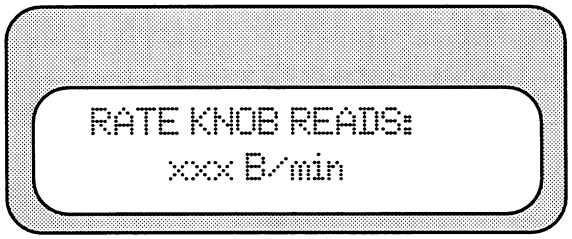
50 - 100	2 mL
100 - 250	5 mL
250 - 1000	10 mL
1000 - 1500	20 mL

b. Set the tidal volume to 300. The pointer and display should correspond.

c. If not, adjust the knob:

- Set the tidal volume to display 300.
- Loosen both set screws.
- Position the pointer to 300 (do not rotate the shaft).
- Tighten one set screw.
- Set the display to 50. Does the pointer correspond?
- Set the display to 1500. Does the pointer correspond?
- Tighten the second set screw.

16. Check the Rate Knob



a. Rotate the rate knob through its range.

Resolution Table

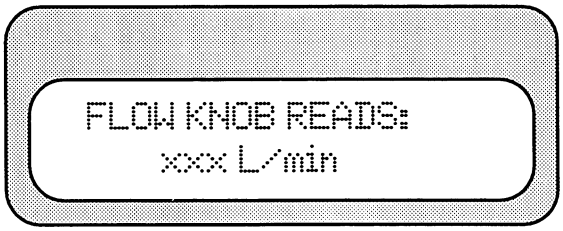
2 - 100	1 B/min.

b. Set the rate to 20. The pointer and display should correspond.

c. If not, adjust the knob.

- Set the rate to display 20.
- Loosen both set screws.
- Position the pointer to 20 (do not rotate the shaft).
- Tighten one set screw.
- Set the display to 2. Does the pointer correspond?
- Set the display to 100. Does the pointer correspond?
- Tighten the second set screw.

17. Check the Inspiratory Flow Knob



a. Rotate the inspiratory flow knob through its range.

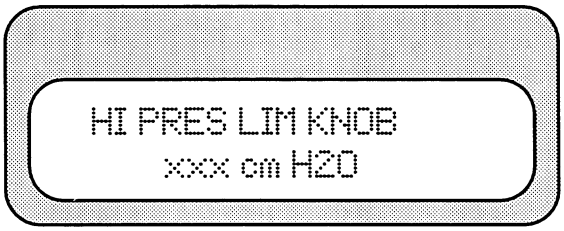
Resolution Table

10 - 100	1 L/min.

b. Set the inspiratory flow to 10. The pointer and display should correspond.

c. If not, adjust the knob.
- Set the inspiratory flow to display 10.
- Loosen both set screws.
- Position the pointer to 10 (do not rotate the shaft).
- Tighten one set screw.
- Set the display to 100. Does the pointer correspond?
- Tighten the second set screw.

18. Check the Inspiratory High Pressure Limit Knob



Note: To set the inspiratory pressure limit, press in on the knob and turn.

a. Rotate the inspiratory pressure limit knob through its range. When you push and turn, the knob should move smoothly. Confirm that the displayed value does not change if you do not push in.

Resolution Table

20 - 100	1 cm H_2O

b. Set the limit to 60. The pointer and display should correspond.

c. If not, adjust the knob.
- Set the inspiratory pressure limit to display 60.
- Loosen both set screws.
- Position the pointer to 60 (do not rotate the shaft).
- Tighten one set screw.
- Set the display to 20. Does the pointer correspond?
- Set the display to 100. Does the pointer correspond?
- Tighten the second set screw.
- Confirm that the knob rotates freely and does not stick:
  - the setting should change when you push and turn,
  - the setting should not change when you do not push.
- If the knob sticks, do the adjustment again.

Pushwheel Checks

The next three checks are for the pushwheel limit switches low $\dot{V}_E$, low O_2 and high O_2. Step the pushwheels through their least significant and most significant digits. The display should match the setting on the pushwheel. All pushwheels should move evenly in both directions. If not, replace the front panel board.

19. Check the Low Minute Volume Limit Pushwheels

a. Step the low $\dot{V}_E$ tenths digit.

b. Step the low $\dot{V}_E$ ones digit.

20. Check the Low Oxygen Limit Pushwheels

Note: 18% is the minimum % shown.

a. Step the low O_2 ones digit.

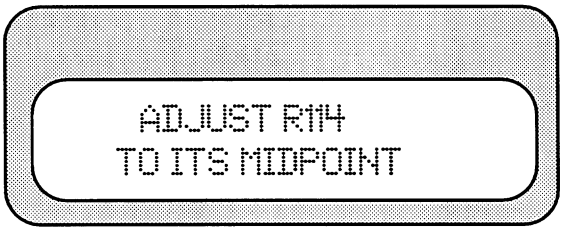
b. Step the low O_2 tens digit.

21. Check the High Oxygen Limit Pushwheels

a. Step the high O_2 ones digit.

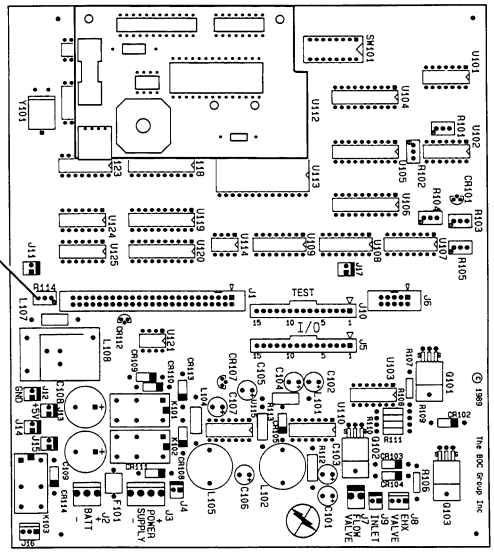
b. Step the high O_2 tens digit.

22. Check the Back-Light



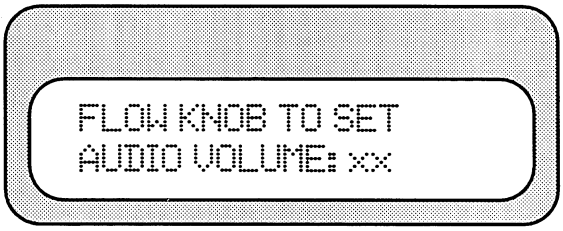
a. The back-light should be visible.

b. If not present, adjust the intensity:
   - Turn R114 fully counterclockwise (20 turn pot). You will hear and feel a click.
   - Turn R114 ten (10) turns clockwise. This is the midpoint. The display back-light should be visible in normal light.



c. If the back-light is still not visible:
   - Look for a missing jumper J11 (control board).
   - Check the ribbon cable between J1 (control board) and J1 (front panel board).
   - Replace the LCD, the front panel board, or the control board.

23. Check the Audio Volume



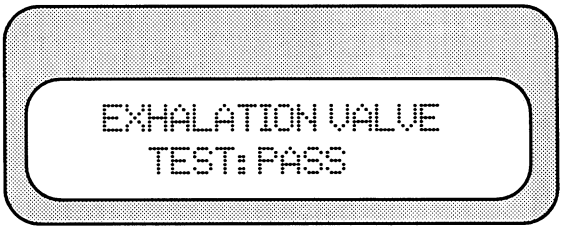
a. Note the initial "VOLUME: (xx)."

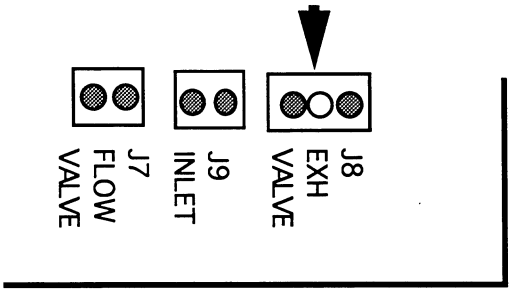
b. Turn the inspiratory flow knob. The volume should change.

c. Reset to the initial value "(xx)."

d. If the volume does not change:
   - Be sure the speaker is plugged into J8 (front panel board).
   - Check the ribbon cable between J1 (control board) and J1 (front panel board).
   - Replace the speaker, or the front panel board.

24. Check the Exhalation Solenoid





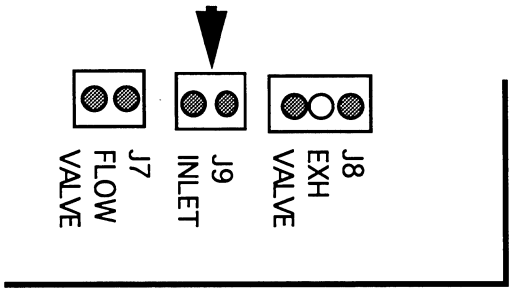
"PASS" = correct

If "FAIL" appears:

a. Check the cable connection to J8 (control board).

b. Replace the exhalation solenoid (SOL2), or the control board.

25. Check the Inlet Solenoid



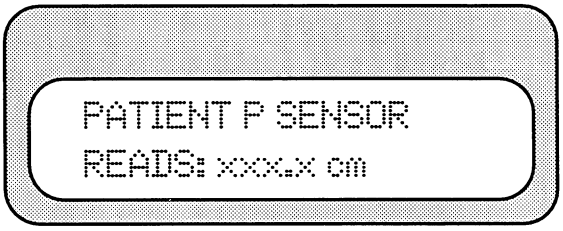
"PASS" = correct

If "FAIL" appears:

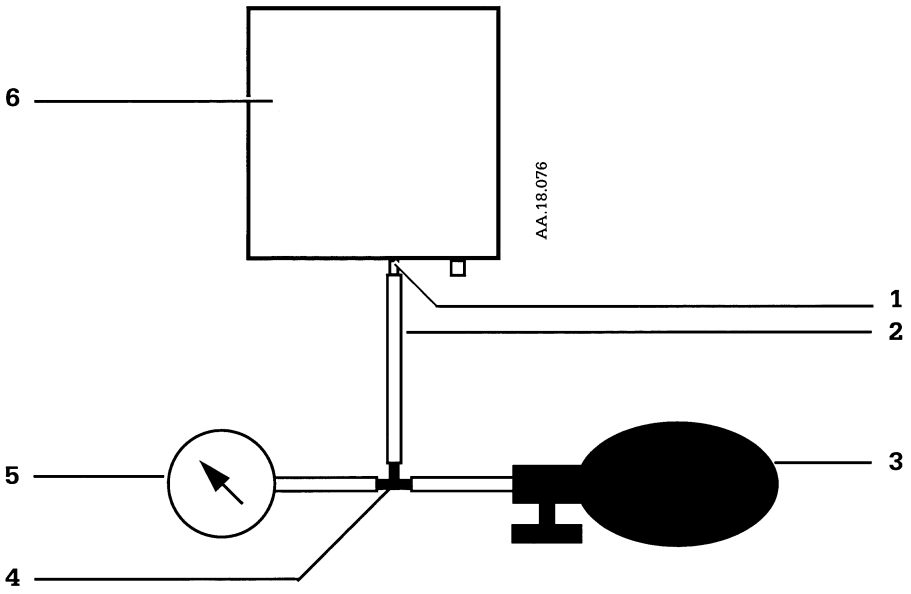
a. Check the cable connections to J9 (control board).

b. Replace the inlet solenoid (SOL1), or the control board.

26. Check the Patient Pressure Sensor Calibration



a. Attach a squeeze bulb with valve and a pressure gauge capable of measuring 0-150 cm H_2O to the patient pressure sensing input.



1. Patient Pressure Sensing Input
2. Tubing
3. Squeeze Bulb with Valve
4. Tee
5. Pressure Gauge
6. Control Module

Figure 4-2 Patient Pressure Sensor Calibration

Important: If you adjust either the zero or the gain, you must check the other adjustment. Repeat the zero and gain calibration until both are within specification without any adjustment.

b. The display should read 0.0 ± 0.5 cm H_2O. If not, adjust R102 (zero) on the pressure transducer board.

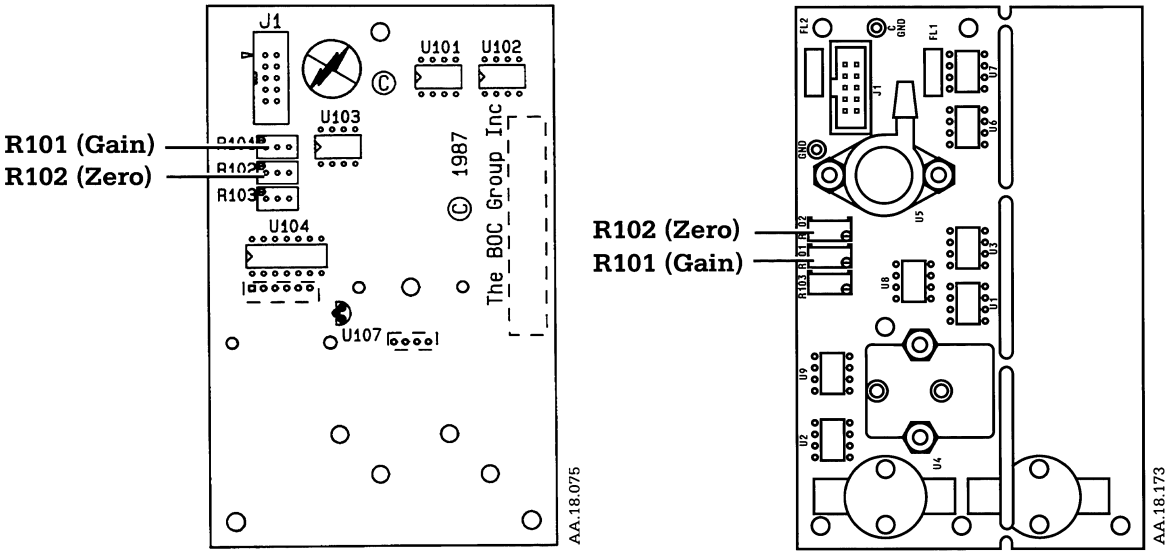


Figure 4-3 Patient Pressure Sensor, Zero and Gain Calibration

c. Lightly squeeze the bulb to bring the pressure to 100 cm H_2O on the gauge.

d. The display should read ± 1 of the gauge reading. If not, adjust R101 (gain) on the pressure transducer board.

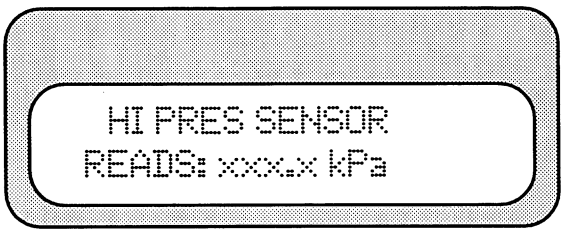
If the gain was adjusted, release the pressure and repeat the zero calibration. Repeat the zero and gain calibration until both are within specification without any adjustment.

e. Check the sensor linearity by lightly squeezing the bulb to bring the pressure to 50 cm H_2O on the gauge. The display should read ± 2 of the gauge reading.

If the zero, gain, or linearity specifications can not be met, replace the pressure transducer board.

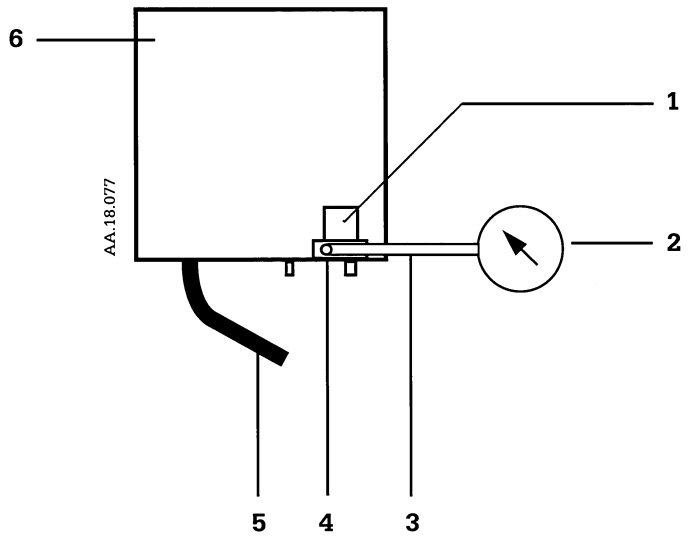
f. Remove the test equipment.

27. Check the High Pressure Sensor Calibration



a. Disconnect the gas supply if present.

b. Install a tube (3/16 inch O.D.) in the test port and attach a pressure gauge, capable of measuring 400 kPa (58 psi).



1. Pneumatic Manifold Assembly
2. Pressure Gauge
3. High Pressure Tube
4. Test Port
5. Gas Supply
6. Control Module

Figure 4-4 High Pressure Sensor Calibration

c. Connect the gas supply 276 ± 14 kPa (40 ± 2 psi).

d. The gauge should read approximately 180 kPa (26.1 psi). The display should read ± 3 kPa (± 0.4 psi) of the gauge reading. If not, adjust R103 (offset) on the pressure transducer board.

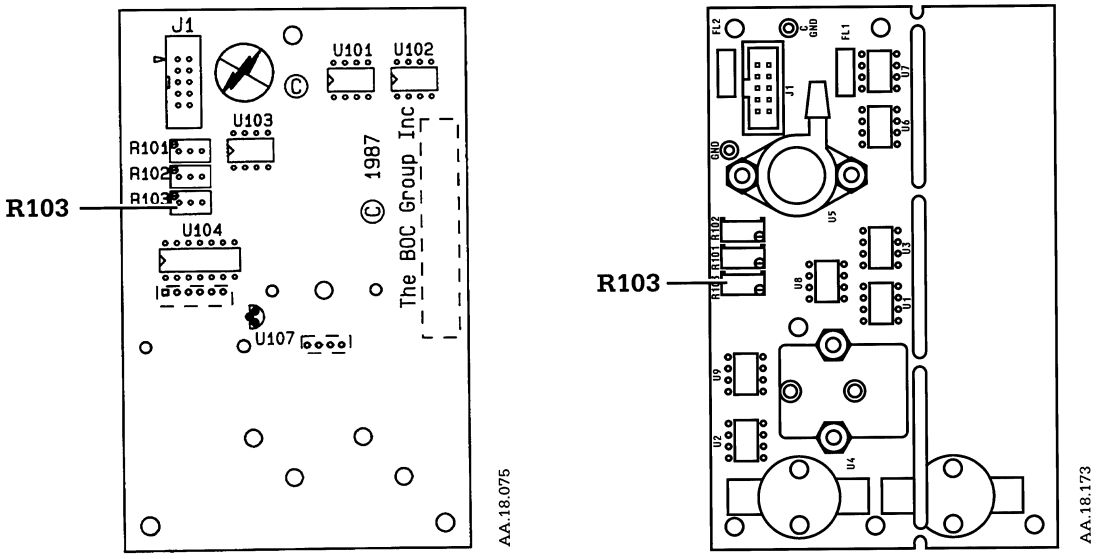
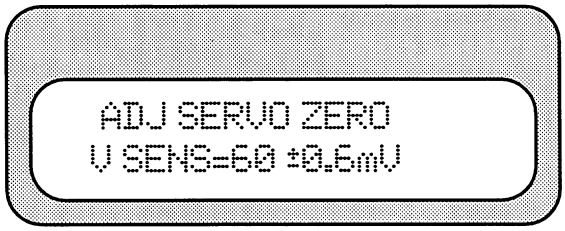


Figure 4-5 High Pressure Sensor Offset Calibration

e. If the specification cannot be met, replace the pressure transducer board.

f. Leave the gauge attached.

28. Check the Flow Control Zero Calibration



a. Move the mechanical ventilation switch to ON.

Note: With the mechanical ventilation switch in the ON position, pressing the alarm silence button allows you to toggle repeatedly between the zero and gain checks.

Important: If you adjust either the zero or the gain, you must check the other adjustment. Repeat the zero and gain calibration until both are within specification without any adjustment.

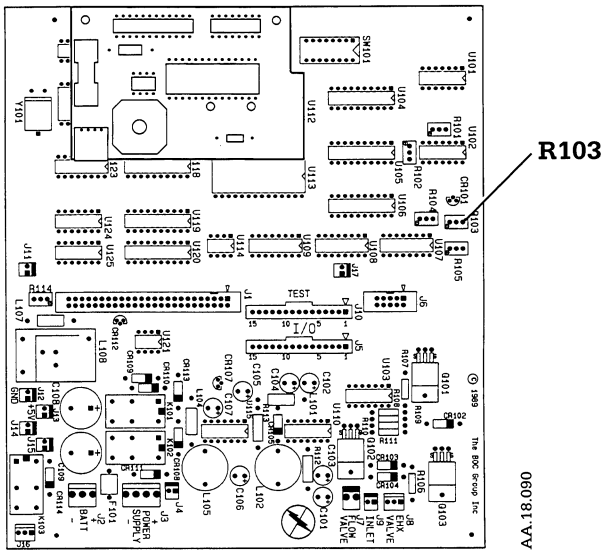
b. Measure between J10, pin 4 and pin 10 on the control board. The meter reading should be 60.0 ± 0.6 mV dc.

c. If not, adjust R103 (zero) on the control board.

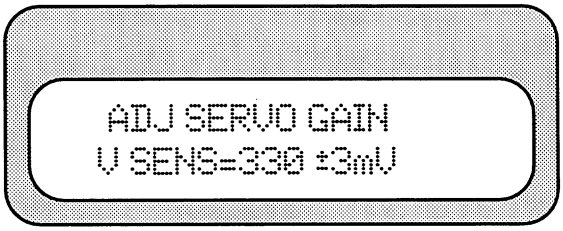
d. If not adjustable:

- Check the cable connection to J7 (control board).
- Replace the control board.

e. Press the alarm silence button to toggle to the gain calibration.



29. Check the Flow Control Gain Calibration



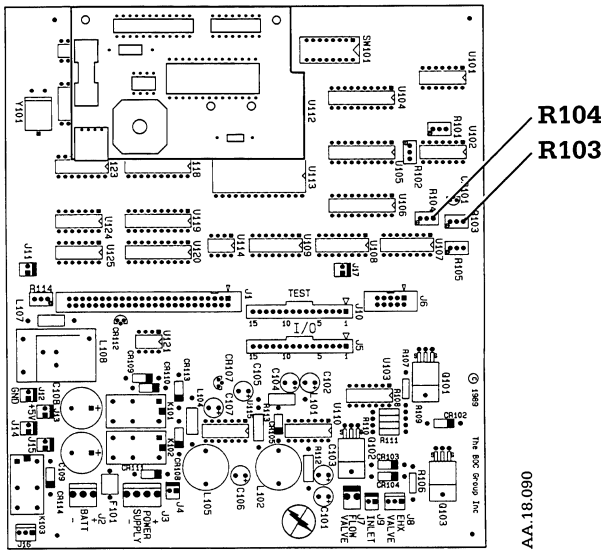
a. Measure between J10, pin 4 and pin 10 on the control board. The meter reading should now be 330 ± 3 mV dc.

b. If not, adjust R104 (gain) on the control board.

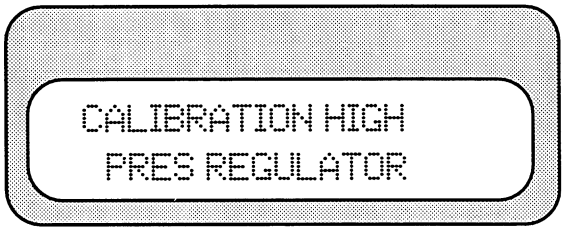
c. If not adjustable:
   - Check the cable connection to J7 (control board).
   - Replace the control board.

d. If the gain was adjusted, press the alarm silence button and repeat the zero calibration. Repeat the zero and gain calibration until both are within specification without any adjustment.

e. Move the mechanical ventilation switch to OFF, when the zero and gain are both within specification.



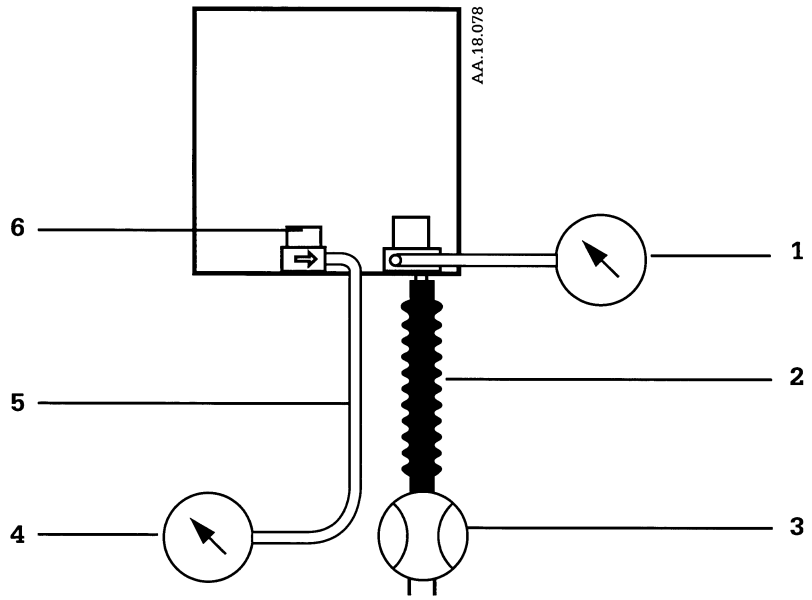
30. Regulator Calibration Setup



a. A pressure gauge, 400 kPa (58 psi), should still be attached to the test port.

b. Disconnect the output tube (TB-6) from the output of the secondary regulator. Attach a pressure gauge capable of measuring 150 cm H_2O.

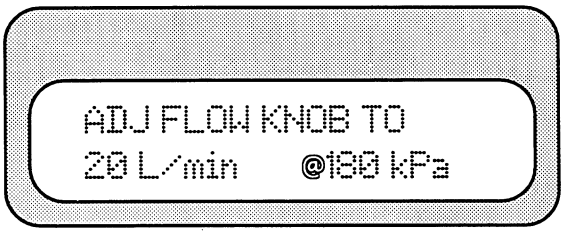
c. Attach a flowmeter capable of measuring 0-100 L/min. to the drive gas outlet.



1. Pressure Gauge
2. 17 mm Hose
3. Flowmeter
4. Pressure Gauge
5. Tubing
6. Secondary Regulator

Figure 4-6 Regulator Calibration Setup

31. Check the Regulator Pressures



Check the primary regulator pressure gauge, 180 ± 3 kPa (26.1 psi ± 0.4 psi). The primary regulator must be working before the secondary regulator can be checked.

Check the Secondary Regulator Calibration

a. The output pressure should be 125 ± 5 cm H_2O.

b. If not:
   - Adjust the secondary regulator.
   - Check the primary regulator pressure.
   - Replace the secondary regulator.

c. Remove the gauge from the secondary regulator and attach the tube.

Check the Primary Regulator Calibration

Important: If you adjust the primary regulator you must check the secondary regulator calibration again.

d. Move the mechanical ventilation switch to ON.

e. Adjust the inspiratory flow knob to acquire 20.0 ± 0.5 L/min. output.

f. Check the primary regulator pressure. Is it 180 ± 2 kPa (26.1 ± 0.3 psi)?
- If not, adjust the primary regulator while maintaining 20 L/min. flow.
- If you can not adjust to 180 ± 2 kPa (26.1 ± 0.3 psi) while maintaining 20 L/min. flow, replace the primary regulator.

g. Adjust the inspiratory flow knob to acquire 10.0 ± 0.5 L/min. output.

h. Check the pressure. Is it 180 ± 7 kPa (26.1 ± 1.0 psi)?
- If not, replace the primary regulator.

i. Adjust the inspiratory flow knob to acquire 100 ± 5 L/min. output.

j. Check the pressure. Is it 180 +0/ -14 kPa (26.1 +0/-2.0 psi)?
- If not, replace the primary regulator.

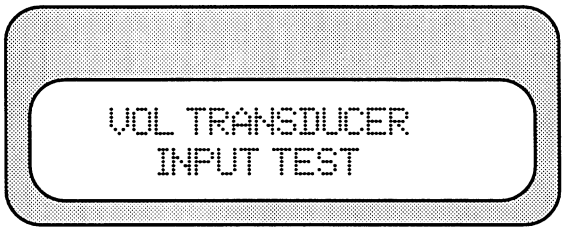
k. Move the mechanical ventilation switch to OFF.

Important: If the primary regulator was adjusted, repeat the secondary regulator calibration.

l. Disconnect the gas supply.

m. Remove all test equipment. Install the test port plug.

32. Volume Transducer Input Setup

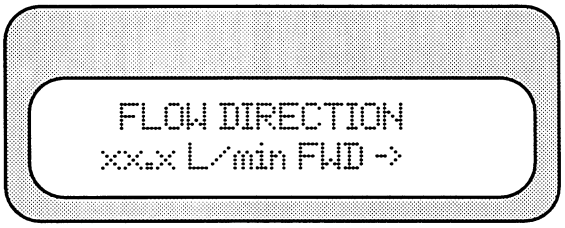


a. Adjust the tidal volume knob above 300.

b. Connect the volume transducer to the system common gas outlet. Arrows in the direction of flow.

c. Set the anesthesia system oxygen flow to 8 L/min.

33. Check the Flow Detection



a. The display should read "8.0 L/min. FWD->" ± 2 L/min.

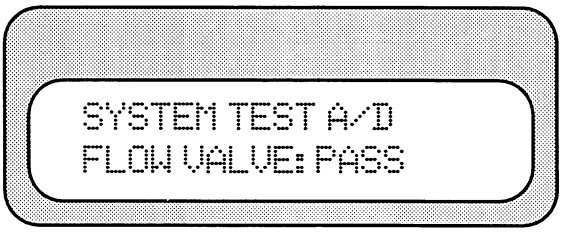
b. Reverse the sensor clip direction. The arrows against the direction of flow.

c. The display should now read "8.0 L/min. <-REV" ± 2 L/min.

d. If either flow detection doesn't work:
- Check the sensor.
- Check the sensor interface panel connections.
- Check the sensor cable (Modulus II, Excel) to the ventilator EMC/Interface board.
- Check the internal ventilator cable between P3 (EMC/Interface board) and J2 (front panel board).
- Check the EMC/Interface board.
- Check the 50 pin ribbon cable between J1 (front panel board) and J1 (control board).
- See the Modulus II or Excel service manuals for more information.

e. Return the sensor assembly to the breathing system.

34. Check the Analog to Digital Conversion of Flow Valve Drive



"PASS" = correct

If "FAIL" appears, replace the control board.

35. High Pressure Limit Setup

Connect an adjustable pressure source (90 - 135 cm H_2O) and a pressure gauge to the ventilator drive gas outlet.

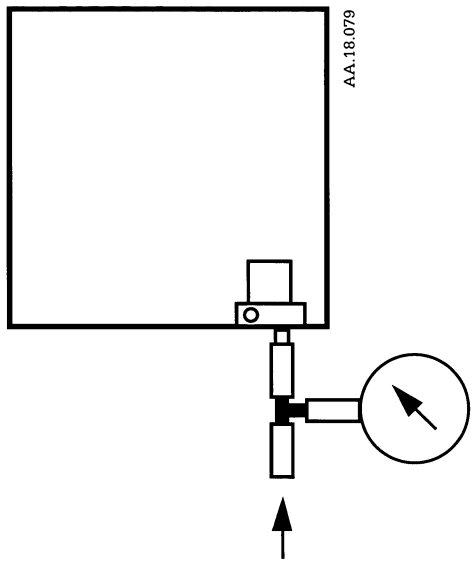
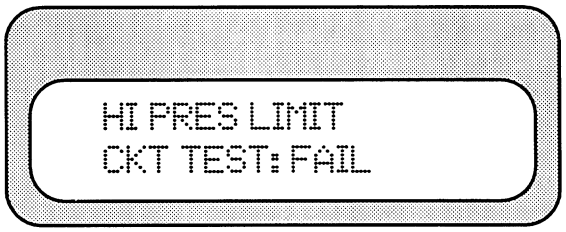


Figure 4-7 High Pressure Limit Setup

36. Check the High Pressure Limit



"FAIL" is displayed upon entering this check.

a. Raise the pressure slowly and check that the pressure drops sharply between 105 and 115 cm H_2O. The display should read "PASS" after the pressure drops.

Note: The flow control valve may have a small leak (within specification). If supply gas is connected and the drive gas outlet is blocked, this leakage can cause the pressure to slowly increase. If the free breathing valve leaks, the pressure may slowly decrease.

b. If the pressure does not drop:

- Check the cable connection to J16 (control board).
- Check the tubing.
- Replace the high pressure limit switch.

c. To repeat this check, move the mechanical ventilation switch to ON and press the alarm silence button twice.

d. To exit, the mechanical ventilation switch must be OFF.

e. Remove the test equipment.

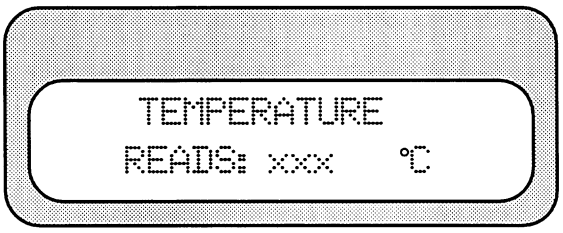
37. Check the Altitude Setting

a. Turn the inspiratory flow knob. The altitude should change from 0 to 3000 in increments of 100 meters.

b. Enter the correct altitude (1 foot = 0.3048 meters). Advise the hospital personnel if this selection is different than the original.

⚠ WARNING: If the altitude setting is wrong, false pressure readings can potentially cause the ventilator to operate out of calibration.

38. Check the Temperature Sensor



a. Identify which type of pressure transducer board you have.

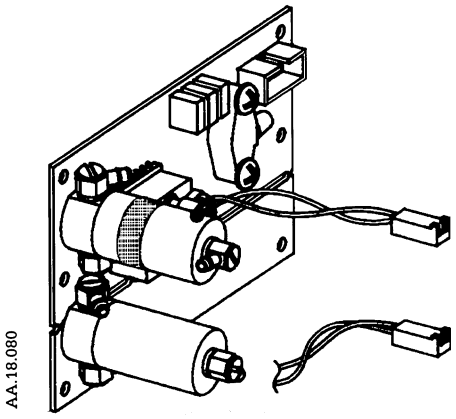
b. If you have the Universal pressure transducer board the display should indicate 25±1 °C.

c. If not, replace the pressure transducer board.

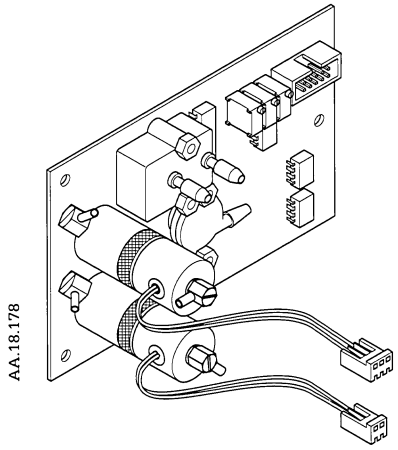
d. If you have the original pressure transducer board:

- Place a temperature probe (or thermometer) next to the transducer (U107).
- The measured temperature and the temperature on the display should be within ± 6 °C.

e. If not, replace the pressure transducer board.



Universal Pressure Transducer Board



Original Pressure Transducer Board

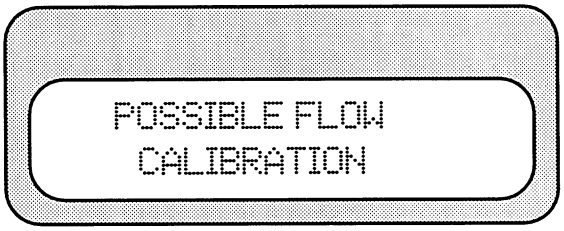
Ensure DIP SW101, switch 4 is still OFF.

⚠CAUTION: If switch 4 is left ON and you move to the next check, the EEPROM may get corrupted.

39. Flow Calibration Status

If DIP SW101, switch 4 is OFF (the correct setting), this step is bypassed.

If DIP SW101, switch 4 is ON, the following display will appear.

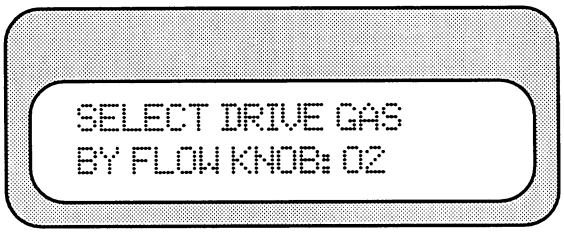


Ensure DIP SW101, switch 4 is OFF.

⚠CAUTION: If switch 4 is left ON and you move to the next check the EEPROM will be corrupted.

Press the alarm silence button to enter the next check.

40. Check the Drive Gas Selection



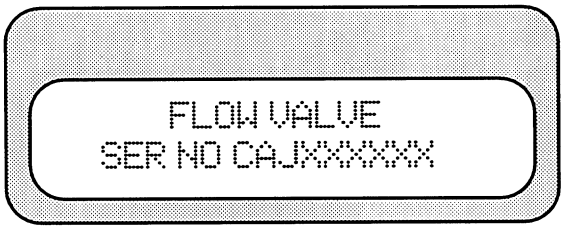
a. Note the setting. This must correspond to the existing gas supply connection.

b. If the drive gas selection must be changed, rotate the inspiratory flow knob to select the correct drive gas. Advise hospital personnel if you change the setting.

c. If "ERR" appears, and cannot be changed to "O_2" or "Air," replace the EEPROM and pneumatic manifold assembly.

⚠WARNING: When the gas selection is changed, further changes must be made to the ventilator gas supply connections.

41. Check the Flow Control Valve Serial Number

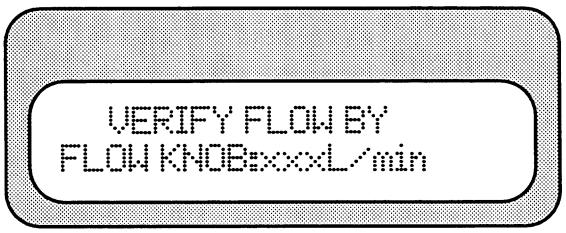


a. The displayed serial number should match the number on the flow control valve.

b. If "??????" appears, the EEPROM is probably an early EEPROM (number not entered). The EEPROM and pneumatic manifold assembly do not have to be replaced.

c. If not "??????" and the serial numbers do not match, replace the EEPROM and pneumatic manifold assembly.

42. Check the Flow



a. Connect the gas supply, 276 ± 14 kPa (40 ± 2 psi).

b. Attach a flow measuring device capable of measuring 0-100 L/min. to the drive gas outlet.

c. Move the mechanical ventilation switch to ON.

d. Adjust the inspiratory flow as per the table.

Important: The accuracy limits of the measuring device shall not be greater than ± 3%. The total flow specification for the ventilator, and measuring device, is ± 10%.

Inspiratory Flow Setting	Flow Specification (liters per minute)	* Respirometer Readings after 60 Seconds (liters)	
		Minimum	Maximum
16	16 ± 10%	14.8	17.0
60	60 ± 10%	60.6	69.7

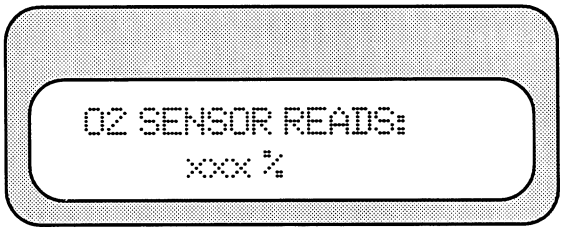
* The minimum and maximum respirometer readings, in the table, have been adjusted to compensate for the response characteristics, and ± 3% accuracy, of type RM121, and RM211 respirometers.

e. If the flow does not meet specification:
- Ensure the supply pressure stays at 276 ± 14 kPa (40 ± 2 psi) for each flow setting.
- Check the primary regulator pressure.
- Check the secondary regulator pressure.
- Ensure the exhalation valve is inflated (the high pressure limit switch could cause it to deflate).
- Check for blockage in the pneumatic manifold assembly.
- Replace the EEPROM and pneumatic manifold assembly.

f. Move the mechanical ventilation switch to OFF.

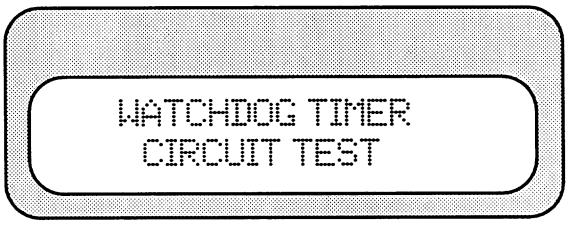
g. Remove the test equipment.

43. Check the O_2 Sensor



Calibrate the oxygen sensor as specified in the O&M Manual.

44. Check the Watchdog Timer



a. Press the alarm silence button.

b. If a watchdog board is installed, the following sequence will occur:
   - You will hear a short (1 kHz) beep, followed by long repeating (1 kHz) beeps.
   - Within 25 seconds, you will hear (3 kHz) beeps coming from the buzzer on the watchdog board.
   - The yellow LED flashes the same sequence.

c. If not:
   - Check the connections between the watchdog board and the control board.
   - Replace the watchdog board or the control board.

d. If a watchdog board is NOT installed, the following sequence will occur:
   - You will hear a short (1 kHz) beep, followed by long repeating (1 kHz) beeps.
   - The yellow LED flashes the same sequence.

e. If not:
   - Replace the control board.

f. Set the control board DIP switches (SW101) to operational mode (1 ON, 2 OFF, 3 OFF, 4 OFF).

⚠WARNING: Failure to return the DIP switches to their proper positions may cause the ventilator to malfunction and injury to the patient could occur.

You have now completed the service calibration mode for version 4.XX software. Proceed to "F. Touch Sense Test", "G. Leak Test" "H. Ground Impedance Test" and then "I. Leakage Current Test."

D. Checking User Parameters, 1.xx Software

Important: The different versions of software require different calibration procedures. Be certain you are using the correct procedure before you proceed.

To Check User Parameters

1. Move the mechanical ventilation switch to OFF.
2. Electrically power ON the ventilator.
3. Hold down the alarm silence button, and press the inspiratory pause button.

If you do not see this screen: check the control board DIP switch SW101 (1 ON, 2 OFF, 3 OFF and 4 OFF). This is the setting for operational mode.

This screen includes the following information:

The Ventilator Model: 7800

If 7800 is not displayed, check the battery connector. The battery is not being recognized.

The Software Revision Number: REV 1.xx

The Supply Gas: /O

/O = Oxygen Supply Gas, /A = Air Supply Gas, and /E indicates an Error or no supply gas selection has been made.

The Language Selection: ENGLISH

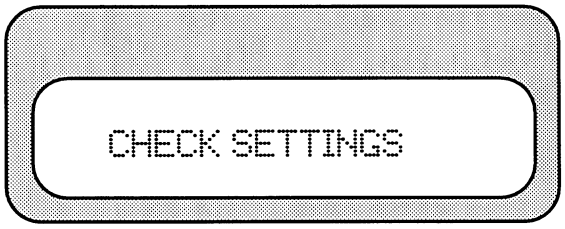
Record for future reference:

- Ventilator Model 7800
- Software Revision Number 1.xx
- Supply Gas Selection O_2 or AIR
- Language _____

Repeatedly press the alarm silence button and record for future reference:

- Reverse Flow Alarm ON or OFF
- Contrast number xx
- Audio Volume number xx .

Press the alarm silence button .



The ventilator will return to operational mode.

E. Service Calibration Mode, 1.xx Software

Important: The different versions of software require different calibration procedures. Be certain you are using the correct procedure before you proceed.

Tools Required:

- Pressure Gauge, 0-400 kPa (0-58 psi)
- Pressure Gauge, 0-150 cm H_2O
- Squeeze bulb and valve
- Digital Multi-Meter, 4 1/2 digit
- Stopwatch
- Flowmeter, 0-100 L/min. (or Respirometer)
- Pressure Source, 276 kPa (40 psi)
- Pressure Source, 90-135 cm H_2O adjustable

The service calibration routines perform electronic and pneumatic checks on the control module. Each check begins with a special display screen. Not all screens require action.

You must step through the checks sequentially. After completing each check, press the alarm silence button  to enter the next check in the sequence.

Do not turn OFF the ventilator during these routines. Service calibration can only be started from step 1.

1. Enter the Service Routine

a. Move the control board DIP switches (SW101) 1 OFF, 2 OFF, 3 OFF, 4 OFF.

b. Press and hold the alarm silence button and power ON the ventilator.

c. The display may be difficult to read until the contrast is adjusted later.

d. If this display does not appear:

- Check the ribbon cable between J1 (control board) and J1 (front panel board).
- Replace the control board, or the front panel board.

2. Check the Contrast

a. Note the initial "CONTRAST (xx)" number.

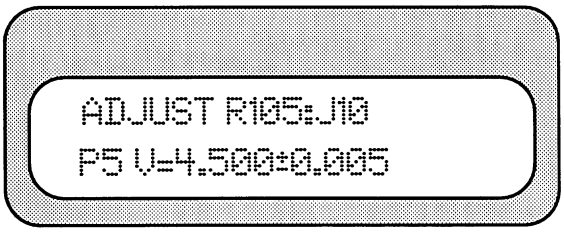
b. Turn the inspiratory flow knob. The display contrast should change.

c. Reset to the initial value "(xx)."

d. If no change:

- Check the ribbon cable between J1 (control board) and J1 (front panel board).
- Replace the LCD, the front panel board, or the control board.

3. Check the 4.500 Volt Reference



The 4.500 V dc was checked during the power supply tests.

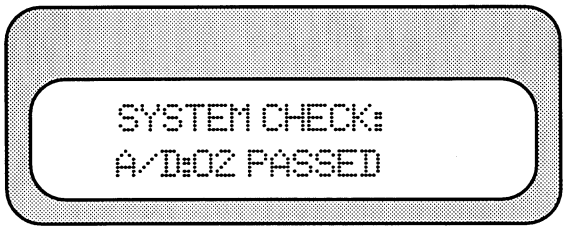
4. Measure the Oxygen Output Reference

a. Measure between J10, pin 2 and pin 15 (AGND) on the control board (+1.000 ± 0.005 V dc).

b. If out of range, adjust R101 (control board).

c. If not adjustable, replace the control board.

5. Check the Analog to Digital Conversion of the Oxygen Output



"PASSED" = correct

If "FAILED" appears, replace the control board.

6. Measure the Patient Pressure Output Reference

a. Measure between J10, pin 1 and pin 15 (AGND) on the control board (+1.000 ± 0.005 V dc).

b. If out of range, adjust R102 (control board).

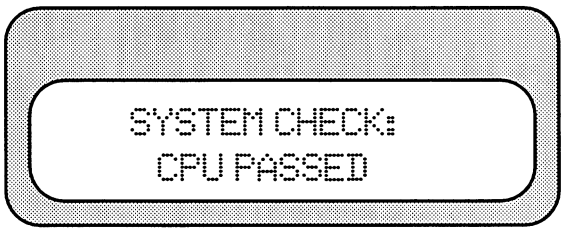
c. If not adjustable, replace the control board.

7. Check the Analog to Digital Conversion of the Patient Pressure Output

"PASSED" = correct

If "FAILED" appears, replace the control board.

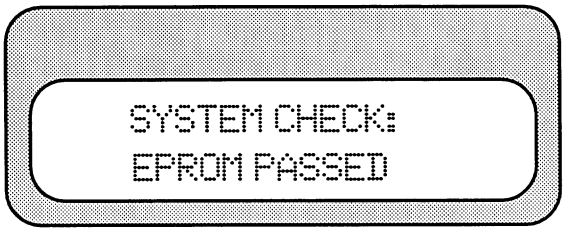
8. Check the CPU



"PASSED" = correct

If "FAILED" appears, replace the control board.

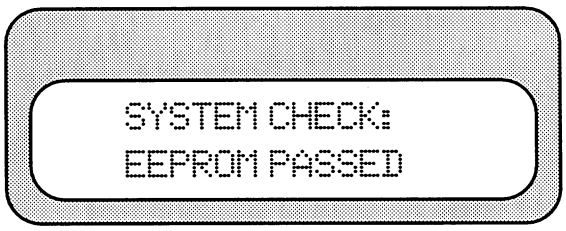
9. Check the EPROM



"PASSED" = correct

If "FAILED" appears, replace the EPROM or control board.

10. Check the EEPROM

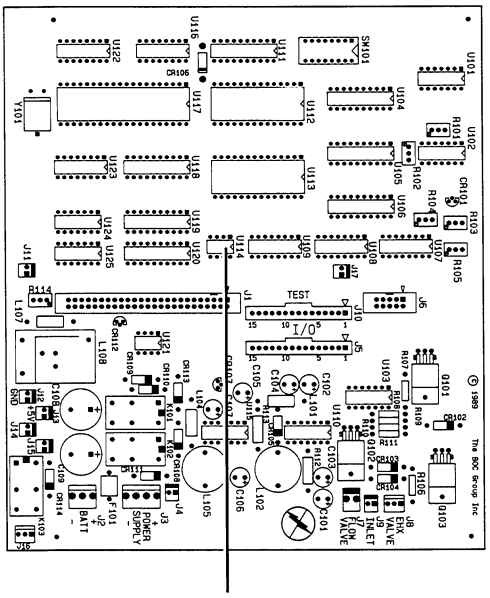


"PASSED" = correct

If "FAILED" appears,

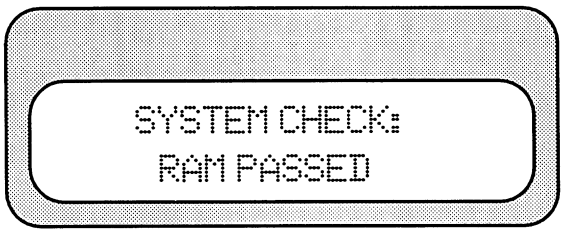
a. Check the EEPROM (U114) for correct installation.

b. Replace the EEPROM (U114) and pneumatic manifold assembly, or the control board.



Important: The EEPROM and the pneumatic manifold assembly must be replaced together.

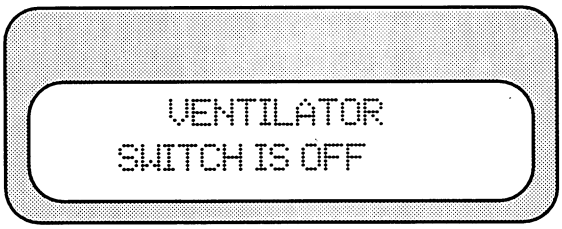
11. Check the RAM



"PASSED" = correct

If "FAILED" appears, replace the control board.

12. Check the Mechanical Ventilation Switch

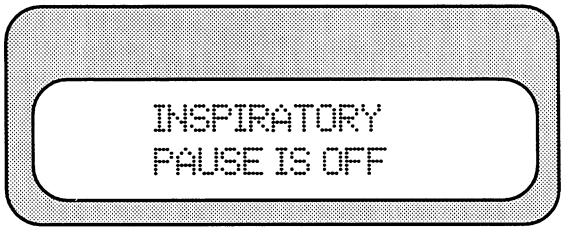


a. Move the mechanical ventilation switch ON and OFF. The screen should correspond to the switch position.

b. If not:

- Check the 50 pin ribbon cable.
- Replace the front panel board or the switch.

13. Check the Inspiratory Pause Button



a. Toggle the inspiratory pause button between ON and OFF. The screen should read "ON" when the green LED is ON. "OFF" when the green LED is OFF.

b. If not:

- Replace the switch.
- Check the 50 pin ribbon cable.
- Replace the front panel board.

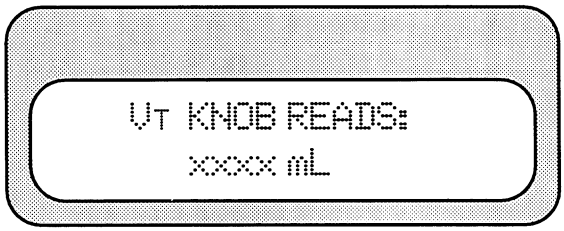
14. Check the DIP Switches

Important: Do not change the position of the switches while in service calibration mode.

a. The display should match the switch bank (SW101).

b. If not, replace the control board.

15. Check the Tidal Volume Knob



a. Rotate the tidal volume knob through its range.

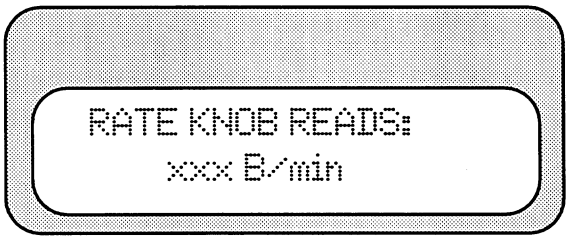
Resolution Table

50 - 100	2 mL
100 - 250	5 mL
250 - 1000	10 mL
1000 - 1500	20 mL

b. Set the tidal volume to 300. The pointer and display should correspond.

c. If not, adjust the knob:
- Set the tidal volume to display 300.
- Loosen both set screws.
- Position the pointer to 300 (do not rotate the shaft).
- Tighten one set screw.
- Set the display to 50. Does the pointer correspond?
- Set the display to 1500. Does the pointer correspond?
- Tighten the second set screw.

16. Check the Rate Knob



a. Rotate the rate knob through its range.

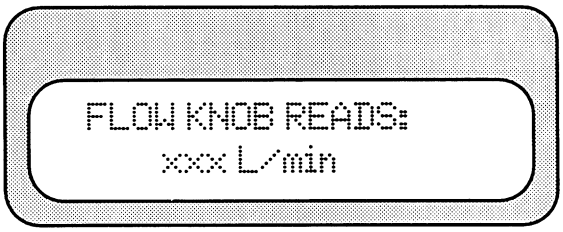
Resolution Table

2 - 100	1 B/min.

b. Set the rate to 20. The pointer and display should correspond.

c. If not, adjust the knob.
- Set the rate to display 20.
- Loosen both set screws.
- Position the pointer to 20 (do not rotate the shaft).
- Tighten one set screw.
- Set the display to 2. Does the pointer correspond?
- Set the display to 100. Does the pointer correspond?
- Tighten the second set screw.

17. Check the Inspiratory Flow Knob



a. Rotate the inspiratory flow knob through its range.

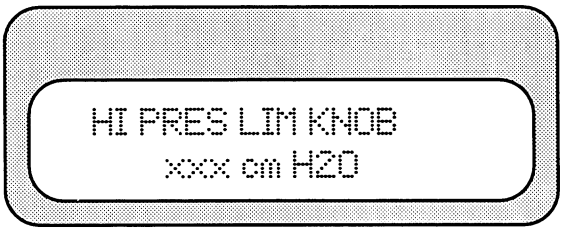
Resolution Table

10 - 100	1 L/min.

b. Set the inspiratory flow to 10. The pointer and display should correspond.

c. If not, adjust the knob.
- Set the inspiratory flow to display 10.
- Loosen both set screws.
- Position the pointer to 10 (do not rotate the shaft).
- Tighten one set screw.
- Set the display to 100. Does the pointer correspond?
- Tighten the second set screw.

18. Check the Inspiratory High Pressure Limit Knob



Note: To set the inspiratory pressure limit, press in on the knob and turn.

a. Rotate the inspiratory pressure limit knob through its range. When you push and turn, the knob should move smoothly. Confirm that the displayed value does not change if you do not push in.

Resolution Table

20 - 100	1 cm H_2O

b. Set the limit to 60. The pointer and display should correspond.

c. If not, adjust the knob.
- Set the inspiratory pressure limit to display 60.
- Loosen both set screws.
- Position the pointer to 60 (do not rotate the shaft).
- Tighten one set screw.
- Set the display to 20. Does the pointer correspond?
- Set the display to 100. Does the pointer correspond?
- Tighten the second set screw.
- Confirm that the knob rotates freely and does not stick:
  - the setting should change when you push and turn,
  - the setting should not change when you do not push.
- If the knob sticks, do the adjustment again.

Pushwheel Checks

The next three checks are for the pushwheel limit switches low $\dot{V}_E$, low O_2 and high O_2. Step the pushwheels through their least significant and most significant digits. The display should match the setting on the pushwheel. All pushwheels should move evenly in both directions. If not, replace the front panel board.

19. Check the Low Minute Volume Limit Pushwheels

a. Step the low $\dot{V}_E$ tenths digit.

b. Step the low $\dot{V}_E$ ones digit.

20. Check the Low Oxygen Limit Pushwheels

Note: 18% is the minimum % shown.

a. Step the low O_2 ones digit.

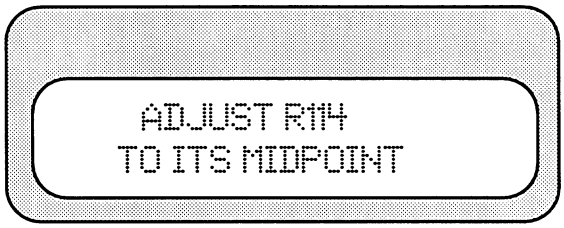
b. Step the low O_2 tens digit.

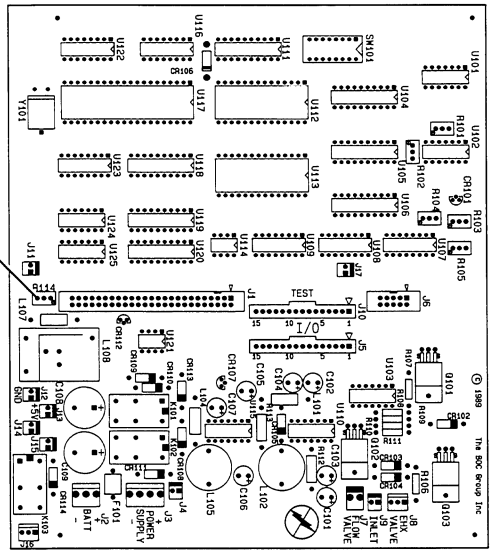
21. Check the High Oxygen Limit Pushwheels

a. Step the high O_2 ones digit.

b. Step the high O_2 tens digit.

22. Check the Back-Light



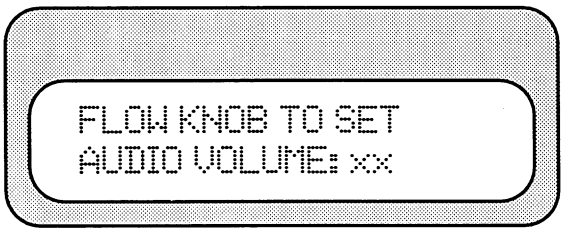


a. The back-light should be visible.

b. If not present, adjust the intensity:
- Turn R114 fully counterclockwise (20 turn pot). You will hear and feel a click.
- Turn R114 ten (10) turns clockwise. This is the midpoint. The display back-light should be visible in normal light.

c. If the back-light is still not visible:
- Look for a missing jumper J11 (control board).
- Check the ribbon cable between J1 (control board) and J1 (front panel board).
- Replace the LCD, the front panel board, or the control board.

23. Check the Audio Volume



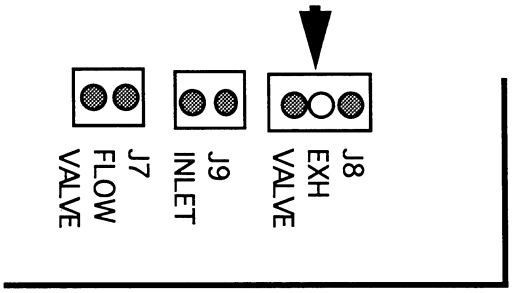
a. Note the initial "VOLUME: (xx)."

b. Turn the inspiratory flow knob. The volume should change.

c. Reset to the initial value "(xx)."

d. If the volume does not change:
   - Be sure the speaker is plugged into J8 (front panel board).
   - Check the ribbon cable between J1 (control board) and J1 (front panel board).
   - Replace the speaker, or the front panel board.

24. Check the Exhalation Solenoid



"PASS" = correct

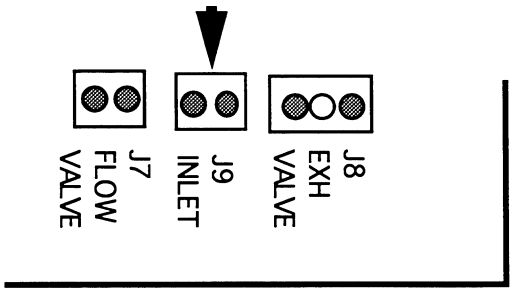
If "FAIL" appears:

a. Check the cable connection to J8 (control board).

b. Replace the exhalation solenoid (SOL2), or the control board.

1.XX

25. Check the Inlet Solenoid



"PASS" = correct

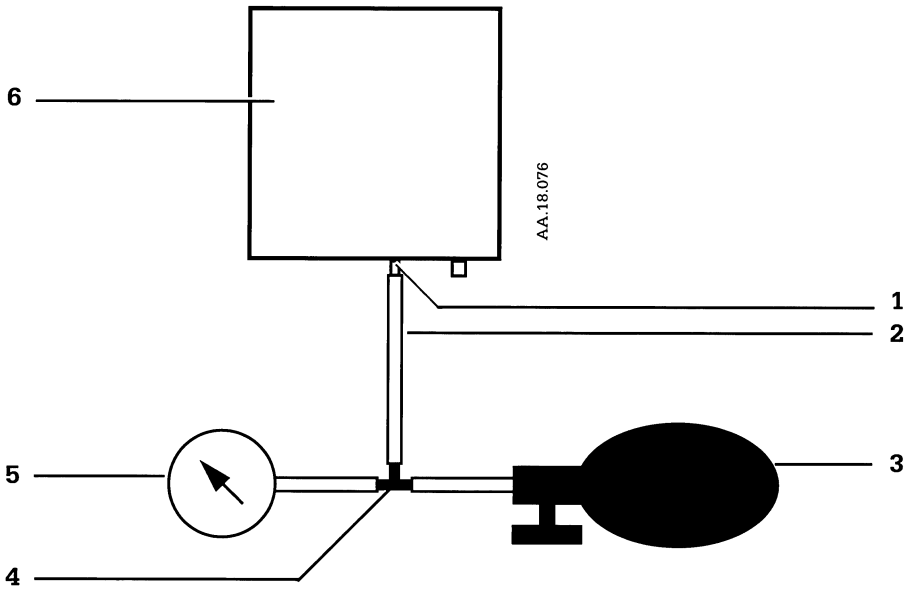
If "FAIL" appears:

a. Check the cable connections to J9 (control board).

b. Replace the inlet solenoid (SOL1), or the control board.

26. Check the Patient Pressure Sensor Calibration

a. Attach a squeeze bulb with valve and a pressure gauge capable of measuring 0-150 cm H_2O to the patient pressure sensing input.



1. Patient Pressure Sensing Input
2. Tubing
3. Squeeze Bulb with Valve
4. Tee
5. Pressure Gauge
6. Control Module

Figure 4-8 Patient Pressure Sensor Calibration

Important: If you adjust either the zero or the gain, you must check the other adjustment. Repeat the zero and gain calibration until both are within specification without any adjustment.

b. The display should read 0.0 ± 0.5 cm H_2O. If not, adjust R102 (zero) on the pressure transducer board.

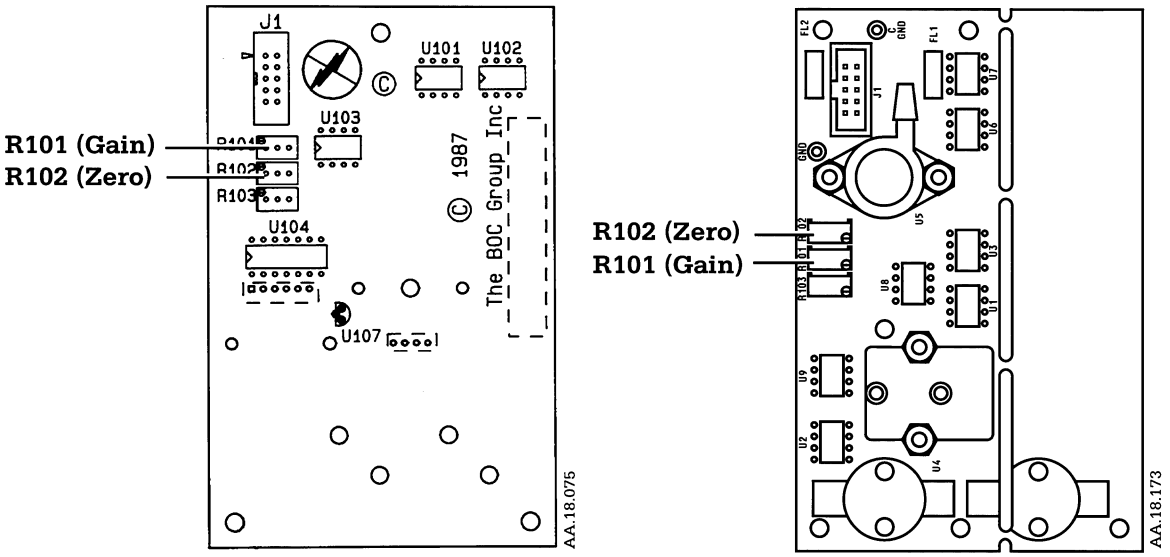


Figure 4-9 Patient Pressure Sensor, Zero and Gain Calibration

c. Lightly squeeze the bulb to bring the pressure to 100 cm H_2O on the gauge.

d. The display should read ± 1 of the gauge reading. If not, adjust R101 (gain) on the pressure transducer board.

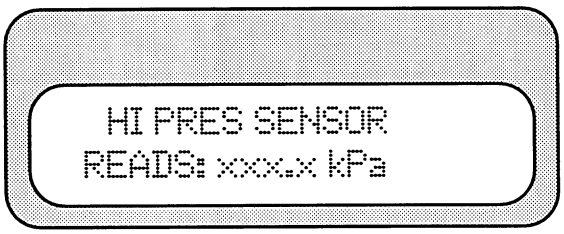
If the gain was adjusted, release the pressure and repeat the zero calibration. Repeat the zero and gain calibration until both are within specification without any adjustment.

e. Check the sensor linearity by lightly squeezing the bulb to bring the pressure to 50 cm H_2O on the gauge. The display should read ± 2 of the gauge reading.

If the zero, gain, or linearity specifications can not be met, replace the pressure transducer board.

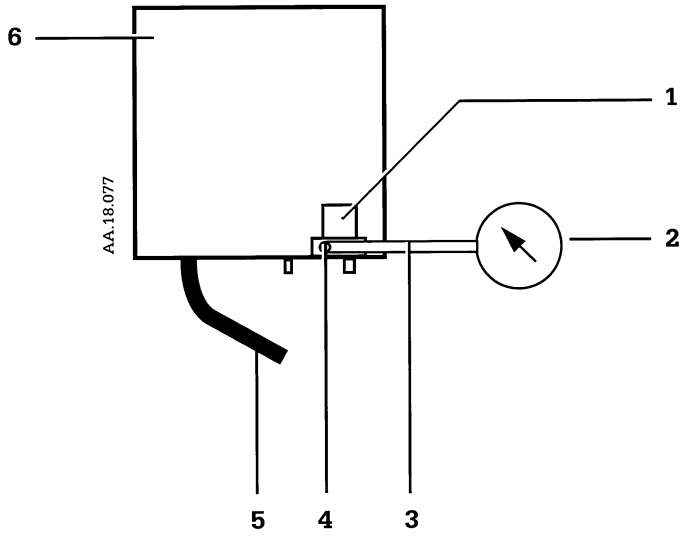
f. Remove the test equipment.

27. Check the High Pressure Sensor Calibration



a. Disconnect the gas supply if present.

b. Install a tube (3/16 inch O.D.) in the test port and attach a pressure gauge, capable of measuring 400 kPa (58 psi).



1. Pneumatic Manifold Assembly
2. Pressure Gauge
3. High Pressure Tube
4. Test Port
5. Gas Supply
6. Control Module

Figure 4-10 High Pressure Sensor Calibration

c. Connect the gas supply 276 ± 14 kPa (40 ± 2 psi).

d. The gauge should read approximately 180 kPa (26.1 psi). The display should read ± 3 kPa (± 0.4 psi) of the gauge reading. If not, adjust R103 (offset) on the pressure transducer board.

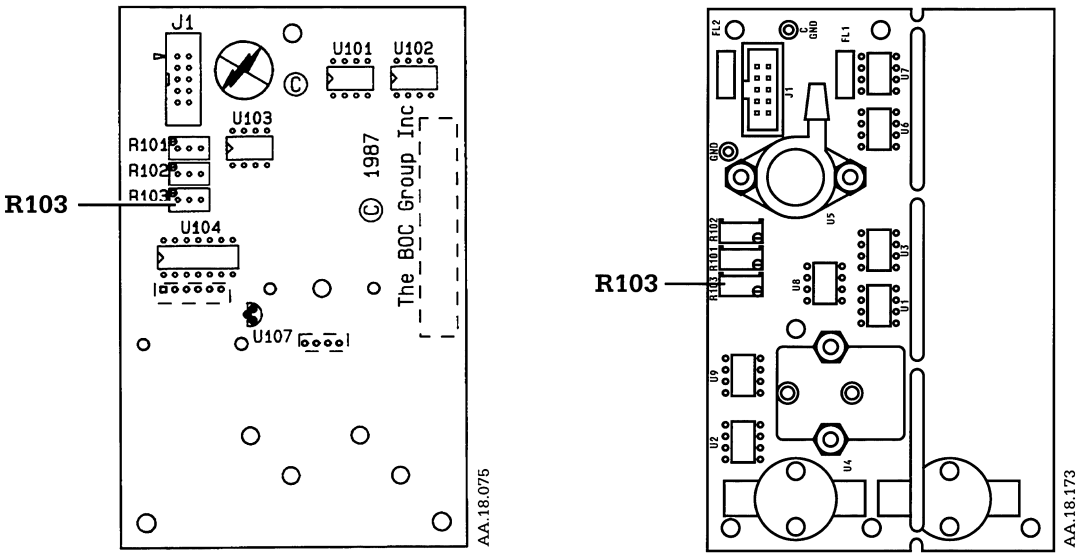
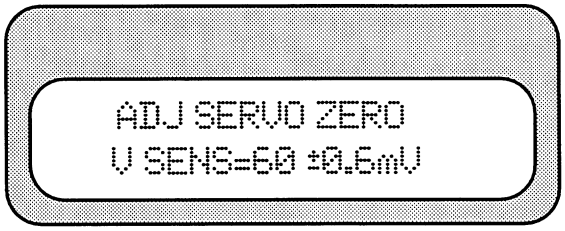


Figure 4-11 High Pressure Sensor Offset Calibration

e. If the specification can not be met, replace the pressure transducer board.

f. Leave the gauge attached.

28. Check the Flow Control Zero Calibration



a. Move the mechanical ventilation switch to ON.

Note: With the mechanical ventilation switch in the ON position, pressing the alarm silence button allows you to toggle repeatedly between the zero and gain checks.

Important: If you adjust either the zero or the gain, you must check the other adjustment. Repeat the zero and gain calibration until both are within specification without any adjustment.

b. Measure between J10, pin 4 and pin 10 on the control board. The meter reading should be 60.0 ± 0.6 mV dc.

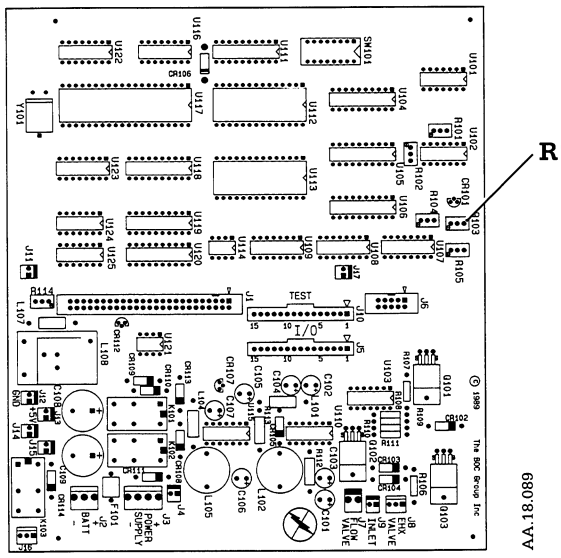
c. If not, adjust R103 (zero) on the control board.

d. If not adjustable:

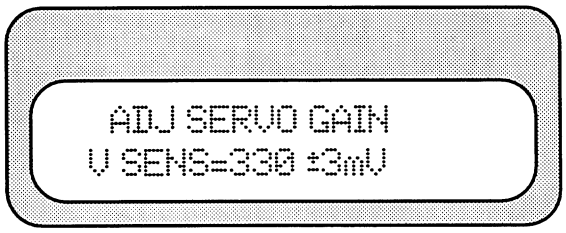
- Check the cable connection to J7 (control board).
- Replace the control board.

e. Press the alarm silence button to toggle to the gain calibration.

e. Press the alarm silence button to toggle to the gain calibration.



29. Check the Flow Control Gain Calibration



a. Measure between J10, pin 4 and pin 10 on the control board. The meter reading should now be 330 ± 3 mV dc.

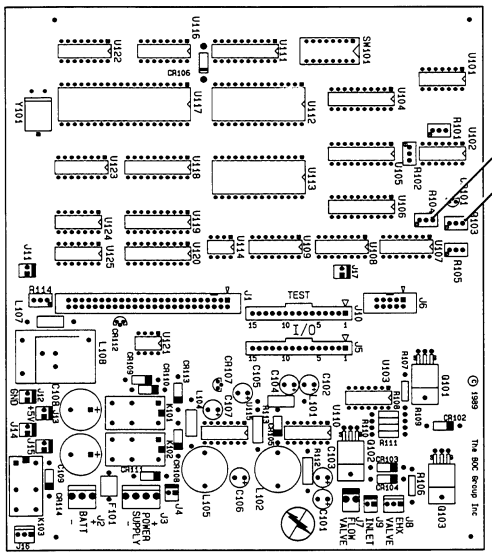
b. If not, adjust R104 (gain) on the control board.

c. If not adjustable:

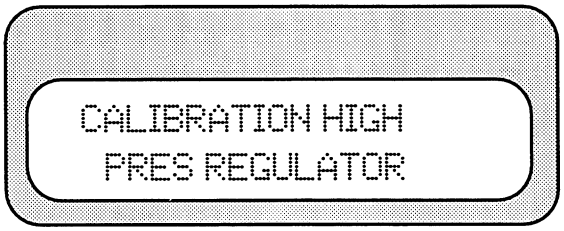
- Check the cable connection to J7 (control board).
- Replace the control board.

d. If the gain was adjusted, press the alarm silence button and repeat the zero calibration. Repeat the zero and gain calibration until both are within specification without any adjustment.

e. Move the mechanical ventilation switch to OFF, when the zero and gain are both within specification.



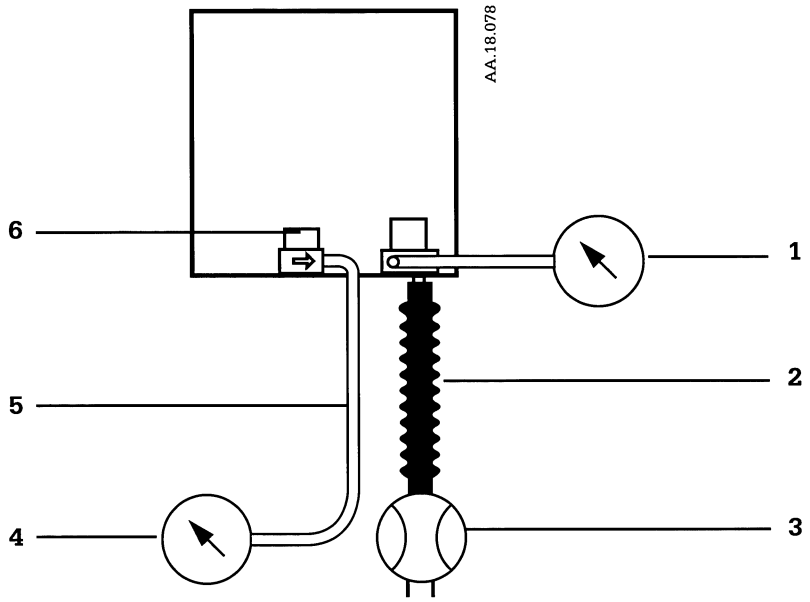
30. Regulator Calibration Setup



a. A pressure gauge, 400 kPa (58 psi), should still be attached to the test port.

b. Disconnect the output tube (TB-6) from the output of the secondary regulator. Attach a pressure gauge capable of measuring 150 cm H_2O.

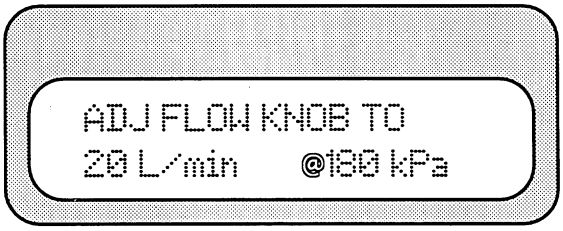
c. Attach a flowmeter capable of measuring 0-100 L/min. to the drive gas outlet.



1. Pressure Gauge
2. 17 mm Hose
3. Flowmeter
4. Pressure Gauge
5. Tubing
6. Secondary Regulator

Figure 4-12 Regulator Calibration Setup

31. Check the Regulator Pressures



Check the primary regulator pressure gauge, 180 ± 3 kPa (26.1 psi ± 0.4 psi). The primary regulator must be working before the secondary regulator can be checked.

Check the Secondary Regulator Calibration

a. The output pressure should be 125 ± 5 cm H_2O.

b. If not:
   - Adjust the secondary regulator.
   - Check the primary regulator pressure.
   - Replace the secondary regulator.

c. Remove the gauge from the secondary regulator and attach the tube.

Check the Primary Regulator Calibration

Important: If you adjust the primary regulator you must check the secondary regulator calibration again.

d. Move the mechanical ventilation switch to ON.

e. Adjust the inspiratory flow knob to acquire 20.0 ± 0.5 L/min. output.

f. Check the primary regulator pressure. Is it 180 ± 2 kPa (26.1 ± 0.3 psi)?
- If not, adjust the primary regulator while maintaining 20 L/min. flow.
- If you can not adjust to 180 ± 2 kPa (26.1 ± 0.3 psi) while maintaining 20 L/min. flow, replace the primary regulator.

g. Adjust the inspiratory flow knob to acquire 10.0 ± 0.5 L/min. output.

h. Check the pressure. Is it 180 ± 7 kPa (26.1 ± 1.0 psi)?
- If not, replace the primary regulator.

i. Adjust the inspiratory flow knob to acquire 100 ± 5 L/min. output.

j. Check the pressure. Is it 180 +0/ -14 kPa (26.1 +0/-2.0 psi)?
- If not, replace the primary regulator.

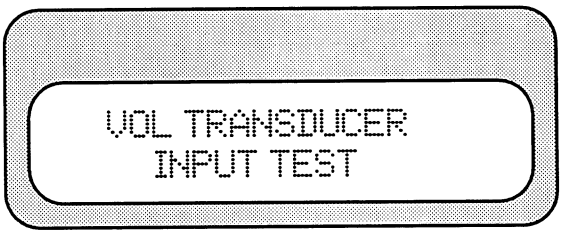
k. Move the mechanical ventilation switch to OFF.

Important: If the primary regulator was adjusted, repeat the secondary regulator calibration.

l. Disconnect the gas supply.

m. Remove all test equipment. Install the test port plug.

32. Volume Transducer Input Setup

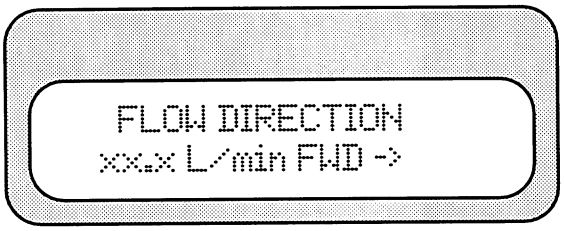


a. Adjust the tidal volume knob above 300.

b. Connect the volume transducer to the system common gas outlet. Arrows in the direction of flow.

c. Set the anesthesia system oxygen flow to 8 L/min.

33. Check the Flow Detection



a. The display should read "8.0 L/min. FWD->" ± 2 L/min.

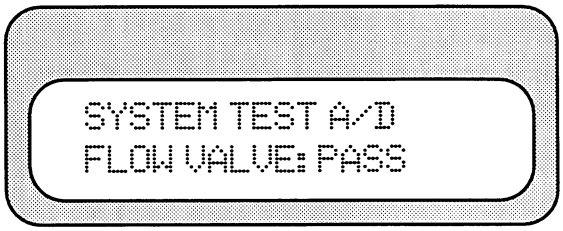
b. Reverse the sensor clip direction. The arrows against the direction of flow.

c. The display should now read "8.0 L/min. <-REV" ± 2 L/min.

d. If either flow detection doesn't work:
- Check the sensor.
- Check the sensor interface panel connections.
- Check the sensor cable to the EMC/Interface board.
- Check the internal ventilator cable between P3 (EMC/Interface board) and J2 (front panel board).
- Check the EMC/Interface board.
- Check the 50 pin ribbon cable between J1 (front panel board) and J1 (control board).
- See the Modulus® II or Excel anesthesia system service manuals for more information.

e. Return the sensor assembly to the breathing circuit.

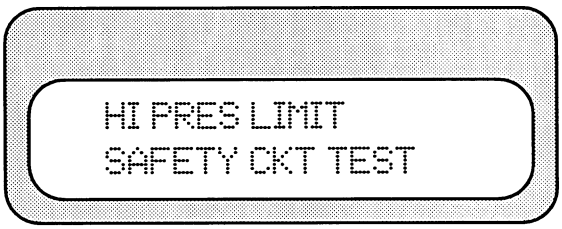
34. Check the Analog to Digital Conversion of Flow Valve Drive



"PASS" = correct

If "FAIL" appears, replace the control board.

35. High Pressure Limit Setup



Connect an adjustable pressure source (90 - 135 cm H_2O) and a pressure gauge to the ventilator drive gas outlet.

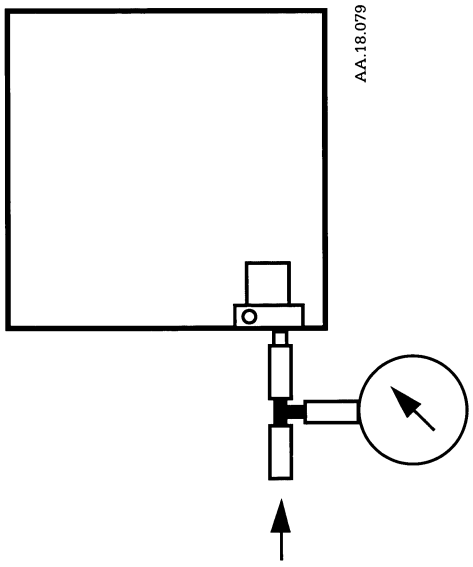
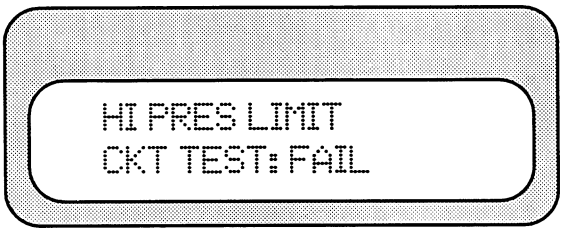


Figure 4-13 High Pressure Limit Setup

36. Check the High Pressure Limit



"FAIL" is displayed upon entering this check.

a. Raise the pressure slowly and check that the pressure drops sharply between 105 and 115 cm H_2O. The display should read "PASS" after the pressure drops.

Note: The flow control valve may have a small leak (within specification). If supply gas is connected and the drive gas outlet is blocked, this leakage can cause the pressure to slowly increase. If the free breathing valve leaks, the pressure may slowly decrease.

b. If the pressure does not drop:

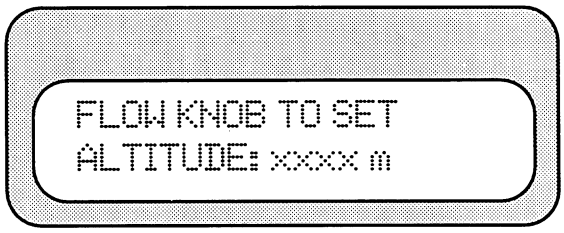
- Check the cable connection to J16 (control board).
- Check the tubing.
- Replace the high pressure limit switch.

c. To repeat this check, move the mechanical ventilation switch to ON and press the alarm silence button twice.

d. To exit, the mechanical ventilation switch must be OFF.

e. Remove the test equipment.

37. Check the Altitude Setting

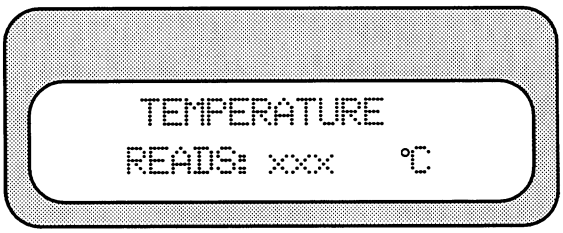


a. Turn the inspiratory flow knob. The altitude should change from 0 to 3000 in increments of 100 meters.

b. Enter the correct altitude (1 foot = 0.3048 meters). Advise the hospital personnel if this selection is different than the original.

⚠ WARNING: If the altitude setting is wrong, false pressure readings can potentially cause the ventilator to operate out of calibration.

38. Check the Temperature Sensor



a. Identify which type of pressure transducer board you have.

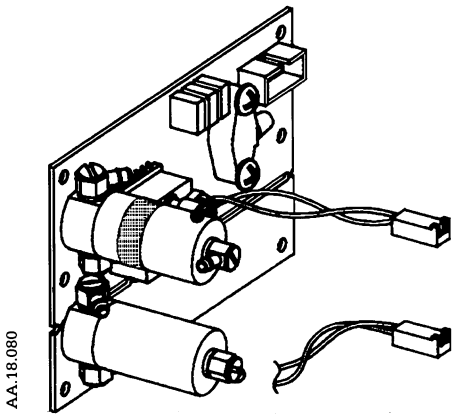
b. If you have the Universal pressure transducer board the display should indicate 25±1 °C.

c. If not, replace the pressure transducer board.

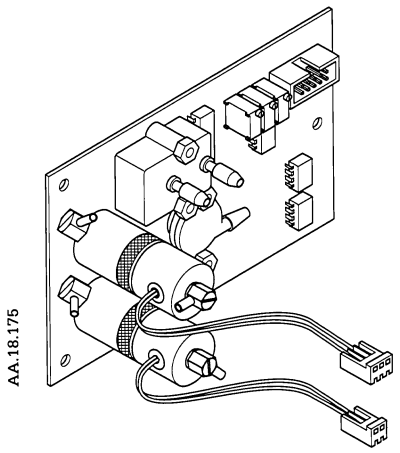
d. If you have the original pressure transducer board:

- Place a temperature probe (or thermometer) next to the transducer (U107).
- The measured temperature and the temperature on the display should be within ± 6 °C.

e. If not, replace the pressure transducer board.



Universal Pressure Transducer Board



Original Pressure Transducer Board

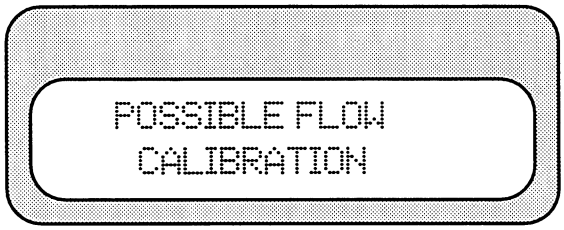
Ensure DIP SW101, switch 4 is still OFF.

⚠ CAUTION: If switch 4 is left ON and you move to the next check, the EEPROM may get corrupted.

39. Flow Calibration Status

If DIP SW101, switch 4 is OFF (the correct setting), this step is bypassed.

If DIP SW101, switch 4 is ON, the following display will appear.

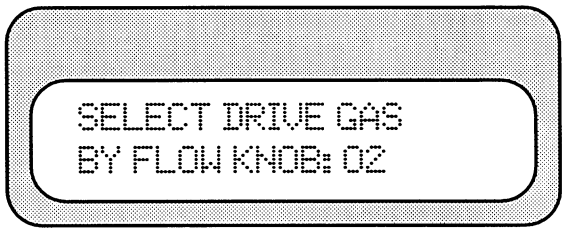


Ensure DIP SW101, switch 4 is OFF.

⚠CAUTION: If switch 4 is left ON and you move to the next check the EEPROM will be corrupted.

Press the alarm silence button ⊠ to enter the next check.

40. Check the Drive Gas Selection



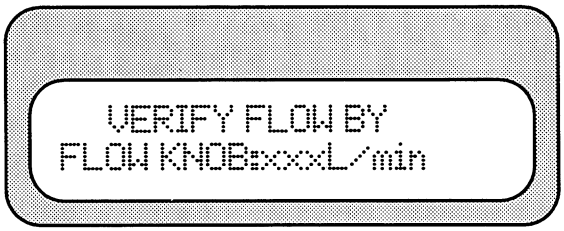
a. Note the setting. This must correspond to the existing gas supply connection.

b. If the drive gas selection must be changed, rotate the inspiratory flow knob to select the correct drive gas. Advise hospital personnel if you change the setting.

c. If "ERR" appears, and cannot be changed to "O_2" or "Air," replace the EEPROM and pneumatic manifold assembly.

⚠WARNING: When the gas selection is changed, further changes must be made to the ventilator gas supply connections.

41. Check the Flow



a. Connect the gas supply, 276 ± 14 kPa (40 ± 2 psi).

b. Attach a flow measuring device capable of measuring 0-100 L/min. to the drive gas outlet.

c. Move the mechanical ventilation switch to ON.

d. Adjust the inspiratory flow as per the table.

Important: The accuracy limits of the measuring device shall not be greater than ± 3%. The total flow specification for the ventilator, and measuring device, is ± 10%.

Inspiratory Flow Setting	**Flow Specification (liters per minute)**	*** Respirometer Readings after 60 Seconds (liters)**	
		Minimum	Maximum
16	16 ± 10%	14.8	17.0
60	60 ± 10%	60.6	69.7

* The minimum and maximum respirometer readings, in the table, have been adjusted to compensate for the response characteristics, and ± 3% accuracy, of type RM121, and RM211 respirometers.

e. If the flow does not meet specification:

- Ensure the supply pressure stays at 276 ± 14 kPa (40 ± 2 psi) for each flow setting.
- Check the primary regulator pressure.
- Check the secondary regulator pressure.
- Ensure the exhalation valve is inflated (the high pressure limit switch could cause it to deflate).
- Check for blockage in the pneumatic manifold assembly.
- Replace the EEPROM and pneumatic manifold assembly.

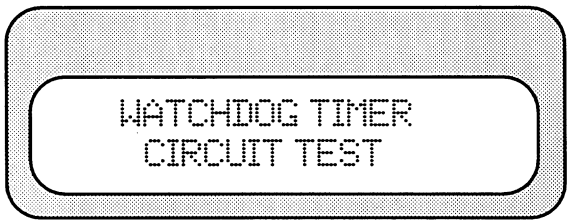
f. Move the mechanical ventilation switch to OFF.

g. Remove the test equipment.

42. Check the O_2 Sensor

Calibrate the oxygen sensor as specified in the O&M Manual.

43. Check the Watchdog Timer



a. Press the alarm silence button.

b. The following sequence will repeat:

- The display will go blank.
- You will hear a (1 kHz) beep.
- The yellow LED will go ON and OFF.
- Then all the LEDs will flash.

c. If not, replace the control board, or the front panel board.

d. Set the control board DIP switches (SW101) to operational mode (1 ON, 2 OFF, 3 OFF, 4 OFF).

⚠WARNING: Failure to return the DIP switches to their proper positions may cause the ventilator to malfunction and injury to the patient could occur.

You have now completed the service calibration mode for version 1.XX software. Proceed to "F. Touch Sense Test", "G. Leak Test" "H. Ground Impedance Test" and then "I. Leakage Current Test."

F. Touch Sense Test

1. Set the touch to read controls as follows:
   - Tidal Volume 300 mL
   - Rate 20 B/min.
   - Inspiratory Flow 100 L/min.
2. Move the mechanical ventilation switch to ON.
3. Touch each of the knobs. The display should indicated the knob that is touched. No touch-to-read message should appear unless the knob is touched.

If not, adjust the sensitivity.

The adjustment resistors are on the back side of the front panel board (solder side). From the front of the control module, the adjustments go from left to right (R83, R82, R81) corresponding to the location of the knobs.

Knob	Test Point	Adjustment
Tidal Volume	J10, pin 2	R83
Rate	J10, pin 3	R82
Inspiratory Flow	J10, pin 4	R81

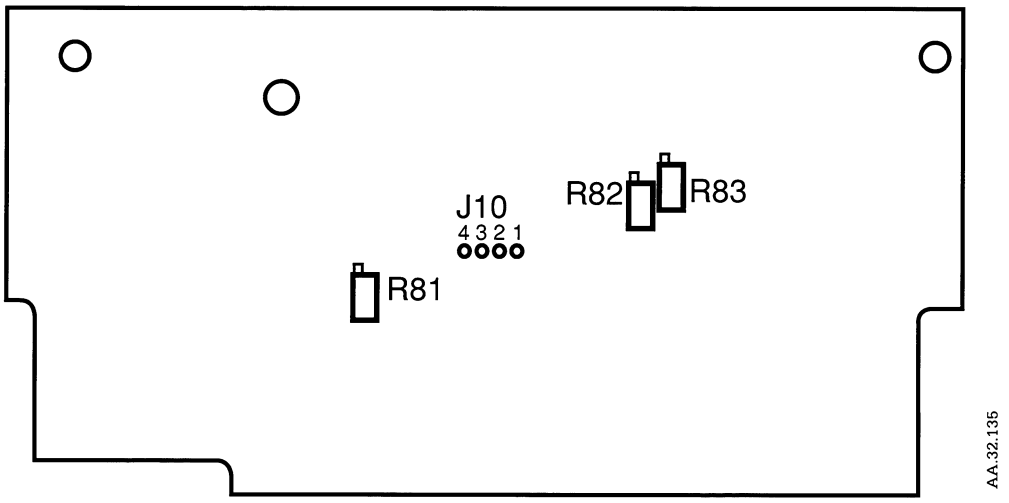


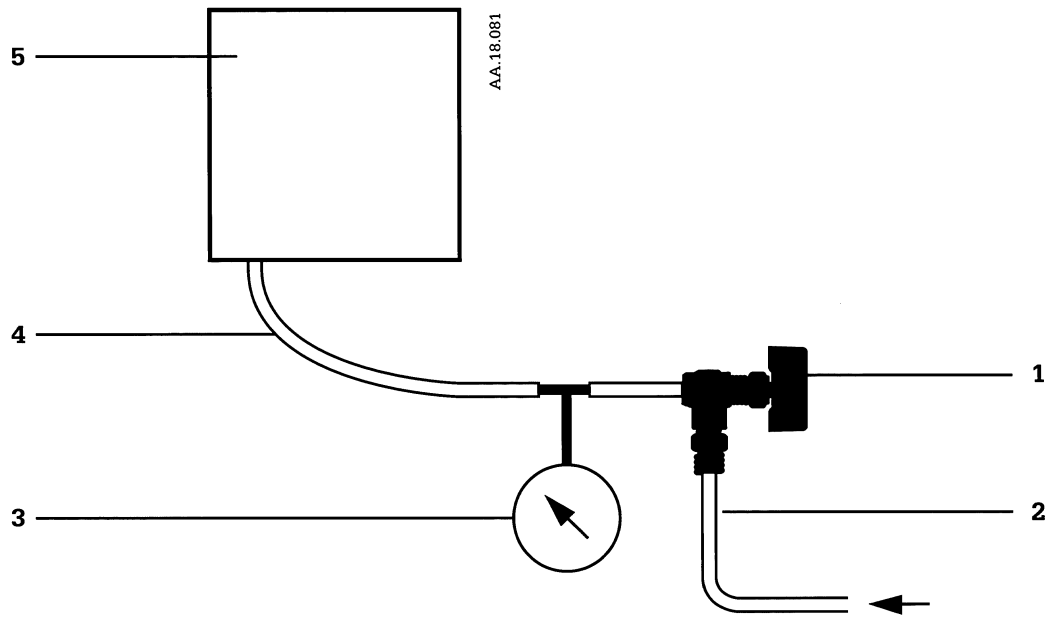
Figure 4-14 Front Panel Board, Back Side

1. Adjust for 0 V dc with respect to J10, pin 1 (AGND) on the front panel board.
2. Adjust the resistor an additional 7 turns counterclockwise after adjusting for 0 V dc.
3. Repeat the test.

G. Leak Test

Tools Required:

- Pressure Gauge, 400 kPa accurate to 5 kPa (58 psi accurate to 0.7 psi)
- Shut off valve
- Stopwatch, not shown



1. Shut Off Valve
2. Gas Supply
3. Pressure Gauge
4. Supply Gas Hose
5. Control Module

Figure 4-15 Leak Test.

If applicable turn on the ventilator. Mechanical ventilation must be off.

1. Connect supply gas to the control module as shown in the illustration.
2. Pressurize the control module to 345 kPa.
3. Close the shut off valve and start the stopwatch. The pressure drop should not exceed 5 kPa in 87 seconds.

If pressure cannot be maintained:

- Check for loose hose fittings, holes in the hoses, or
- Repair the control module.

4. Remove the test equipment.

H. Ground Impedance Test

1. Measure the resistance between the ground termination on the line cord, and the equipotential connector. It should be less than 0.10 Ohms (less than 0.20 Ohms for hard wired power cords). The other two line cord terminations should have a high resistance with respect to the equipotential connector.

If the resistance is too high:

- Check for loose or oxidized connections, or replace the power cord.

1. Equipotential Connector
2. Meter
3. Ground Termination
4. Line Cord
5. Control Module

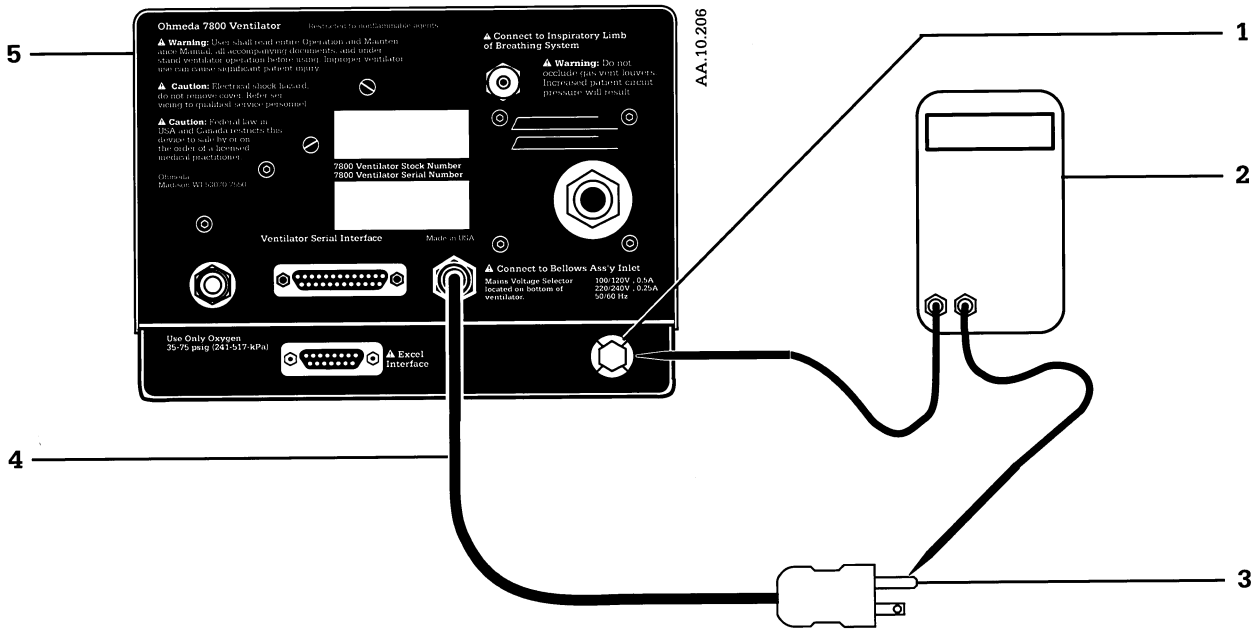


Figure 4-16 Ground Impedance Test.

I. Leakage Current Test

Tools Required:

- Leakage current tester

Follow the instructions included with the leakage current tester. You must measure the leakage current in four wiring configurations. With the ventilator grounded and ungrounded, and with the line and neutral wires normal and reversed. In all cases there must be less than 100 micro amperes of leakage current, with any ventilator voltage selector setting.

- Ventilator ON, polarity normal, grounded.
- Ventilator ON, polarity normal, ungrounded.
- Ventilator ON, polarity reversed, grounded.
- Ventilator ON, polarity reversed, ungrounded.

End of Test and Calibration

You have now completed all of the checks and calibrations. Ensure that all previously recorded parameters have been restored.

Install the control module into the anesthesia system and perform section "3/ Post-Service Checkout."

⚠WARNING: You must perform section "3/ Post-Service Checkout" before returning the system to clinical use. Failure to do so could cause injury to the patient.

5/Maintenance

5.1 Maintenance Schedule

⚠WARNING: Do not perform testing or maintenance on this instrument while it is being used to ventilate a patient, possible injury may result.

⚠WARNING: Items may be contaminated due to infectious patients. Wear sterile rubber gloves. Contamination can spread to yourself and others.

Yearly Maintenance

Inspect:

- Ventilator Tubing
- Bellows

Replace:

- Exhalation Valve Diaphragm
- Exhalation Valve Retainer O-ring
- Free Breathing Valve
- Free Breathing Valve Seat O-ring
- Inlet Valve O-Rings (2)
- Inlet Valve U-Cup Seals (2)
- 5 micron Filter (Secondary Regulator)

Test:

- Perform section 4/Tests and Calibration
- Perform section 3/Post-Service Checkout

Two Year Maintenance

Replace:

- Internal Battery

Test:

- Perform section 4/Tests and Calibration
- Perform section 3/Post-Service Checkout
- Charge Battery

During a maintenance visit, user level maintenance must be performed in addition to this maintenance. User level maintenance can be found in the 7800 Ventilator, Operation and Maintenance manual.

5.2 Maintenance Procedures

To perform maintenance you must remove the control module from the anesthesia system and remove the cover, see section "7/Repair Procedures" for more information.

Exhalation Valve Maintenance

1. Remove the retaining ring and lift the assembly out of the manifold.

Important: Do not loosen the elbow fitting.

2. Replace the diaphragm on the retainer.

3. Replace the O-ring. Lubricate with a thin film of KRYTOX™ (oxygen-use-approved) lubricant.

4. Insert the assembly into the manifold.

5. Install the retaining ring flat side up (away from the manifold).

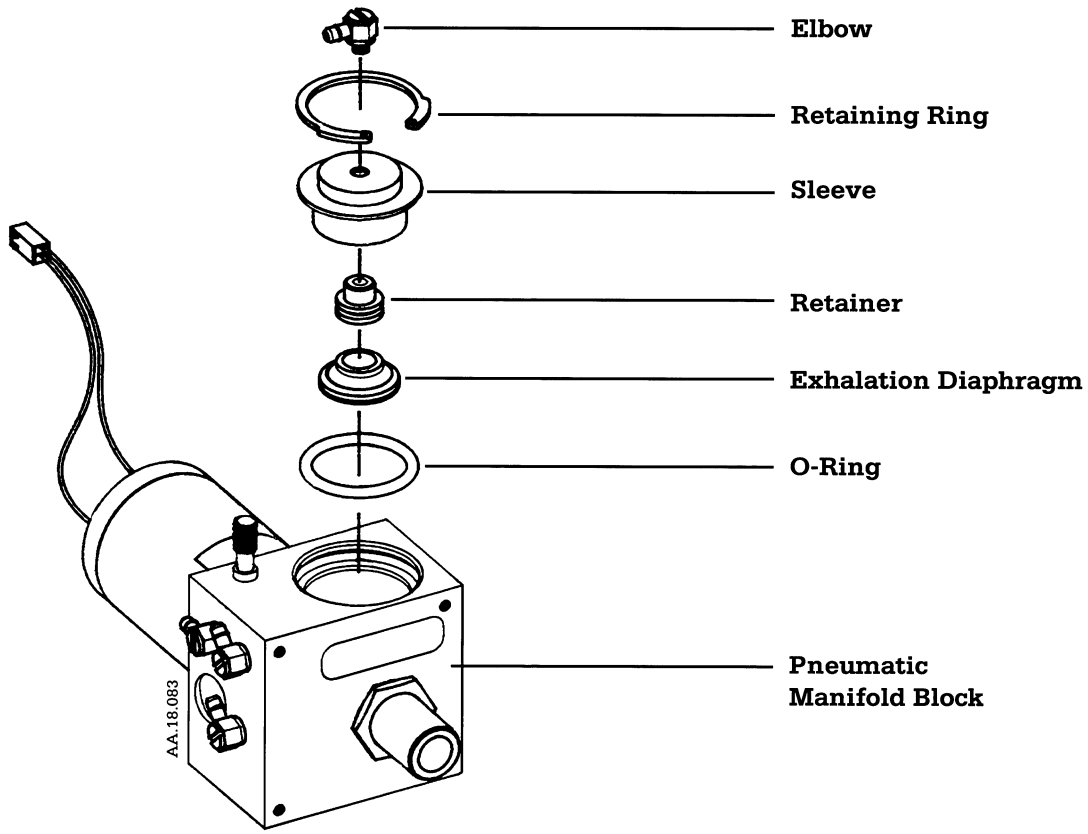


Figure 5-1 Exhalation Valve Maintenance

Free Breathing Valve Maintenance

6. Remove the access plug (if present) from the bottom of the control module and unscrew the valve seat.

7. Pull the free breathing valve out.

8. Inspect the valve seat for cleanliness.

9. Pull the tail of the new free breathing valve through the center of the valve seat until it locks in place.

10. Trim the tail in line with the bottom edge of the valve seat.

11. Replace the O-ring. Lubricate with a thin film of KRYTOX™.

12. Screw the assembly into the manifold.

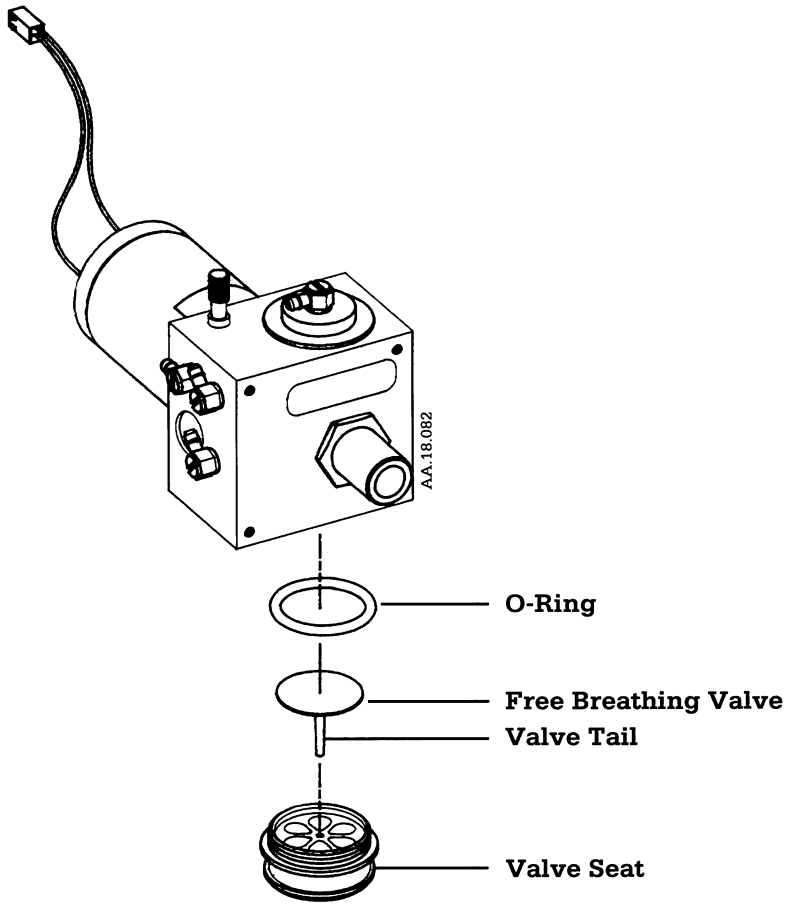


Figure 5-2 Free Breathing Valve Maintenance

Gas Inlet Valve Maintenance

13. Remove the retaining ring and cap.

14. Remove the shuttle and replace the first U-cup seal. Lubricate the seal with KRYTOX™.

15. Replace the second O-ring and second U-cup seal. Lubricate the O-ring and seal with KRYTOX™.

16. Install the shuttle.

17. Replace and lubricate the first O-ring as you install the inlet valve cap.

18. Install the retaining ring flat side out (away from the block).

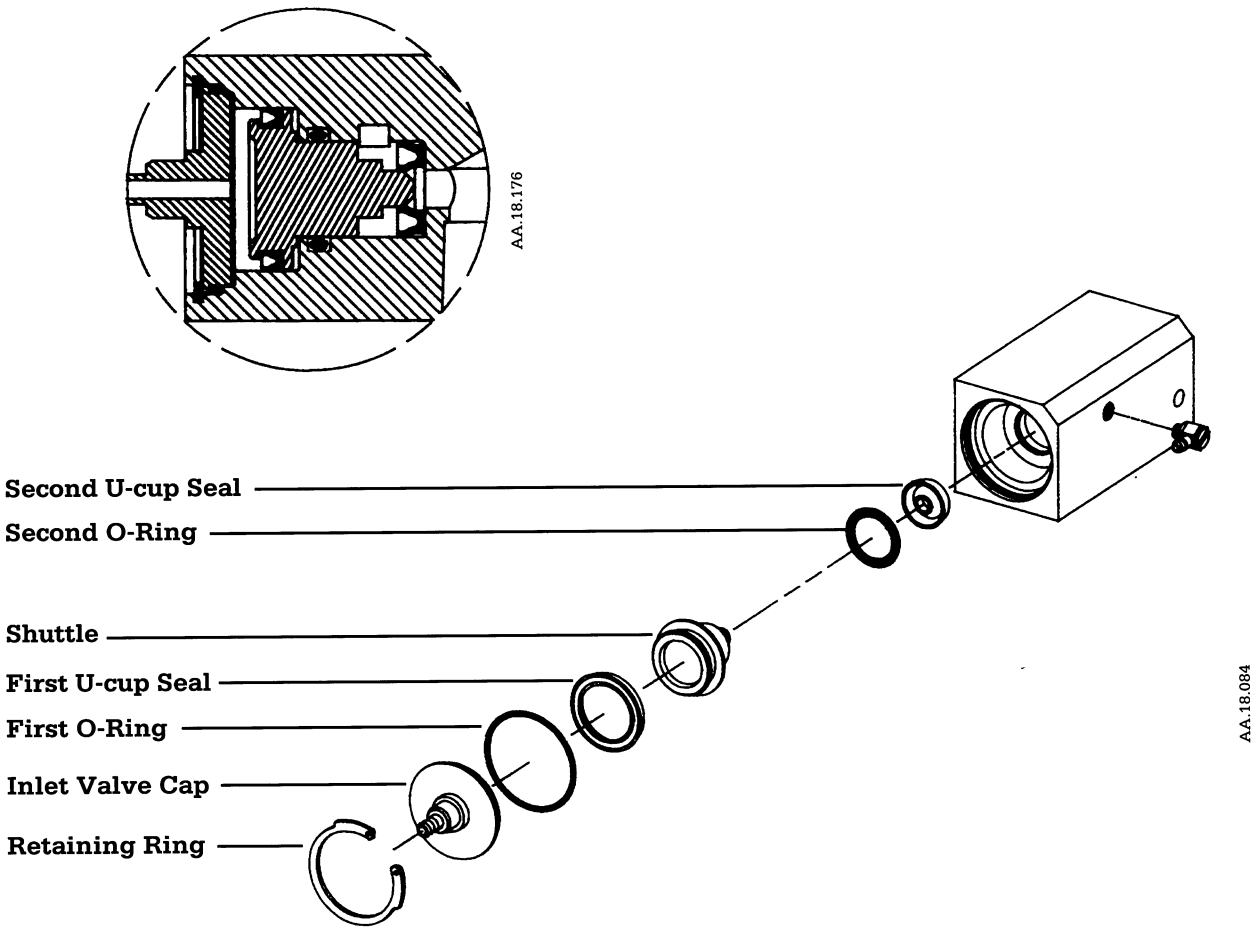


Figure 5-3 Gas Inlet Valve

Secondary Regulator Filter Replacement

19. Replace the filter assembly (TB1, filter, TB13). Route the filter below the primary regulator.

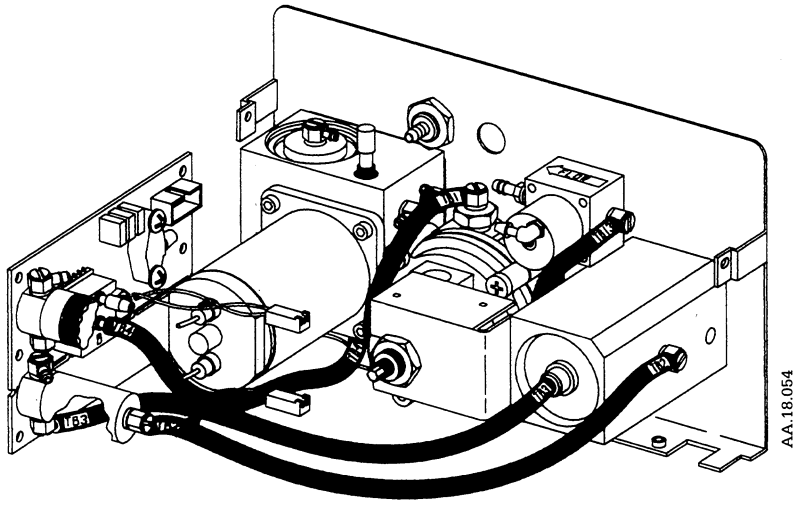


Figure 5-4 Secondary Regulator Filter

Battery Replacement

20. Replace the battery every two years, J2 (control board).

    a. Remove the battery and dispose of according to local regulations.

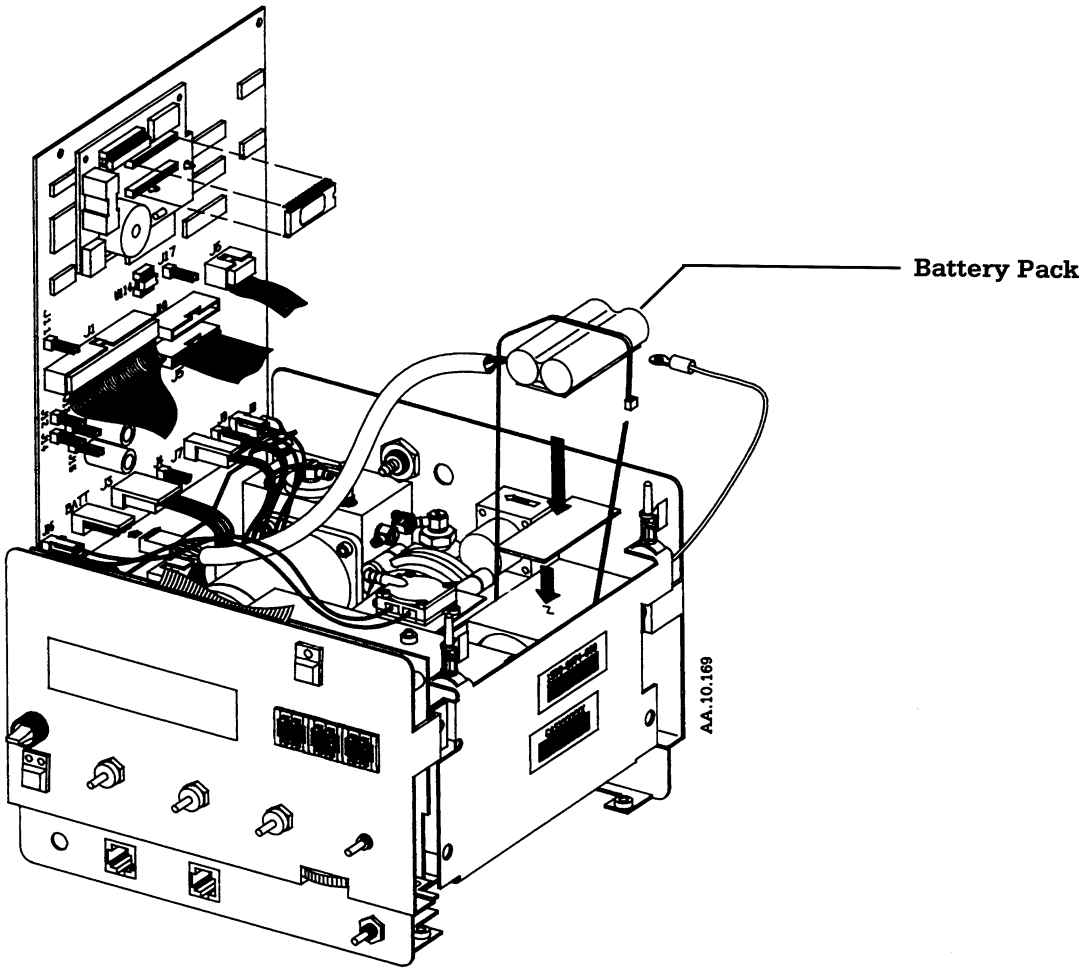


Figure 5-5 Battery

    b. Install a properly conditioned replacement battery.

Important: Check the conditioning date marked on the replacement battery. Do not install a battery which is 60 days past the conditioning date. If the replacement battery is 60 days past the conditioning date, return the replacement battery for conditioning, or dispose of according to local regulations.

Testing After Maintenance

21. Perform section "4/Test and Calibration" and then section "3/Post-Service Checkout."

22. Charge the battery for 24 hours before returning the ventilator to clinical use.

    a. Plug in and turn ON the ventilator.

    b. If "Low Battery" appears, the message should go away within 5 minutes. If the message does not go way, the battery is not being charged properly.

    c. The ventilator must remain plugged in and turned ON to continue charging the battery.

Notes:

6/Troubleshooting

6.1 General Information

Operational alarm messages are found in the Operation and Maintenance manual.

Some ventilator problems may not generate any ventilator messages, even though the ventilator may not be functioning correctly. Perform section "4 Tests and Calibration" to identify a malfunction.

6.2 Troubleshooting Guide

Symptom	Probable Cause	Action
Bellows does not expand or tends to collapse during ventilation.	1. Leak in the breathing circuit.	1. Check breathing circuit and absorber for leaks.
	2. Bellows not installed properly.	2. Check the bellows to base attachment.
	3. Tear or leak in bellows.	3. Check the entire surface of the bellows. Pay close attention to the angles in the convolutions.
	4. Insufficient fresh gas flow.	4. Check that settings on flowmeters are adequate.
	5. Improperly functioning pressure relief valve.	5. Check pressure relief valve.
Bellows distended and/or slips off base.	1. Bellows retention problem.	1. Check bellows.
	2. Bellows assembly exhaust restricted.	2. Check the waste gas scavenging system for high vacuum or blockage.
	3. Bellows assembly pressure relief valve problem.	3. Control port plugged or drive gas inlet hose blocked.

Symptom	Probable Cause	Action
Ventilator cycles normally but low pressure alarm sounds continuously.	1. Pressure sensing tube disconnected, plugged or constricted.	1. Check the connections at the control module and at the connector.
Continuous flow of supply gas before machine is turned ON.	1. Internal hose leak.	1. Check hoses.
	2. Inlet solenoid leak.	2. Check inlet solenoid.
Bellows does not descend during inspiration.	1. Bag/APL-Vent selector in Bag/APL position.	1. Place the Bag/APL-Vent selector in the Vent position.
	2. Drive gas hose disconnected or leaking.	2. Reconnect drive gas hose or check for leaks. Replace O-ring in the drive gas adapter.
	3. Failure of exhaust valve.	3. Check exhaust valve.
Volume readings are consistently low.	1. Volume sensor cartridge failed.	1. Replace the volume sensor cartridge.
	2. Drive gas leakage.	2. Check for leaks.
System sounds alarms at incorrect pressures.	1. Liquid in pressure sensing tube.	1. Drain the sensing tube.
Reverse flow alarm is activated while the volume sensor is in the distal position at the expiratory limb of the breathing circuit.	1. Volume monitor sensor clip is not placed in the proper flow direction.	1. Check placement of sensor clip.
	2. Expiratory check valve on absorber has stuck open.	2. Check the expiratory check valve on the absorber for moisture or damaged disc.

Symptom	Probable Cause	Action
Alarms sound without apparent cause and cannot be silenced.	1. Microprocessor failure.	1. Replace control board.
No display on the LCD. No alarms sounding.	1. Anesthesia system power failure or ventilator power disconnected.	1. Check power connections or Excel/ventilator interface cable.
	2. Circuit breaker.	2. The circuit breaker can be reset (without removing the cover) through a small hole in the bottom right side.
	3. +5 V dc power supply, transformer or cables.	3. Check +5V dc at J10, pin 14. If no +5 V check fuses F1, F2, and F3 on the power supply board.
	4. Control board analog power.	4. Check fuse F101 on the control board. Check +7.5 V dc at J10, pin 9. Check -7.5 V dc at J10, pin 8.
Settings do not meet specifications.	1. Out of calibration.	1. Calibrate.

6.3 Ventilator Failure Messages

Symptom	Probable Cause	Action
VENT FAIL 0!	A/D conversion timing failure.	Replace control board.
VENT FAIL 1!	CPU test failed.	Replace control board.
VENT FAIL 2!	EEPROM checksum or Write/Read failure.	Go into user setup pages, change contrast setting, power OFF and power ON, then verify all user parameters. If Vent Fail 2 is still present, go into power-up setup pages, change altitude setting, power OFF and power ON, then verify all user parameters. If Vent Fail 2 is still present, go into service/calibration mode, change drive gas setting, exit service mode, then verify all user parameters. If Vent Fail 2 is still present, replace EEPROM and pneumatic manifold assembly or replace control board.
VENT FAIL 3!	Write/Read failure (CPU internal RAM test).	Replace control board.

VENT FAIL 4!	Supply pressure greater than 207 kPa (30 psig).	Check regulator inlet pressure, regulator output pressure, or calibration on the pressure transducer board. Calibrate and check for drift in 30 minutes.
VENT FAIL 5!	No +5V dc.	Check power connectors. Check anesthesia system power supply.
VENT FAIL 6!	1. Flow valve failure.	1. Check flow valve, check calibration or replace control board.
	2. Electrical noise.	2. Check the location of electrosurgical units or other electrical noise generators.
DRIVE CKT OPEN!	Water build up in the drive tube.	Check the drive circuit for fluid.
	Exhalation solenoid failure or drive circuit pressure too high.	Ensure J8 is plugged in. Check solenoid valves. Check Bag/APL-Vent selector on absorber. Check pressure switch or replace control board.
VENT FAIL 8!	Gas inlet valve failure.	Check gas inlet valve or check solenoid valve. Ensure J9 is plugged in or replace control board.
VENT FAIL 9!	D/A conversion, patient pressure feedback error.	Check pressure transducer board calibration or replace control board.

Symptom	Probable Cause	Action
VENT FAIL 10!	Measured temperature = 0 (zero) or > 60°.	Check 10-pin ribbon cable connection or replace pressure transducer board.
VENT FAIL 11!	+7.5 V dc supply is out of range.	Replace control board, front panel board, or pressure transducer board.
VENT FAIL 12!	Flow control valve table values corrupted.	Verify flow table section "4/Test and Calibration," or replace control board.
VENT FAIL 13!	Software failure.	Replace control board or EPROM.
VENT FAIL 14!	Overvoltage on +5 V dc on multilayer control board (for IEC ventilator only).	Replace control board.
VENT FAIL 15!	Auxiliary port selected but French language not selected (for IEC ventilator only).	Replace control board.
VENT FAIL 16!	EPROM CRC failure.	Replace EPROM.
VENT FAIL 17!	D/A conversion, O_2 feedback error.	Replace control board.
VENT FAIL 18!	-8.3 V dc supply out of range on multilayer control board (for IEC ventilator only).	Replace control board.
VENT FAIL 19!	External RAM Write/Read failure.	Replace control board.

Symptom	Probable Cause	Action
VENT FAIL 20!	Control board watchdog circuit failure.	Replace control board.
VENT FAIL 21!	Watchdog circuit failure on multilayer control board (for IEC ventilator only).	Replace control board.
HARDWARE ERROR A	Low O_2 pushwheel circuit reads non-decimal number.	Replace front panel board.
HARDWARE ERROR B	High O_2 pushwheel circuit reads non-decimal number.	Replace front panel board.
HARDWARE ERROR C	Low minute volume pushwheel circuit reads non-decimal number.	Replace front panel board.
SOFTWARE ERROR A through SOFTWARE ERROR F	Software calculation error.	Replace EPROM or replace control board.

Note: Operational alarm messages are found in the Operation and Maintenance manual.

IMPORTANT

If the ventilator experiences extreme electrical interference, it may interrupt mechanical ventilation. If this interruption occurs, the ventilator generates an internal reset function and resumes normal operation after two (2) seconds. For situations where continuous electrical interference is experienced by the ventilator, causing a continuous interruption, the ventilator's internal reset repeats until the interference ceases.

If the electrical interference is continuously present and mechanical ventilation is interrupted for approximately 30 seconds, the ventilator produces a continuous beeping audio alarm. Manual ventilation of the patient must be performed while the mechanical ventilation is interrupted. When the electrical interference ceases, the continuous beeping audio alarm can be silenced only by turning the ventilator or anesthesia machine, as applicable, power switch OFF and after five seconds back ON.

Notes:

7/Repair Procedures

7.1 General Information

The 7800 Ventilator can be an integral part of the Modulus® II Anesthesia System (Modulus® II Upgrade), Excel Anesthesia System (Excel Mount) or externally attached to various other anesthesia systems (Stand Alone). In some configurations it is possible to test and repair the control module while attached to the anesthesia system, in other configurations the control module must be removed. You must determine if it is necessary to detach the control module in order to gain access for service or maintenance.

The special service shelf (and standoff) allows you to mount the ventilator control module behind the Modulus® II and connect required hoses and cables.

After servicing the ventilator, perform section "4/Test and Calibration" to ensure that the ventilator is completely operational.

⚠WARNING: Failure to perform section "4/Test and Calibration" could cause injury to the patient .

After performing section "4/Test and Calibration," perform section "3/Post Service Checkout."

⚠WARNING: Failure to perform section "3/Post-Service Checkout" before returning the system to clinical use, could cause injury to the patient.

⚠WARNING: Electrical Shock Hazard. Do not touch exposed wires or conductive surfaces while the panels are removed.

⚠CAUTION: Avoid static. Wear an anti static wrist strap when handling static sensitive components. Some parts can be damaged by improper handling.

Ground Wires

The panels and covers in this ventilator are interconnected, electrically, by heavy gauge ground wires. These wires may need to be removed to separate the panels. All ground wires must be reattached when assembling the ventilator.

Lubricate O-rings

Apply a thin film of KRYTOX™ GPL 205 (oxygen-use-approved) lubricant as indicated to O-rings prior to installation.

KRYTOX™ is a Trademark of E.I. DuPont de Nemours Co. Inc.

7.2 Control Module Removal, Test Setup and Installation

A. Removal and Service Shelf Mounting

Excel Mountings

The control module may be mounted directly to the top shelf, or lowered from the top shelf by using a mounting box (configurations A, B, C and D). See the Excel Anesthesia System service manual for mounting to an Excel SE.

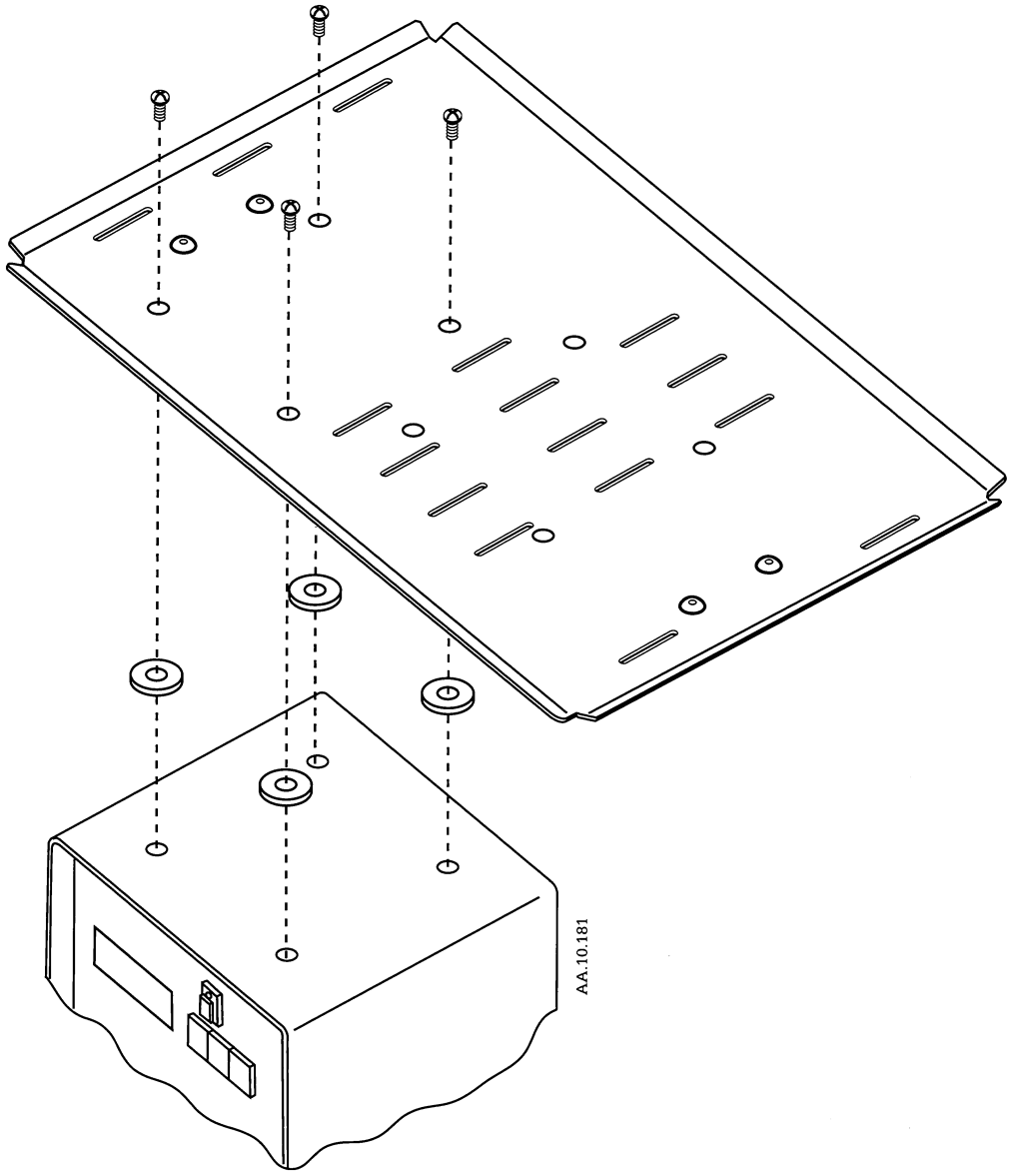


Figure 7-1 Excel Shelf Mounting, Configuration A

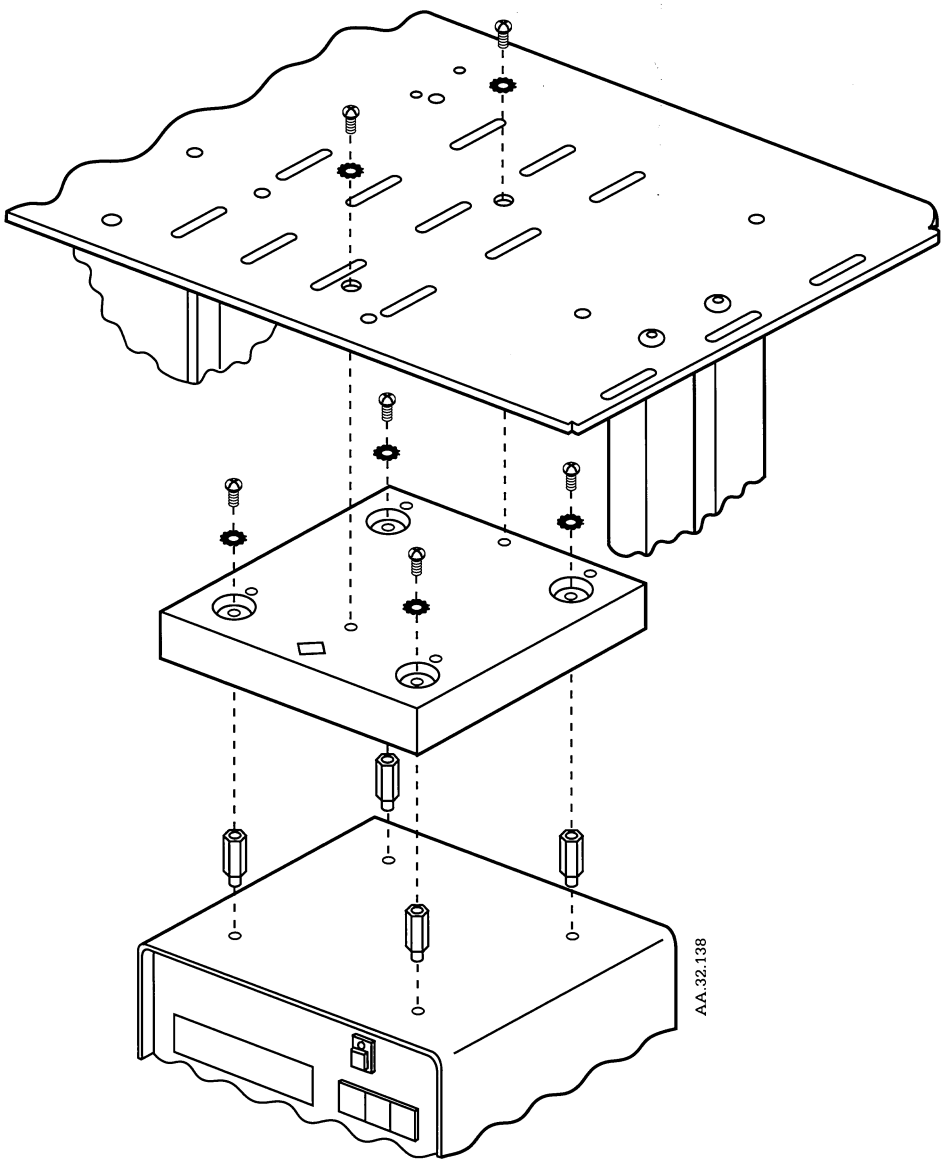


Figure 7-2 Excel Shelf Mounting, Configuration B

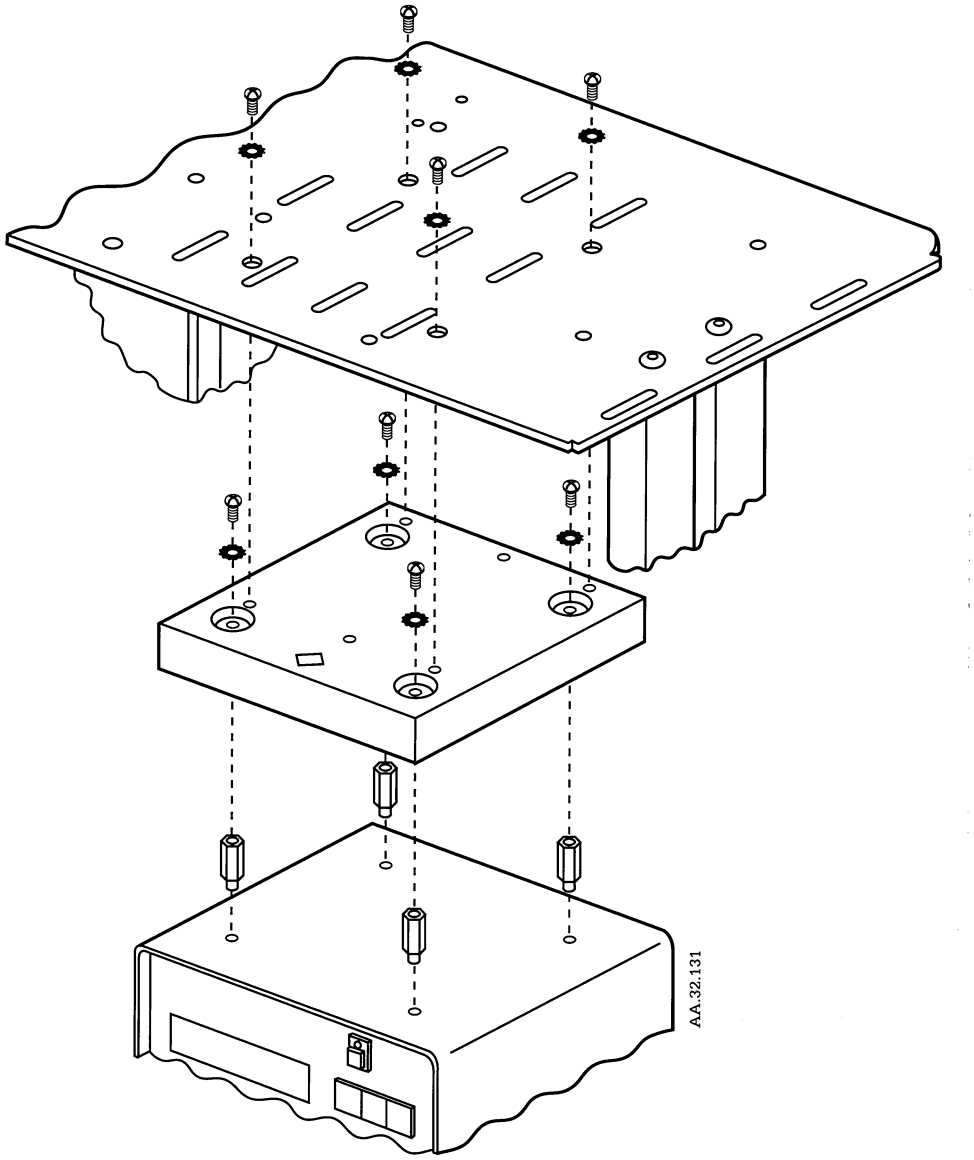


Figure 7-3 Excel Shelf Mounting, Configuration C

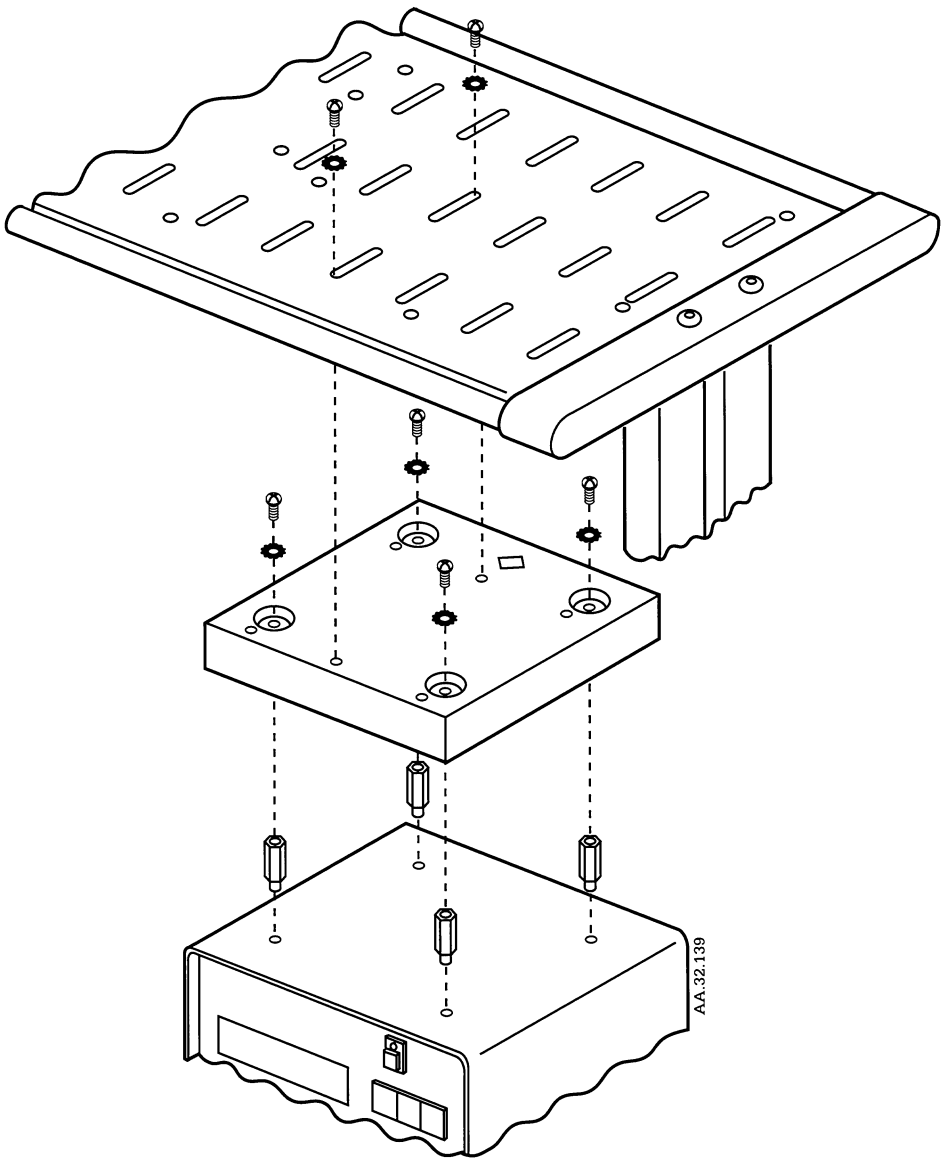


Figure 7-4 Excel Shelf Mounting, Configuration D

Optional Arm Mounting

The control module may be mounted outboard, secured to an arm by three (3) screws.

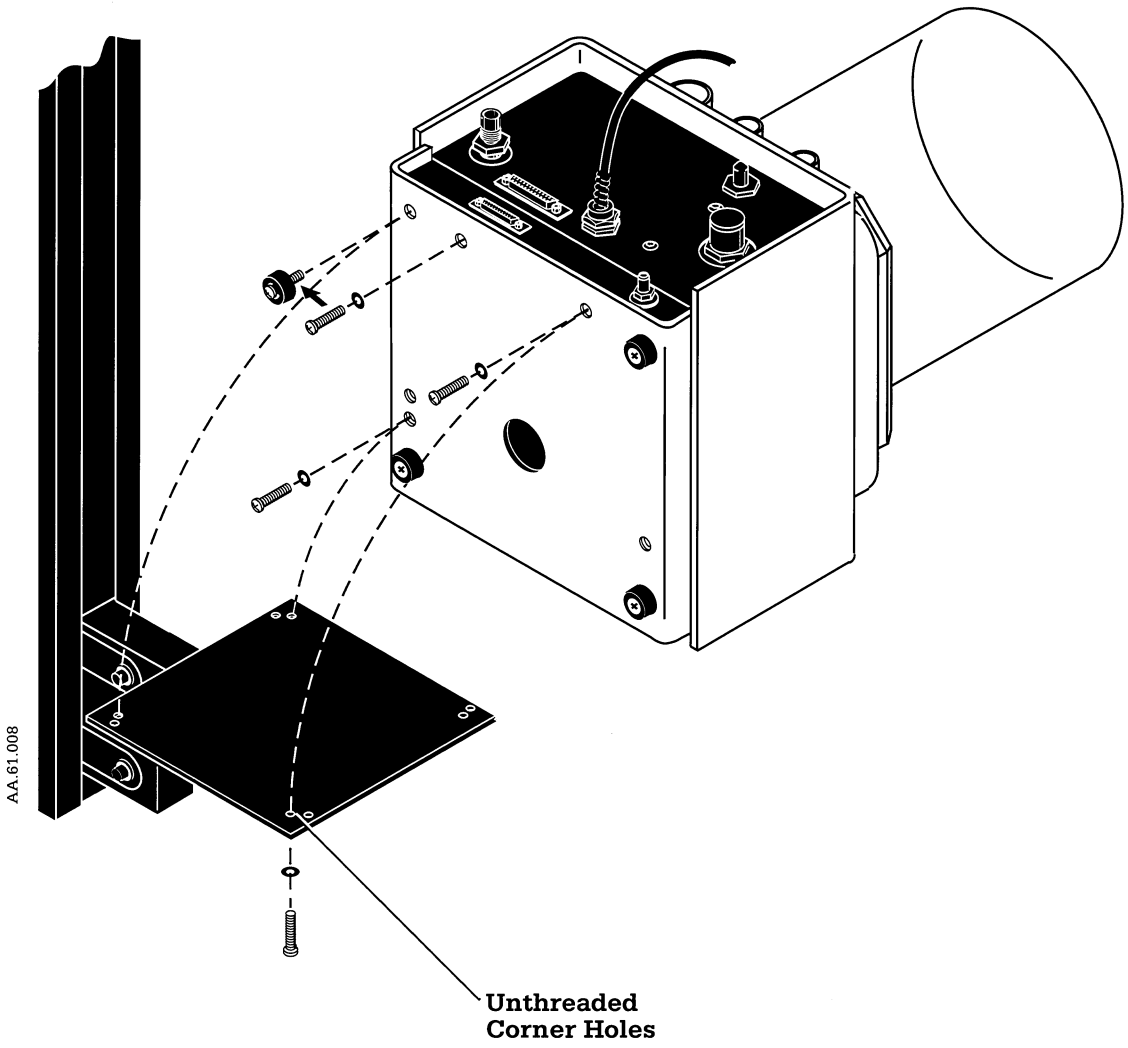


Figure 7-5 Optional Arm Mounting

Modulus II Upgrade

1. Turn the anesthesia system OFF and unplug the power cord.
2. Turn OFF the supply cylinders and disconnect the gas supply pipeline.
3. Press the oxygen flush to relieve pressure.
4. Remove loose equipment from the shelves and tilt the top shelf up.
5. Disconnect the drive gas hose and pressure sensing tube.
6. Remove the panel and bezel from below the control module.
7. Disconnect the gas supply hose from the bottom of the control module.
8. Mount the service shelf on the tilt-spring mounting block.

⚠WARNING: The clamp must be firmly seated over the tilt-spring mounting block. Otherwise the control module could fall and cause injury.

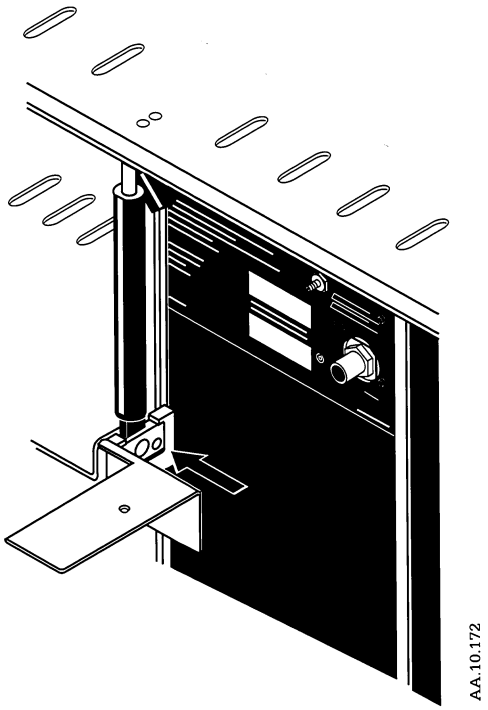


Figure 7-6 Service Shelf

9. Remove the screws (2) that hold the EMC/Interface board to the mounting plate.

10. Loosen the knurled thumbscrew that secures the control module.

11. Lift and slide the control module out the back of the system.

12. Thread the standoff into the bottom of the control module.

13. Turn the control module so that the front panel faces to your right (as viewed from the rear of the anesthesia system).

14. Set the control module on the service shelf and secure it with the knurled thumbscrew.

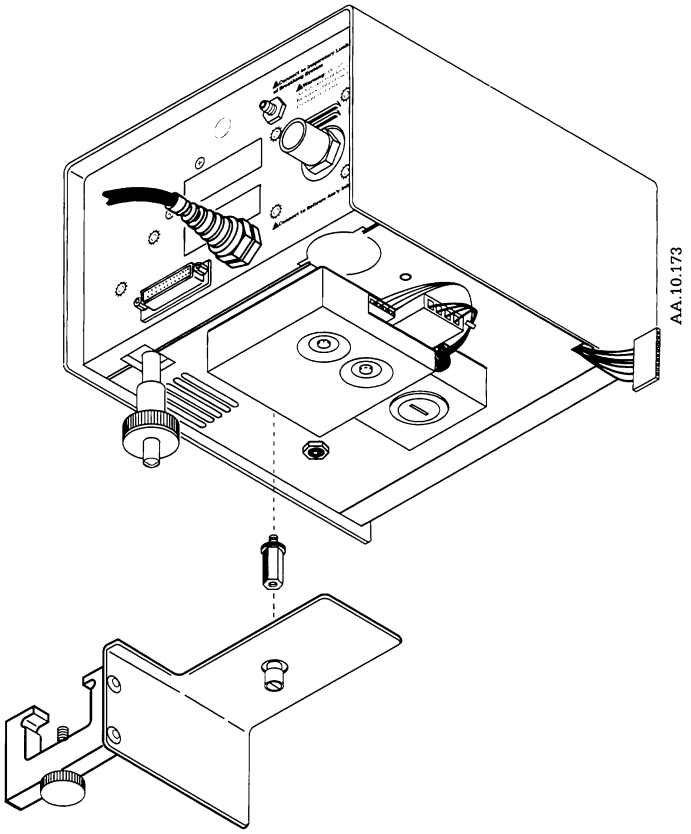


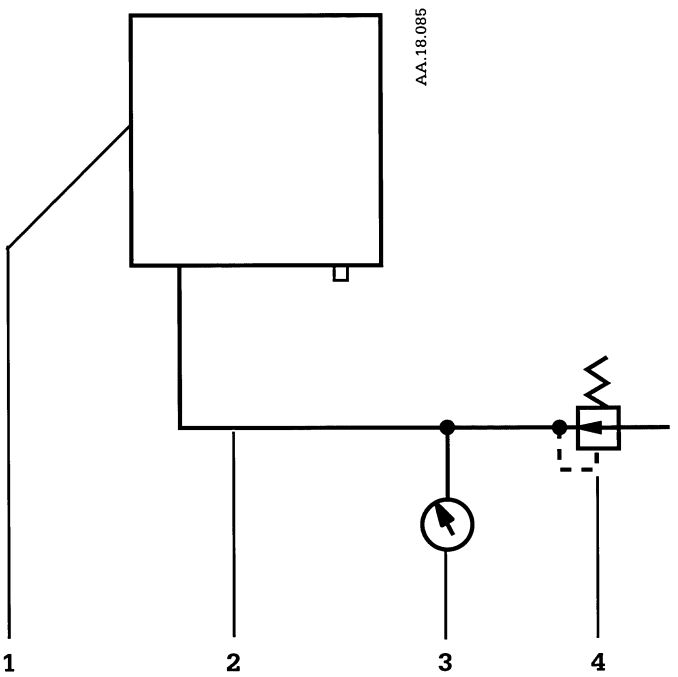
Figure 7-7 Control Module on Service Shelf

B. Test Setup

1. Remove the cover.
2. Swing the control board up.
3. Connect the test equipment to the control module, supply gas inlet.
4. The control module is ready for service.

Tools Required:

- Pressure gauge, 400 kPa accurate to 5 kPa (58 psi accurate to 0.7 psi)
- Regulator, 276-345 kPa (40-50 psi) output



1. Control Module
2. Supply Gas Hose
3. Pressure Gauge
4. Regulator

Figure 7-8 Test Equipment Schematic

C. Installation

Excel Mount and Stand Alone

1. Turn the anesthesia system OFF and unplug the power cord.
2. Turn OFF the supply cylinders and disconnect the gas supply pipeline.
3. Press the oxygen flush to relieve pressure.
4. Ensure the DIP switches are set to operational mode (1 ON, 2 OFF, 3 OFF, 4 OFF) and clip the control board down.
5. Install the cover.
6. Mount the control module.
7. Ensure all cables and ground wires are connected.
8. Connect the gas supply hose.
9. Perform section "3/Post-Service Checkout."

⚠WARNING: You must perform section "3/Post-Service Checkout" before returning the system to clinical use. Failure to do so could cause injury to the patient.

Modulus II Upgrade

1. Turn the anesthesia system OFF and unplug the power cord.
2. Turn OFF the supply cylinders and disconnect the gas supply pipeline.
3. Press the oxygen flush to relieve pressure.
4. Ensure the DIP switches are set to operational mode (1 ON, 2 OFF, 3 OFF, 4 OFF) and clip the control board down.
5. Install the cover.
6. Slide the control module into the anesthesia system.

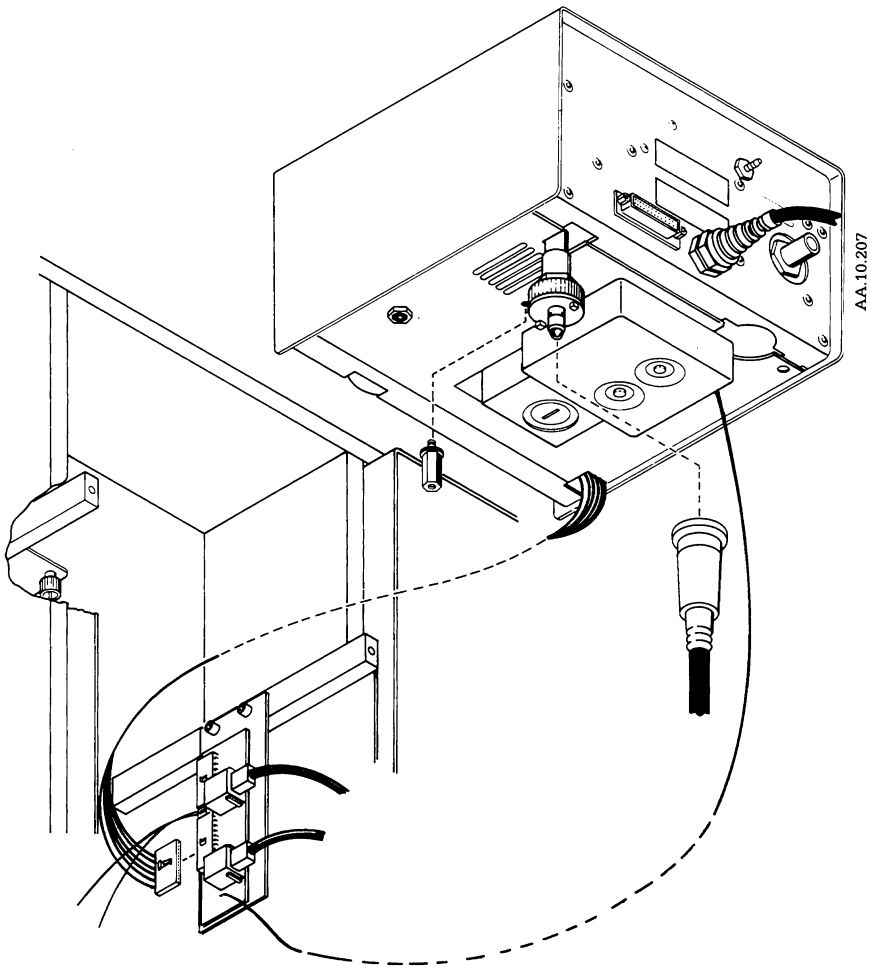


Figure 7-9 EMC/Interface Board, Modulus II Upgrade

7. Align the control module with the front bezel and tighten the knurled thumbscrew.

8. Remove the service shelf.

9. Ensure all cables and ground wires are connected.

10. Position the EMC/Interface board and secure with screws and washers.

11. Connect the gas supply hose.

12. Install the bezel and rear panel.

13. Perform section "3/Post-Service Checkout."

⚠WARNING: You must perform section "3/Post-Service Checkout" before returning the system to clinical use. Failure to do so could cause injury to the patient.

7.3 Major Assembly Replacement

A. Control Board, Piggyback Watchdog Board and EPROM Replacement

⚠ CAUTION: Avoid static. Wear an anti static wrist strap when handling static sensitive components. Some parts can be damaged by improper handling.

Important: The control board jumper configuration for 7800 is: J11 installed, J4, J14, J15 and J17 removed.

Removal:

1. Remove the control board and place on an anti-static surface.
2. Remove the piggyback watchdog board by pinching the retainers. Move the piggyback watchdog board, retainers and EPROM to the replacement control board.

   If no piggyback watchdog board is present, move the EPROM to the replacement board.
3. Remove the socketed 8-pin EEPROM, U114 (control board). Move to the replacement board.

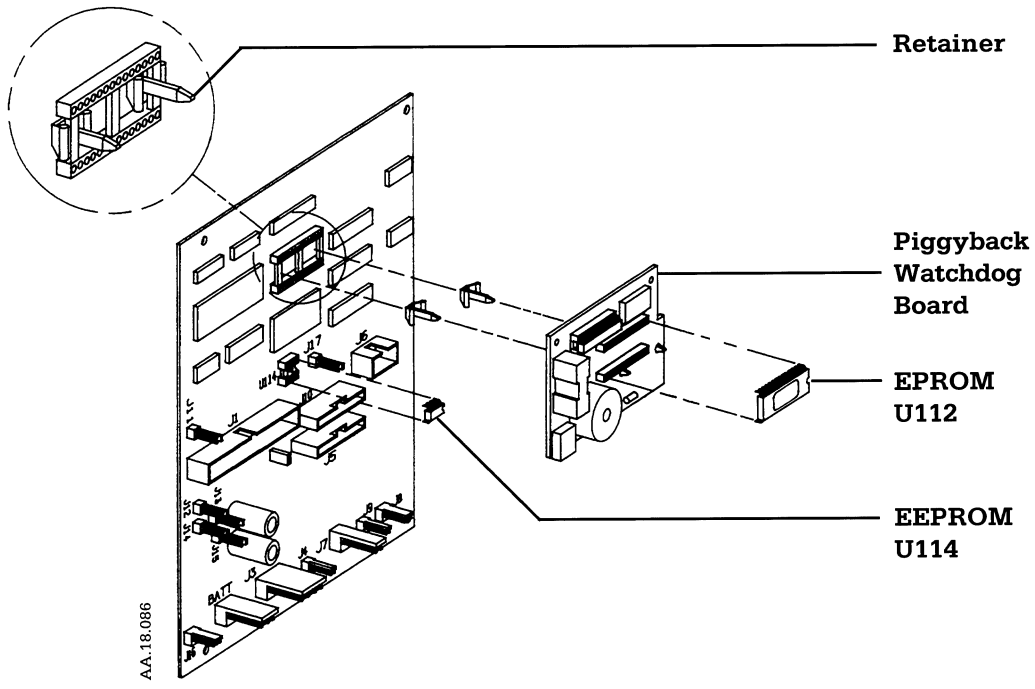


Figure 7-10 EPROM and EEPROM Location

Installation:

1. Install the control board and connect the cables.
   - J2 (Battery Pack)
   - J3 (Power Supply)
   - J7 (Flow Control Valve)
   - J8 (Exhalation Solenoid, SOL 1)
   - J9 (Inlet Solenoid, SOL 2)
   - J16 (High Pressure Limit Switch)
   - J1 (Front Panel Board) 50 position ribbon
   - J5 (Serial Interface)
   - J6 (Pressure Transducer Board) 10 position ribbon

2. Perform section "4/Test and Calibration" and then section "3/Post-Service Checkout."

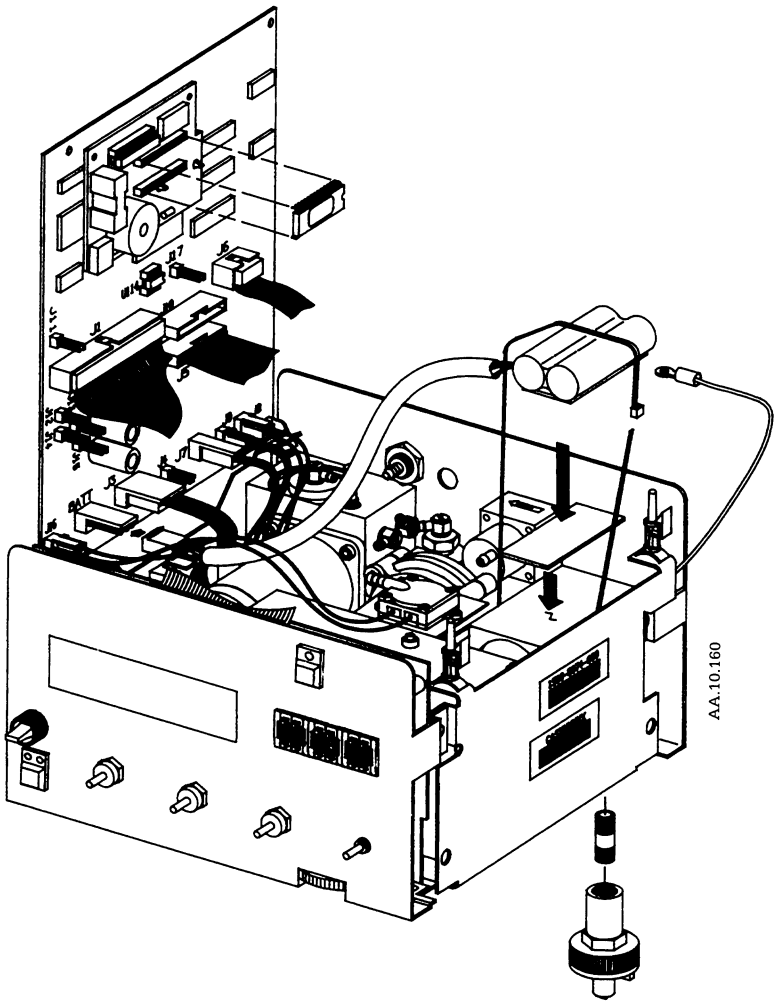


Figure 7-11 Cable Connections, with EMC

B. Front Panel Board Replacement

⚠ CAUTION: Avoid static. Wear an anti static wrist strap when handling static sensitive components. Some parts can be damaged by improper handling.

Removal:

In order to remove the front panel board you must remove the lower shroud, the lower front panel and the entire front panel assembly. The front panel board is attached by screws, torque nuts and a switch guard.

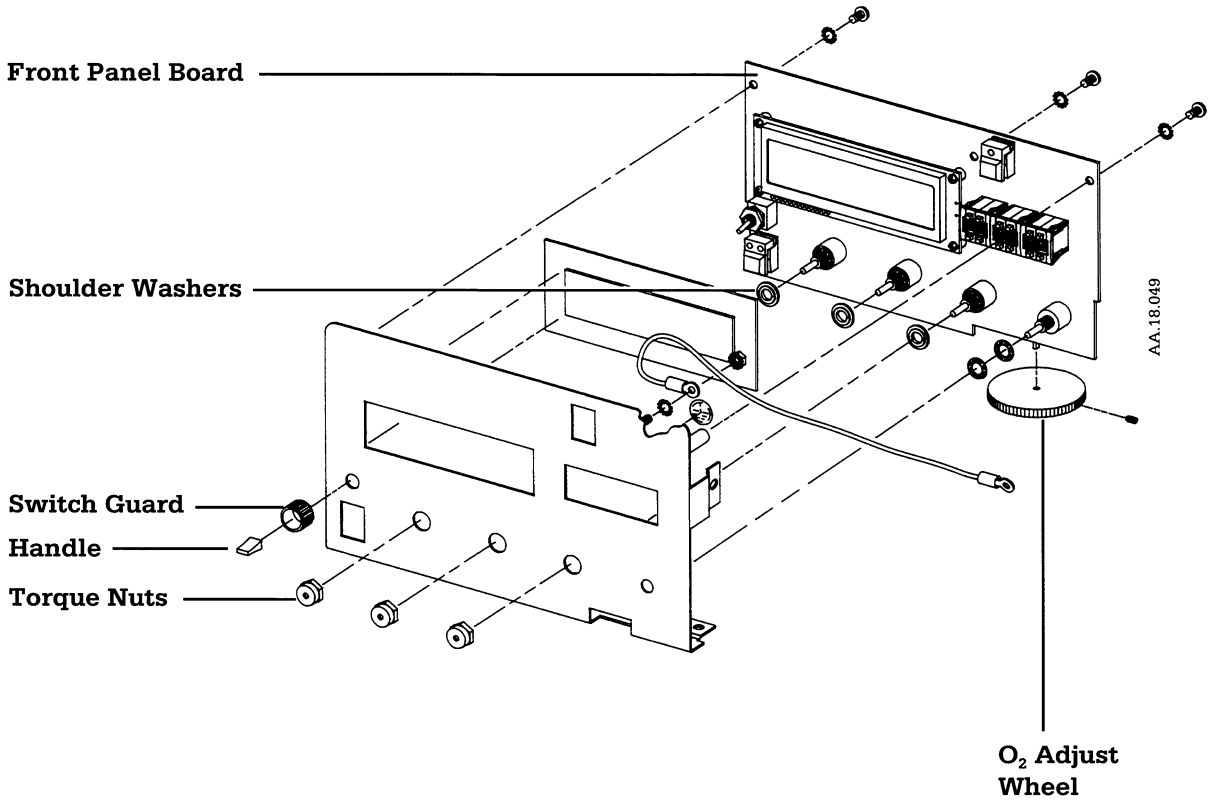


Figure 7-12 Removing Front Panel

Installation:

1. Install the O_2 adjustment wheel. Tighten the screw on the flat part of the shaft.
2. Install the three (3) shoulder washers onto the replacement board.
3. Install the two (2) washers onto the inspiratory pressure limit shaft.
4. Insert the right side of the front panel board (as viewed from the front) into the sheet metal. Snap the board in place.
5. Install the torque nuts. Do not over tighten.
6. Install the switch guard and press on the handle.
7. Attach the screws and washers that hold the circuit board in place.
8. Attach the front panel assembly.
9. Connect the cables.
   - J1 (control board) 50 position ribbon
   - J2 (EMC/Interface board)
   - J8 (speaker)
10. The knobs will be installed and adjusted when you perform section "4/Test and Calibration."
11. Perform section "4/Test and Calibration" and then section "3/Post-Service Checkout."

C. Pressure Transducer Board Replacement

⚠ CAUTION: Avoid static. Wear an anti static wrist strap when handling static sensitive components. Some parts can be damaged by improper handling.

Removal:

The pressure transducer board mounts on the side of the chassis. You may want to loosen the rear panel assembly to improve access.

1. The pressure transducer board is attached by snap top standoffs. Pull to release.
2. Disconnect the ribbon cable, green hose and clear tube.
3. Remove the solenoids.

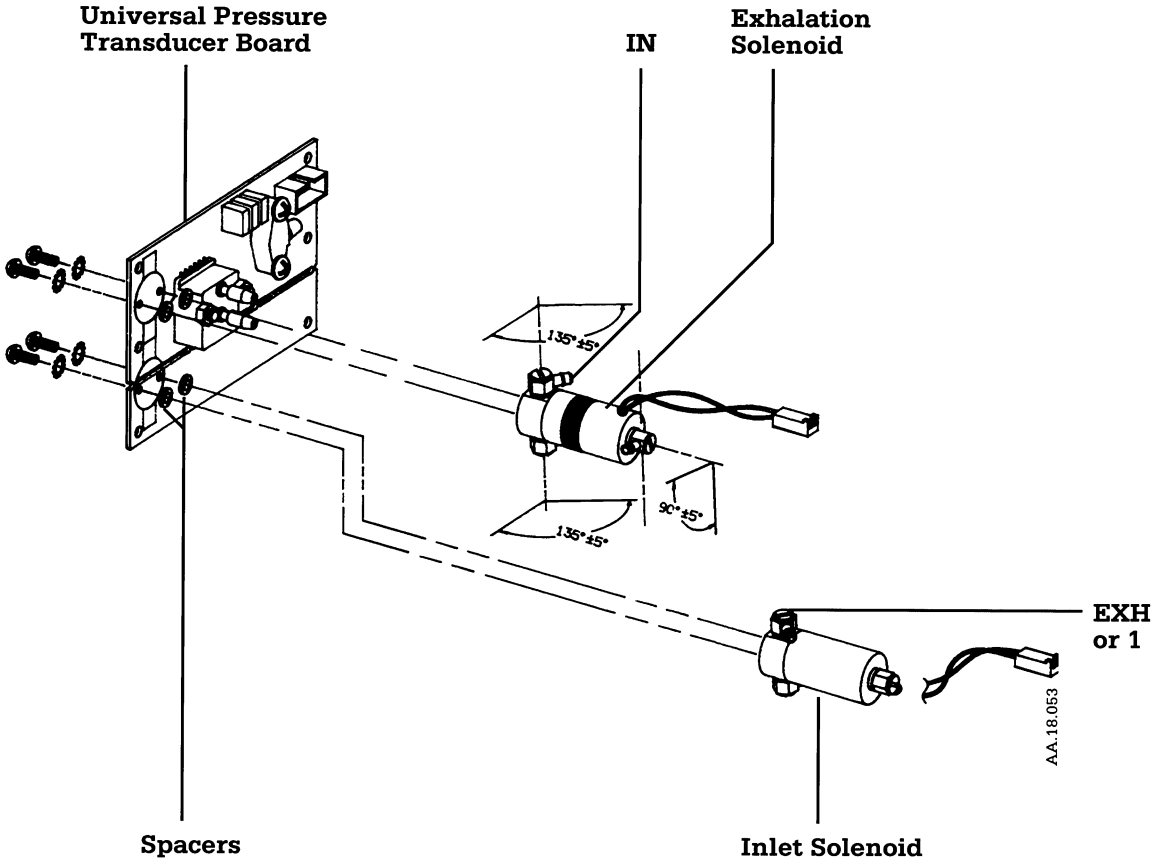


Figure 7-13 Universal Pressure Transducer Board

Installation:

1. Install the solenoids onto the replacement board. Use the spacers.

   Note: The direction of the solenoid fittings may need to be adjusted.

2. Connect the ribbon cable.

3. Connect the green hose TB4 to the "B" port of the high pressure transducer.

4. Connect the clear tube TB7 to the low pressure transducer.

5. Position the board and press into place.

6. Attach the rear panel assembly.

7. Ensure the hoses, tubes and cables are still in place.

8. Perform section "4/Test and Calibration" and then section "3/Post-Service Checkout."

D. EMC/Interface Board Replacement (Excel Mount and Stand Alone)

Removal:

In order to remove the EMC/Interface board you must remove the lower shroud and the lower front panel. The board is attached by three (3) screws.

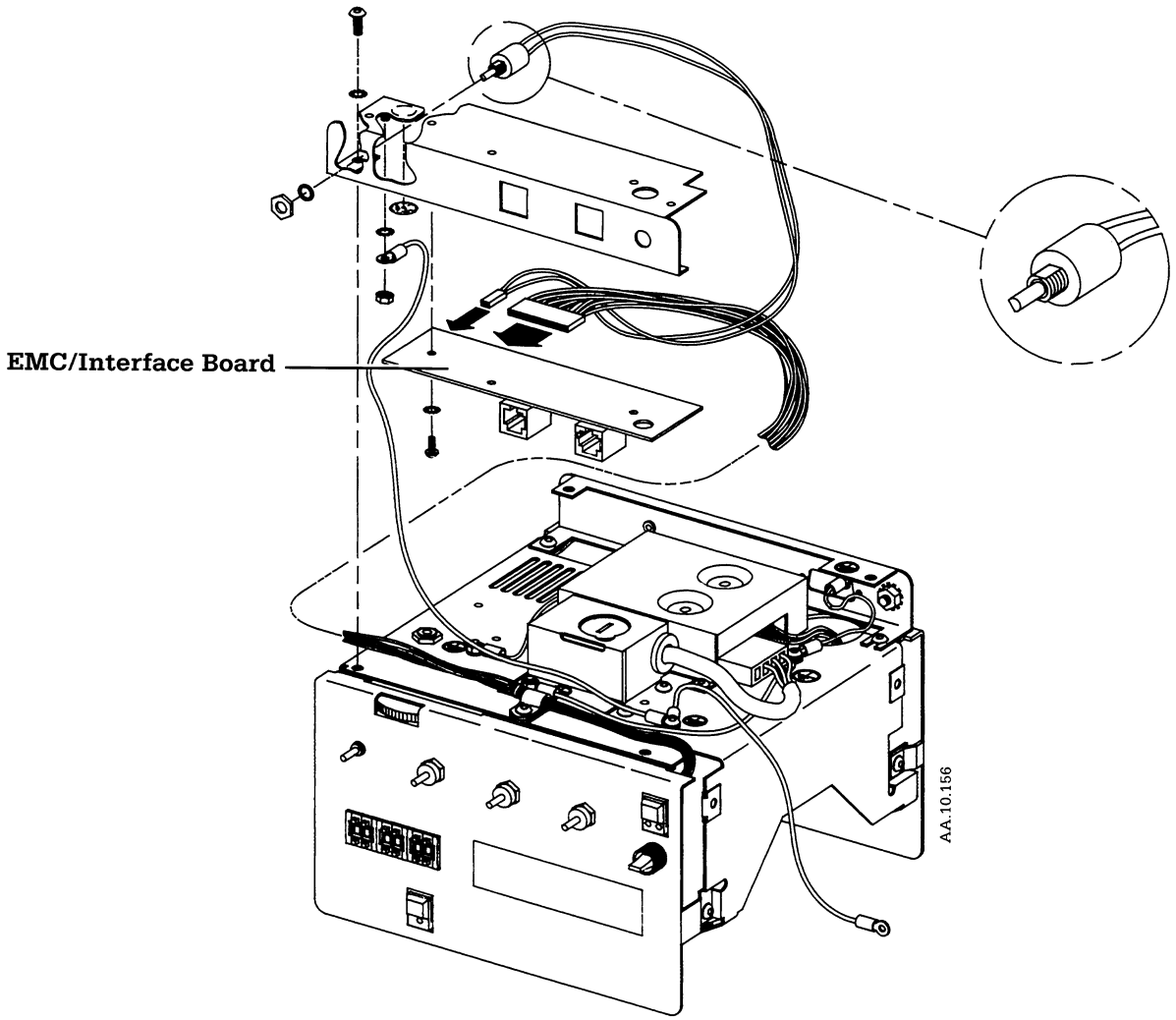


Figure 7-14 EMC/Interface Board, International, Stand Alone

Installation:

1. Mount the EMC/Interface board in the lower front panel.
2. Connect the cables.
   - P2/J5 (Sensor/Remote) Excel Mount Only
   - P3/J1 (Front Panel)
   - P4/J2 (ON/Standby) Stand Alone Only
3. Attach the lower front panel and lower shroud.
4. Perform section "4/Test and Calibration" and then section "3/Post-Service Checkout."

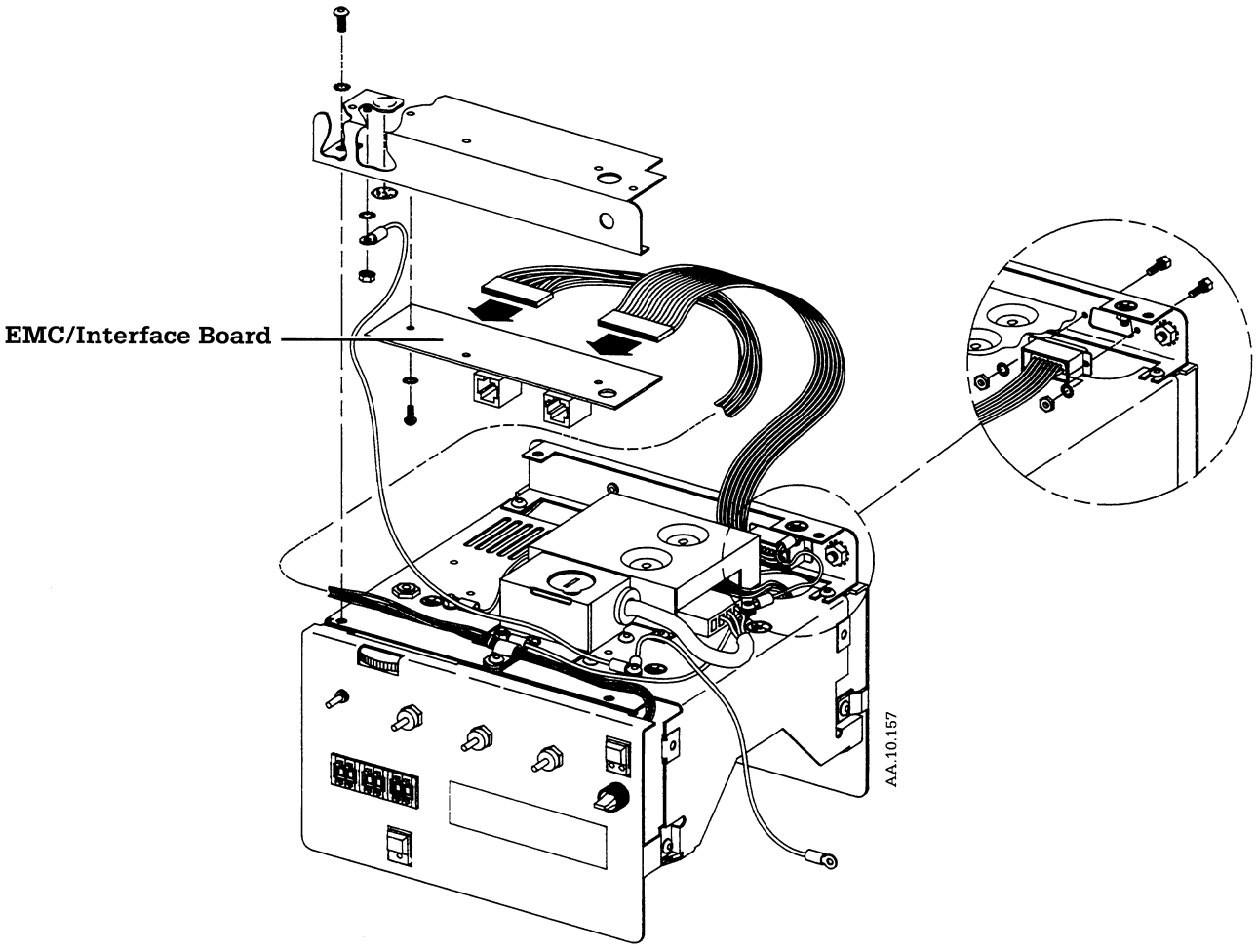


Figure 7-15 EMC/Interface Board, International, Excel Mount

E. EMC/Interface Board Replacement (Modulus® II Upgrade)

Removal:

The EMC/Interface board is mounted in the Modulus II by socket head screws (2).

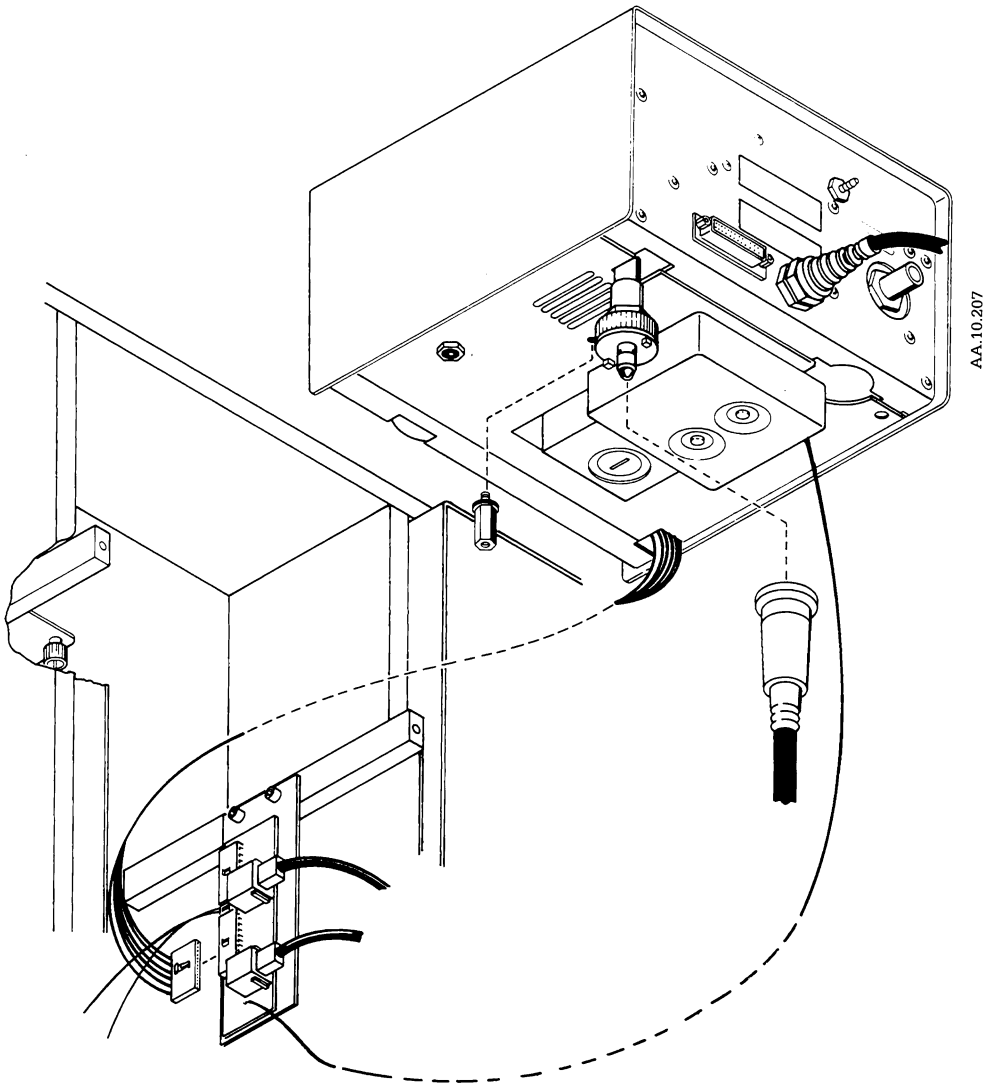


Figure 7-16 EMC/Interface Board, Modulus II Upgrade

Installation:

The EMC/Interface board will be mounted when the control module is installed.

1. Connect the cables.
   - J1 Sensor Interface (Front Panel)
   - J2 Power ON/OFF Switch (Modulus® II)
   - J3 TVX, Sensor Interface Panel (Modulus® II)
   - J4 O_2, Sensor Interface Panel (Modulus® II)
   - Ground Wire to Chassis

2. Perform section "4/Test and Calibration" and then section "3/Post-Service Checkout."

F. Power Supply Board Replacement

⚠CAUTION: Avoid static. Wear an anti static wrist strap when handling static sensitive components. Some parts can be damaged by improper handling.

Removal:

In order to remove the power supply board you must remove the lower shroud on Excel Mount and Stand Alone variants. The power supply board is attached by two (2) screws.

Installation:

1. Align the insulator and attached the box assembly.
2. Connect the cables.
   - J1 (Transformer)
   - J2 (Control Board)
3. Attach the lower shroud.
4. Perform section "4/Test and Calibration" and then section "3/Post-Service Checkout."

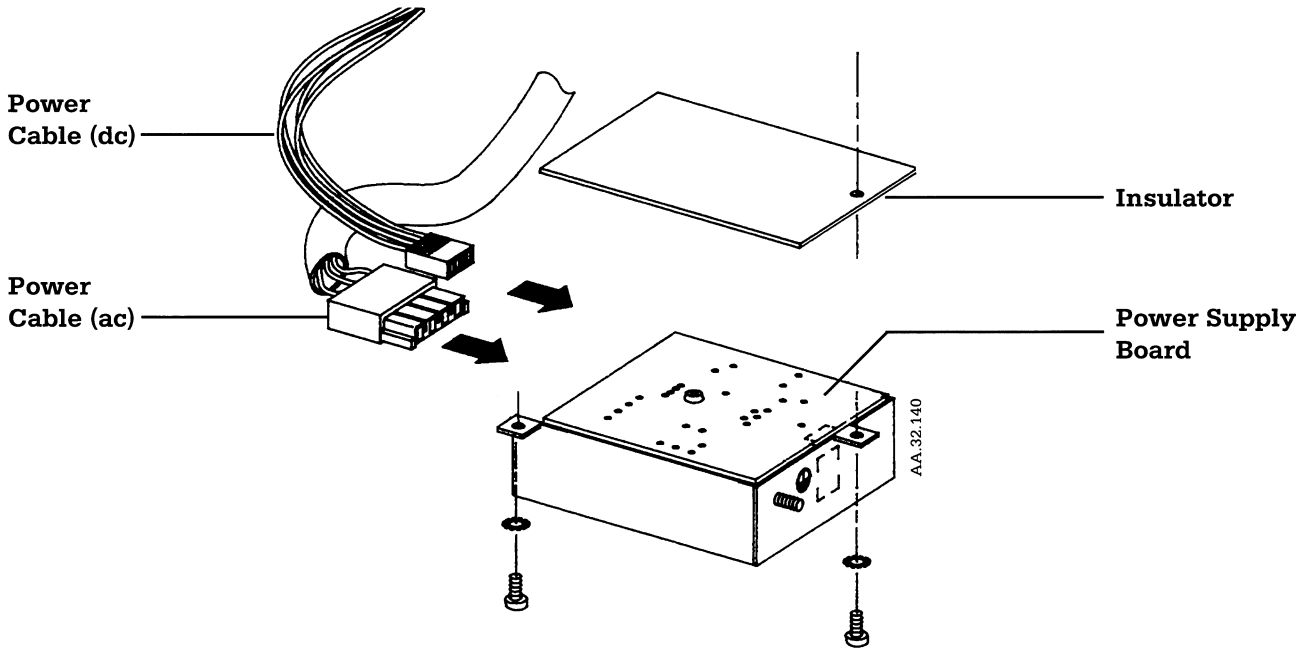


Figure 7-17 Power Supply Board Replacement

G. Primary Regulator Replacement

Removal:

The primary regulator and gas inlet valve are held together by a bracket. Loosen the rear panel assembly to improve access.

1. Remove the screws that mount the gas inlet valve and the pneumatic manifold assembly.
2. Separate the gas inlet valve and primary regulator, from the pneumatic manifold assembly.
3. Loosen the jam-nut on the primary regulator. Slide out and away from the gas inlet valve.

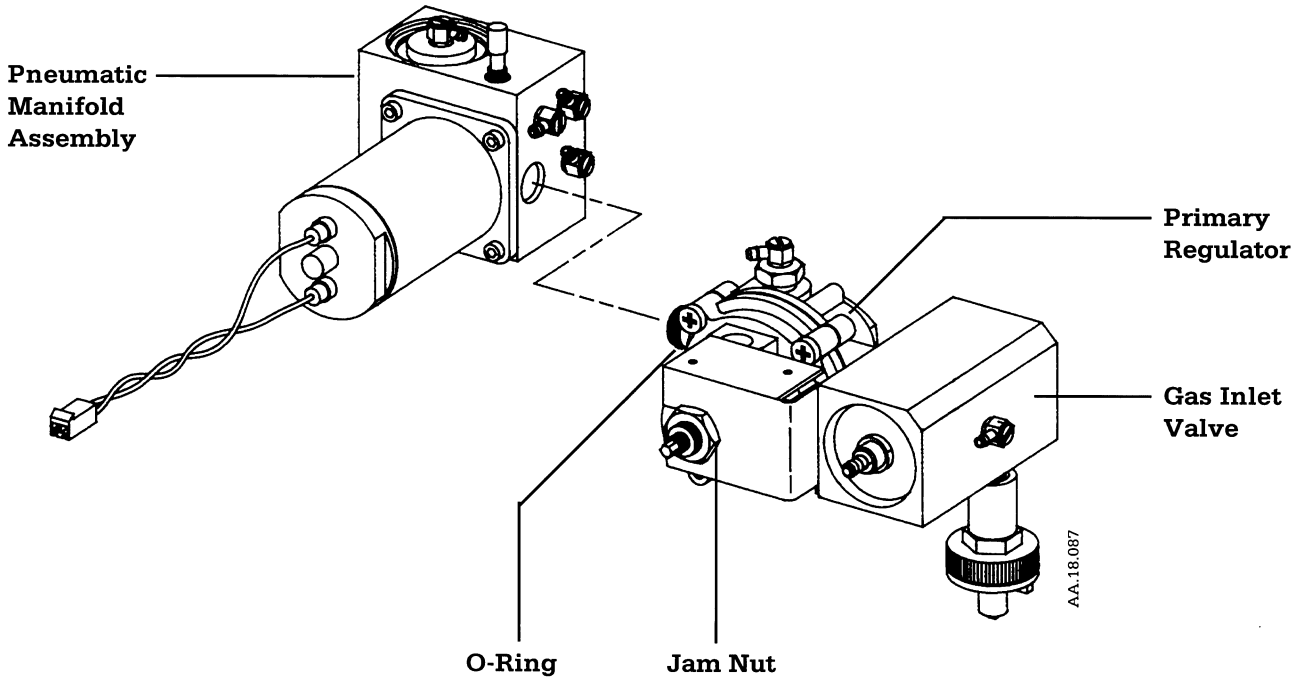


Figure 7-18 Primary Regulator and Gas Inlet Valve

Installation:

1. Lubricate both O-rings on the primary regulator. Use a thin film of KRYTOX™ (oxygen-use-approved) lubricant.

2. Move the primary regulator into position and tighten the jam-nut.

3. Align the gas inlet valve and primary regulator with the pneumatic manifold assembly. Attach the pneumatic manifold assembly — ensure the gasket is in place. Attach the gas inlet valve.

4. Ensure J16 (high pressure limit switch) is connected to the control board.

5. Connect the hose, TB1 (filter) green.

6. Attach the rear panel assembly.

7. Perform section "4/Test and Calibration" and then section "3/Post-Service Checkout."

H. Pneumatic Manifold Assembly and EEPROM Replacement

⚠CAUTION: Avoid static. Wear an anti static wrist strap when handling static sensitive components. Some parts can be damaged by improper handling.

The pneumatic manifold assembly and matched EEPROM must be replaced together. The EEPROM contains the pneumatic manifold calibration numbers, and user parameters. When you replace the EEPROM, the new EEPROM will have only the new pneumatic manifold calibration numbers. You must record the original user parameters and transfer this information to the new EEPROM.

Removal:

1. Record the current parameter settings. You will enter these parameters when you perform section "4/Test and Calibration."
   - Ventilator Model — 7800
   - Software Revision Number — xx.xx
   - Supply Gas Selection — O_2 or AIR
   - Language — _____
   - Altitude (4.xx and Greater) — xxxx meters
   - Reverse Flow Alarm — ON or OFF
   - SIGH (4.xx and Greater) — ON or OFF
   - Contrast — number xx
   - Audio Volume — number xx
2. Loosen the rear panel assembly to improve access.
3. Remove the screws that mount the gas inlet valve and the pneumatic manifold assembly.
4. Separate the pneumatic manifold assembly from the regulator.

Installation:

1. Install the pneumatic manifold assembly — ensure the gasket is in place.

2. Mount the gas inlet valve.

3. Connect the hose and tubing.
   - TB4 (High Pressure Transducer) Green, not shown.
   - TB12 (High Pressure Limit Switch) Clear
   - TB5 (Secondary Regulator) Clear
   - TB9 (Exhaust Tee) Clear
   - TB8 (Exhalation Solenoid) Clear

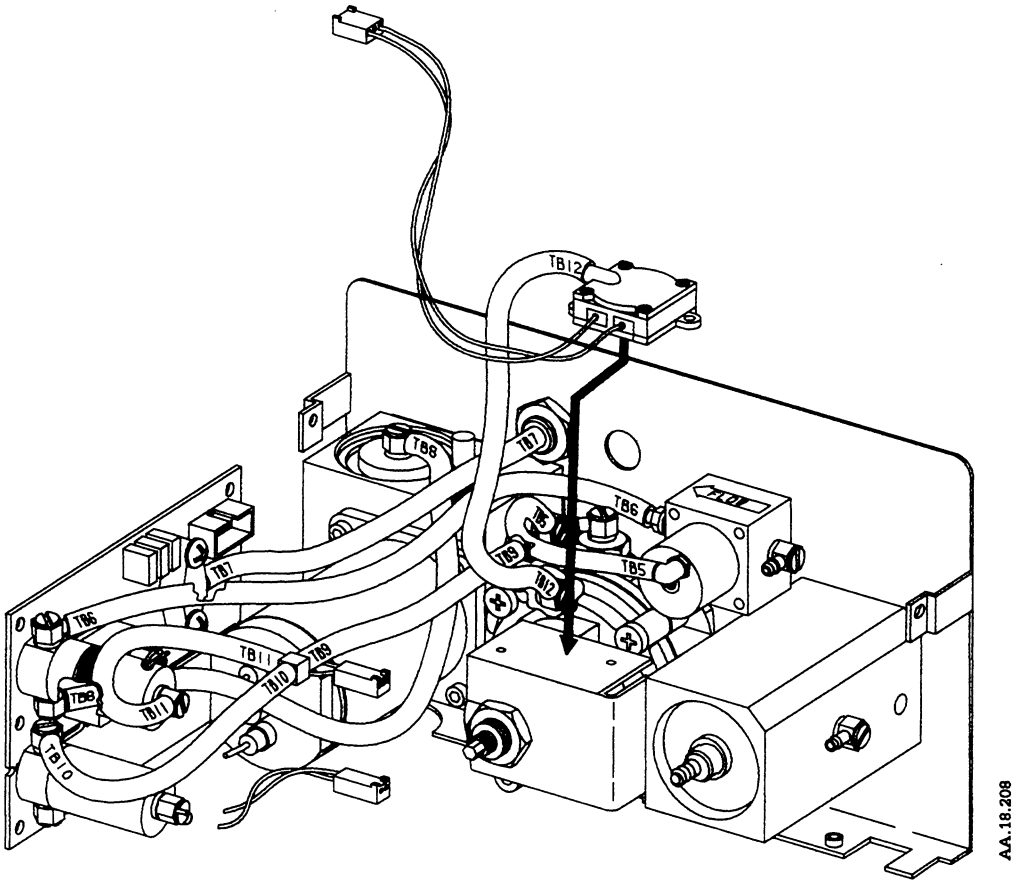
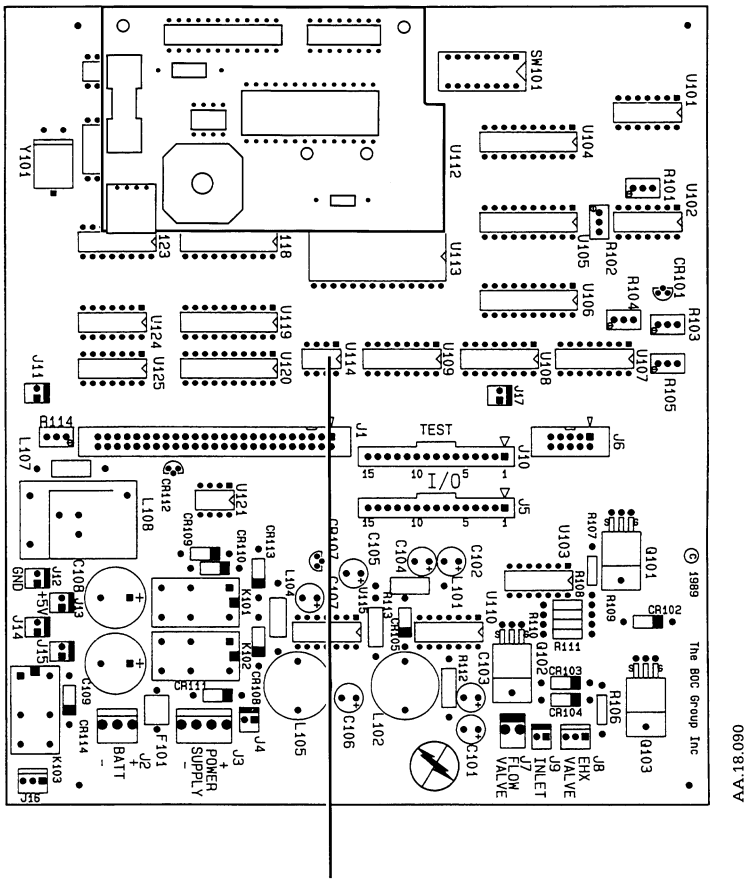


Figure 7-19 Internal Hose and Tubing

4. Connect the cables.
   - J16 (Control Board) High Pressure Limit Switch
   - J7 (Control Board) Flow Control Valve

5. Attach the rear panel assembly.

6. Replace the socketed 8 pin EEPROM, U114 (control board).



EEPROM U114

Figure 7-20 EEPROM Location

7. Perform section "4/Test and Calibration" and then section "3/Post-Service Checkout."

Notes:

8/Illustrated Parts List

8.1 General Information

The illustrated parts in this section are subject to change at any time without notice.

⚠WARNING: Complete section "3/Post-Service Checkout" after performing any maintenance or service. Failure to do so could result in injury to the patient.

⚠CAUTION: Wear a grounding wrist strap when handling static sensitive assemblies.

Current Parts or Historical Parts

All parts that are currently in production are listed in section "8.1 General Assemblies and Components." Parts which are no longer used in the manufacture of new ventilators are listed in section "8.2 Historical Parts."

Special Instructions

Apply a thin coat of oxygen-use-approved lubricant to O-rings prior to installation (unless otherwise noted). Use:

KRYTOX™ GPL 205, Ohmeda Stock Number — 1001-3854-000

All pipe thread joints should have pipe seal applied when assembling, unless otherwise noted. Teflon™ pipe seal tape is not allowed. Use:

Loctite™#59231, thread seal, Ohmeda Stock Number — 0220-5006-300

Some screws require an anti-loosening bond. Use:

Loctite™ #24231, screw lock, Ohmeda Stock Number — 0220-5016-300

When replacing fittings, position the barb end in the same direction as the original fitting to make hose connections easier.

8/Illustrated Parts List

Major Assemblies

Circuit Board Assemblies	Stock Number
64K Control Board, does not include Piggyback Watchdog board, EPROM, or EEPROM	1500-8026-000
64K Control Board, not EMC modified, does not include EPROM or EEPROM	Not Available
Piggyback Watchdog board	1500-3299-000
Pressure Transducer board, Universal, does not include solenoids	1500-8016-000
Pressure Transducer board, Original, 7800/7850	Not Available
Front Panel board, Universal, 7810/7800	1500-8022-000
Front Panel board, Original, 7810/7800	Not Available
EMC/Interface board, International, 7800 (requires additional cable 1500-7036-000 when in Excel Mount)	1500-3315-000
EMC/Interface board, Original, 7800 (requires additional cable 1500-7038-000 when in Excel Mount)	1500-7041-000
Power Supply Board Assembly, 7800	1500-7059-000

Software	Stock Number
64K EPROM kit, English, version 4.22, 7800 includes Operation and Maintenance manual	1500-8076-000

Important: Upgrading software from version 1.xx to 4.xx requires an upgraded Operation and Maintenance manual, and personnel notification of all user visible changes.

64K EPROM kit, English, version 1.11, 7800/7850	1500-8030-000

8/Illustrated Parts List

Pneumatic Assemblies	Stock Number
Primary Regulator Assembly includes O-rings (2), Adapters (2), Elbow Fitting	1500-7071-000
Secondary Regulator Assembly, with fittings	1500-7072-000
High Pressure Limit Switch, to J16 (Control Board), with adhesive tape	1500-3132-000
EEPROM and Pneumatic Manifold Assembly, 7800, CMOS, requires version 1.11 minimum software, available only as matched pair. If less than version 1.11 is installed, order higher software.	1500-8071-000
EEPROM and Pneumatic Manifold Assembly, 7800, NMOS, matched pair only, if not available order 1500-8071-000	Not Available
Inlet Solenoid, to J9 (Control Board)	1500-7088-000
Exhalation Solenoid, to J8 (Control Board)	1500-7005-000

Maintenance Kits	Stock Number
Yearly Ventilator Maintenance Kit	1500-8036-000

8.2 General Assemblies and Components

Non-Autoclavable Bellows Assembly

⚠ WARNING: Parts for the Non-Autoclavable Bellows Assemblies can not be used in the Autoclavable Bellows Assembly (ABA). Part failure could result in injury to the patient.

⚠ CAUTION: Do not autoclave any of the Non-Autoclavable Bellows Assembly components. The Non-ABA components are not designed to withstand high temperatures. Damage to the components and Autoclave may occur.

	Description	Stock Number	Quantity
1.	Adult Bellows Housing, Non-Autoclavable (replaces 0229-0014-300	1500-3225-000	
2.	Bellows Assembly, Autoclavable replaces 0229-1013-700	1500-3378-000	
3.	Seal, U-cup, for Bellows Housing, Non-Autoclavable	0210-0784-300	
4.	Pop-off Thumbscrew, 6-32 inch thread	0400-3507-300	(3)
5.	Pop-off Valve Assembly	0229-1029-800	
6.	Bellows Base, Non-Autoclavable	0229-0060-100	
7.	Label, Port Identification, English	0205-4753-300	
	Label, Port Identification, French	1010-3231-000	
8.	O-Ring, for Pop-off valve, Do Not Lubricate	1500-3267-000	
9.	Pediatric Bellows mounting ring and retainer, Non-Autoclavable	0229-1023-700	
10.	Pediatric Bellows, Non-Autoclavable	0229-1018-700	
11.	Bellows Thumbscrew, 10-32 inch thread	0400-3524-300	(4)
12.	Pediatric Bellows Housing, Non-Autoclavable, replaces 0229-0034-300	1500-3215-000	

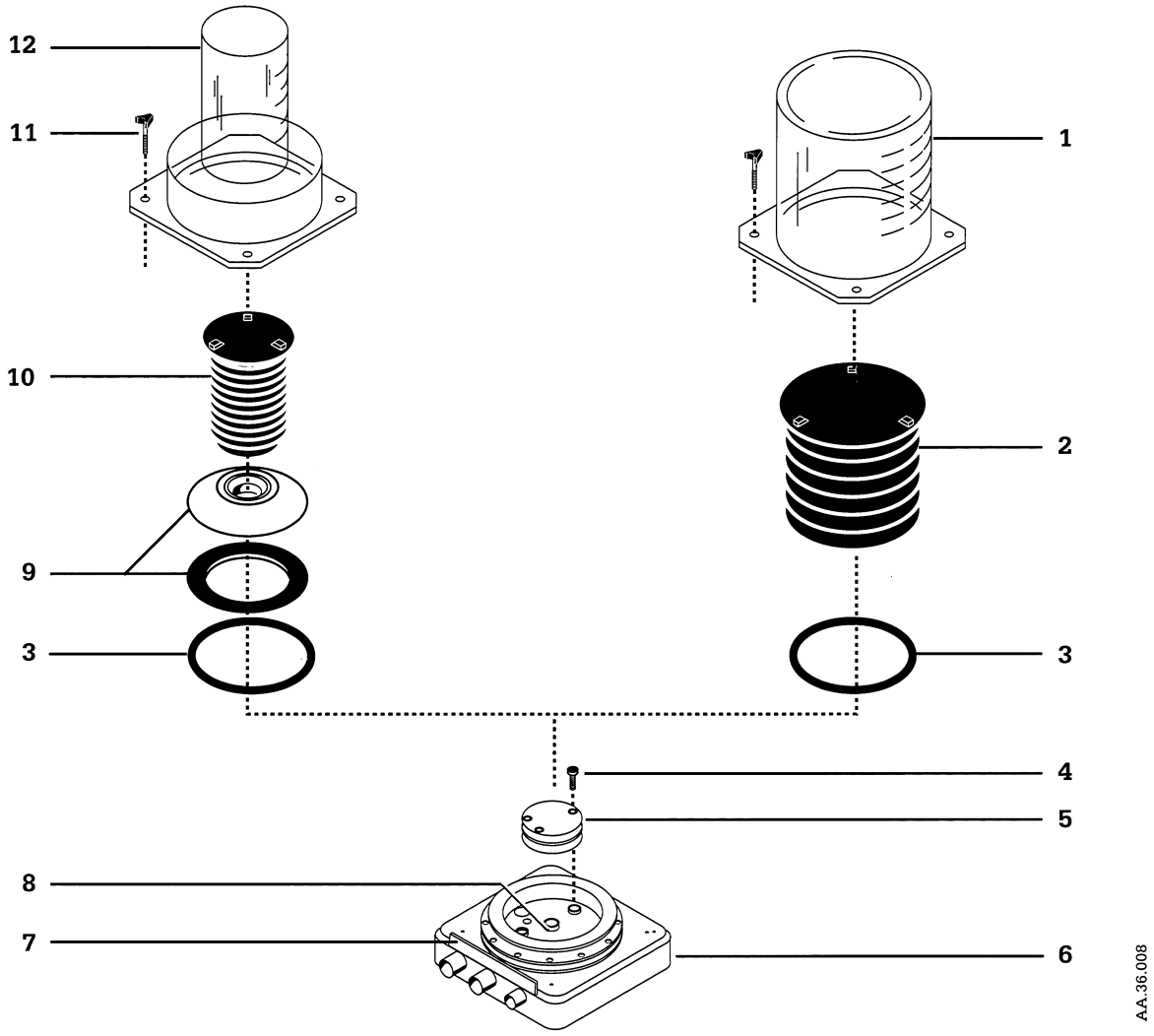


Figure 8-1 Adult and Pediatric Bellows Assembly, Non-Autoclavable

Autoclavable Bellows Assembly

⚠ WARNING: Parts for the Non-Autoclavable Bellows Assemblies can not be used in the Autoclavable Bellows Assembly (ABA). Part failure could result in injury to the patient.

	Description	Stock Number	Quantity
1.	Adult Bellows Housing, Autoclavable	1500-3117-000	
2.	Adult Bellows, Autoclavable	1500-3378-000	
	Disk/Ring/Bumper Assembly, for ABA, not shown	1500-3381-000	
3.	Rim, Bellows Base, Autoclavable	1500-3351-000	
4.	Diaphragm and Seat Assembly, Autoclavable	1500-3377-000	
5.	Latch, Autoclavable	1500-3352-000	
6.	Seal, Autoclavable	1500-3359-000	
7.	Bellows Base, Autoclavable	1500-3350-000	
8.	Mounting Plate, ABA assembly, with lever and screws	1500-3379-000	
9.	Screw, 10-32 x 1/2 inch	0140-6631-109	(4)

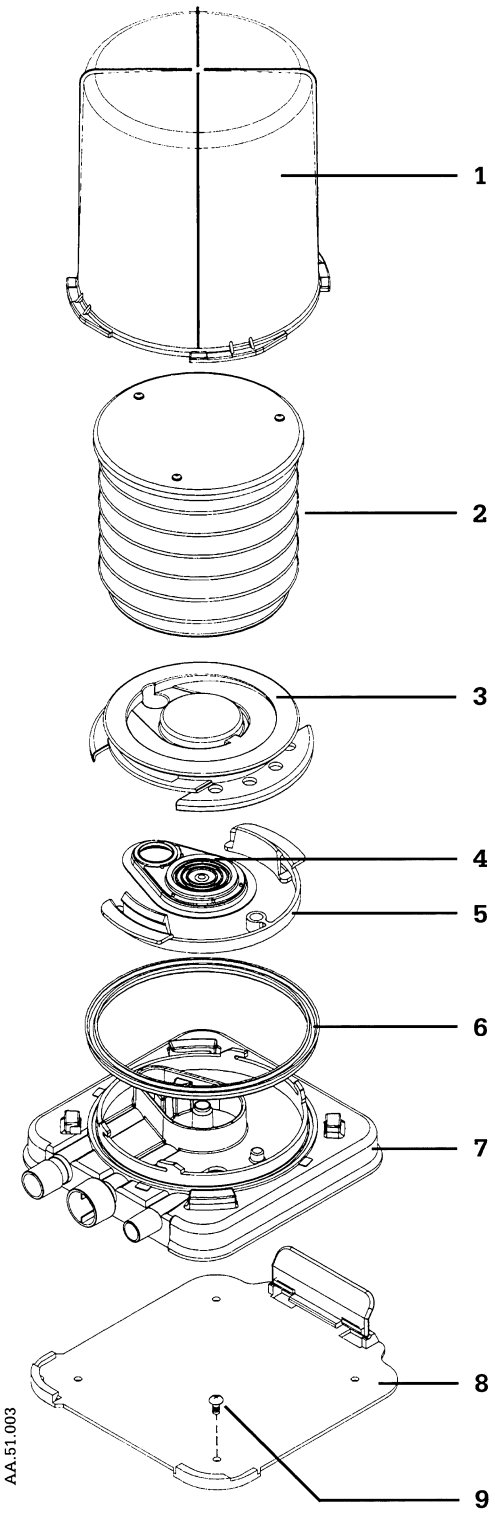


Figure 8-2 Adult Bellows Assembly, Autoclavable

Primary Regulator and Gas Inlet Valve

	Description	Stock Number	Quantity
1.	Fitting, O_2 Gas Supply to Inlet Valve	1500-5050-000	
2.	Gas Inlet Valve Body, with Cap, must replace both at same time, also order items 1 and 4	1500-8075-000	
3.	Elbow Fitting, Adjustable	1500-3159-000	(2)
4.	Plug, Hex head, 1/8 NPT	1500-3412-000	
5.	U Cup Seal*, Inlet Valve, Second	See Maintenance Kit	
6.	O-Ring*, Inlet Valve, Second	See Maintenance Kit	
7.	Inlet Valve Shuttle (Spoppet)	1500-5019-000	
8.	U Cup Seal*, Inlet Valve, First	See Maintenance Kit	
9.	O-Ring*, Inlet Valve, First	See Maintenance Kit	
10.	Retaining Ring, TRUARC, 34.9mm housing	1500-3158-000	
11.	Primary Regulator Assembly includes O-rings (2), Adapter (2), Elbow Fitting	1500-7071-000	
12.	O-Ring*, Primary Regulator fitting	9221-3009-624	(2)
13.	Screw, M4 x 6	9211-1040-067	(2)
14.	Washer, lock, external, M4	9213-0540-003	(2)
15.	Regulator Support Bracket	1500-5003-000	

Note: * Apply a thin film of KRYTOX™ GPL 205, an oxygen-use-approved lubricant.

Yearly Ventilator Maintenance Kit — 1500-8036-000

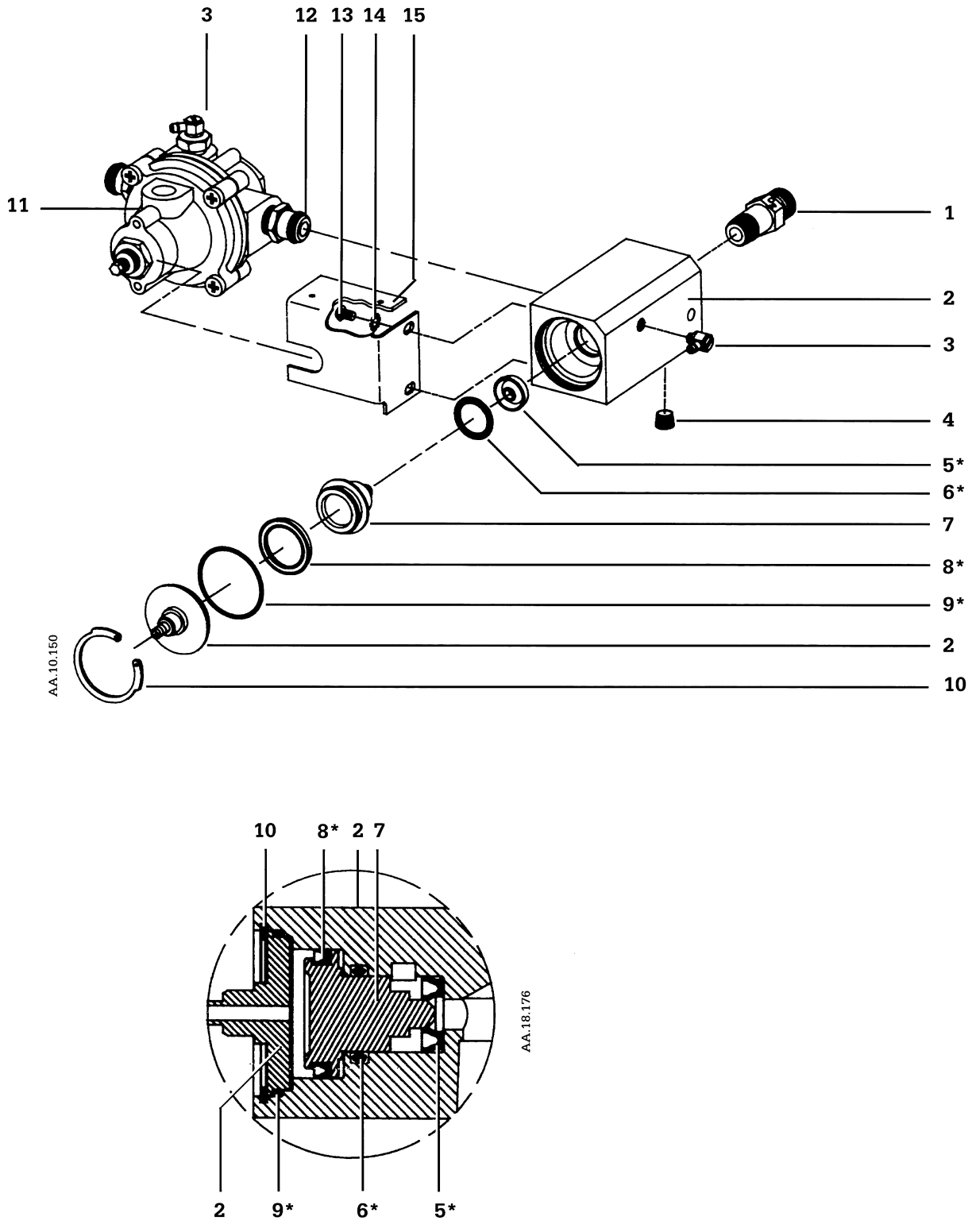


Figure 8-3 Primary Regulator and Gas Inlet Valve

Pneumatic Manifold

Exhalation Valve

Description	Stock Number	Quantity
1. Elbow Fitting, Adjustable	1500-3159-000	(4)
2. Retaining Ring, TRUARC, 34.9mm housing	1500-3158-000	
3. Sleeve, Exhalation Valve	1500-5062-000	
4. Retainer, Exhalation Valve	1500-5006-000	
5. Diaphragm, Exhalation Valve	See Maintenance Kit	
6. O-Ring, for Exhalation Valve Retainer and Sleeve	See Maintenance Kit	

Free Breathing Valve

Description	Stock Number
10. Seat, for Free Breathing Valve	0207-5590-100
11. Free Breathing Valve	See Maintenance Kit
12. O-Ring, for Free Breathing Valve Seat	See Maintenance Kit

Other Pneumatic Manifold Parts

Description	Stock Number
8. O-Ring*, for Drive Gas Adapter	9221-3016-116
9. Drive Gas Adapter, straight	1500-5005-000
13. Screen, 150 Mesh	0214-7107-325
14. Legris Plug, 3/16 inch OD tubing	0213-4728-300

Pneumatic Manifold Assembly

Description	Stock Number
7. EEPROM and Pneumatic Manifold Assembly, 7800, CMOS, requires version 1.11 minimum software, available only as matched pair. If less than version 1.11 is installed, order higher software	1500-8071-000
EEPROM and Pneumatic Manifold Assembly, 7800, NMOS, matched pair only, if not available order 1500-8071-000	Not Available

Yearly Ventilator Maintenance Kit — 1500-8036-000

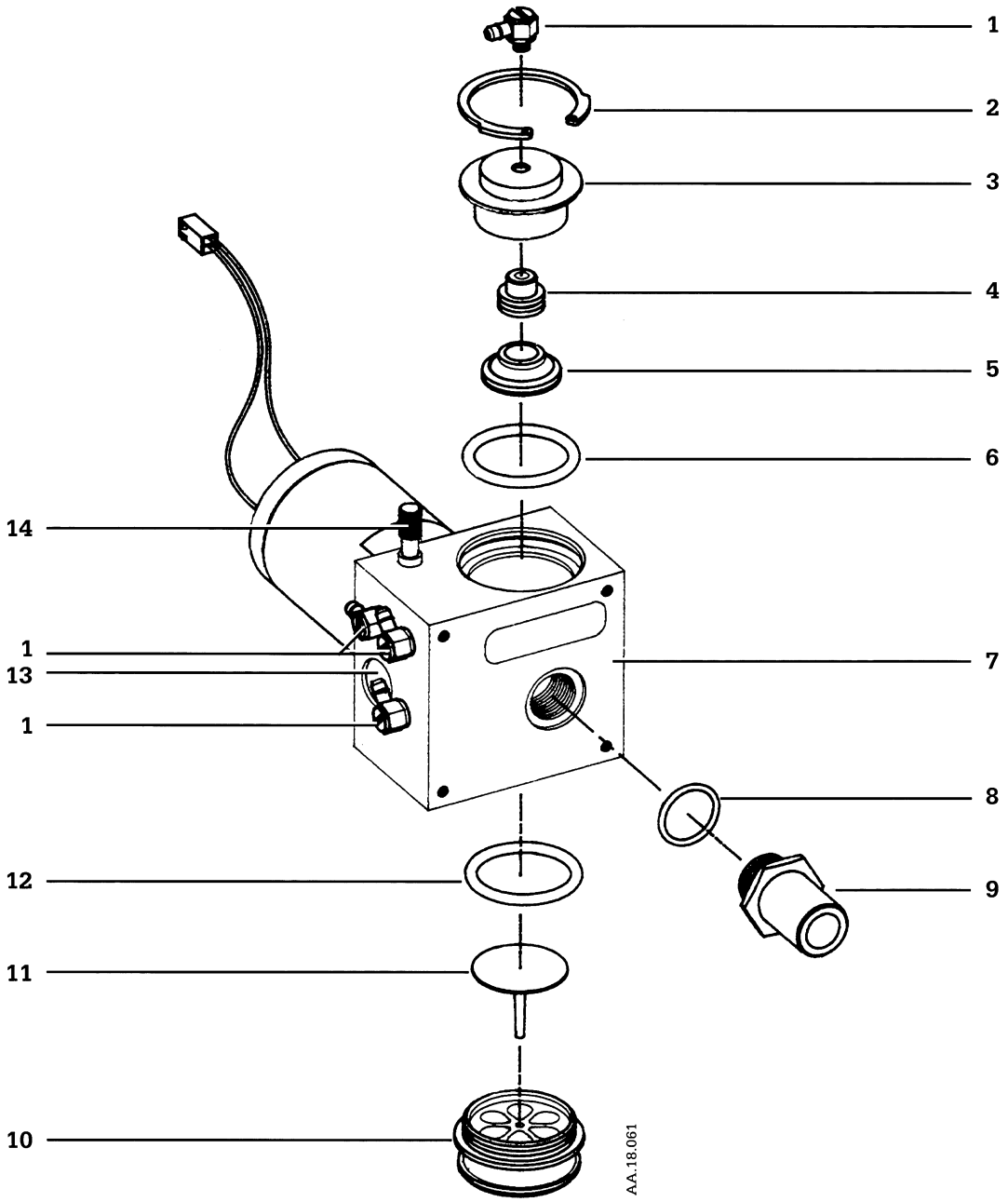


Figure 8-4 Pneumatic Manifold

Front Panel

	Description	Stock Number	Quantity
1.	Screw, M4 x 6	9211-1040-067	(3)
2.	Washer, lock, external, M4	9213-0540-003	(4)
3.	Front Panel board, Universal, 7810/7800	1500-8022-000	
	Front Panel board, Original, 7810/7800	Not Available	
4.	Potentiometer, 10K one turn, panel mount	1500-3061-000	(4)
5.	Washer, external lock, 1/4 inch	0202-3415-300	(2)
6.	Wheel, O_2 adjustment, 7810/7800	1500-5015-000	
7.	Setscrew, M3 x 5	9211-0830-053	
8.	Washer, shoulder, insulating	1500-3128-000	(3)
9.	Chassis Ground wire, 300mm	1500-7037-000	
10.	Nut, Keps, M4, with external lock washer	0144-3717-314	
11.	Nut Torque, 1/4-32 x 7/16 inch, High Friction Fit, Do Not over tighten	1500-3129-000	(3)
12.	Switch Handle	1500-3409-000	
13.	Switch Guard, with 1/4-40 inch threads	0690-2500-344	
14.	Panel, Front, three piece chassis	1500-5036-000	
15.	Lens, Front Panel Window, use adhesive on lens to adhere	1500-3147-000	
16.	Switch, Momentary, red and yellow LEDs	1500-3089-000	
17.	Switch, Mechanical Ventilation	1500-3090-000	
18.	Switch, Momentary, green LED	1500-3055-000	
19.	LCD Kit, with EL Panel	1500-8091-000	

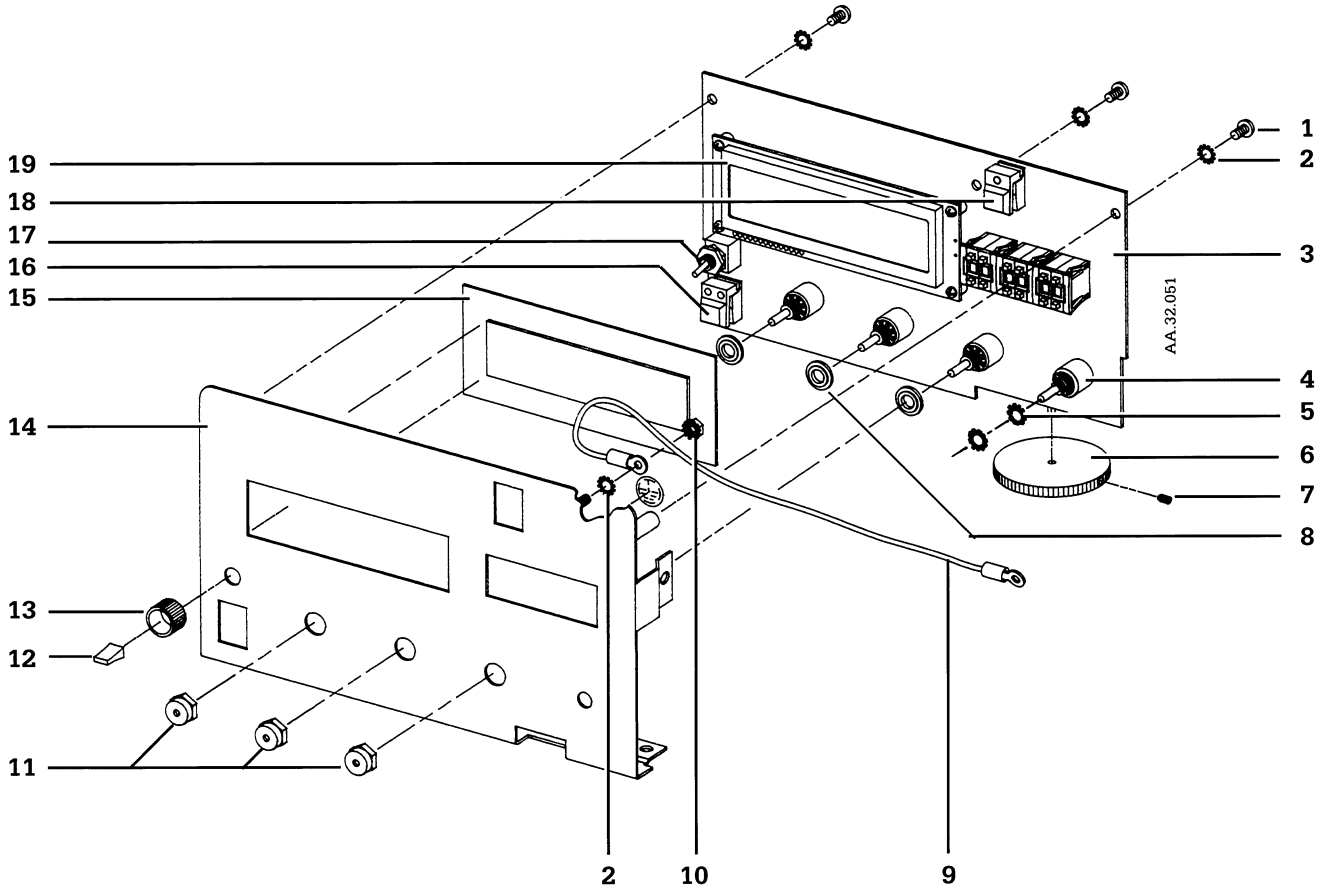


Figure 8-5 Front Panel

Transformer

	Description	Stock Number	Quantity
1.	Filter, AC inlet, 7800	0690-1650-309	
2.	Washer, lock, external, M4	9213-0540-003	(4)
3.	Screw, M4 x 6	9211-1040-067	(2)
4.	Cable, AC power, filter to circuit breaker, 7800	1500-7039-000	(2)
5.	Circuit Breaker	1500-3182-000	
6.	Nut, Keps, M3, with external lock washer	0144-3717-302	(2)
7.	Box, Voltage selector	1500-5146-000	
8.	Transformer Assembly, with selector switch, (requires additional cable 1500-7057-000 when in CAT)	1500-7056-000	
9.	Nut, Keps, M4, with external lock washer	0144-3717-314	
10.	Box, Transformer Assembly	1500-5025-000	
11.	Screw, 6-32 x 1/4 inch	0140-6524-105	(2)

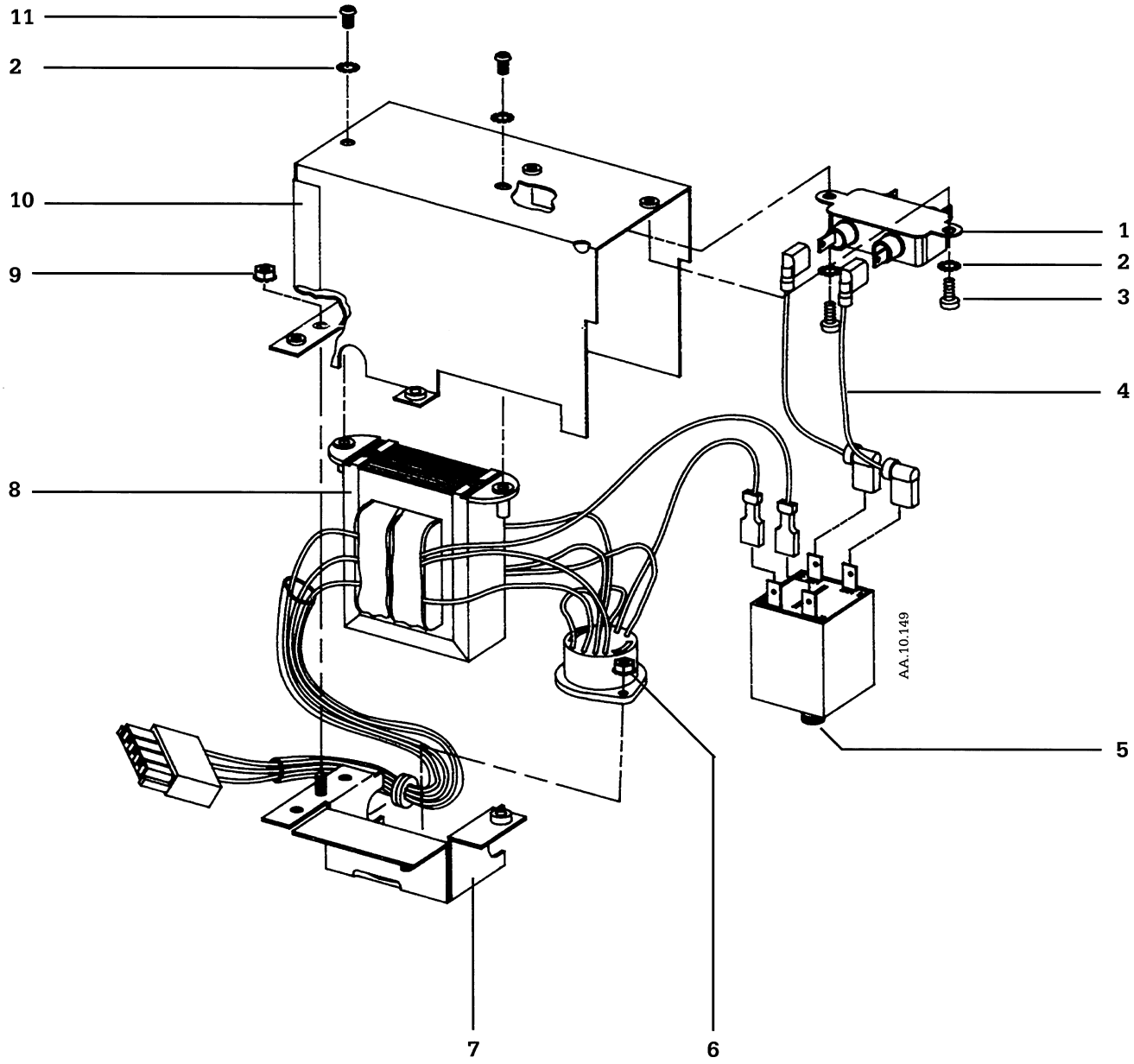


Figure 8-6 Transformer

Power Supply

	Description	Stock Number	Quantity
1.	Retainer, large nose, printed circuit board edge	1500-3150-000	(2)
2.	Nut, Speed, M4, U type	1500-3152-000	(4)
3.	Chassis, Main, three piece	1500-5147-000	
4.	Insulator, Power Supply Board	1500-3260-000	
5.	Power Supply board, includes box and guide	1500-7059-000	
6.	Alignment Guide, Power Supply Board	1500-5041-000	
7.	Adhesive Tape, double sided sticky	0220-5102-300	
8.	Screw, M4 x 10	9211-1040-109	(6)
9.	Washer, lock, external, M4	9213-0540-003	(6)
10.	Box, Power Supply board	1500-5145-000	
11.	Standoff, hinged, Control Board	1500-3148-000	(2)
12.	Nut, Keps, 6-32 inch, with external lock washer	0202-1130-300	(2)
13.	Cable, J3 (Control Board) to J2 (Power Supply board)	1500-7057-000	

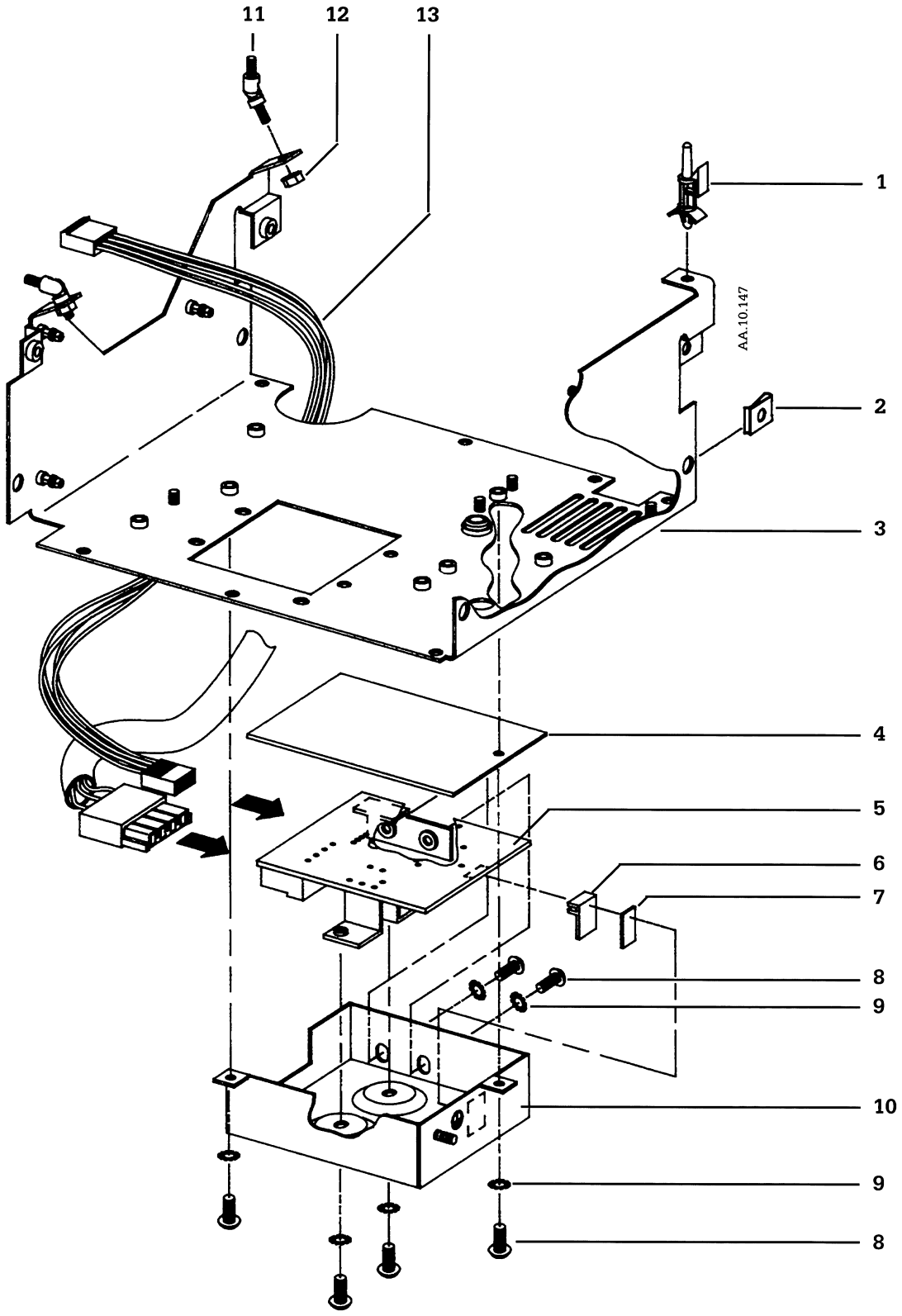


Figure 8-7 Power Supply

Transformer Mounting

Description	Stock Number	Quantity
1. Chassis Ground wire, filter to chassis	1500-7028-000	
2. Screw, M4 x 10	9211-1040-109	(4)
3. Washer, lock, external, M4	9213-0540-003	(4)

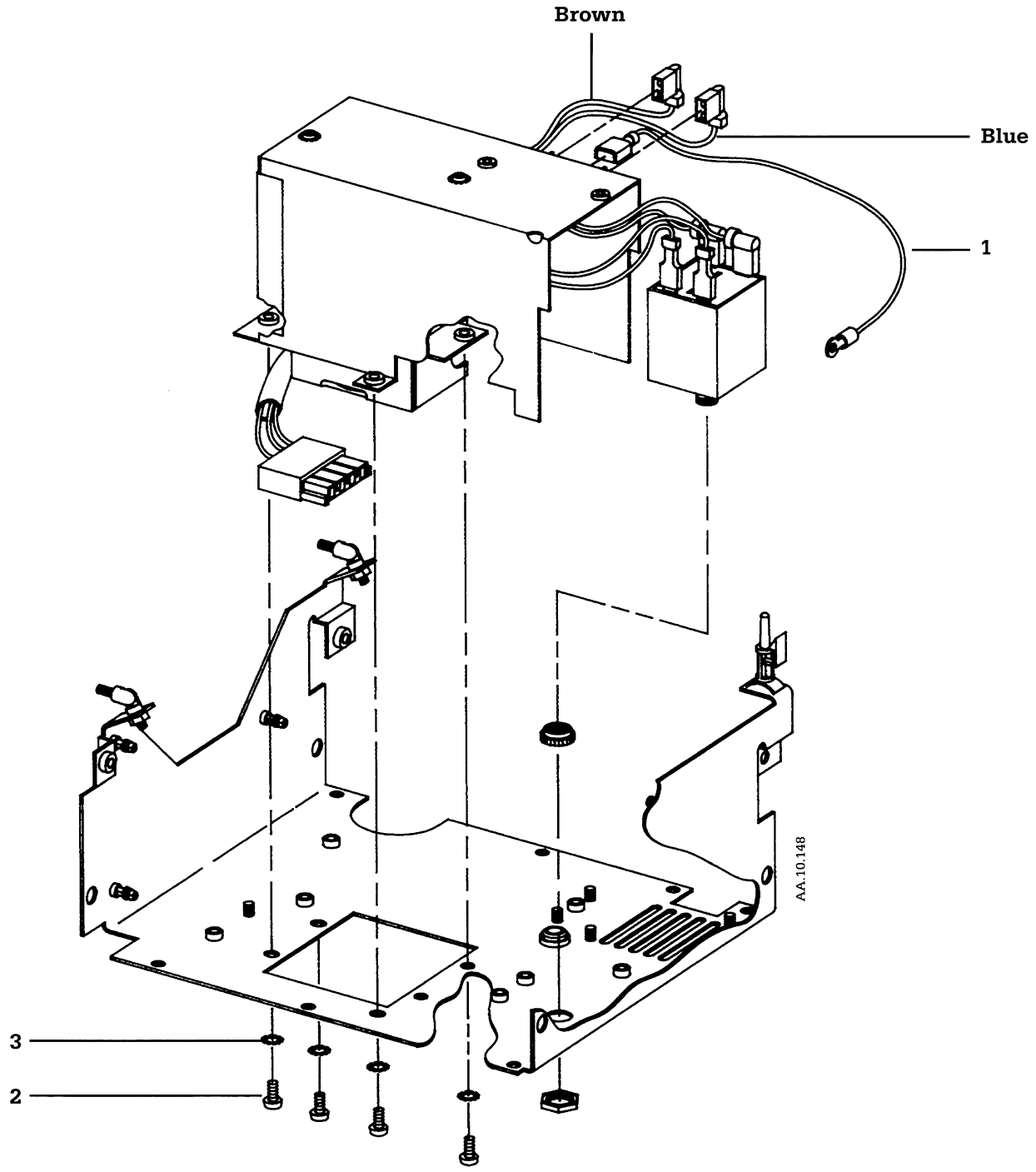


Figure 8-8 Transformer Mounting

Rear Panel, Cables

	Description	Stock Number	Quantity
1.	Spacer, Jackpost, Hex Nut 4-40, set	0402-0250-300	
2.	Cable, RS232 and Internal I/O to J5 (Control Board), 7800	1500-7030-000	
3.	Chassis Ground wire, 300mm	1500-7037-000	
4.	Washer, lock, ext-4	0202-3223-300	(2)
5.	Cable Clamp	1500-3198-000	
6.	Power Cord, 7800	1500-7024-000	
7.	Nut, Keps, M4, with external lock washer	0144-3717-314	(2)
8.	Washer, lock, external, M4	9213-0540-003	
9.	Panel, Rear, three piece chassis	1500-5028-000	

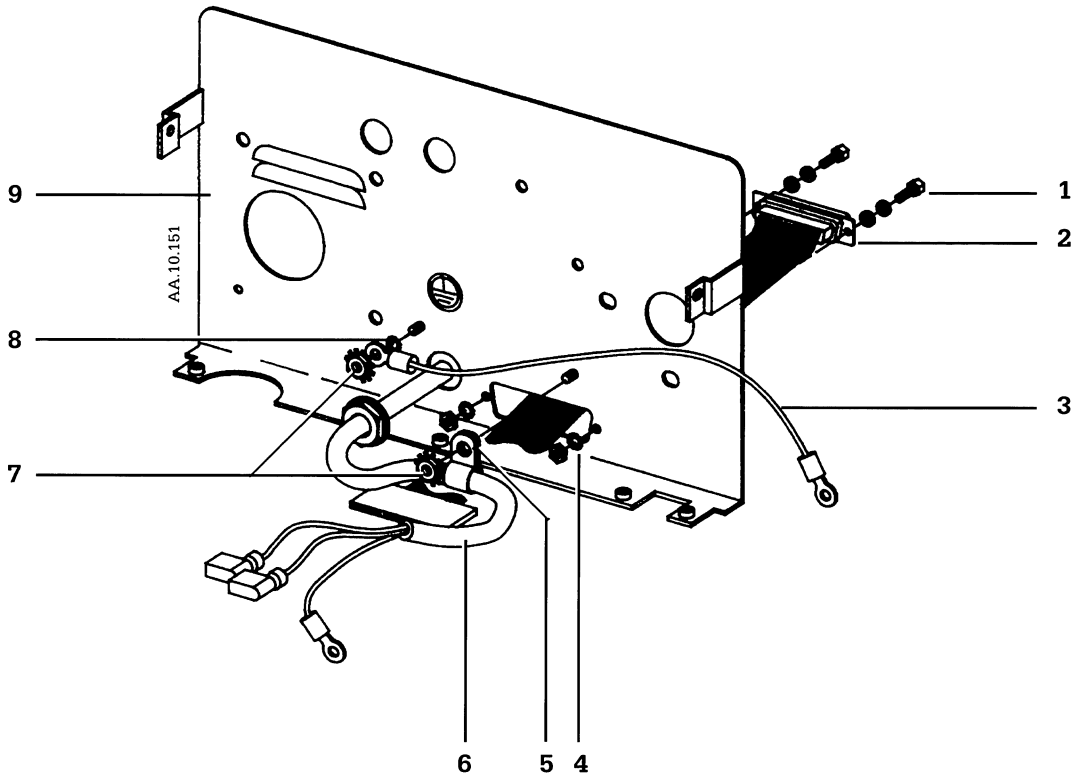


Figure 8-9 Rear Panel, Cables

Rear Panel, Pneumatics

	Description	Stock Number	Quantity
1.	Screw, 6 x 3/8 inch	0142-4163-107	(2)
2.	Screw, M4 x 6	9211-1040-067	(6)
3.	Washer, lock, external, M4	9213-0540-003	(2)
4.	EEPROM and Pneumatic Manifold Assembly 7800, CMOS, requires version 1.11 minimum software, available only as matched pair. If less than version 1.11 is installed, order higher software	1500-8071-000	
5.	Secondary Regulator Assembly, with fittings	1500-7072-000	
6.	Gasket, Pneumatic Manifold Assembly	1500-3149-000	
7.	Jam Nut, 7/16-24 inch, 0.125 T	0402-1683-535	
8.	Washer, lock, internal, 7/16 inch	0202-3422-340	
9.	Distal Sensing Connector	0229-0006-535	

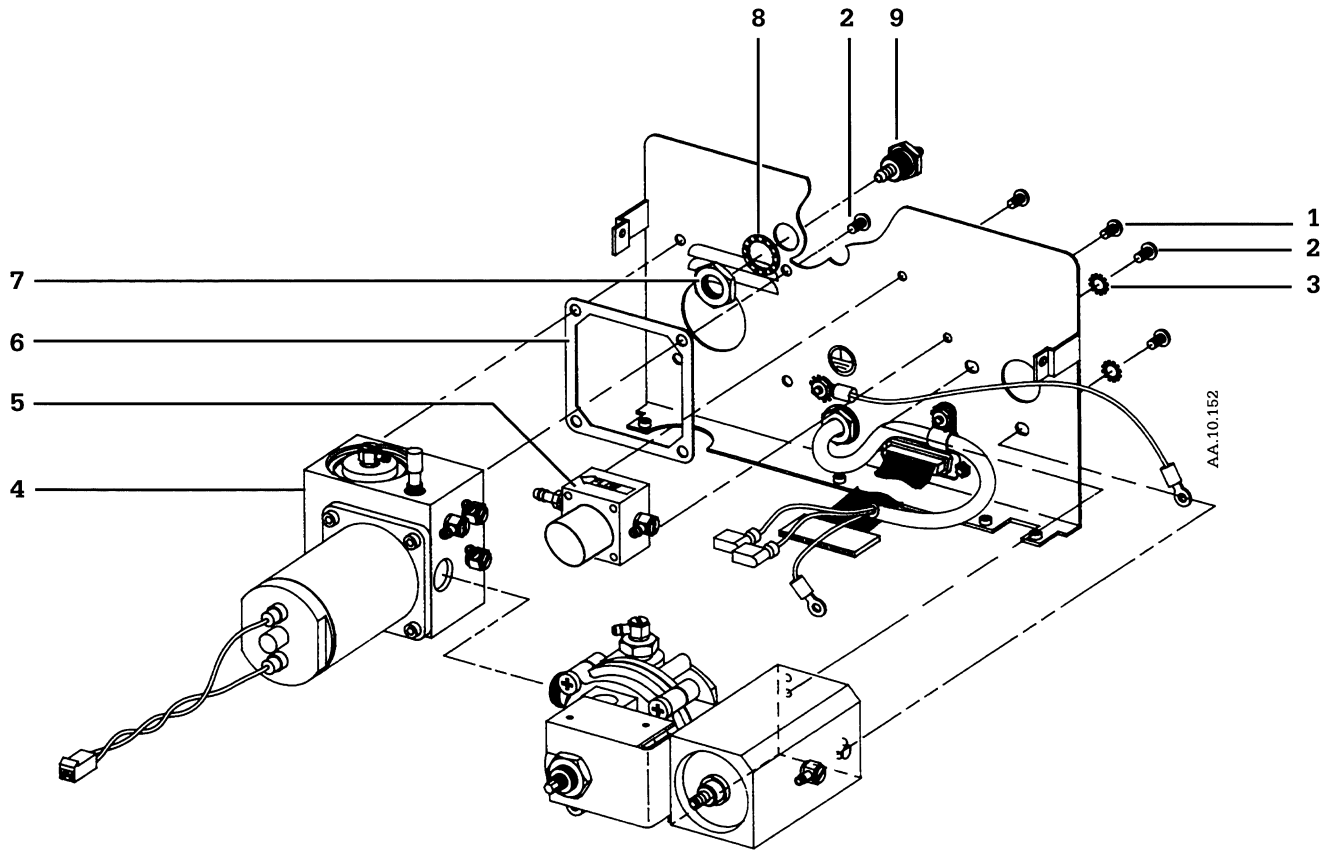


Figure 8-10 Rear Panel, Pneumatics

Solenoids and Universal Pressure Transducer Board

Description	Stock Number	Quantity
1. Screw, 6-32 x 1/4 inch	0140-6524-105	(4)
2. Washer, lock, external, M4	9213-0540-003	(4)
3. Pressure Transducer board, Universal, does not include solenoids	1500-8016-000	
4. Exhalation Solenoid, to J8 (Control Board)	1500-7005-000	
5. Inlet Solenoid, to J9 (Control Board)	1500-7088-000	
6. Spacer (must be used with solenoids)	0144-1010-131	(4)

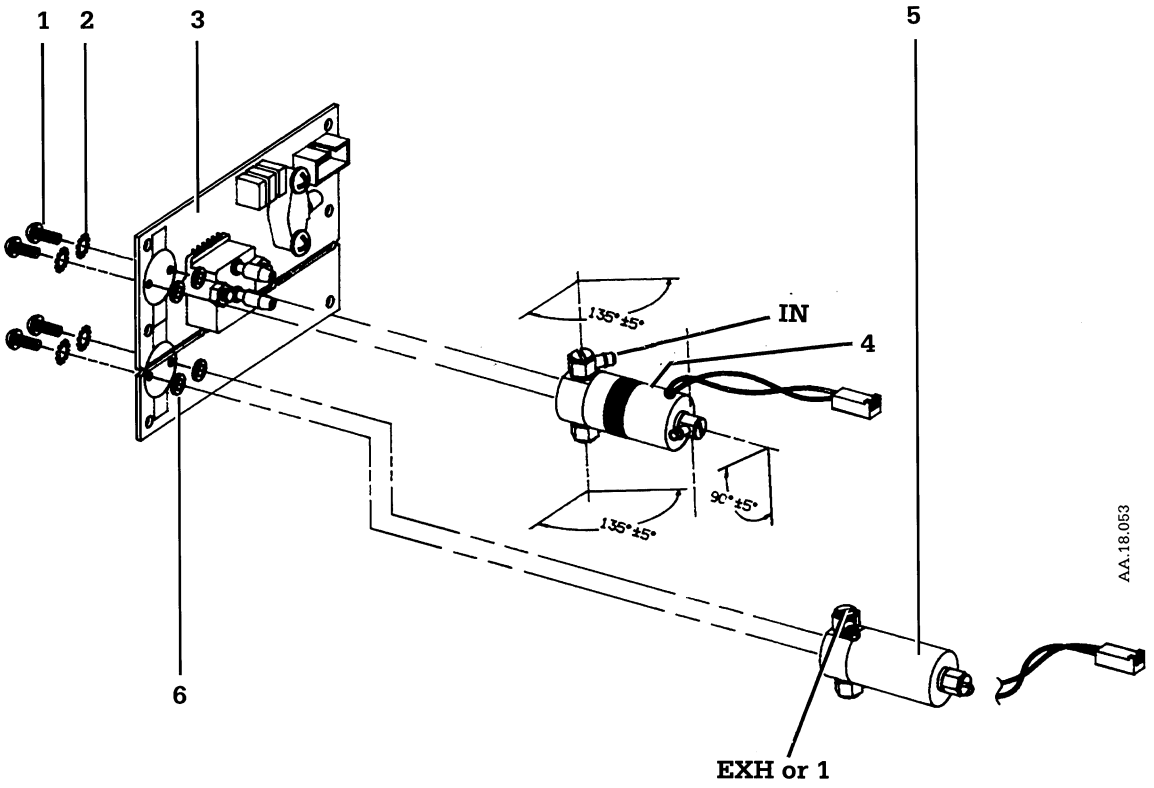


Figure 8-11 Solenoids and Universal Pressure Transducer Board

Hoses TB1 - TB4 and TB13 with Universal Pressure Transducer Board

Description	Stock Number
1. Filter Assembly (TB1, Filter, TB13)	1500-7062-000
2. Green High Pressure Hose	0994-6374-010

Connection	Type	Length (mm)
TB1	Green Hose	120*
TB2	Green Hose	275*
TB3	Green Hose	275*
TB4	Green Hose	195*
TB13	Green Hose	120*

Note: * All lengths in mm +/- 6mm. When ordering, specify length in units of one foot (one foot equals 304.8mm).

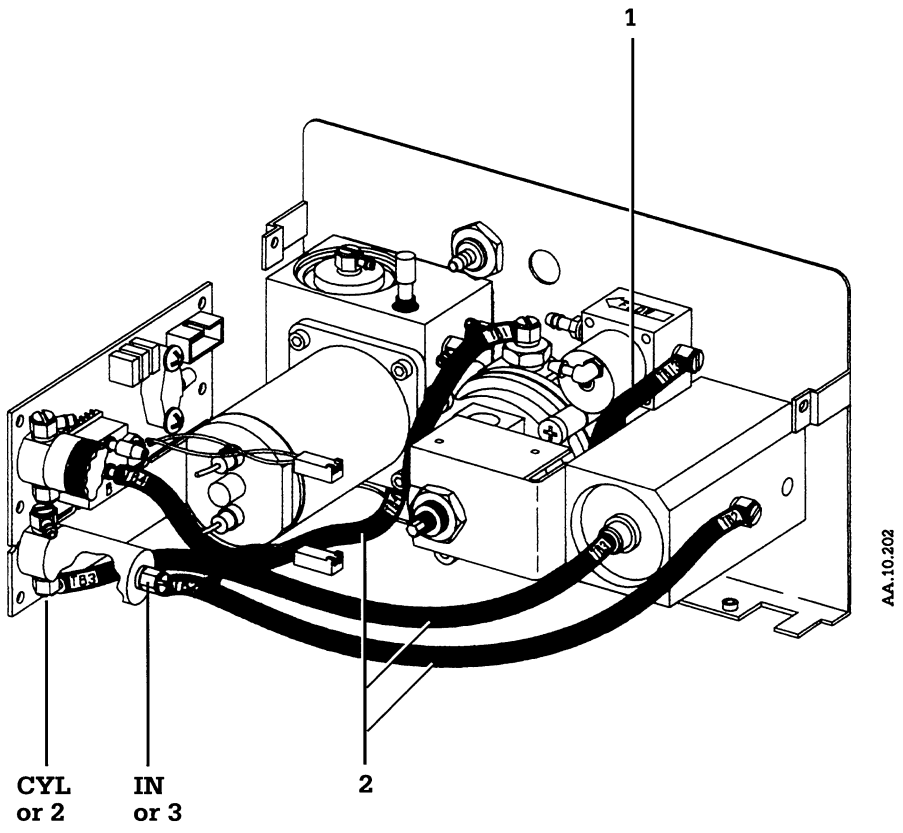


Figure 8-12 Hoses TB1 - TB4 and TB13 with Universal Pressure Transducer Board

Tubes TB5 - TB12 with Universal Pressure Transducer Board

Description	Stock Number
1. High Pressure Limit Switch, to J16 (Control Board), with adhesive tape	1500-3132-000
2. Clear Low Pressure Tubing	0994-6370-010
3. Tee Brass, with 3 x 1/8 inch barbs	0204-8847-300

Connection	Type	Length (mm)
TB5	Clear Tubing	100*
TB6	Clear Tubing	200*
TB7	Clear Tubing	130*
TB8	Clear Tubing	220*
TB9	Clear Tubing	170*
TB10	Clear Tubing	50*
TB11	Clear Tubing	50*
TB12	Clear Tubing	100*

Note: * All lengths in mm +/- 6mm. When ordering, specify length in units of one foot (one foot equals 304.8mm).

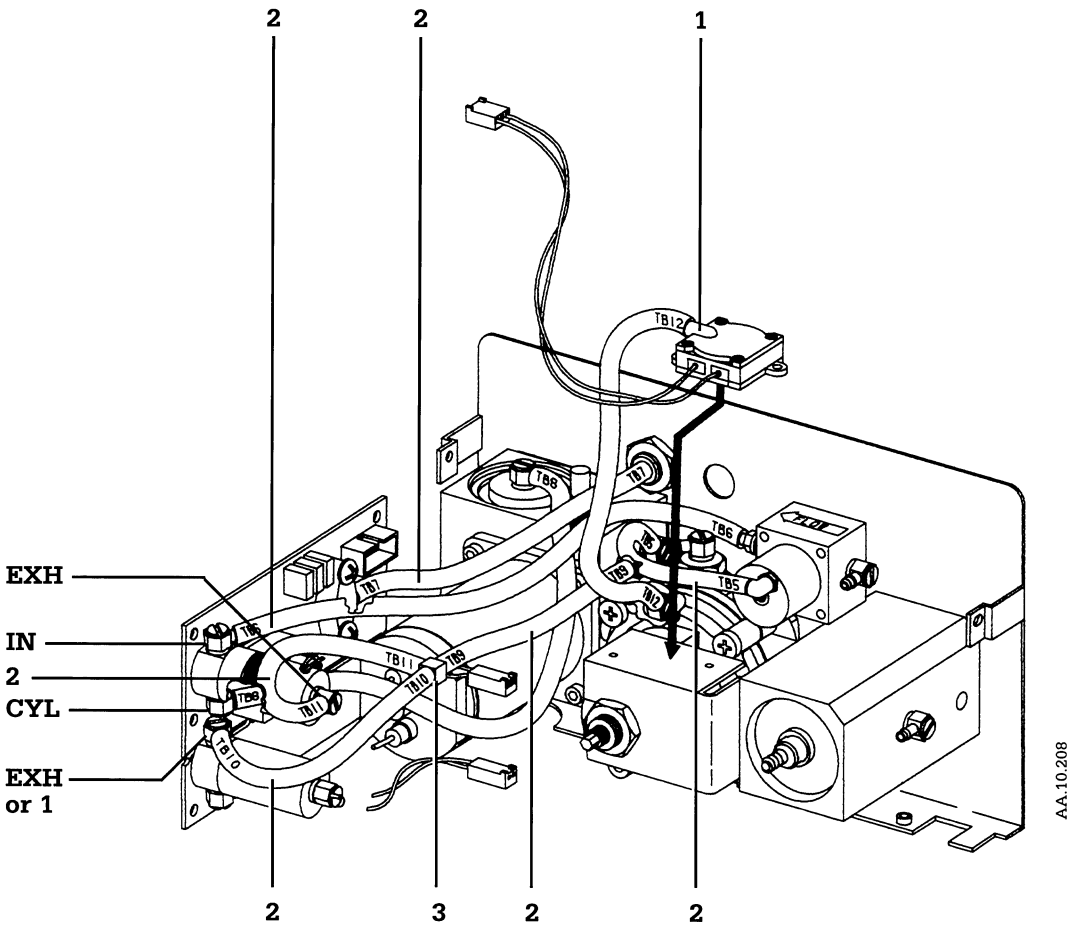


Figure 8-13 Tubes TB5 - TB12 with Universal Pressure Transducer Board

Chassis with EMC

Description	Stock Number	Quantity
1. Washer, lock, external, M4	9213-0540-003	(10)
2. Screw, M4 x 6	9211-1040-067	(2)
3. Chassis Ground wire, 300mm	1500-7037-000	
4. Nut, Keps, M3, with external lock washer	0144-3717-302	(2)
5. Speaker, with 9 inch leads	0208-1101-700	
6. Nut, Keps, M4, with external lock washer	0144-3717-314	(4)
7. Screw, M4 x 10	9211-1040-109	(3)
8. Chassis Ground wire, 200mm	1500-7048-000	

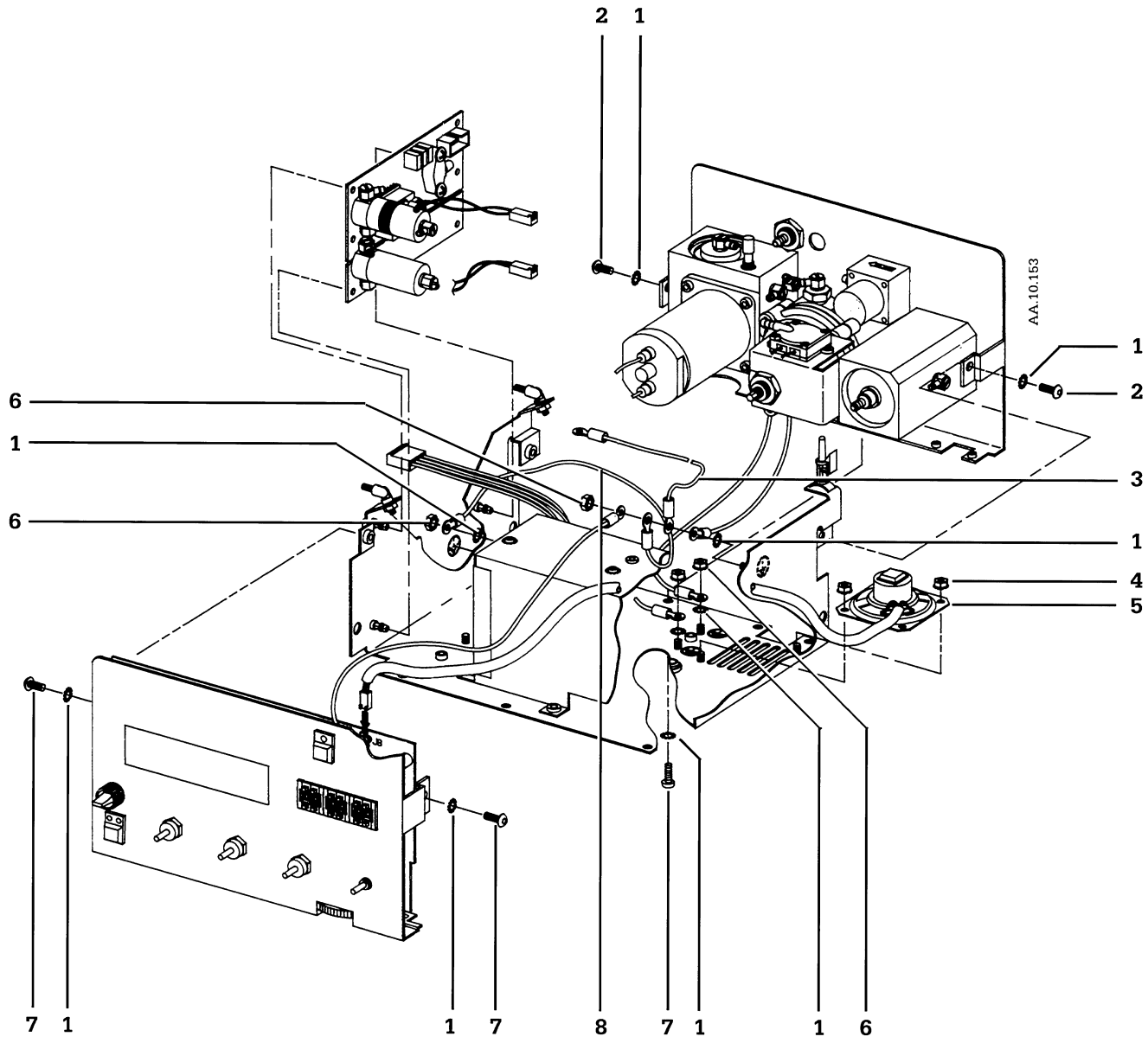


Figure 8-14 Chassis with EMC

Lower Control Module

Description	Stock Number	Quantity
1. Equipotential Stud, Ground, Set	0208-0070-300	
2. Panel, Lower Rear, 7800	1500-5176-000	
3. Washer, lock, external, M4	9213-0540-003	(13)
4. Screw, M4 x 10	9211-1040-109	(7)
5. Nut, Keps, M4, with external lock washer	0144-3717-314	(3)
6. Chassis Ground wire, 100mm	1500-7049-000	(2)
7. Chassis Ground wire, 200mm	1500-7048-000	(3)
8. Cable Clamp	1500-3198-000	

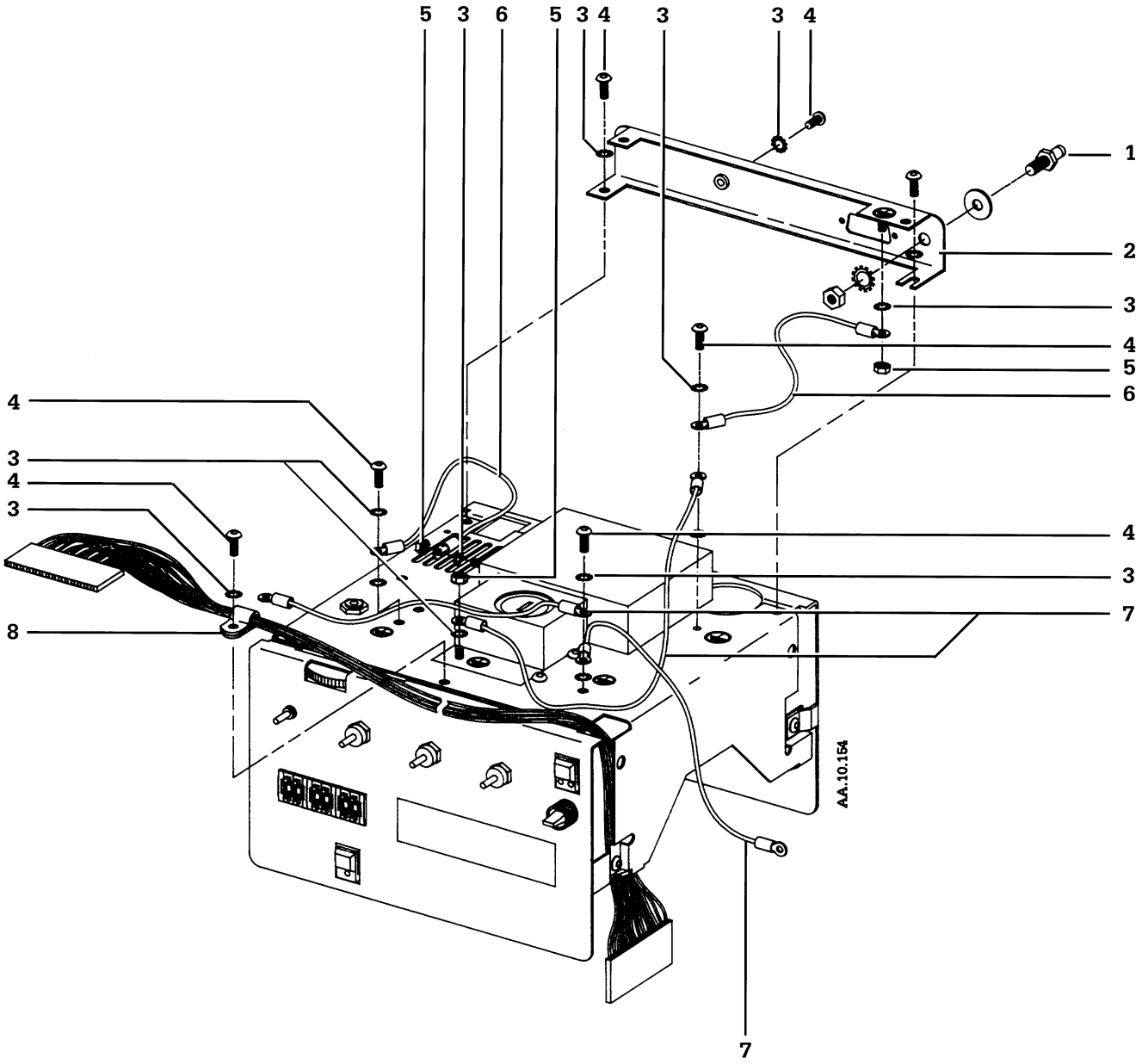


Figure 8-15 Lower Control Module

Piggyback Watchdog Board and 64K Control Board

Description	Stock Number	Quantity
1. Retainer, mounting	1500-3185-000	(2)
2. Piggyback Watchdog board	1500-3299-000	
3. Fuse, 1 Amp, 250 V ac, 5 x 20mm, Fast Action	1502-3004-000	
4. 64K Control Board, does not include Piggyback Watchdog board, EPROM, or EEPROM	1500-8026-000	
5. Fuse, 4 Amp, 250 V ac, Flat Pack	0690-1700-322	

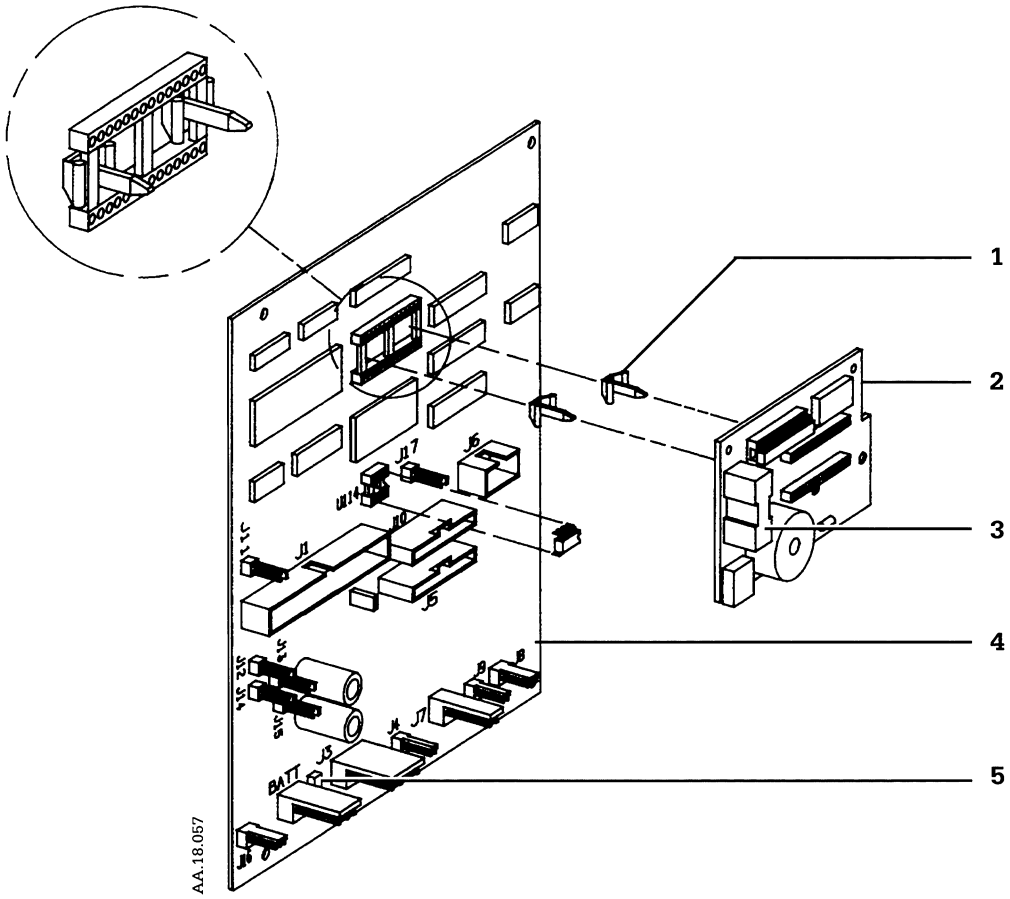


Figure 8-16 Piggyback Watchdog Board and 64K Control Board

64K Control Board Connections

	Description	Stock Number	Quantity
1.	Cable, J6 (Control Board) to J1 (Pressure Transducer board)	1500-7021-000	
2.	Cable, RS232 and Internal I/O to J5 (Control Board) 7800	1500-7030-000	
3.	Exhalation Solenoid, to J8 (Control Board)	1500-7005-000	
4.	Inlet Solenoid, to J9 (Control Board)	1500-7088-000	
5.	EEPROM and Pneumatic Manifold Assembly, 7800, CMOS, requires version 1.11 minimum software, available only as matched pair. If less than version 1.11 is installed, order higher software	1500-8071-000	
	EEPROM and Pneumatic Manifold Assembly, 7800, NMOS, matched pair only, if not available order 1500-8071-000	1500-8038-000	
6.	Cable, J1 (Control Board) to J1 (Front Panel board)	1500-7020-000	
7.	Cable, J2 (Front Panel board) to P3 (EMC/Interface board), 7800	1500-7031-000	
8.	Cable, J3 (Control Board) to J2 (Power Supply board)	1500-7057-000	
9.	High Pressure Limit Switch, to J16 (Control Board), with adhesive tape	1500-3132-000	
10.	Nut, Keps, 6-32 inch, with external lock washer	0202-1130-300	(2)
11.	Jumper, mini, 2-position, J11	0686-1500-300	

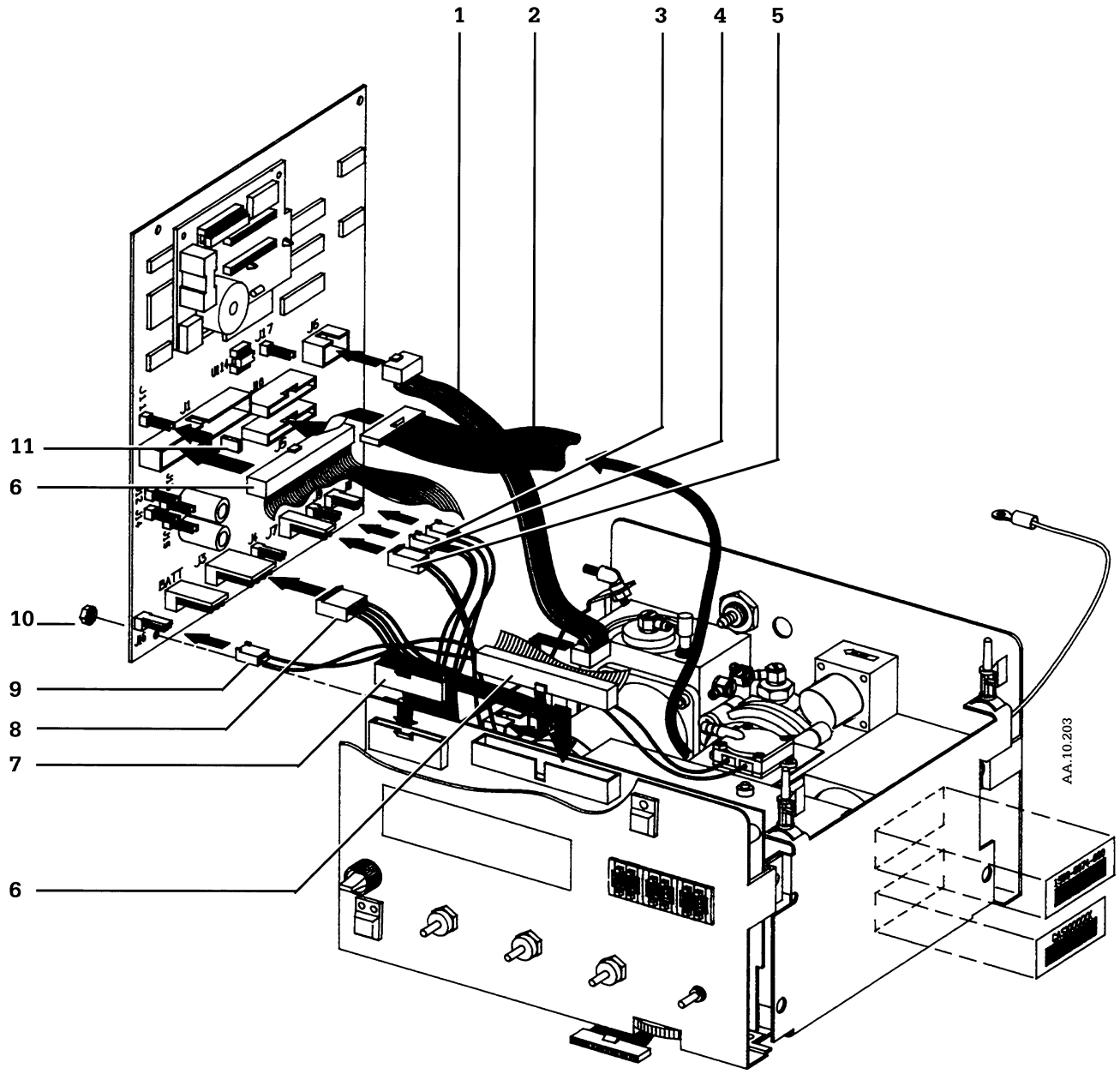


Figure 8-17 64K Control Board, with EMC

EMC/Interface Board — Stand Alone

Description	Stock Number	Quantity
1. Cable, J2 (Front Panel board) to P3 (EMC/Interface board), 7800	1500-7031-000	
2. Chassis Ground wire, 200mm	1500-7048-000	(2)
3. Screw, M4 x 6	9211-1040-067	(3)
4. Washer, lock, external, M4	9213-0540-003	(6)
5. EMC/Interface Board 7800 (requires additional cable 1500-7036-000 when in Excel Mount)	1500-3315-000	
6. Nut, Keps, M4, with external lock washer	0144-3717-314	
7. Panel, Lower Front, Stand Alone	1500-5148-000	
8. Switch and Cable, to P4 (EMC/Interface board) ON/Standby	1500-7032-000	
9. Screw, M4 x 10	9211-1040-109	(2)

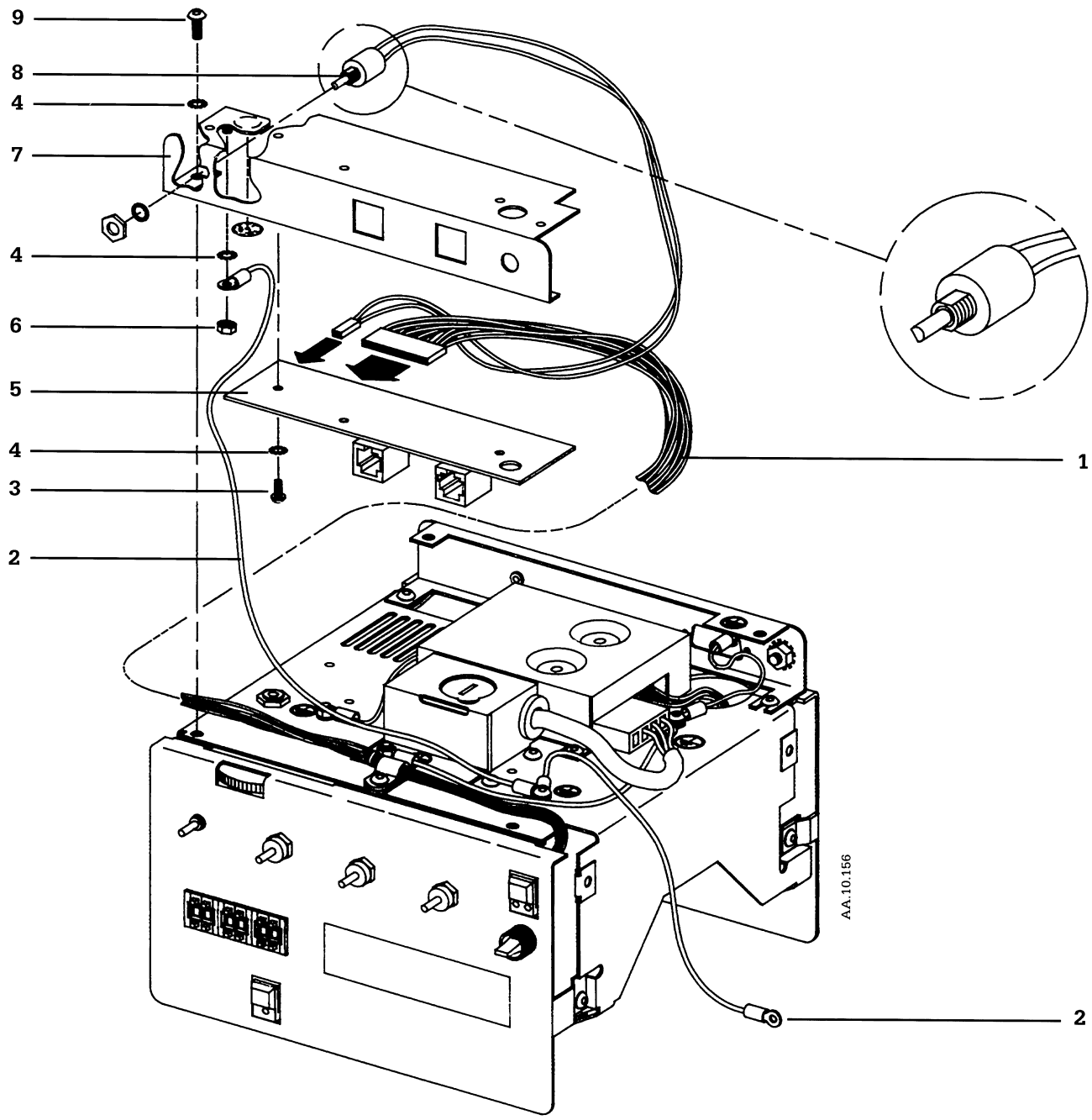


Figure 8-18 EMC/Interface Board, Stand Alone

EMC/Interface Board — Excel Mount

	Description	Stock Number	Quantity
1.	Spacer, Jackpost, Hex Nut 4-40, set	0402-0250-300	
2.	Cable, Sensor/Remote to P2 (EMC/Interface board)	1500-7036-000	
3.	Washer, lock, ext-4	0202-3223-300	(2)
4.	Chassis Ground wire, 200mm	1500-7048-000	(2)
5.	Screw, M4 x 6	9211-1040-067	(3)
6.	Washer, lock, external, M4	9213-0540-003	(6)
7.	EMC/Interface Board 7800 (requires additional cable 1500-7036-000 when in Excel Mount)	1500-3315-000	
8.	Nut, Keps, M4, with external lock washer	0144-3717-314	
9.	Panel, Lower Front, Excel Mount	1500-5143-000	
10.	Screw, M4 x 10	9211-1040-109	(2)
11.	Cable, J2 (Front Panel board) to P3 (EMC/Interface board), 7800	1500-7031-000	

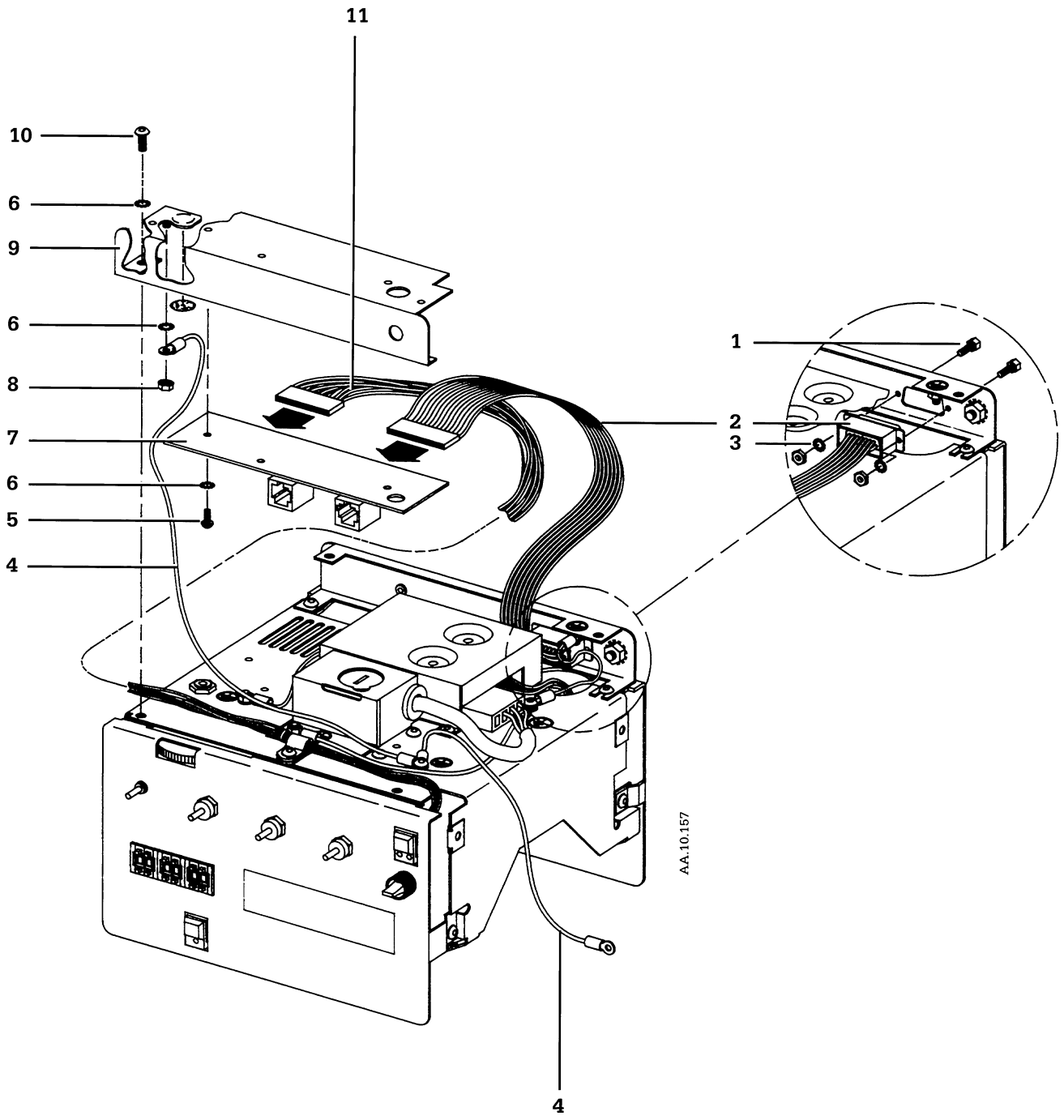


Figure 8-19 EMC/Interface Board, Excel Mount

Voltage Selector Label — Modulus® II Upgrade

Description	Stock Number
1. Label Set, 7800, English, Part A	1500-3206-000

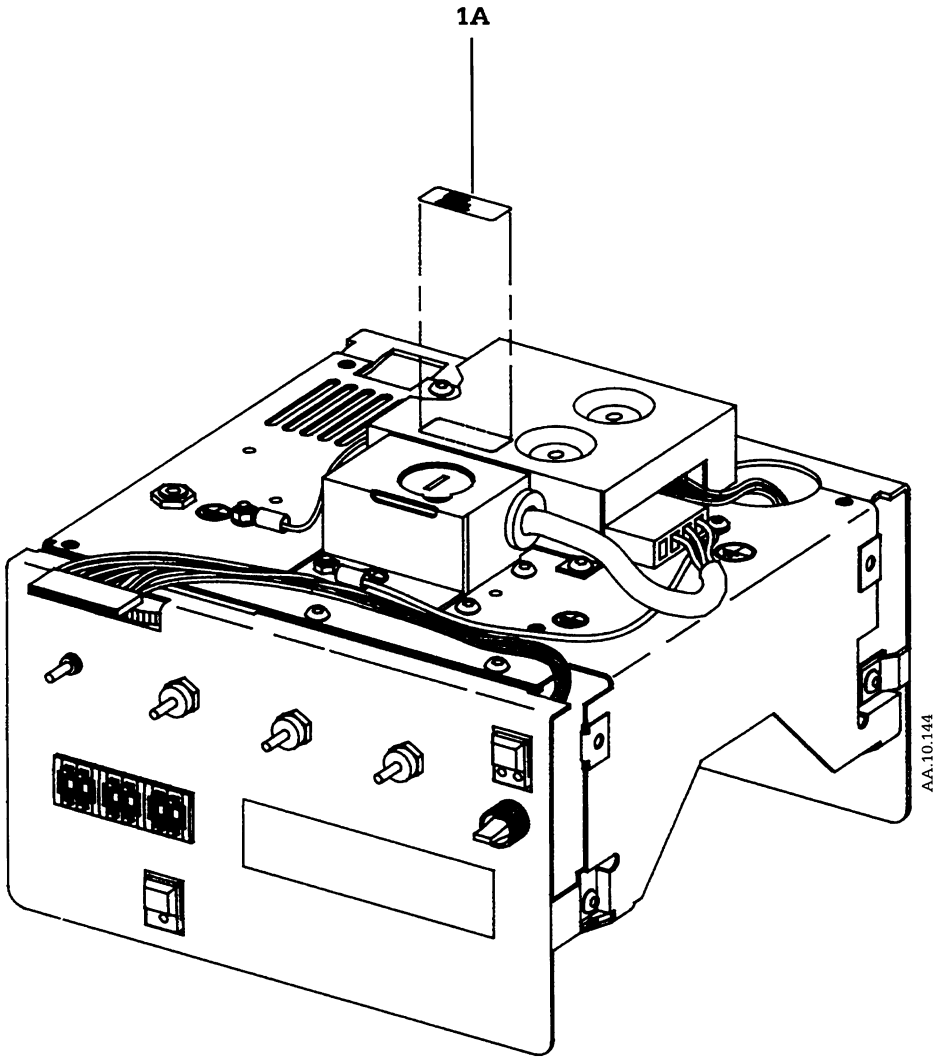


Figure 8-20 Voltage Selector Label, Modulus II Upgrade

Bottom Shroud, Battery and Software — Stand Alone

Description	Stock Number	Quantity
1. 64K EPROM kit, English, version 4.22, 7800 includes Operation and Maintenance manual	1500-8076-000	
Important: Upgrading software from version 1.xx to 4.xx requires an upgraded Operation and Maintenance manual, and personnel notification of all user visible changes.		
2. Battery Pack, Ni-Cd, 4.8 V dc 1.3 Amp hour	1500-3125-000	
3. Cable tie, Long	0203-5917-300	
4. Hook fastener, 75mm long	0999-1108-010	
5. Sleeve, Preoperative Check List	1500-3233-000	
6. Nut, Acorn M4	0144-3127-100	(2)
7. Card, Preoperative Check List, English	1500-3194-000	
8. Label Set, 7800, English, Part A	1500-3206-000	
Label Set, 7800, English, Part F	1500-3206-000	
9. Shroud, Lower	1500-5029-000	
10. Washer, lock, external, M4	9213-0540-003	(5)
11. Screw, M4 x 16	9211-0440-163	(8)
12. Bumper, Recessed, 0.688 inch Diameter Rubber, number 8 screw	0411-1959-100	(4)
13. Nut, Keps, M4, with external lock washer	0144-3717-314	
14. Retainer, push-on, 3.6mm ID, 12.7mm OD, Black Plastic	1001-3845-000	(2)
15. Knob, ON/Standby, Black, 0.125 inch Shaft	1500-3190-000	

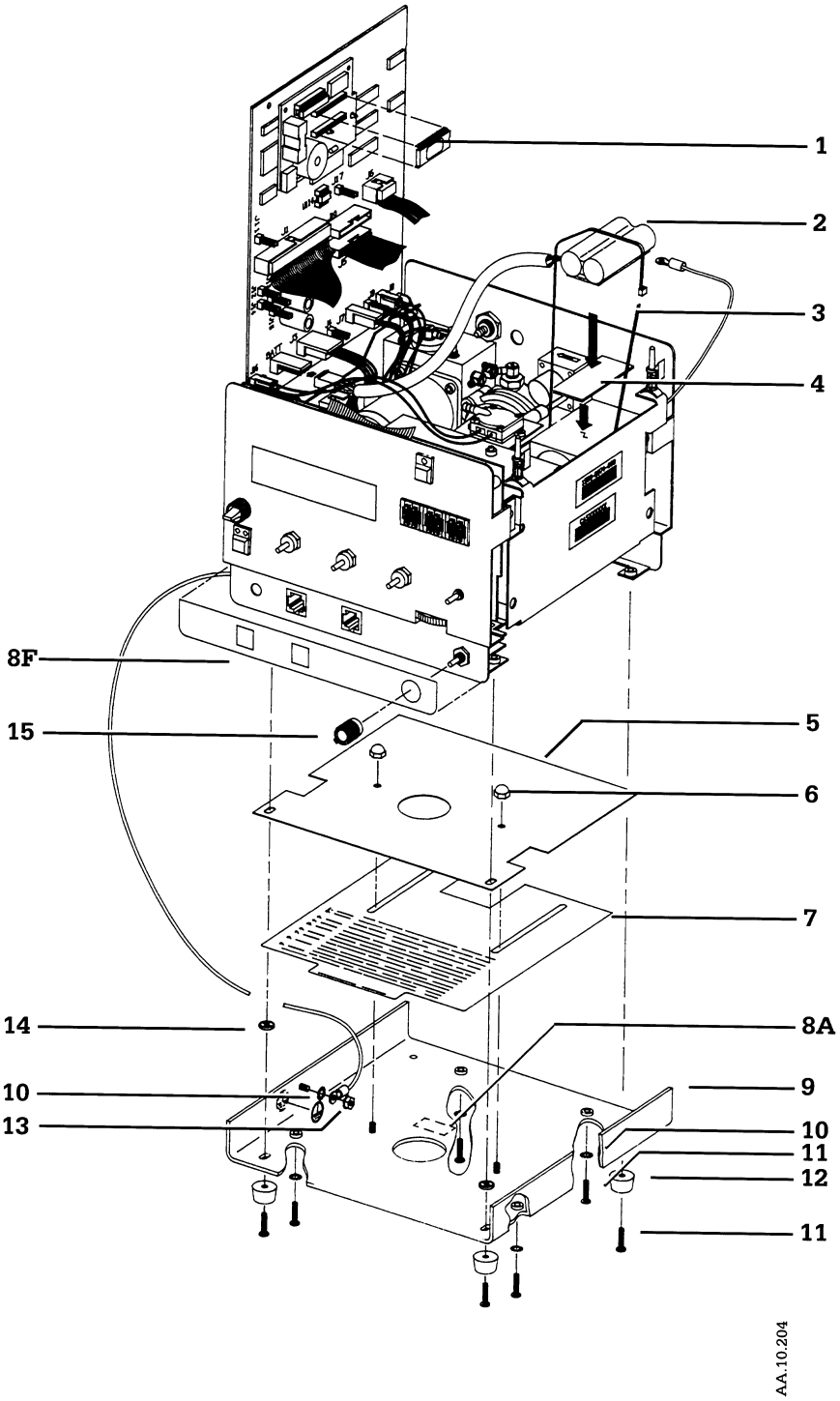


Figure 8-21 Bottom Shroud, Battery and Software, Stand Alone

Bottom Shroud, Battery and Software — Excel Mount

	Description	Stock Number	Quantity
1.	64K EPROM kit, English, version 4.22, 7800 includes Operation and Maintenance manual	1500-8076-000	
	Important: Upgrading software from version 1.xx to 4.xx requires an upgraded Operation and Maintenance manual, and personnel notification of all user visible changes.		
2.	Battery Pack, Ni-Cd, 4.8 V dc 1.3 Amp hour	1500-3125-000	
3.	Cable tie, Long	0203-5917-300	
4.	Hook fastener, 75mm long	0999-1108-010	
5.	Sleeve, Preoperative Check List	1500-3233-000	
6.	Nut, Acorn M4	0144-3127-100	(2)
7.	Card, Preoperative Check List, English	1500-3194-000	
8.	Label Set, 7800, English,Part A	1500-3206-000	
	Label Set, 7800, English, Part E	1500-3206-000	
9.	Shroud, Lower	1500-5029-000	
10.	Washer, lock, external, M4	9213-0540-003	(5)
11.	Screw, M4 x 16	9211-0440-163	(8)
12.	Bumper, Recessed, 0.688 inch Diameter Rubber, number 8 screw	0411-1959-100	(4)
13.	Nut, Keps, M4, with external lock washer	0144-3717-314	
14.	Retainer, push-on, 3.6mm ID, 12.7mm OD, Black Plastic	1001-3845-000	(2)

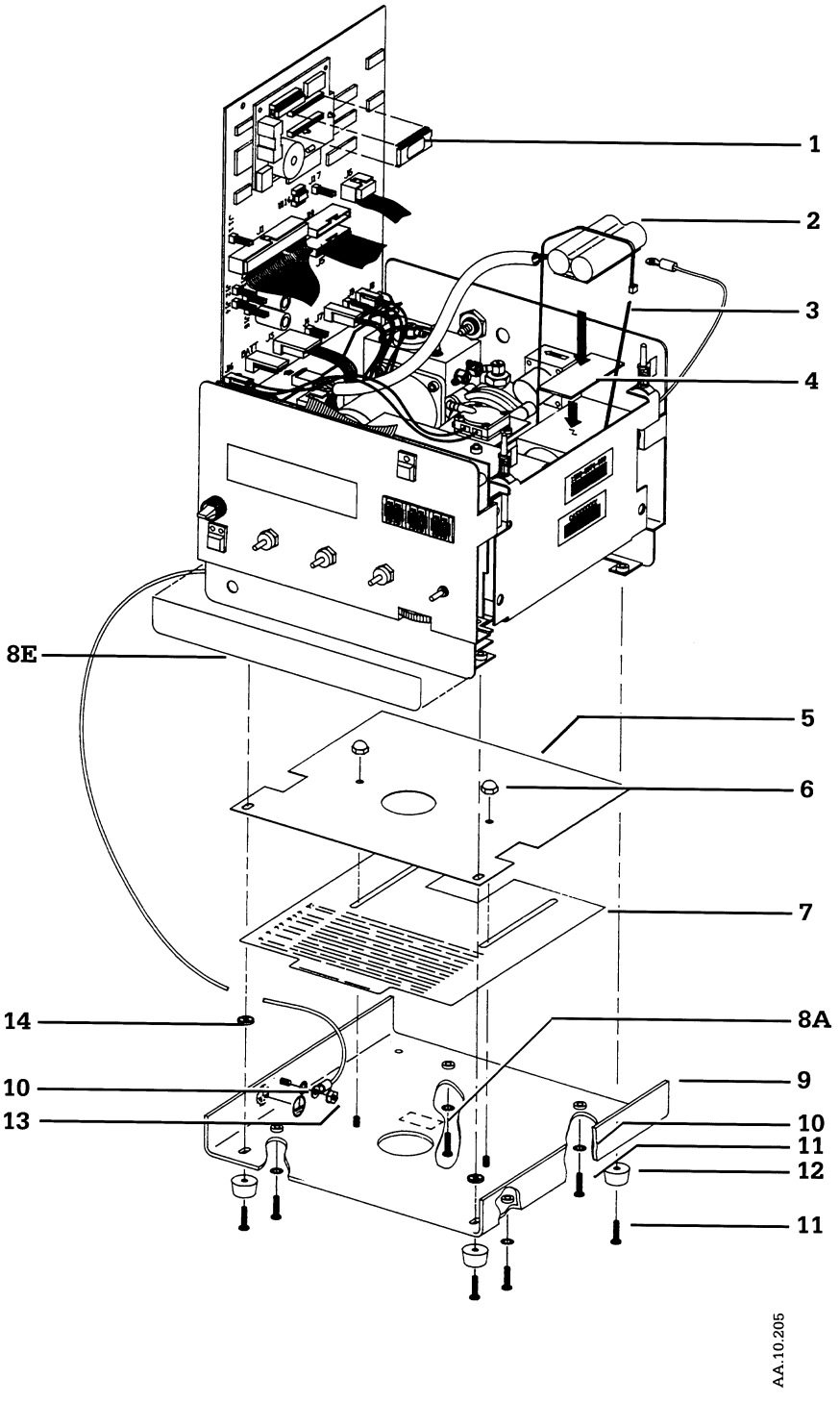


Figure 8-22 Bottom Shroud, Battery and Software, Excel Mount

Battery and Software — Modulus® II Upgrade

Description	Stock Number
1. 64K EPROM kit, English, version 4.22, 7800 includes Operation and Maintenance manual	1500-8076-000

Important: Upgrading software from version 1.xx to 4.xx requires an upgraded Operation and Maintenance manual, and personnel notification of all user visible changes.

2. Battery Pack, Ni-Cd, 4.8 V dc 1.3 Amp hour	1500-3125-000
3. Cable tie, Long	0203-5917-300
4. Hook fastener, 75mm long	0999-1108-010
5. Nipple, 1/8 inch NPT male, 1.5 inch long	0413-1003-500
6. Adapter, Gas Supply, Diamond O_2, 1/8 NPT female	0221-2684-800

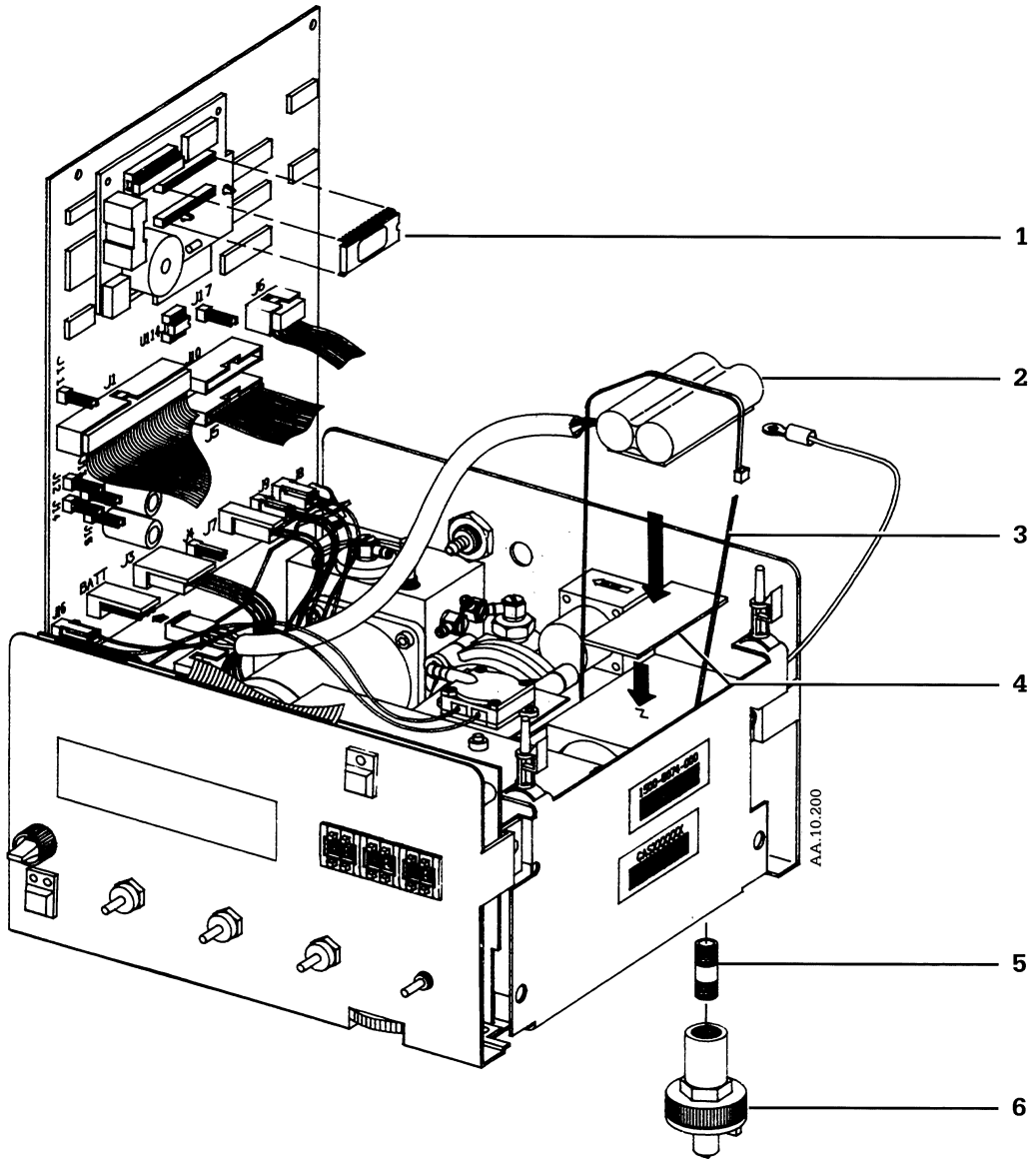


Figure 8-23 Battery and Software, Modulus® II Upgrade

Cover, Front Label and Knobs —

Stand Alone, Excel Mount, and Modulus® II Upgrade

	Description	Stock Number	Quantity
1.	Washer, lock, external, M4	9213-0540-003	
2.	Nut, Keps, 6-32 inch, with external lock washer	0202-1130-300	
3.	Screw, M4 x 12	0140-6226-112	(4)
4.	Knob, Push to Turn, includes two 4-40 inch setscrews and Torque nut	1500-3146-000	
	Torque nut alone	1500-3130-000	
5.	Knob, Knurled Conductive, includes two setscrews	1500-3136-000	(3)
	Setscrew alone, M3 x 6	0140-6217-104	
6.	Label, Front, English	1500-3162-000	
7.	Cover	0229-1001-710	

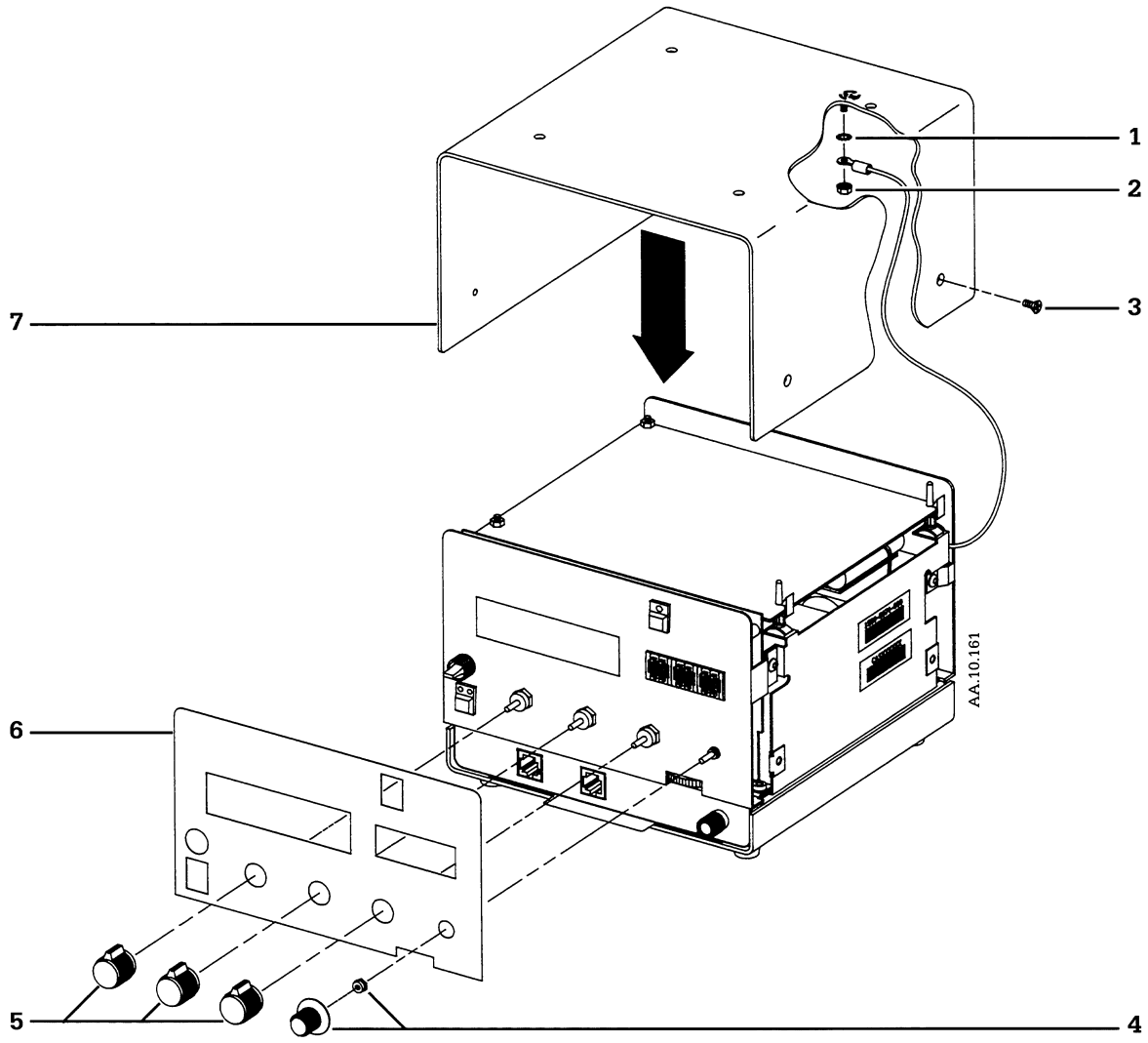


Figure 8-24 Cover, Front Label, and Knobs

Rear Labels — Stand Alone

	Description	Stock Number
1.	Label Set, 7800, English, Part D	1500-3206-000
	Label Set, 7800, English, Part B	1500-3206-000
2.	Label, Ground	1010-3044-000
3.	Label, Rear, 7800, English	1500-3226-000

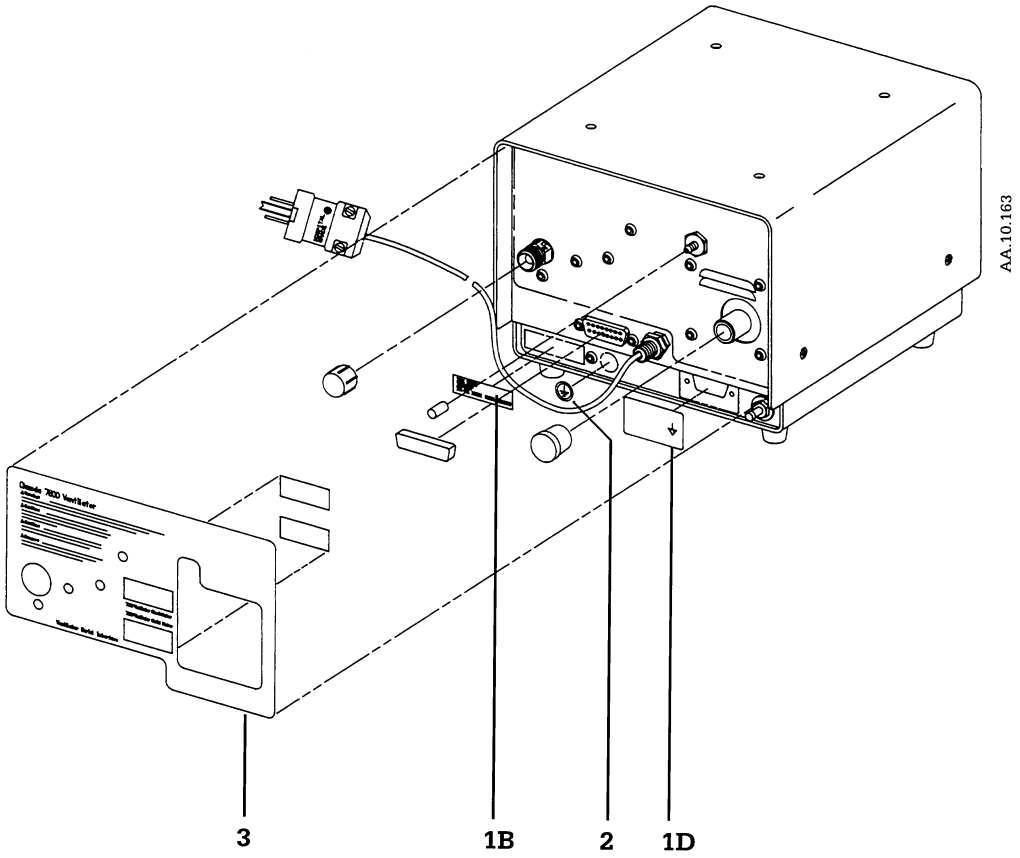


Figure 8-25 Rear Labels, Stand Alone

Rear Labels — Excel Mount

Description	Stock Number
1. Label, Equipotential	1001-3737-000
2. Label, Ground	1010-3044-000
3. Label Set, 7800, English, Part C	1500-3206-000
Label Set, 7800, English, Part B	1500-3206-000
4. Label, Rear, 7800, English	1500-3226-000

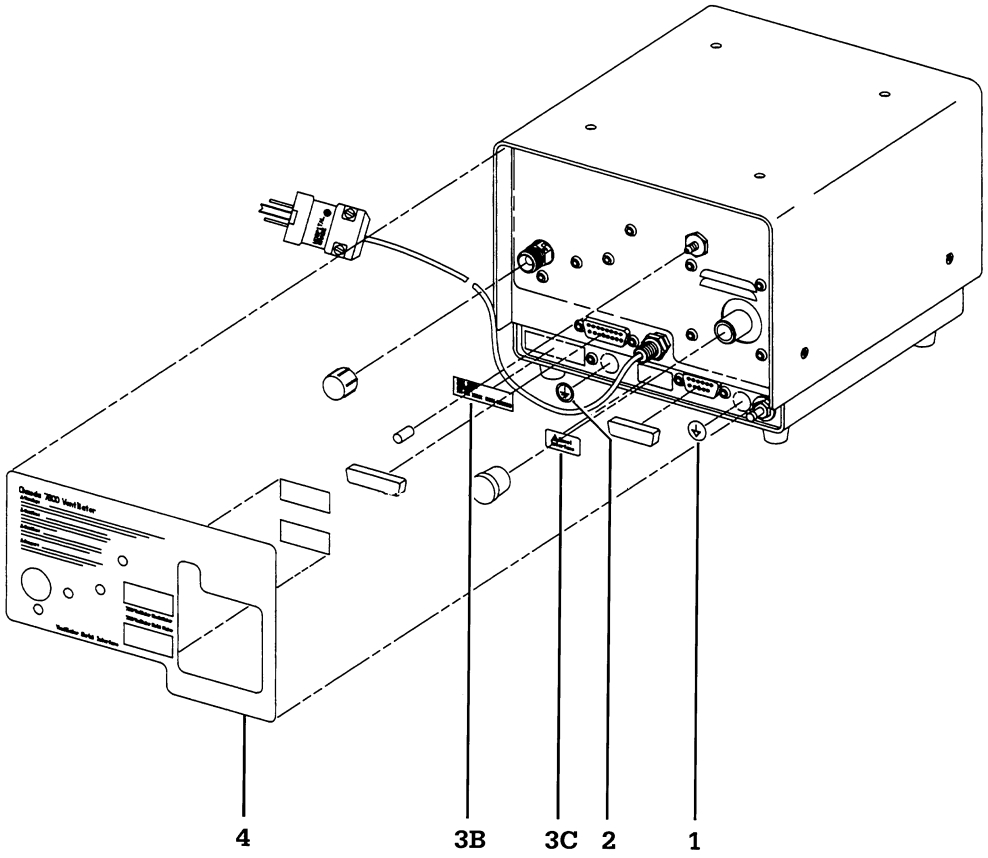


Figure 8-26 Rear Labels, Excel Mount

Rear Label — Modulus® II Upgrade

Description	Stock Number
1. Plug, Hex head, 1/4 NPT	1500-3160-000
2. Label, Rear, 7800, English	1500-3211-000

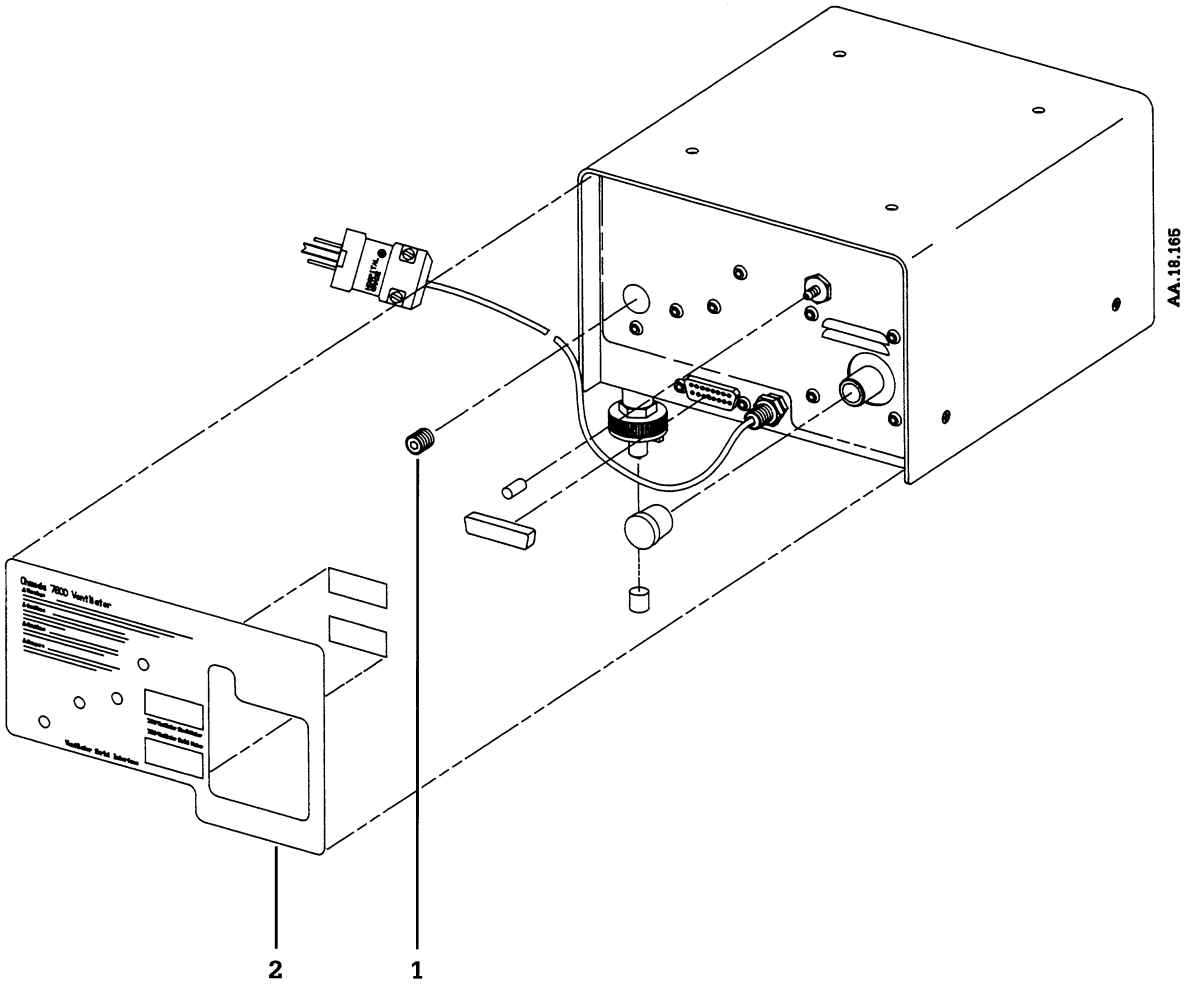


Figure 8-27 Rear Label, Modulus II Upgrade

Canadian Label and Fittings — Stand Alone, Excel Mount

Description	Stock Number
1. Label, Side, 7800, English	1500-3222-000
2. Gland, O2, for 9/16 Union	1010-5093-000
3. Nut, DISS O2, Nickel Chromium	0204-6534-300
4. Bushing, 1/8 inch NPT female, 1/4 inch NPT male	1500-5053-000

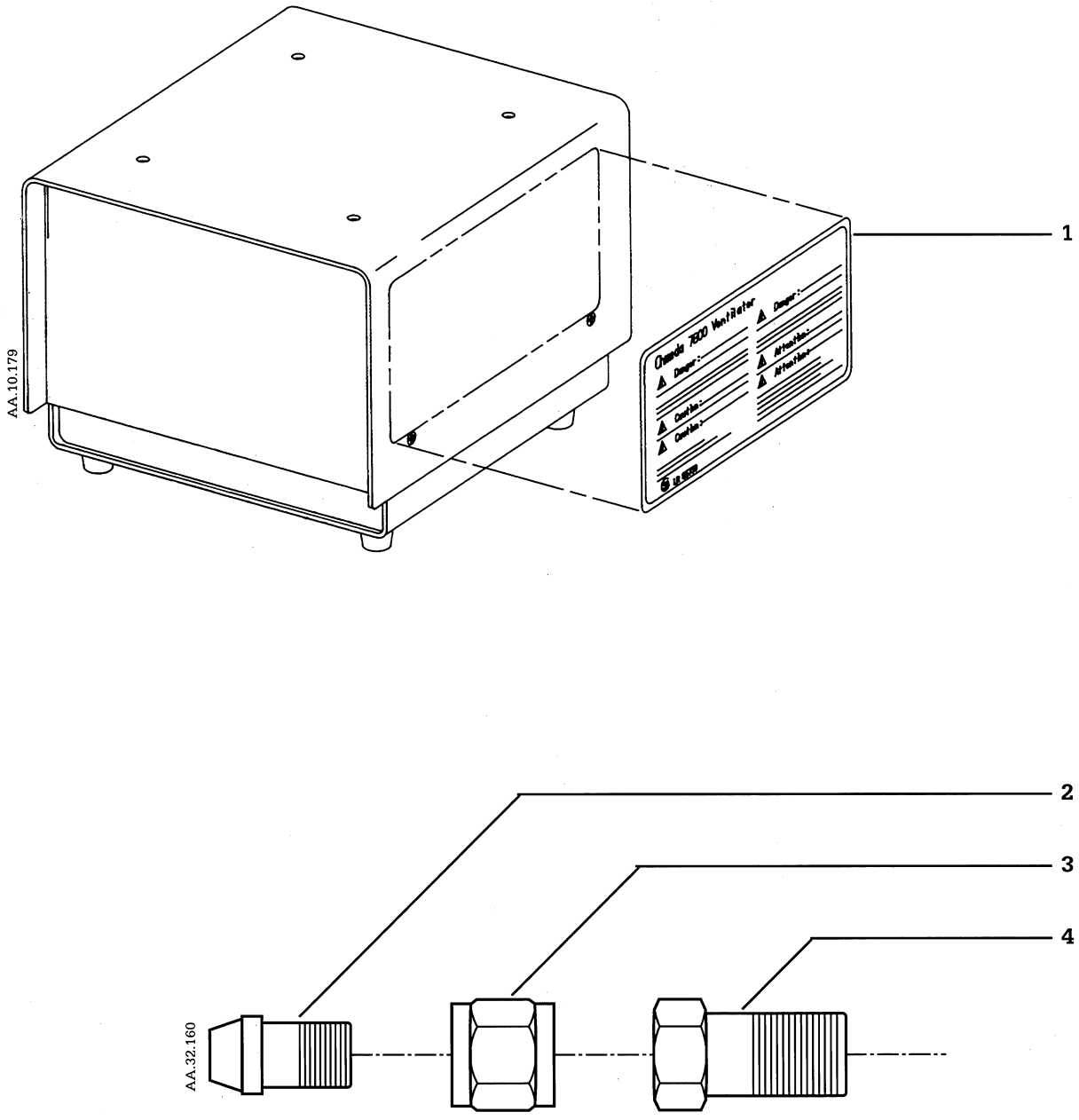


Figure 8-28 Canadian Label and Fittings Stand Alone, Excel Mount

EMC/Interface Board, Original — Modulus® II Upgrade

Description	Stock Number	Quantity
1. Screw, 10-24 x 1/2 inch	0144-2130-206	(2)
2. Washer, lock, ext-10	0202-3211-300	(2)
3. Mounting Plate, EMC/Interface board	1500-5047-000	
4. EMC/Interface board, Original, 7800	1500-7041-000	
5. Washer, lock, external, M4	9213-0540-003	
6. Screw, M4 x 6	9211-1040-067	

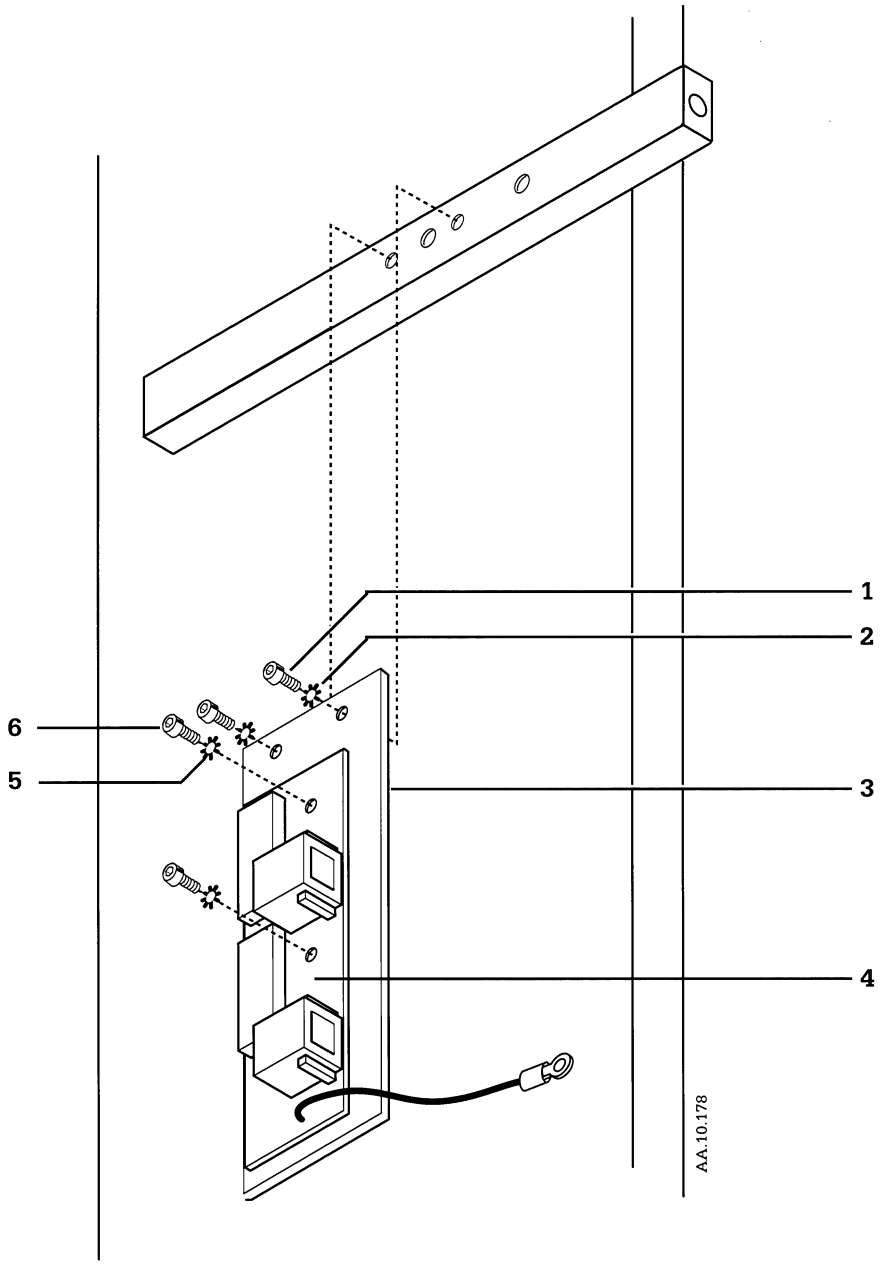


Figure 8-29 EMC/Interface Board, Original Modulus® II Upgrade

8.3 Historical Parts

Old Gas Inlet Valve Body

	Description	Stock Number
1.	Plug, Hex head, 1/4 NPT	1500-3160-000
2.	Adapter, Gas Supply, 1/8 NPT male, O_2 DISS	1500-5049-000
3.	Gas Inlet Valve Body, with Cap, must replace both at same time, Old, 7800	1500-8080-000
4.	Plug, Hex head, 1/8 NPT	1500-3412-000

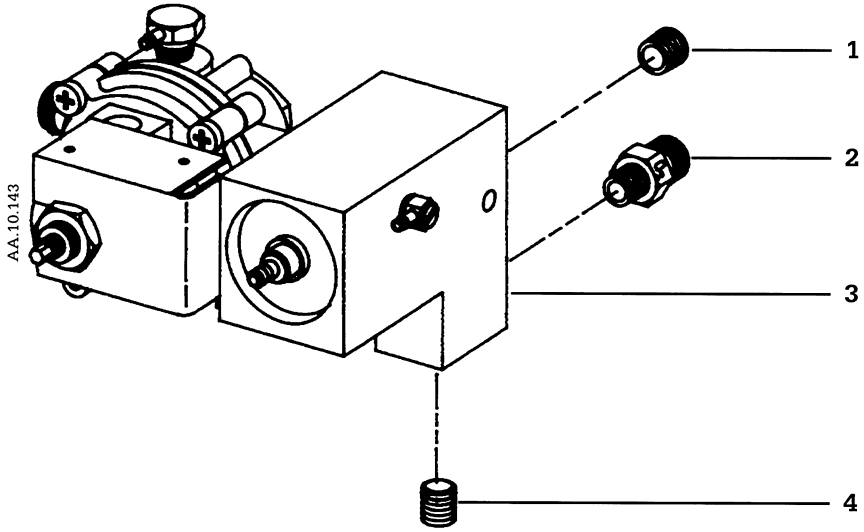


Figure 8-30 Primary Regulator and Gas Inlet Valve

Solenoids and Pressure Transducer Board (Original)

Description	Stock Number
1. Inlet Solenoid, to J9 (Control Board)	1500-7088-000
2. Exhalation Solenoid, to J8 (Control Board)	1500-7005-000
3. Pressure Transducer board, Original, 7800/7850	Not Available
Pressure Transducer board, Universal, does not include solenoids	1500-8016-000

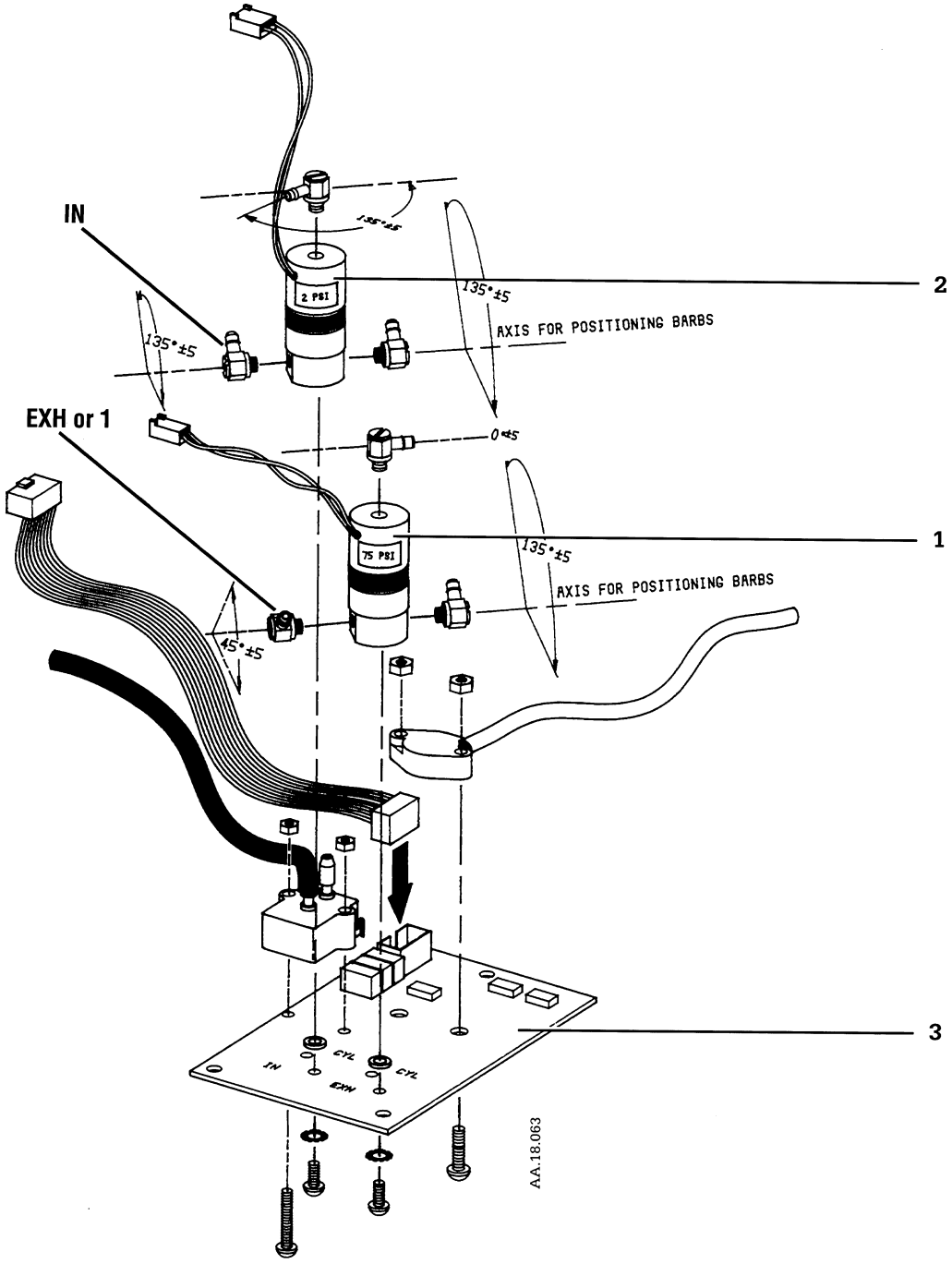


Figure 8-31 Solenoids and Pressure Transducer Board (Original)

Hoses and Tubes, with Pressure Transducer Board (Original)

Description	Stock Number
1. Green High Pressure Hose	0994-6374-010
2. Clear Low Pressure Tubing	0994-6370-010

Connection	Type	Length (mm)
TB1	Green Hose	110*
TB2	Green Hose	275*
TB3	Green Hose	275*
TB4	Green Hose	195*
TB13	Green Hose	30*
TB5	Clear Tubing	130*
TB6	Clear Tubing	200*
TB7	Clear Tubing	170*
TB8	Clear Tubing	220*
TB9	Clear Tubing	170*
TB10	Clear Tubing	50*
TB11	Clear Tubing	50*
TB12	Clear Tubing	100*

Note: * All lengths in mm +/- 6mm. When ordering, specify length in units of one foot (one foot equals 304.8mm).

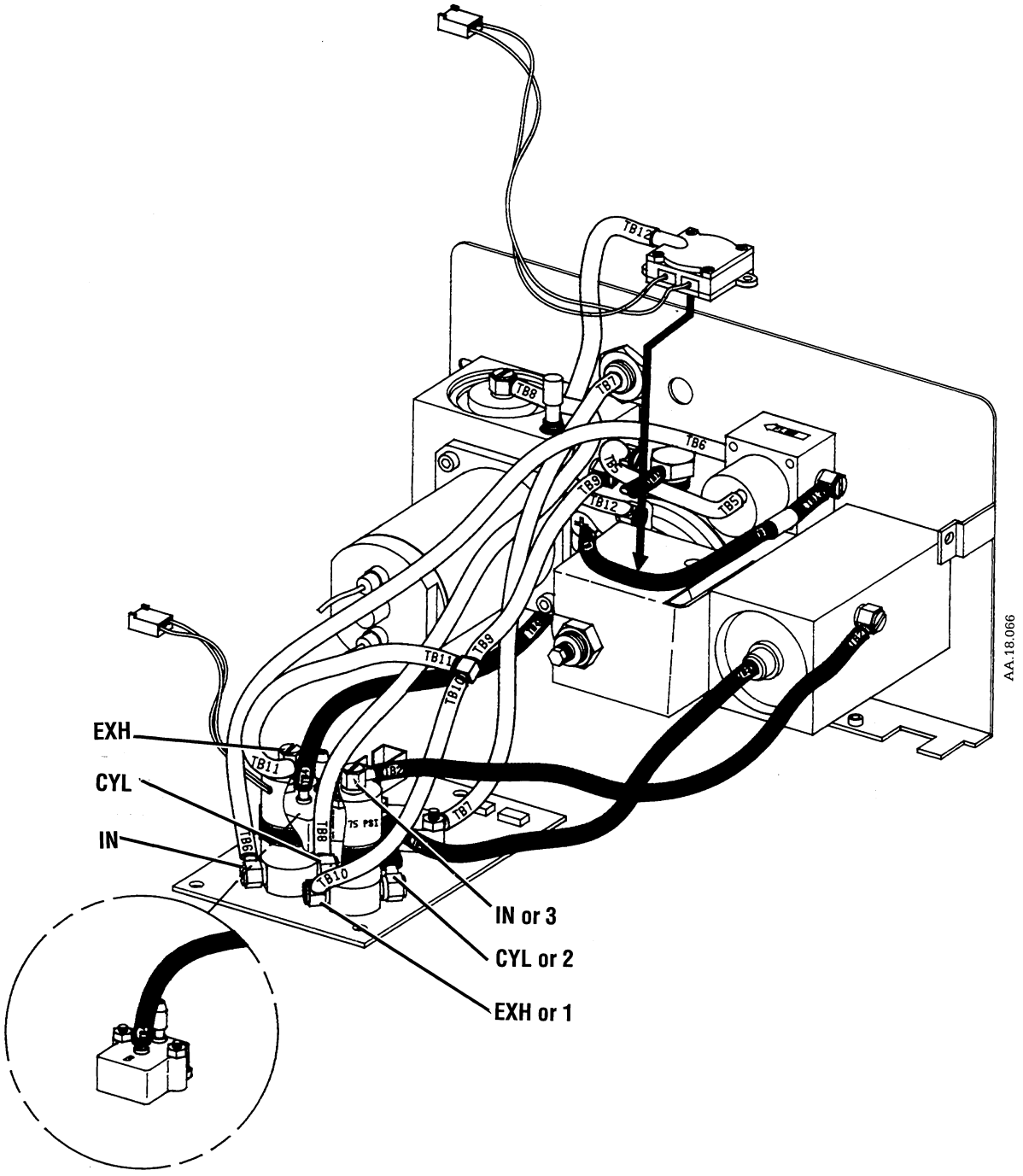


Figure 8-32 Hoses and Tubes, with Pressure Transducer Board (Original)

64K Control Board and Software, without Piggyback Watchdog Board

Description	Stock Number
1. 64K Control Board, not EMC modified, does not include EPROM or EEPROM	Not Available
64K Control Board, does not include Piggyback Watchdog board, EPROM or EEPROM	1500-8026-000
2. 64K EPROM kit, English, version 1.11, 7800/7850	1500-8030-000

Important: Upgrading software from version 1.xx to 4.xx requires an upgraded Operation and Maintenance manual, and personnel notification of all user visible changes.

64K EPROM kit, English, version 4.22, 7800 includes Operation and Maintenance manual	1500-8076-000

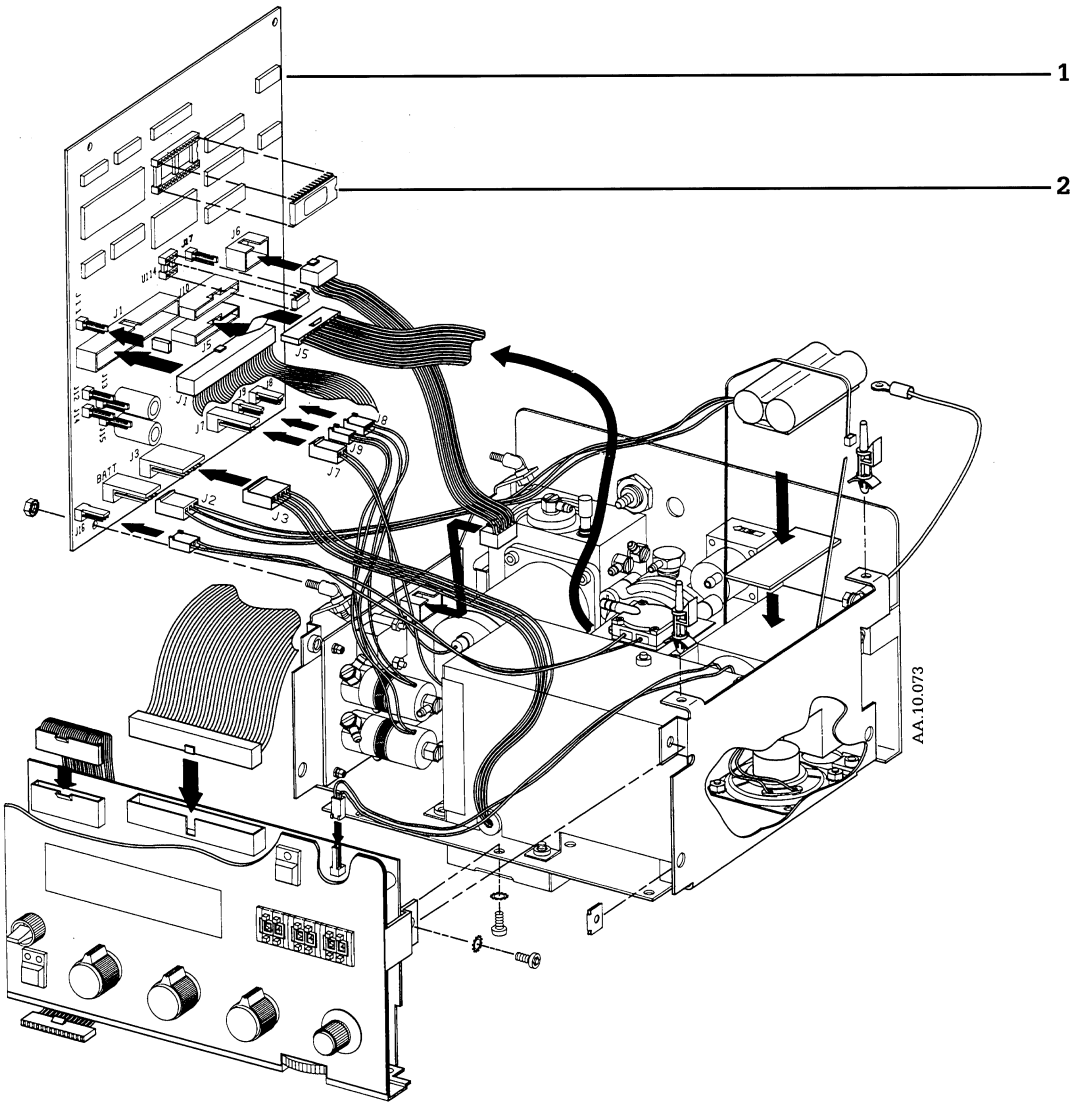


Figure 8-33 64K Control Board and Software, without Piggyback Watchdog Board

EMC/Interface Board, Original — Stand Alone

Description	Stock Number
1. EMC/Interface board, Original, 7800 (requires additional cable 1500-7038-000 when in Excel Mount)	1500-7041-000

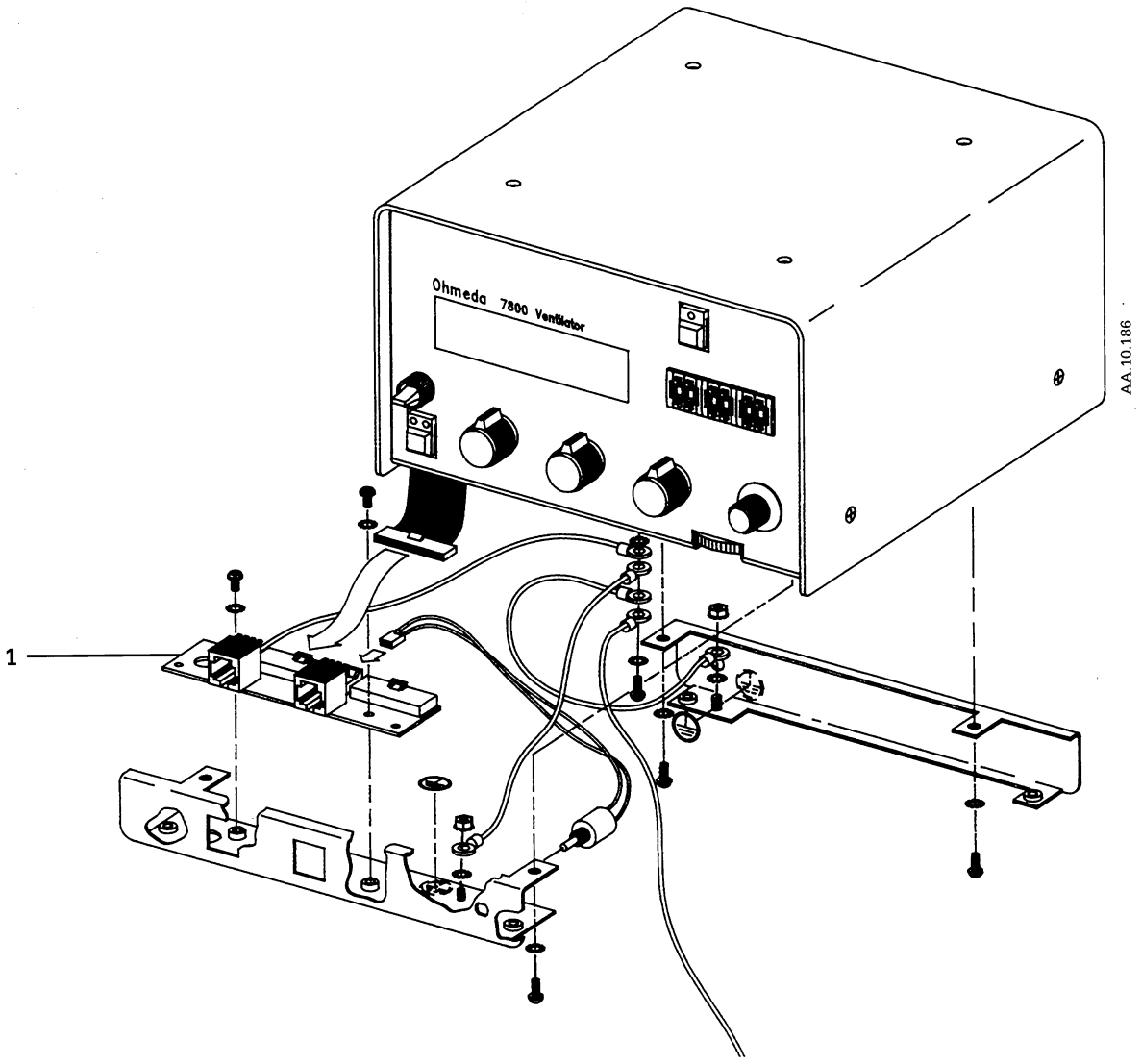


Figure 8-34 EMC/Interface Board, Original Stand Alone

EMC/Interface Board, Original — Excel Mount

Description	Stock Number
1. Cable, Sensor/Remote to J5 (EMC/Interface Board, Original)	1500-7038-000
2. EMC/Interface board, Original, 7800 (requires additional cable 1500-7038-000 when in Excel Mount)	1500-7041-000

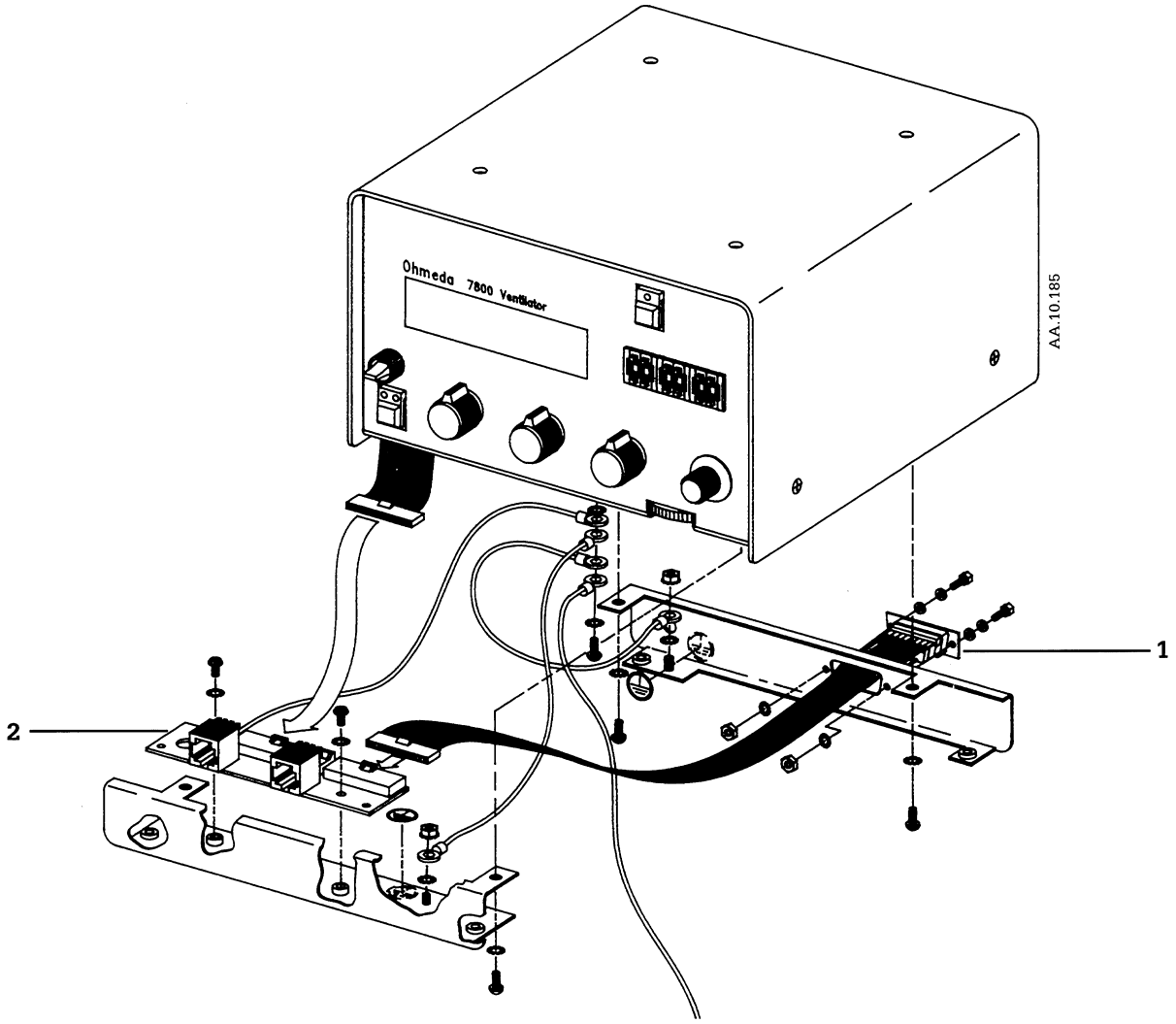


Figure 8-35 EMC/Interface Board, Original Excel Mount

8.4 Mounting

Mounted Directly to Excel, Top Shelf

Description	Stock Number	Quantity
1. Screw, 10-32 x 1/2 inch	0140-6231-108	(4)
2. Spacer, Ventilator mounting Excel ISO	1001-5836-000	(4)

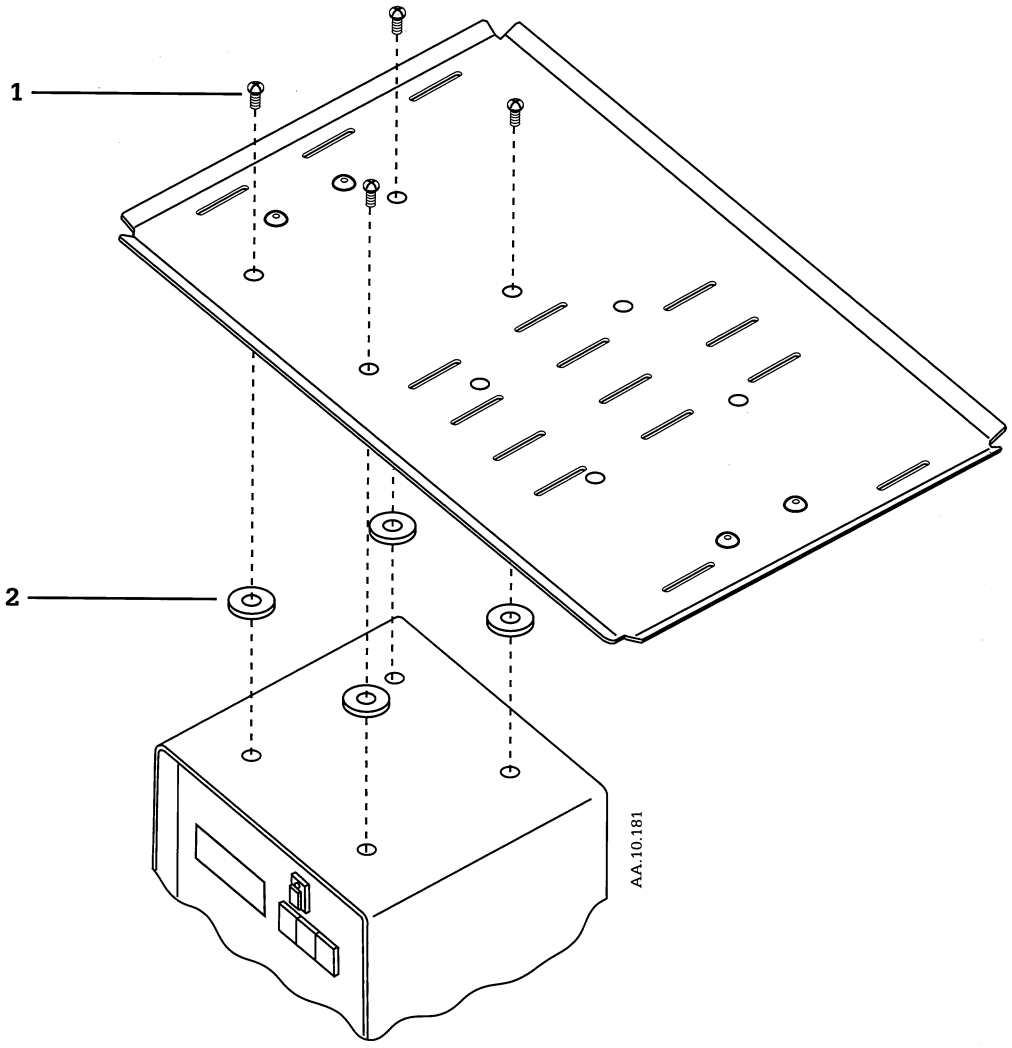


Figure 8-36 Mounted Directly to Excel, Top Shelf

Excel Right Side, Top Shelf

	Description	Stock Number	Quantity
1.	Screw, 10-32 x 3/8 inch	0140-6631-107	(8)
2.	Washer, external lock, 10	0144-1110-231	(8)
3.	Spacer	1001-5882-000	(4)
4.	Kit, Ventilator Mounting , Excel ISO right side, top shelf	1001-8951-000	

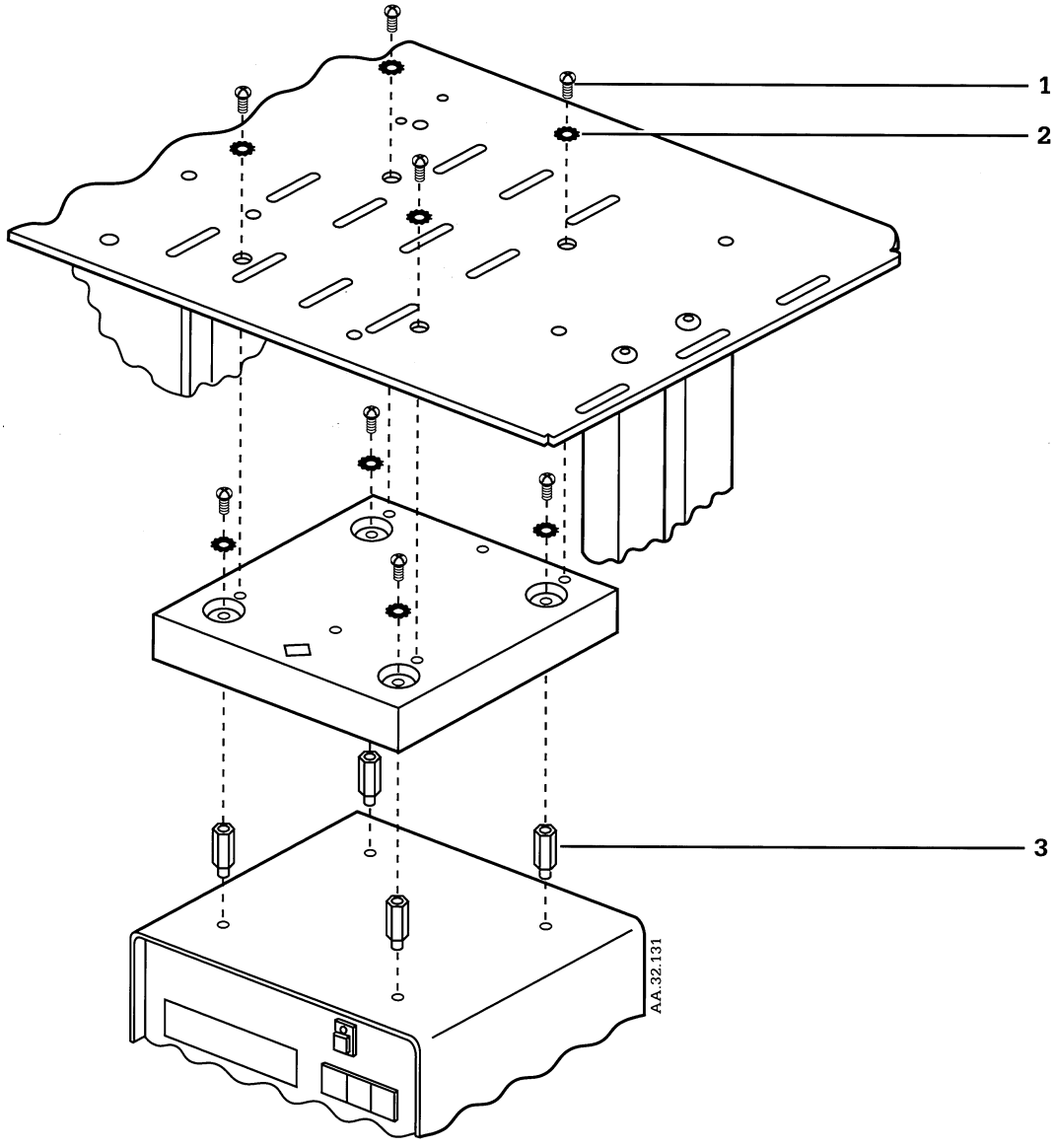


Figure 8-37 Excel Right Side, Top Shelf

Optional Arm

Description	Stock Number	Quantity
1. Washer, lock, external, M4	9213-0540-003	(3)
2. Screw, M4 x 16	9211-0440-163	(3)
3. Kit, Ventilator/Bellows Mounting, Outboard	1001-8953-000	

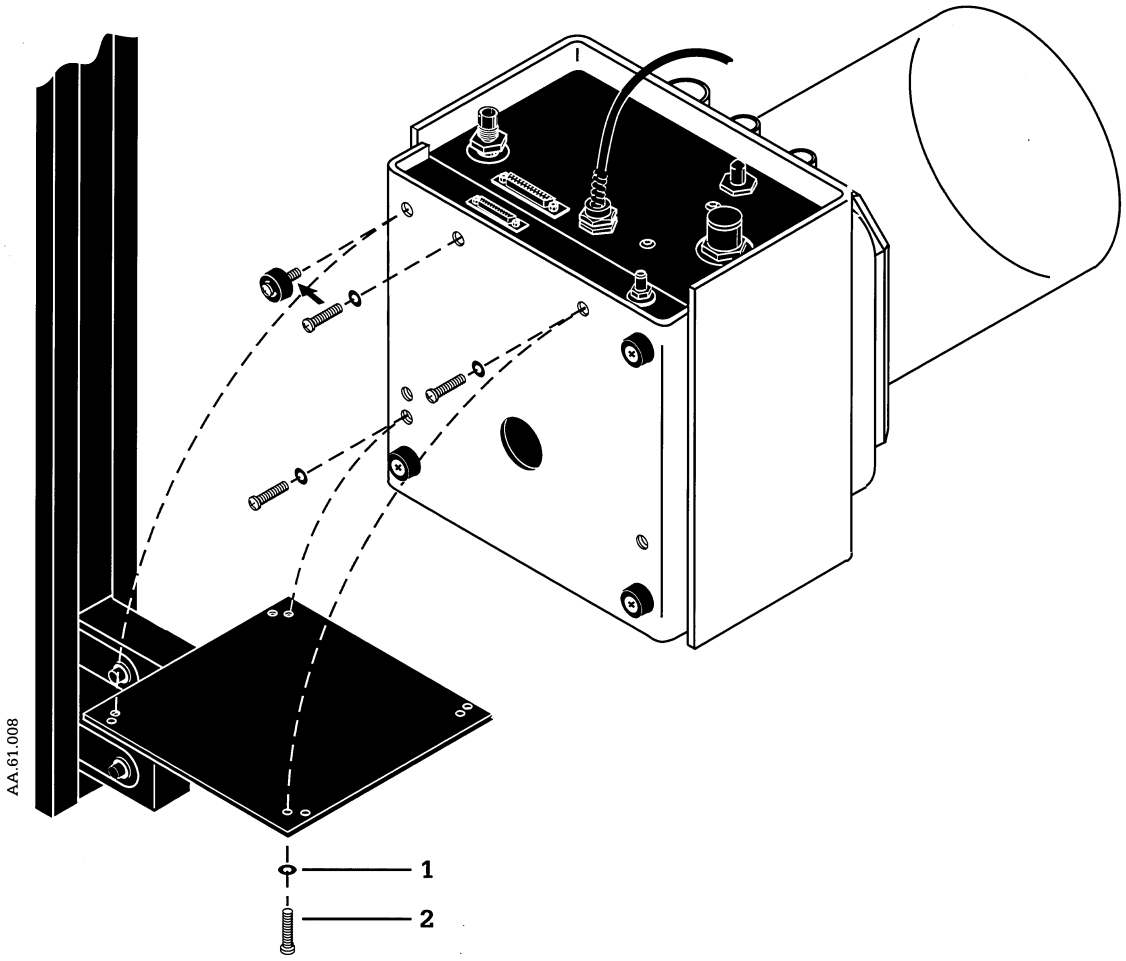


Figure 8-38 Optional Arm

8.5 Accessories

Sensor Related Parts	Stock Number
Volume Sensor clip assembly, 2.4 m (8 foot) cable, English	1201-3000-000
Volume Sensor clip assembly, 4.9 m (16 foot) cable, English	1201-3002-000
Volume Sensor, extension cord kit, 1.8 m (6 foot)	0237-2041-880
Volume Sensor cartridges (10 each), English	1201-3001-000
Pressure Sensing tube, 3mm ID (1/8 inch) x 2.4 m (8 foot)	0211-0721-500
Pressure sensing tee (patient-circuit adapter) 15mm ID, 22mm ID, 22mm OD	0219-7547-700
Oxygen Sensor, with Housing Assembly 1.8 m (6 foot), English	1200-3000-000
Oxygen Sensor, extension cord kit 1.8 m (6 foot)	0237-2040-880
Oxygen Sensor cartridge, English	1200-3001-000
Oxygen sensing tee patient circuit adapter (22mm M, 22mm F, 15mm F)	1500-3115-000

Drive Gas tubes	Stock Number
Short, Corrugated Drive tube, 23 cm (9 inch)	0211-0118-300
Long, Corrugated Drive tube, 195 cm (77 inch) with cuffs	0211-0842-300
Adapter, drive gas, right angle	1500-7086-000

Manifold for GMS Mounting	Stock Number
Manifold with 30mm AGS port for ABA	1500-7090-000
Manifold with 30mm AGS port for Non-ABA	1010-7041-000
Manifold with 19mm AGS port for Non-ABA	0236-0478-700

Excel Interfaces	Stock Number
Sensor Interface Box	1001-8933-000
Cable, Excel to Ventilator interface	1500-3348-000

Mounting Options	Stock Number
Kit, Ventilator Mounting , Excel ISO right side, top shelf	1001-8951-000
Kit, Ventilator/Bellows Mounting, Outboard	1001-8953-000
Stand, 4 wheel	0311-0007-870

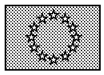
Gas Supply Hose (Excel Mount Only)	Stock Number
Gas Supply Hose, O_2, DISS to DISS	0211-8735-800

Test Tools	Stock Number
Ohmeda Approved Occluding Plug (15mm, 22mm)	2900-0001-000
Service Support Shelf, 7810/7850	1500-8039-000
Standoff Post for Service Support Shelf (for MOD II Upgrade)	1500-7055-000

8.6 Related Manuals

Description	Stock Number
7800 Ventilator, Operation and Maintenance Manual	
English Domestic	1500-0062-000
Autoclavable Bellows Assembly, Supplement,	
English	1500-0250-000
German	1500-0251-000
French	1500-0252-000
Spanish	1500-0253-000
Italian	1500-0254-000
Swedish	1500-0255-000

Corporate Office



EC REP

GE Healthcare Finland Oy
Kuortaneenkatu 2
Helsinki, Finland
FI-00510
Tel 358 10 394 11
Fax 358 9 146 3310

North America

United States

Customer Service, Technical Support and Distribution Center
Datex-Ohmeda, Inc.
PO Box 7550
Madison, WI
53707-7550, USA
Tel 1 800 345 2700
Fax 1 608 221 4384

Equipment Service Center
GE Healthcare
100 Marquette Drive
Jupiter FL 33458
USA
Tel 1 561 575 5000
Fax 1 561 575 5070

Canada

Datex-Ohmeda
(Canada) Inc.
c/o GE Canada
2300 Meadowvale
Boulevard
Mississauga, Ontario
L5N 5P9
Canada
Tel 800 268 1472
Fax 905 858 6208

Asia/Pacific

China

Datex-Ohmeda Pte. Ltd.
Room B416,
COFCO Plaza
8 Jianguomennei
Avenue
Beijing 100005, PR China
Tel 86 10 6526 9773
Fax 86 10 6526 0653

Datex-Ohmeda Pte. Ltd.
Room 1708, Yunlong
Mansion
No. 122 Luoguo Street
Chengdu 610017, PR
China
Tel 86 28 661 4424
Fax 86 28 676 2703

Datex-Ohmeda Pte. Ltd.
403 Huan Shi Dong Road
Room 1602, GIE Tower
Guangzhou, 510095, P R
China
Tel 86 20 8732 2521
Fax 86 20 8732 2518

Datex-Ohmeda Pte. Ltd.
Room 2509 Lippo Plaza
No. 222
Huaihai Road (M)
Shanghai 200021, P.R.
China
Tel 8621 5382 5657
Fax 8621 5382 1691

Datex-Ohmeda Pte. Ltd.
Room 809, Truroll Plaza
Wusheng Road
Wuhan 430033, P R China
Tel 86 27 8571 2536
Fax 86 27 8571 2655

India

Datex-Ohmeda (India)
Pvt. Ltd.
Block EP & GP, Sector V
Plot XI-16, Salt Lake City
Calcutta 700091
India
Tel 91 33 3574002
Fax 91 33 3574001

Indonesia

Datex-Ohmeda Pte. Ltd.
Wisma Danamon Aetna
Life 19th Floor
Jln. Jend Sudirman Kav.
45-46 Jakarta 12930,
Indonesia
Tel 62 21 575 0864
Fax 62 21 575 0865

Japan

GE Yokogawa
Medical Systems
TRC Annex 9F
6-1-1 Heiwajima,
Ohta-ku,
Tokyo 143-0006
Japan
Tel 81 3 5763 6801
Fax 81 3 5763 6838

GE Yokogawa
Medical Systems
Technical Center
TRC A Bldg. AE 4-8
6-1-1 Heiwajima
Ohta-ku,
Tokyo 143-0006
Japan
Tel 81 3 5763 6850
Fax 81 3 5763 6852

Korea

Datex-Ohmeda Pte. Ltd.
10th Floor,
Sam Sung Building
36 - 1, Yoido-Dong, Young-
deungpo-Ku
Seoul, Korea
Tel 82 2 786 7421
Fax 82 2 786 7420

Malaysia

Datex-Ohmeda Pte. Ltd.
Level 2 Bangunan
O'Connor
13 Jalan 223
46100 Petaling Jaya
Selangor, West Malaysia
Tel 60 3 754 7872
Fax 60 3 757 6948

Singapore

Datex-Ohmeda Pte. Ltd.
152 Beach Road
#12-05/07 Gateway East
Singapore 189721
Tel 65 391 8618
Fax 65 291 6618

Taiwan and Philippines

Datex-Ohmeda Pte. Ltd.
2nd Floor, No. 85,
Chien-Kuo North Road,
Sec. 2
Taipei, Taiwan
Republic of China
Tel 886-2 2515-0457
Fax 886-2 2501-9136

Thailand

Datex-Ohmeda Pte. Ltd.
12th Floor (Unit F) Grand
Amarin Tower
1550 New Petchburi
Road, Makasan,
Rajathevi,
Bangkok 10320,
Thailand
Tel 66 2 2071012/13
Fax 66 2 207 1014

Vietnam

Datex-Ohmeda Pte. Ltd.
522G Nguyen
Tri Phuong St.
Ho Chi Minh City, Dist. 10
Vietnam
Tel 848 865 5875
Fax 848 862 5501

Australia

Datex-Ohmeda Pty. Ltd.
Units 1
149 Arthur Street
Locked Bag 356
Homebush
NSW 2140
Australia
Tel 61 1300 722 229
Fax 61 2 9746 1796

Europe

CIS/Baltics

Datex-Ohmeda
Regional Head Office
PO Box 70071
GR-16610 Glyfada -
Athens
Greece
Tel +30 10 9625136-7
Fax +30 10 9623687

France

Datex-Ohmeda S.A.S.
ZAC de Sans-Souci
1211 Chemin de la
Bruyère
F-69760 Limonest
France
Tel 33 (0) 4 78 66 62 10
Fax 33 (0) 4 78 43 26 58

Germany

Datex-Ohmeda GmbH
Munzinger Strasse 3
79111 Freiburg
Germany
Tel +49 761 4543 0
Fax +49 761 4543 233

GE Service Center
T: 0800 434325842273
T: 0800 GEHealthcare

Italy

Datex-Ohmeda S.p.A.
Via Cassanese 100
20090 Segrate, Milan
Italy
Tel 39 2 21693431
Fax 39 2 26926226

Netherlands

Datex-Ohmeda B.V.
De Wel 18
Post Box 22
3870 CA Hoevelaken
Netherlands
Tel 31 33 2541 222
Fax 31 33 2541 223

Spain

Datex-Ohmeda S.L.
C/Manuel Tovar 26
28034 Madrid
Spain
Tel 34 1 334 26 00
Fax 34 1 358 12 84

United Kingdom

Datex-Ohmeda Ltd.
Ohmeda House
71 Great North Road
Hatfield Hertfordshire
AL9 5EN England
Tel 44 1707 263570
Fax 44 1707 260191

Latin America, Caribbean

Datex-Ohmeda
9155 South
Dadeland Blvd.
Suite 1218
Miami, FL 33156, USA
Tel 1 305 670 8540
Fax 1 305 670 2316

Middle East/ Africa

Datex-Ohmeda
Regional Head Office
PO Box 70071
GR-16610 Glyfada -
Athens
Greece
Tel +30 10 9625136-7
Fax +30 10 9623687

The addresses listed on this cover are current as of 4/05. For any location changes please visit our website at www.datex-ohmeda.com and click the contacts button.

7800 Ventilator
Service Manual,
English
1500 0081 000
03 95 B 18 06 12
Printed in USA

CE
0197

9/Schematics

Schematics are subject to change without notice.

Circuit boards are available only as complete assemblies.

These symbols reference supply common.

= Analog Ground

= Digital Ground

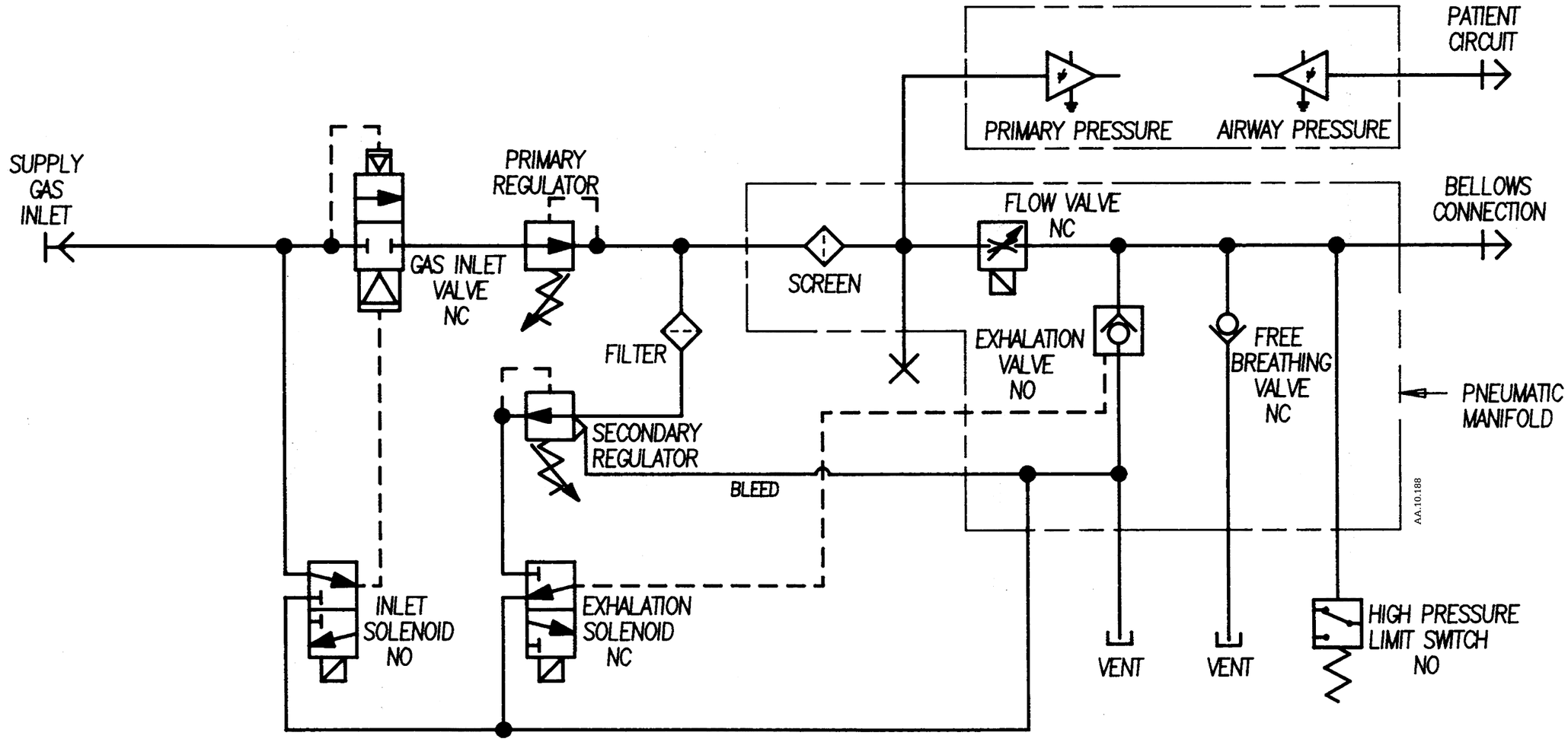


Figure 9-1 Pneumatic Schematic

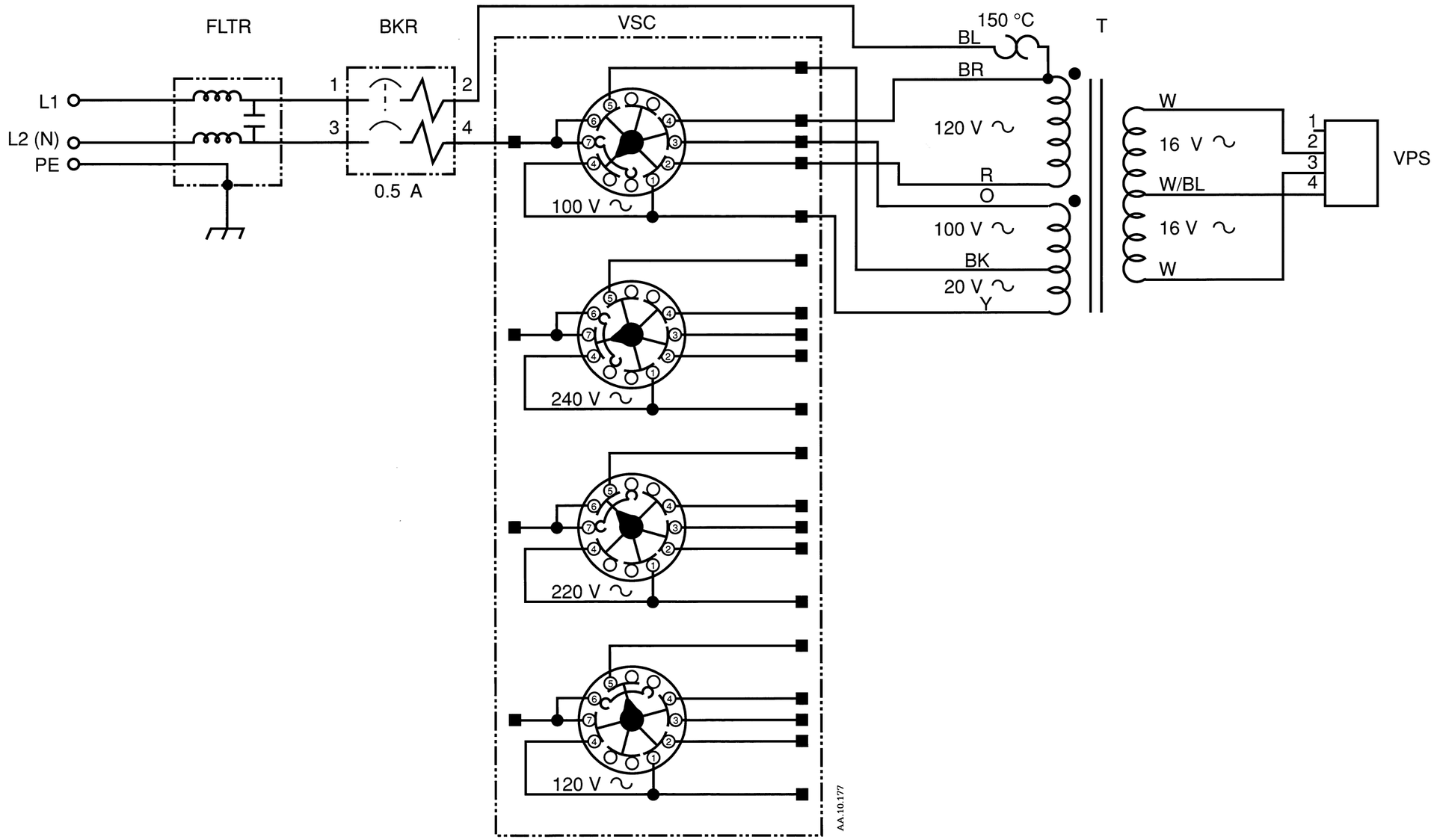


Figure 9-2 Filter, Breaker, Selector, Transformer (Universal)

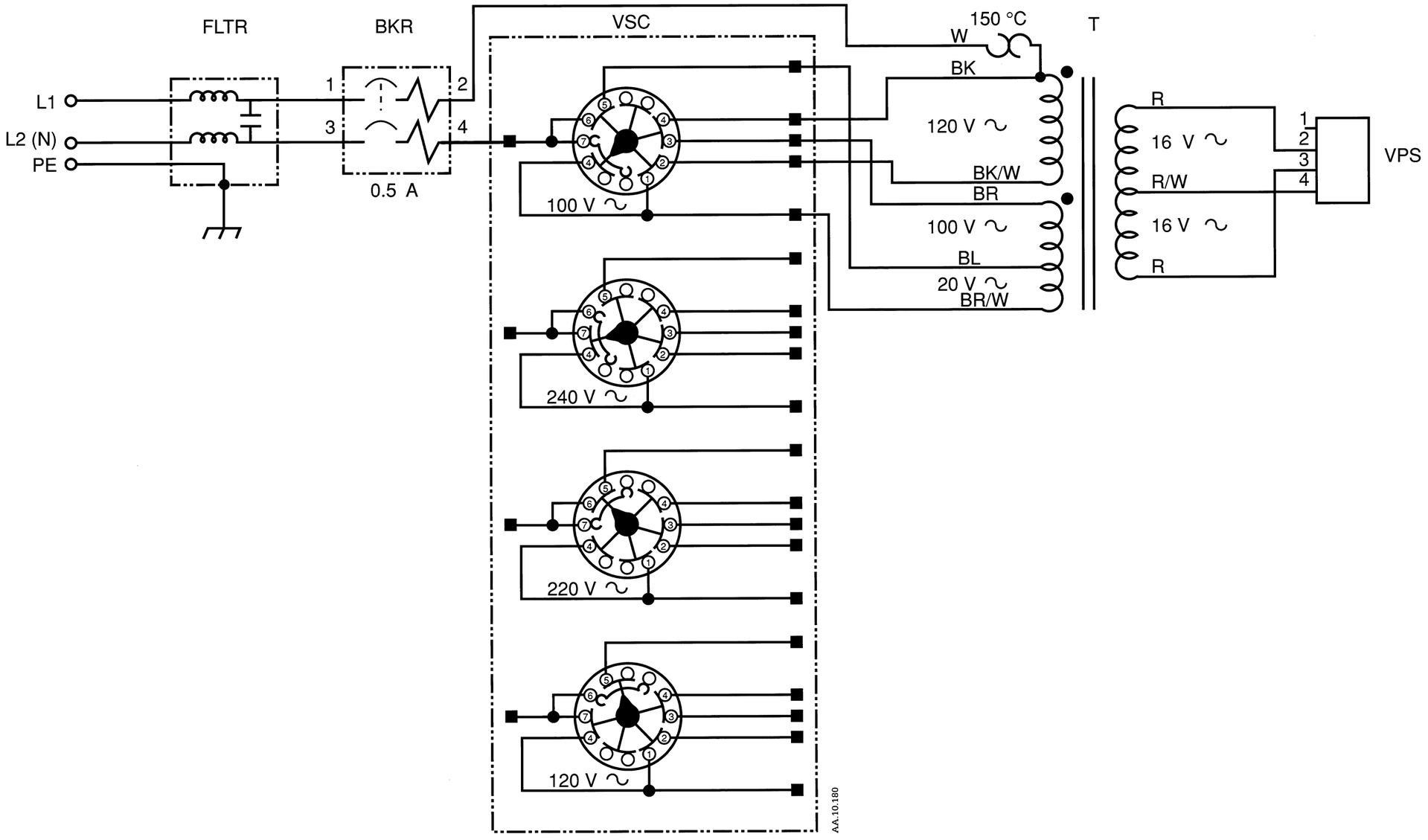
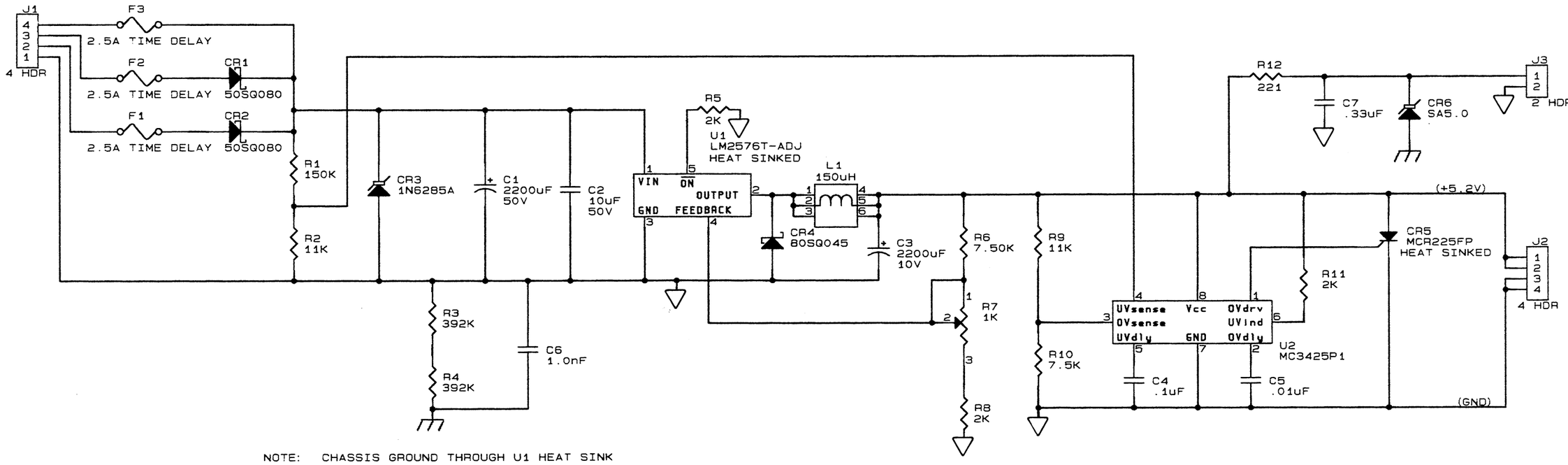


Figure 9-3 Filter, Breaker, Selector, Transformer (Original)



NOTE: CHASSIS GROUND THROUGH U1 HEAT SINK

Figure 9-4 Universal Power Supply Board

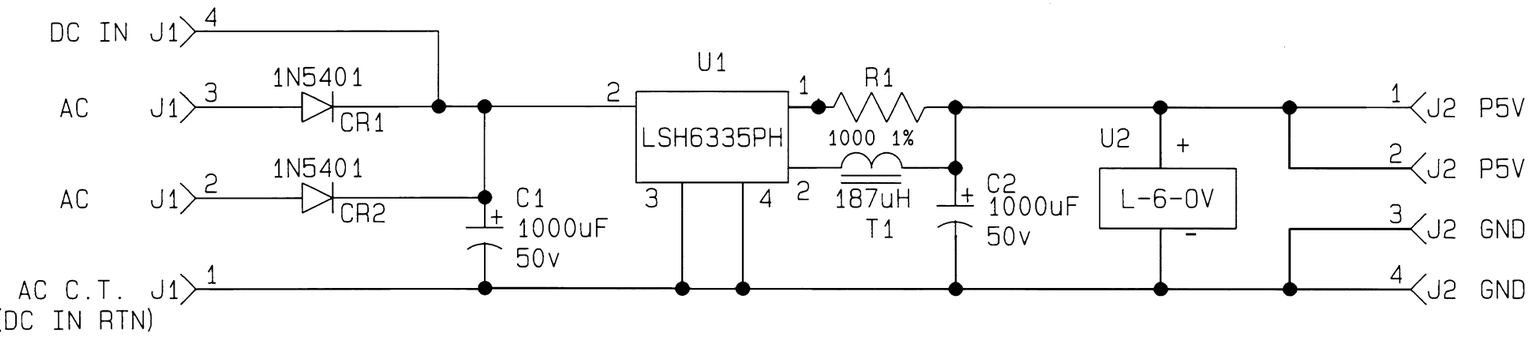


Figure 9-5 Power Supply Board (Original)

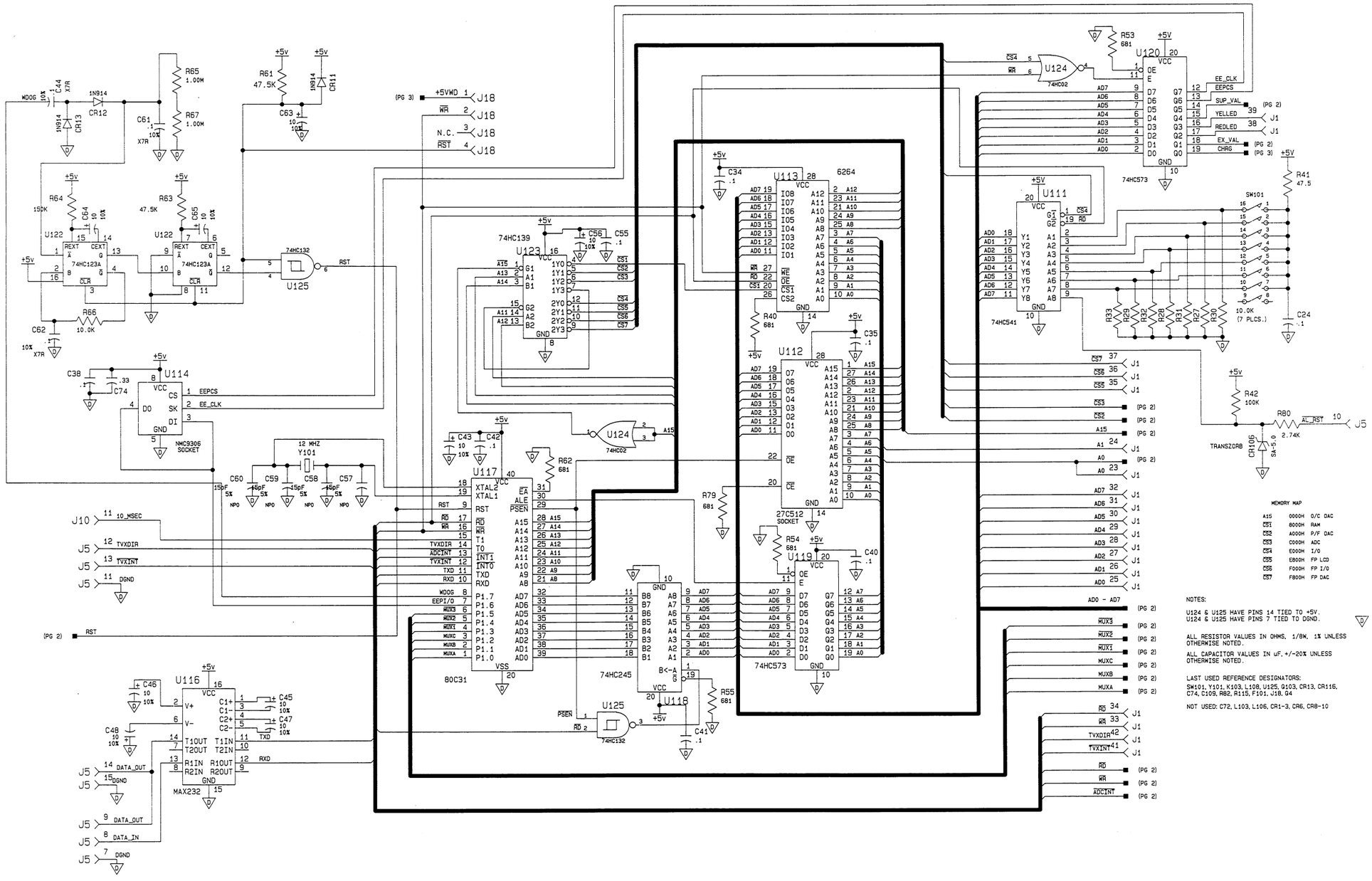


Figure 9-6 64K Control Board, 1 of 3

Figure 9-7 64K Control Board, 2 of 3

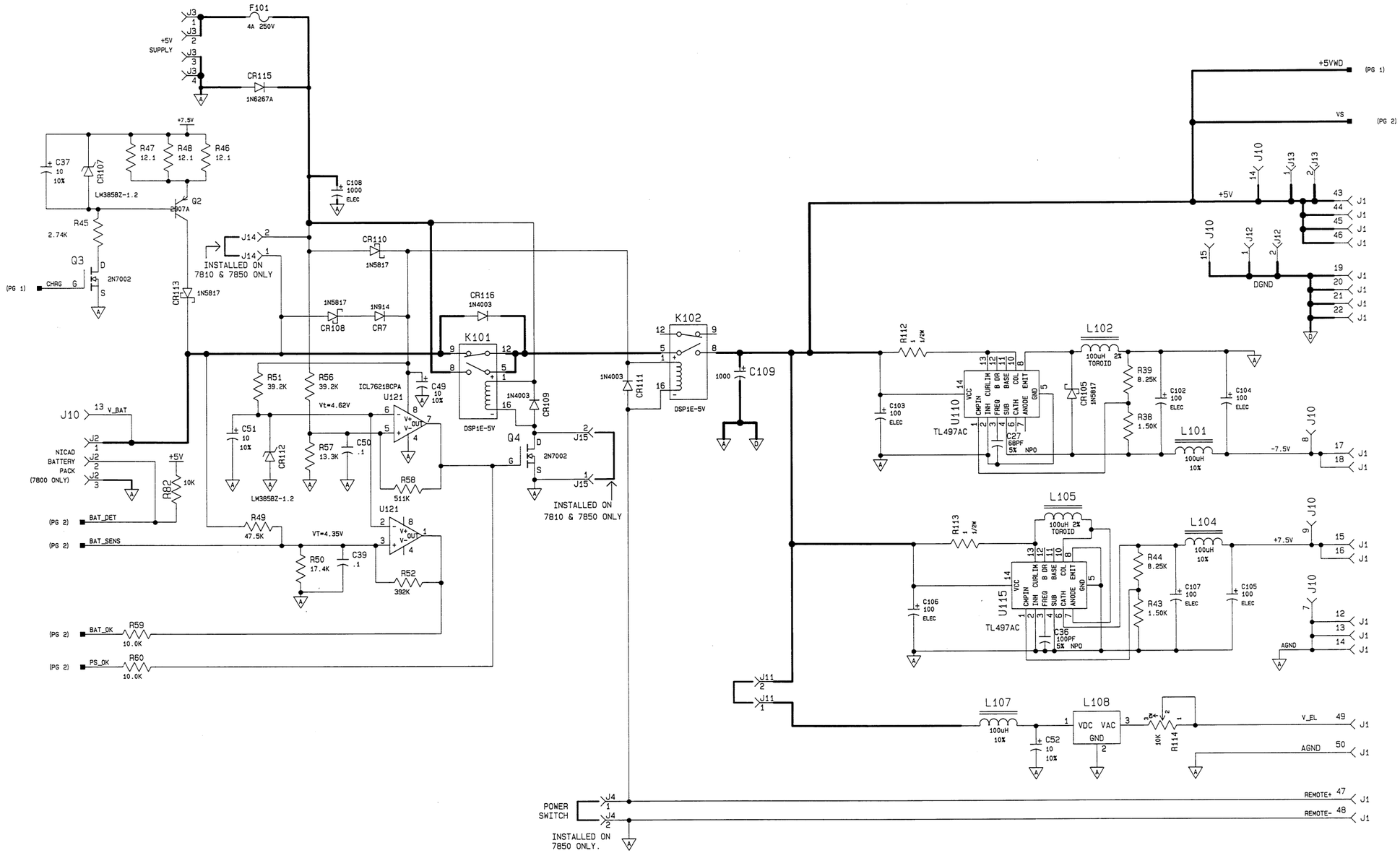
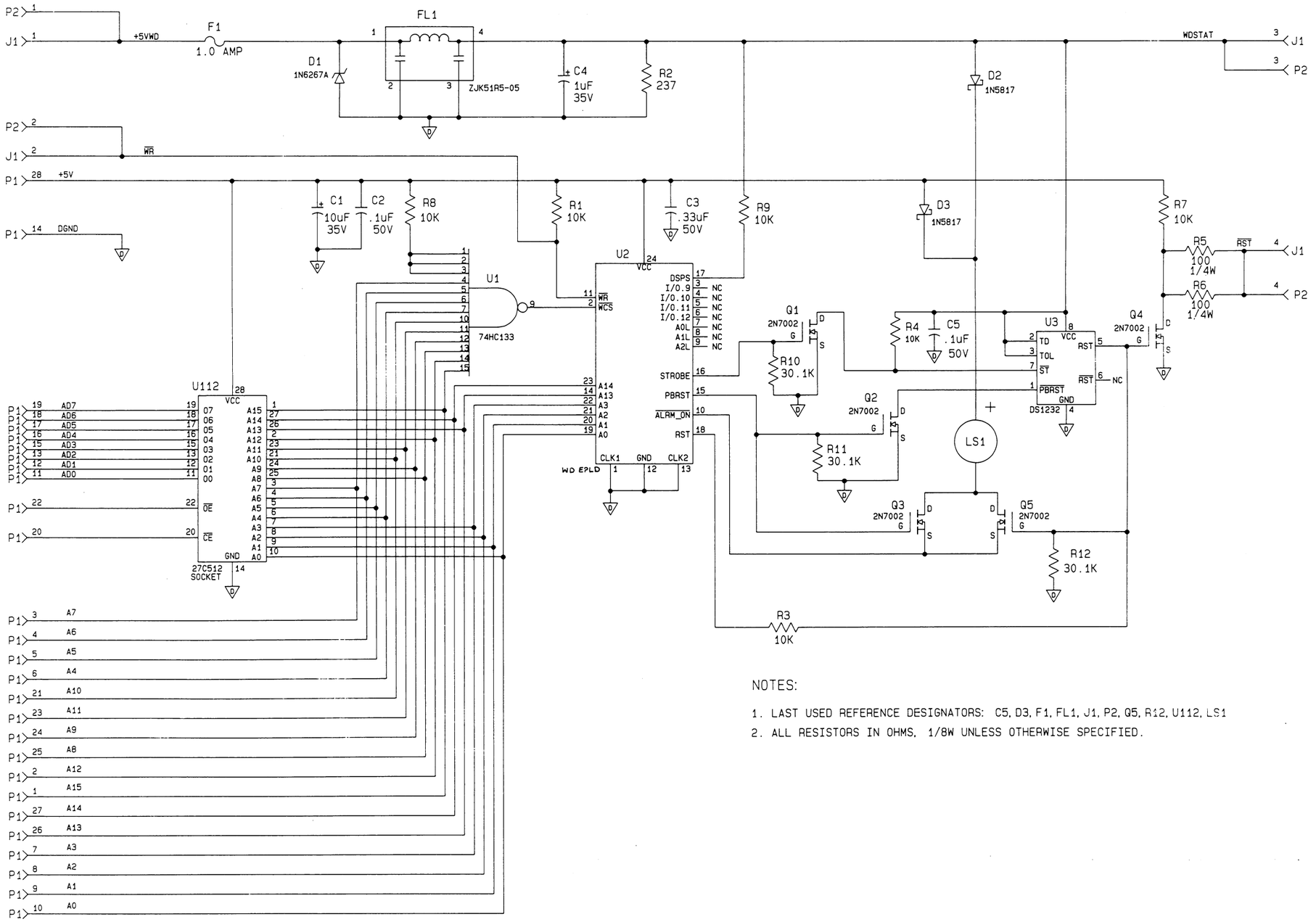


Figure 9-8 64K Control Board, 3 of 3



NOTES:

1. LAST USED REFERENCE DESIGNATORS: C5, D3, F1, FL1, J1, P2, Q5, R12, U112, LS1
2. ALL RESISTORS IN OHMS, 1/8W UNLESS OTHERWISE SPECIFIED.

Figure 9-9 Piggyback Watchdog Board

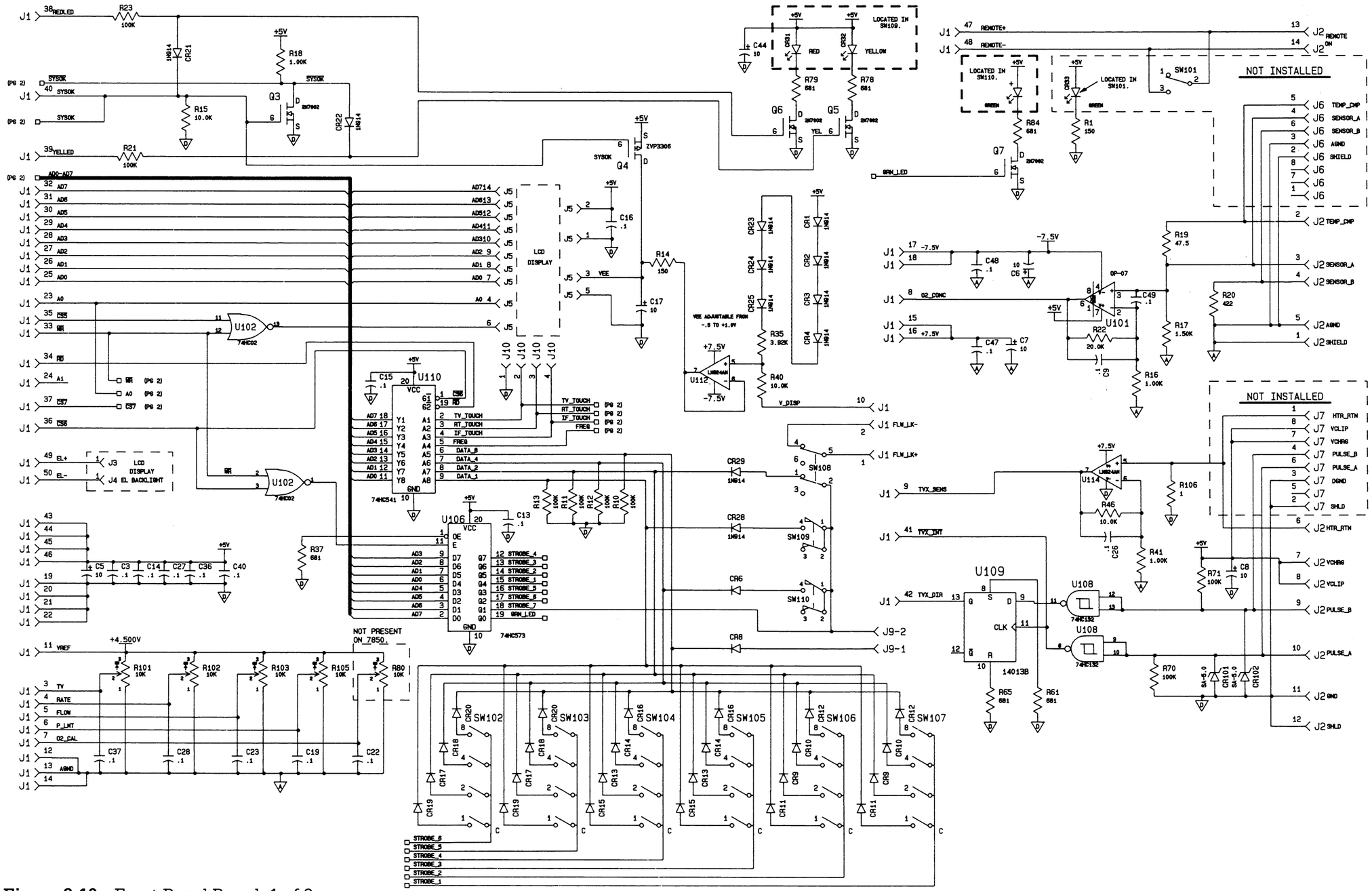


Figure 9-10 Front Panel Board, 1 of 2

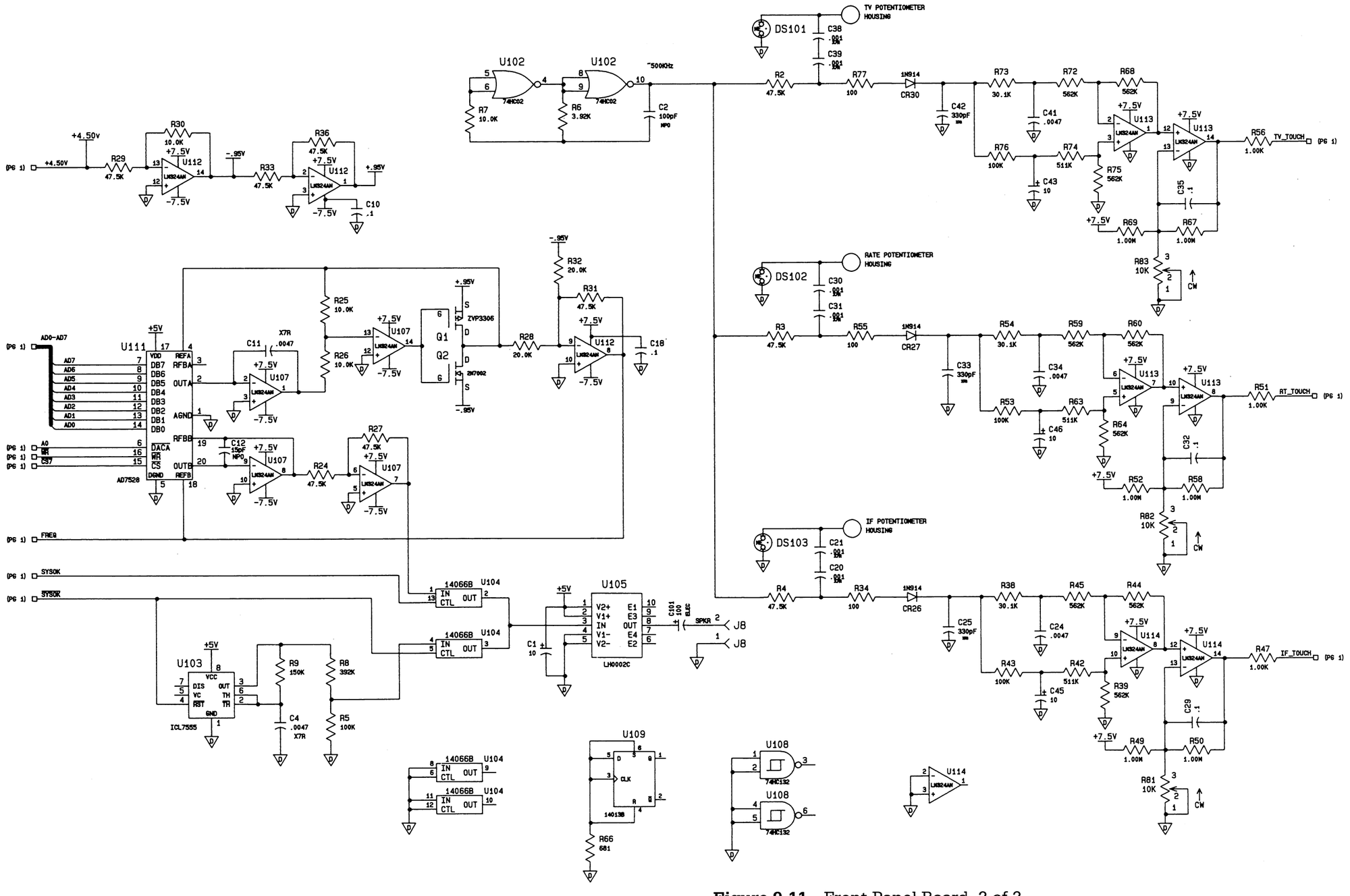


Figure 9-11 Front Panel Board, 2 of 2

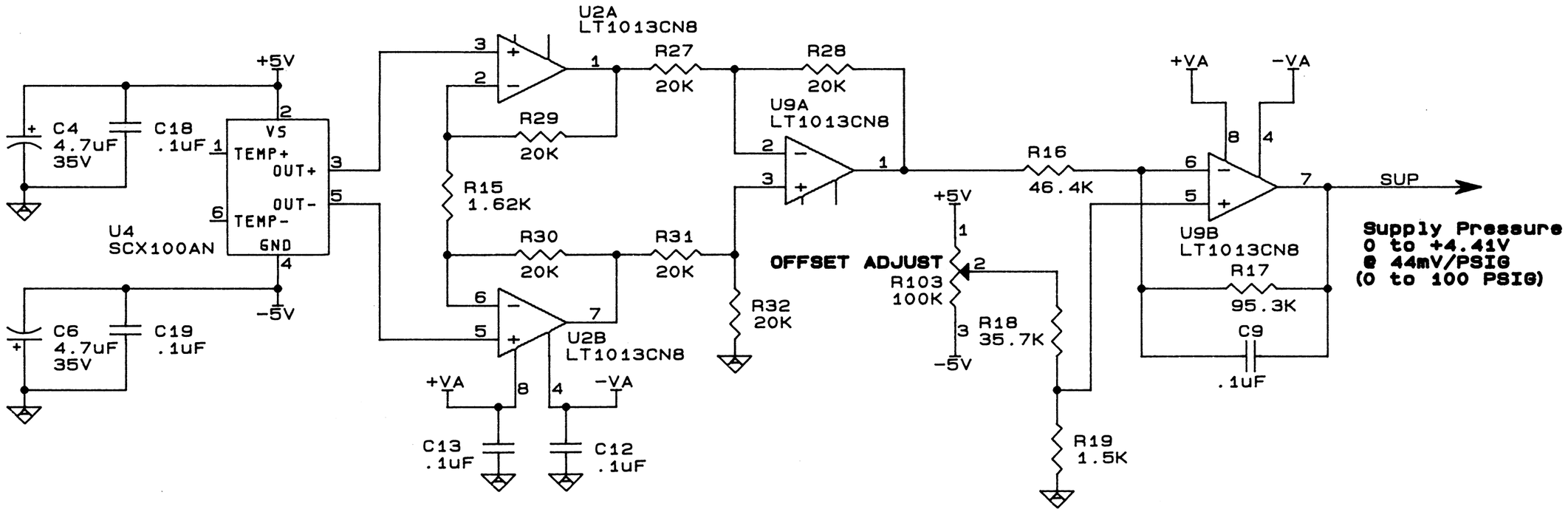


Figure 9-12 Universal Pressure Transducer Board, 1 of 3

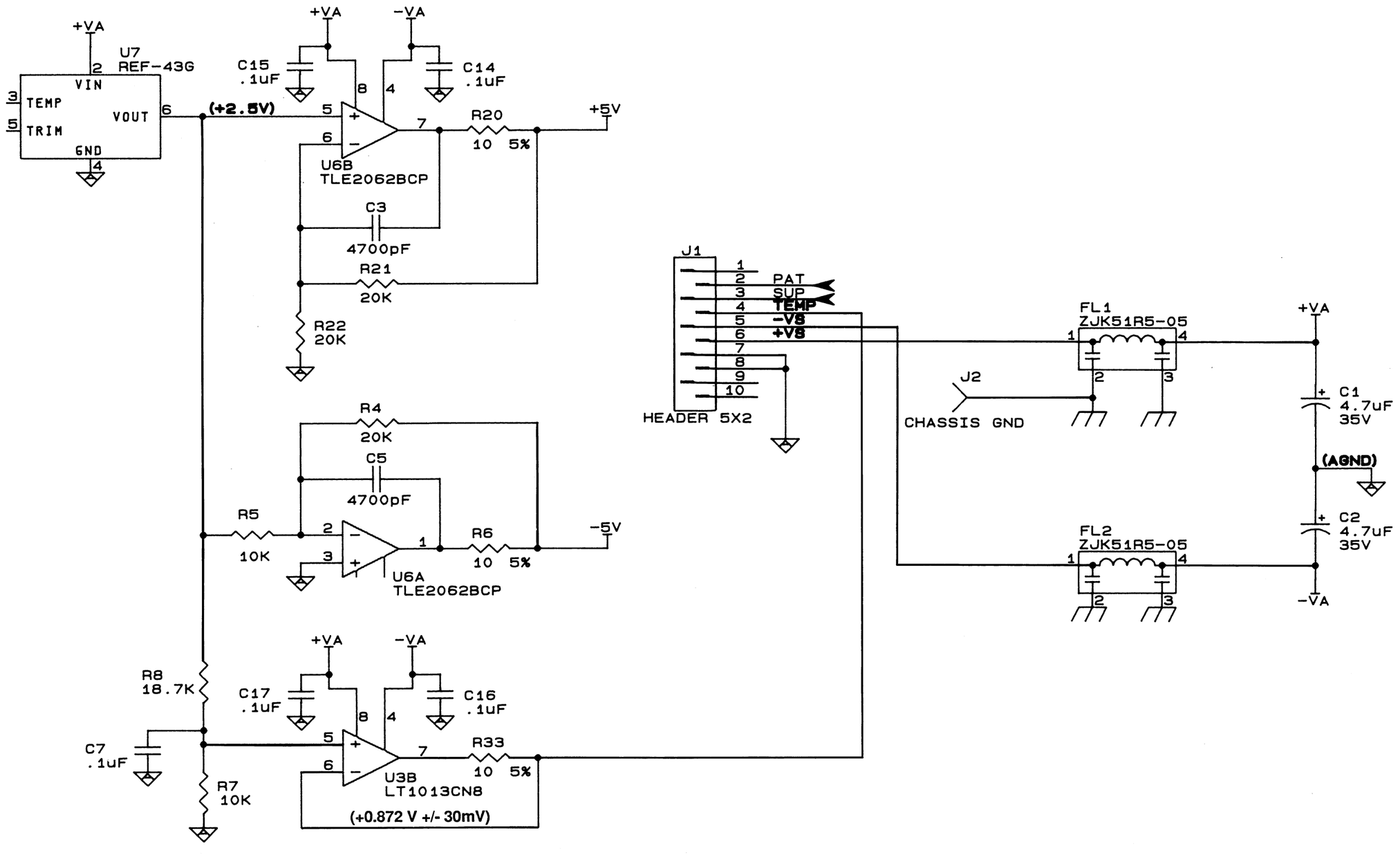


Figure 9-13 Universal Pressure Transducer Board, 2 of 3

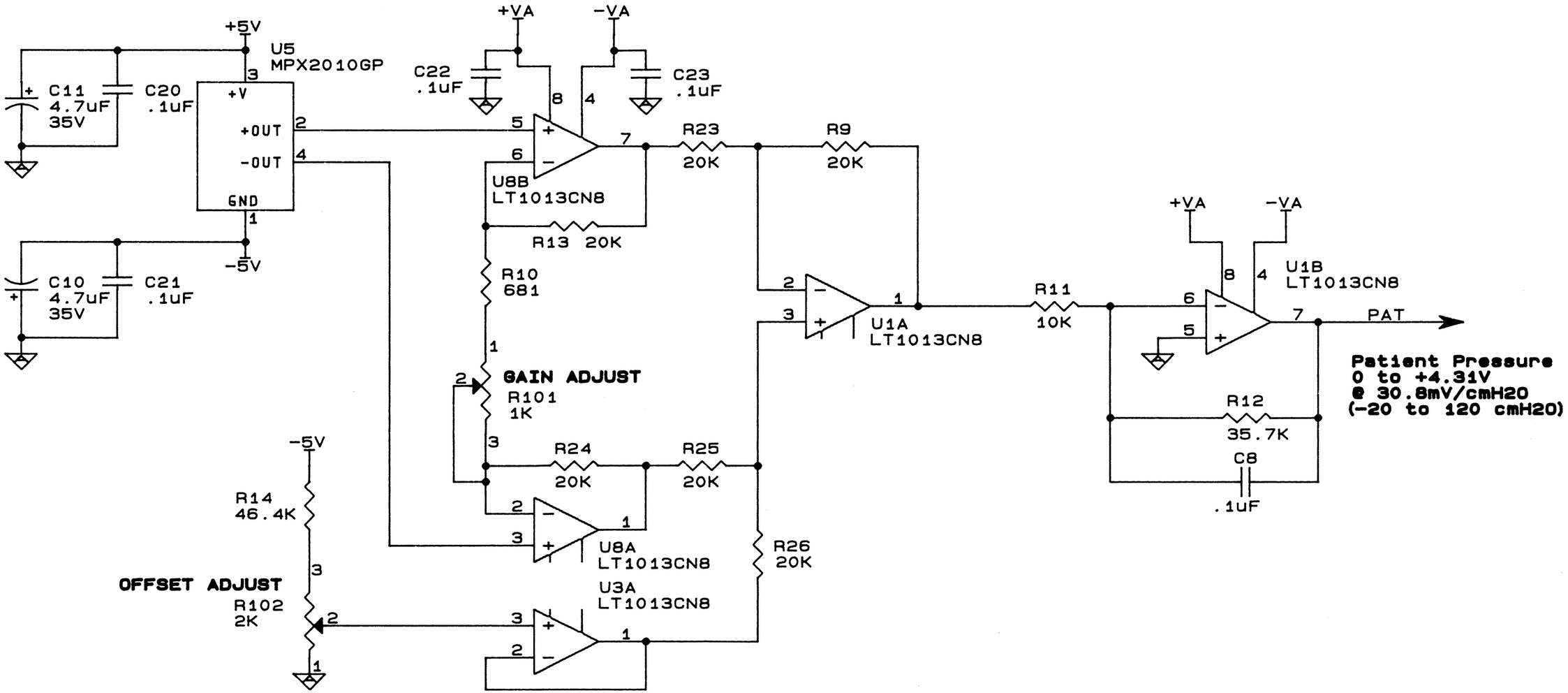


Figure 9-14 Universal Pressure Transducer Board, 3 of 3

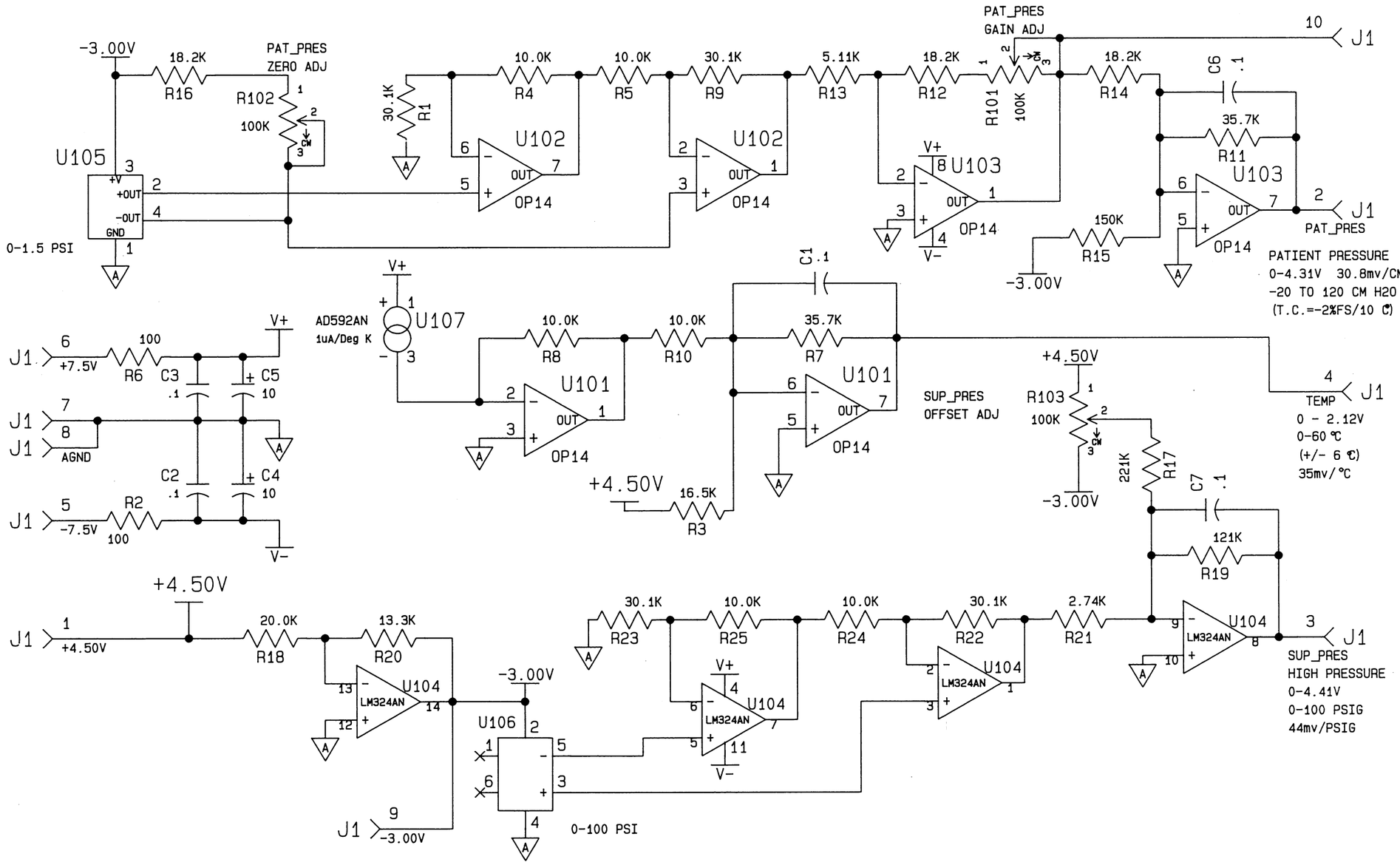


Figure 9-15 Pressure Transducer Board (Original)

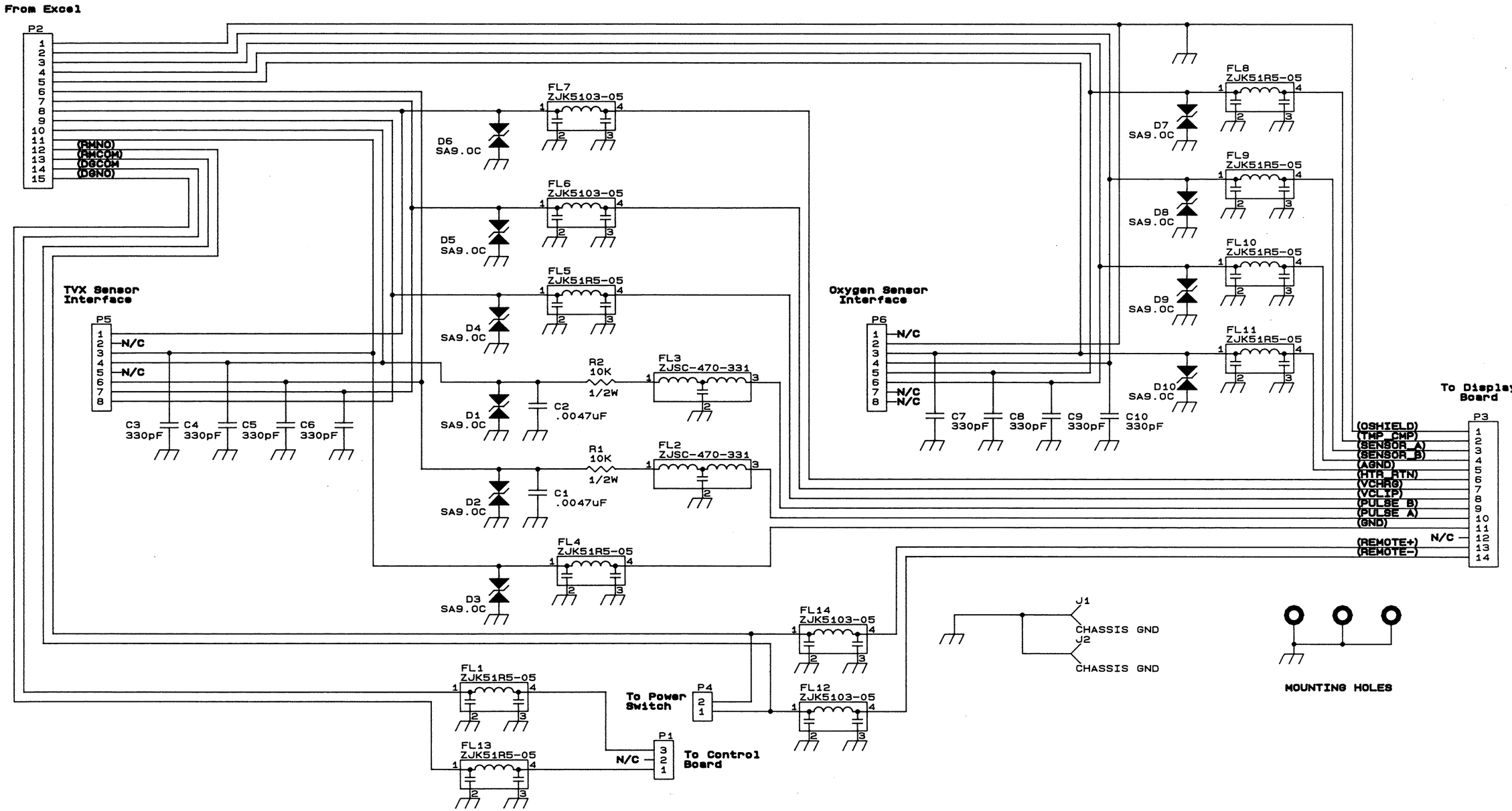
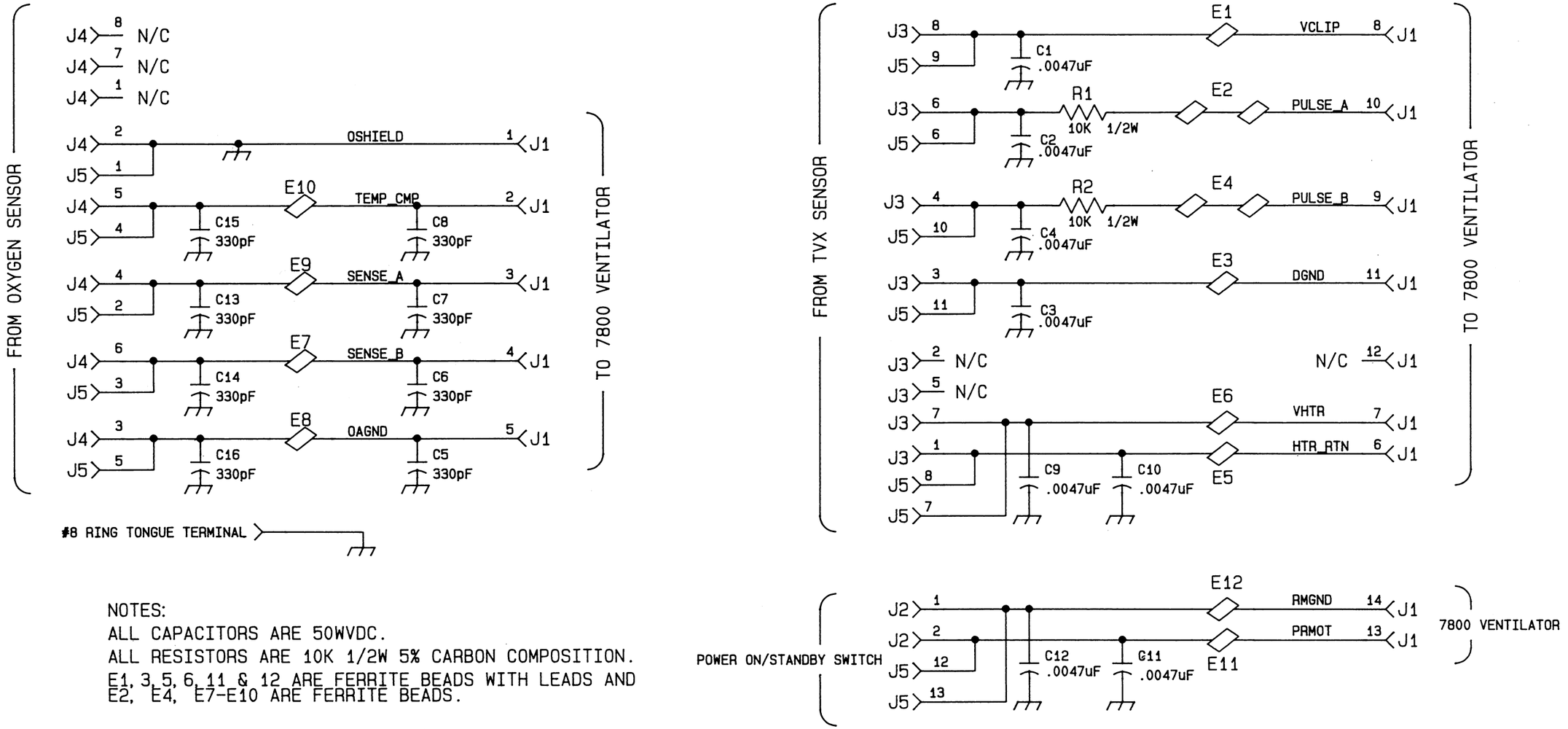


Figure 9-16 EMC/Interface Board (International)



NOTES:
ALL CAPACITORS ARE 50WVDC.
ALL RESISTORS ARE 10K 1/2W 5% CARBON COMPOSITION.
E1, 3, 5, 6, 11 & 12 ARE FERRITE BEADS WITH LEADS AND E2, E4, E7-E10 ARE FERRITE BEADS.

Figure 9-17 EMC/Interface Board (Original)

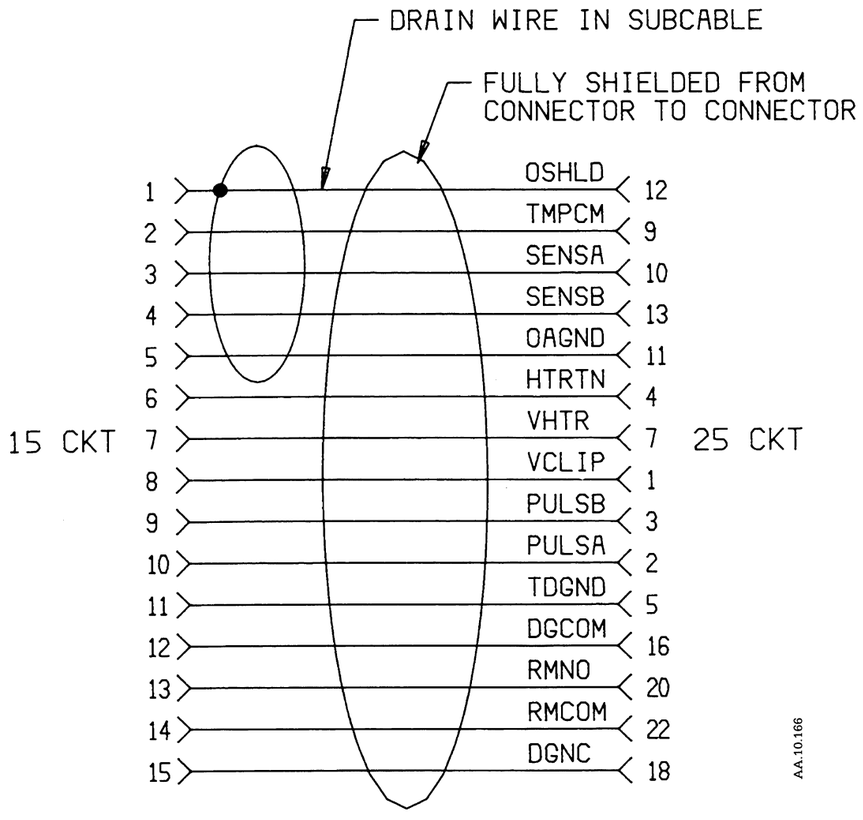


Figure 9-18 Excel/Ventilator Interface Cable (Excel Mount only)

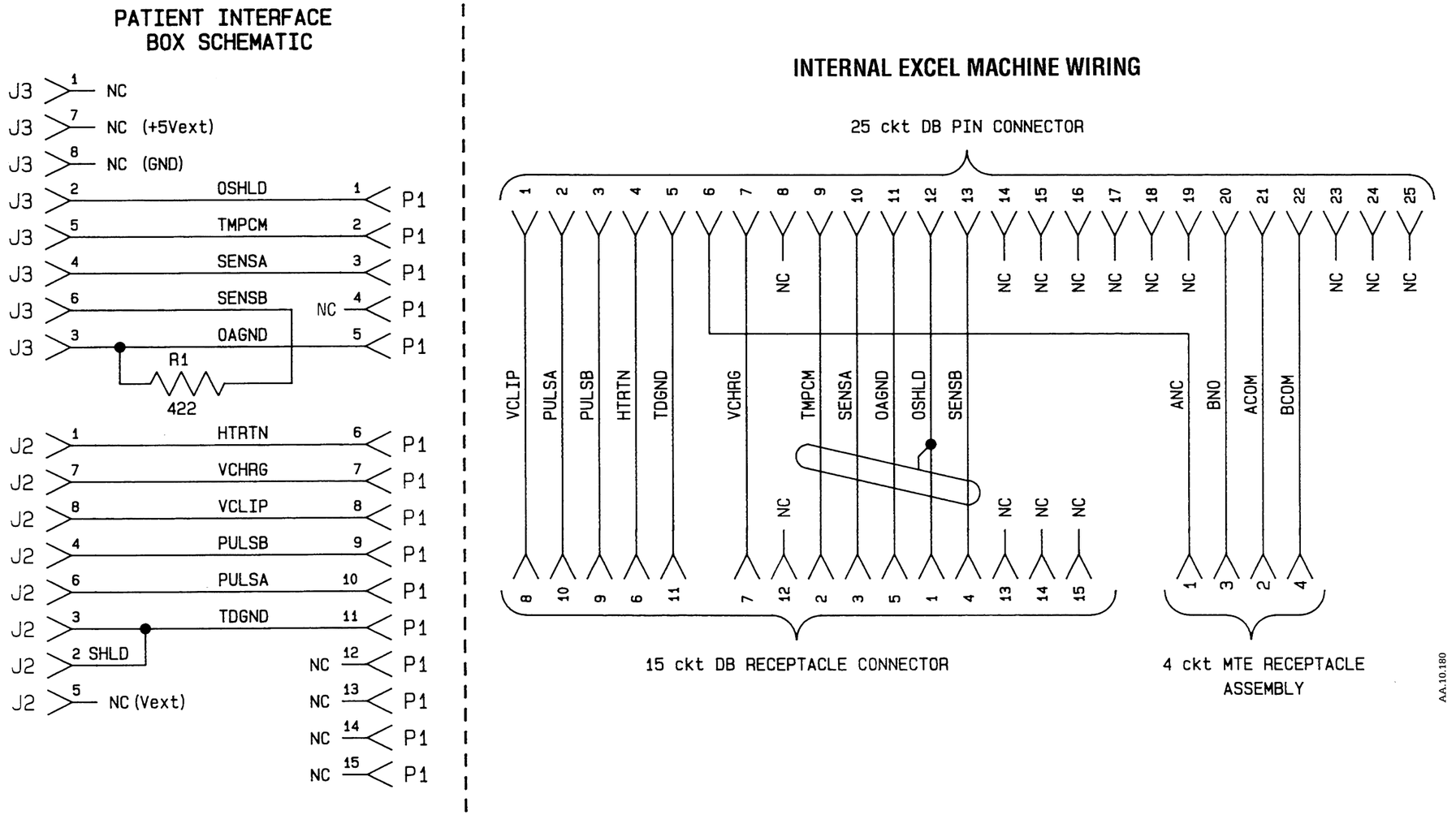


Figure 9-19 Patient/Interface Box and Internal Excel Machine (Excel Mount only)