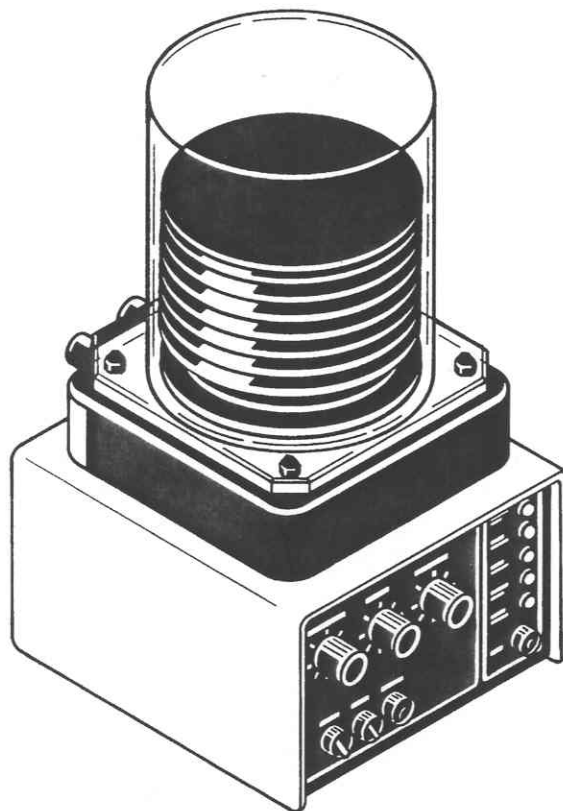


# 7000 Anesthesia Ventilator

(Multi-Voltage Electronic)

Service Manual



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# Important

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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 proper tools and test equipment. Consequently, Ohmeda provides this service manual to its customers purely as a business convenience and for the customers' 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 said 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 thereof before undertaking any service of the equipment. Comments and suggestions on this manual are invited from our customers for consideration by Ohmeda. Please send your comments and/or suggestions to the Manager of Service Education, Ohmeda, Ohmeda Drive, Madison, WI 53707.

**⚠CAUTION:** Servicing of this product in accordance with this service manual 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

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The procedures described in this service manual should be performed by trained and authorized personnel only. Maintenance should be undertaken only 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.

Genuine replacement parts manufactured or sold by Ohmeda are recommended for all repairs.

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.

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# Precautions

## Warnings

Notice: As used in this manual, a WARNING indicates a potentially life threatening situation; a CAUTION indicates a condition that may lead to equipment damage or malfunction.

The following WARNINGS and CAUTIONS are used in various places throughout this manual to appropriately inform the reader of possible hazards and problems.

**Possible Explosion Hazard.** Do not use in the presence of flammable anesthetics.

For protection against shock hazards, connect this equipment only to a three-wire grounded hospital grade receptacle. The three prong plug must be inserted into a properly wired three-wire receptacle. Where a two-wire receptacle is encountered, a qualified electrician must replace it with a properly grounded three-wire receptacle in accordance with the National Electrical Code. Do not, under any circumstances, remove the grounding prong from the power plug. Do not use extension cords or adapters of any type. The power cord and plug must be intact and undamaged.

The information in this manual is intended for use by personnel who have been adequately trained in the use and application of devices of this nature and have been instructed on the use of this specific equipment. Hospital administrative personnel are responsible for making certain that all operators of the instrument(s) described in this manual receive adequate training beforehand and that training courses for operators be scheduled on a regular basis. It is especially important that instruction be given for preventive maintenance as described in this manual.

When mounting the ventilator, use only Ohmeda 7000 Ventilator mounting kits. Inappropriate screws will damage internal components and may create an electrical shock hazard.

If used with an extension cord, the unit may be subject to electro-magnetic interference.

Do not, under any circumstances, perform any testing or maintenance on medical instruments while they are being used to ventilate a patient.

Disconnect power before removing the cover panel. Leave the power disconnected unless specifically instructed otherwise.

**Fire Hazard:** Never oil or grease any anesthesia equipment. In general, oils and greases oxidize readily, and in the presence of oxygen they will burn violently.

The alarm circuit check (Section 7.16) must be performed before the ventilator is returned to use after any service procedure.

Never use the ventilator if the jumper plug is missing; the audible alarm will malfunction. Always check to be sure that the audible alarm works before returning a unit to operation.

**Electrical Shock Hazard.** Do not touch exposed wires or conductive surfaces while the cover panel is removed from the ventilator unless electrical power is disconnected from the unit. Hazardous voltages are present during normal operation. Never wear a grounding wrist strap when working on an energized ventilator.

Do not use the ventilator until all the Preoperative Checkout Procedures have been performed and correct operation has been verified.

Do not connect the ventilator Exhaust directly to a vacuum source. The vacuum may remove required gases from the patient circuit.

Do not use the ventilator if it fails any part of the checkout procedure. Remove for service.

The bellows assembly should be sterilized periodically to minimize the risk of cross-infecting patients. Use a sterilization schedule which complies with the user's infection control and risk management policies.

Liquids or any foreign material trapped within the driving gas circuit of the Pop-off Valve (Port "A", Figure 4-15) and Bellows Base (Port "B" and Ports "C", Figure 4-15) can impair operation of the Pop-off Valve. Do not use the Pop-off Valve or Bellows Base if this is suspected. If complete disassembly is required to remove trapped foreign material, perform Pop-off Valve Performance Test (see Section 3.2) and Bellows Assembly Leak Test (see Section 3.3) before reuse.

Never tamper with or disassemble the flow control solenoid valves. Such actions will compromise the calibration of the Flow Control Unit, which must then be replaced as an assembly.

Only use the new style Pop-off Valve Assembly as a replacement part for a Base Assembly previously fitted with the new style Pop-off Valve. Do not use the new style Pop-off Valve on bases that *Do Not* have a raised identification mark on the left front corner of the Base Assembly.

# Precautions

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## Cautions

Always wear a grounding wrist strap when handling static sensitive assemblies except when working on an energized unit. Otherwise, electrostatic discharges can damage electronic components.

Only control boards with assembly revision 14 or higher can be used with this version of the 7000 Electronic Ventilator. Use of earlier version boards will result in malfunction of the ventilator.

Operation must be checked per Section 3 after performing any maintenance procedure.

Those parts suitable for ethylene oxide sterilization should, following sterilization, be quarantined in a well ventilated area to allow dissipation of residual gas absorbed by components. Follow the sterilizer manufacturer's recommendations for special aeration periods required.

Do not apply excessive force to the circuit board when removing it. Overstressing may damage the printed circuit board.

Be sure the proper voltage is selected on the power inlet module before plugging the unit into a mains receptacle.

Do not apply any compound to the pressure switches. Application of such substances may cause damage to the switch and cause malfunction of the switch.

Perform all calibration steps in the order given.

Connecting TP-20 to ground places the ventilator in a continuous gas delivery phase where the exhaust valve is continuously on (closed). If the ventilator is left on in this condition for more than one minute, overheating of the exhaust valve may occur.

# 1/General Information

## 1.1 Operational Briefs

**⚠ WARNING:** Possible Explosion Hazard. Do not use in the presence of flammable anesthetics.

**⚠ WARNING:** For protection against shock hazards, connect this equipment only to a three-wire grounded hospital grade receptacle. The three prong plug must be inserted into a properly wired three-wire receptacle. When a two-wire receptacle is encountered, a qualified electrician must replace it with a properly grounded three-wire receptacle in accordance with the National Electrical Code. Do not, under any circumstances, remove the grounding prong from the power plug. Do not use extension cords or adapters of any type. The power cord and plug must be intact and undamaged.

**⚠ WARNING:** The information in this manual is intended for use by personnel who have been adequately trained in the use and application of devices of this nature and have been instructed on the use of this specific equipment. Hospital administrative personnel are responsible for making certain all operators of the instruments described in this manual receive adequate training beforehand and that training courses for operators be scheduled on a regular basis. It is especially important that instruction be given for preventive maintenance as described in this manual.

**⚠ WARNING:** When mounting the ventilator, use only Ohmeda 7000 Ventilator mounting kits. Inappropriate screws will damage internal components and may create an electrical shock hazard.

**⚠ WARNING:** If used with an extension cord, the unit may be subject to electro-magnetic interference.

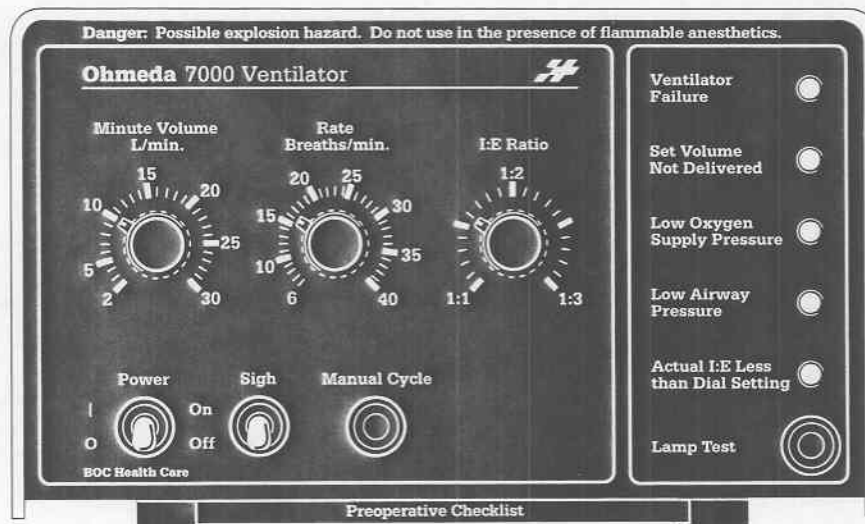
Note: This service manual covers the variation of the 7000 Electronic Ventilator which has selectable mains voltages. Earlier variations of the 7000 Electronic Ventilator are covered in the 7000 Electronic Ventilator Service Manual Stock Number 0178-0125-000.

The Model 7000 Anesthesia Ventilator is an electronically controlled, pneumatically driven device, specifically designed for mechanical ventilation of patients during surgery under general anesthesia. The instrument consists of two major parts:

1. The Bellows Assembly\* connects to both the control unit and anesthesia machine by flexible hoses, and isolates the breathing circle system from the driving gas. Provision is made for mounting the bellows assembly on top of the control unit.

Note: A Kit, (Stock No. 0219-7518-810) is available to be used with the Modulus II Anesthesia System which permits the GMS Absorber to 7000 Ventilator bellows interface. Installation instructions are provided with the kit.

\* The revised Bellows Base Assembly has a raised identification mark on the left front corner of the Base Assembly.



**Figure 1-1**  
Ventilator Controls, Connections and Indicator Lamps Front Panel View

# 1/General Information

2. The Control Unit contains all the electrical and pneumatic components necessary to drive the bellows assembly according to the selected parameters, and to perform the monitoring alarm functions.

The controls on the ventilator (Figure 1-1) are calibrated to linear scales, and are non-interactive so that changing one control setting does not affect the other control settings. They are set to the physiological parameters of Minute Volume, Breathing Rate, and Inspiratory/Expiratory ratio. From these settings, the electronic circuitry in the ventilator calculates the Flow and Tidal Volume to deliver to the patient.

Several alarm conditions are monitored by the electronic circuitry:

1. Low Oxygen Supply Pressure
2. Low Airway Pressure
3. High Airway Pressure
4. Ventilator Failure (electronics)
5. Selected Minute Volume not delivered
6. Actual I:E ratio less than dial setting

The ventilator operates from a nominal 50 psig oxygen source, usually delivered from the power outlet of an anesthesia gas machine. The driving gas consumption is approximately the same as the minute volume delivered.

## 1.2 Specifications

Note: Specifications are subject to change without notice.

### Minute Volume:

Adult Bellows Assembly: 2 to 30 L/min.

Pediatric Bellows Assembly: 2 to 12 L/min.

Accuracy: 5% of dial setting  $\pm 2\%$  full scale.

### Rate:

Calibrated from 6 to 40 Breaths Per Minute (BPM).

Accuracy: 5% of dial setting  $\pm 1$  Breath.

### I:E Ratio:

Calibrated Range from: 1:1 to 1:3.

Accuracy: within 20% of dial setting at sea level.

### Sigh:

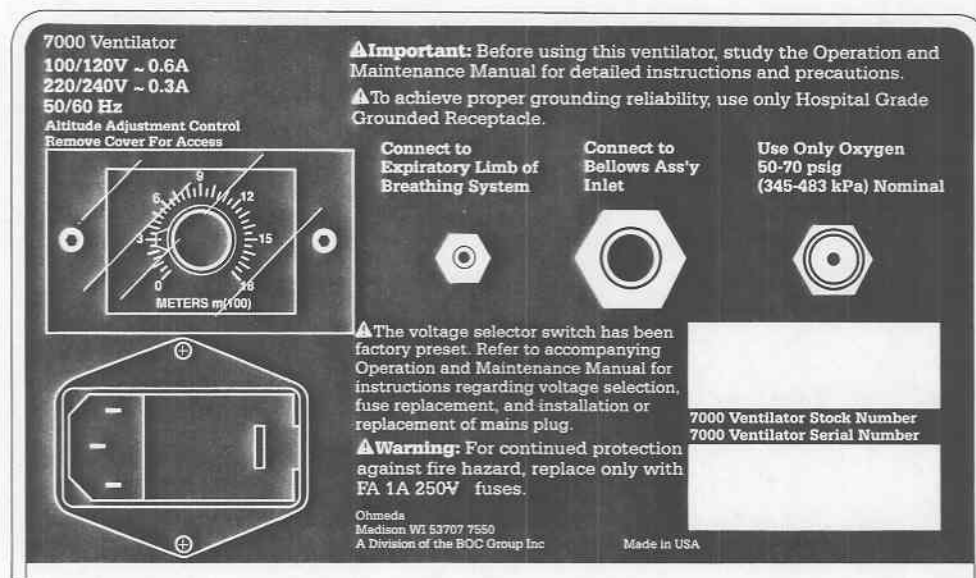
Switchable On or Off sigh function.

One sigh frequency: every 64 breaths  $\pm 2$  breaths.

Sigh-Volume: 150% of tidal volume, with 1.5 liter maximum.

### Manual Cycle:

Pushbutton to initiate breathing cycle manually.



**Figure 1-2**  
Ventilator Controls and Connections, Rear Panel View



# 1/General Information

---

**Altitude Compensation Range:**

0 to 1,800 meters above sea level.

**Tidal Volume:**

Calculated automatically; limited to 1.5 liter maximum.

Note: The bellows scale is an approximation of the Tidal Volume and should be used only as a guide.

**Flow Rate:**

4 to 60 L/min.

**Alarms:**

Set Volume Not Delivered.  
Low Oxygen Supply Pressure.  
Low Airway Pressure.  
Actual I:E Less than Dial Setting.  
Ventilator Failure.  
Power Failure.

**Ventilator Compliance:**

With Adult Bellows:  
Approximately 3 mL/cm H<sub>2</sub>O.  
With Pediatric Bellows:  
Approximately 1.5 mL/cm H<sub>2</sub>O.

Note: Ventilator compliance will vary depending on the length and material of the flexible hose between the control module and bellows assembly.

**Driving Gas Requirement:**

Oxygen at 50 - 70 psig (345 - 483 kPa) and 70 L/min flow.

**Leakage Current:**

There must be less than 35 microamps leakage current at 100/120 V ac or less than 70 microamps leakage current at 220/240 V ac under all conditions.

Ground resistance must be less than .15 ohms.

**Dimensions:****(in centimeters)**

Control unit: 22.1 wide x 23.4 deep x 13.3 high  
Bellows housing: 19.0 wide x 19.0 deep x 22.2 high

**(in inches)**

Control Unit: 8.7 wide x 9.2 deep x 5.2 high  
Bellows Housing: 7.5 wide x 7.5 deep x 8.7 high

**Weight:**

Control unit: 6.3 kilograms (14 pounds)  
Bellows housing: 2.2 kilograms (5 pounds)

**Electrical Requirements:**

53 Watts at 100/120/220/240 V ac  $\pm$  10%  
50/60 Hz

## 2/Theory of Operation

### 2.1 Mathematical Relationships

(Of Breathing Rate, Minute Volume, Tidal Volume, I:E Ratio, and Inspiratory Flow Rates:)

R = Rate, number of breaths per minute.

MV = Minute Volume, number of liters per minute of exchanged gas.

TV = Tidal Volume, the volume of each breath.

I = Inspiration Time, the time during which gas is supplied to the patient lungs.

E = Expiration Time, the time during which gas is exhaled from the lungs of the patient including any end expiratory pause.

I:E = I:E Ratio, the ratio of inspiration and expiration times.

Conventionally expressed as 1: number such as 1:1, 1:2, etc.

F = Flow, the actual inspiratory flow rate at any given instant expressed in liters per minute (L/min).

Given the physiological parameters of MV, R and I:E it is possible to compute TV, F, and E from the following equations:

1.  $TV = MV/R$

2. Avg Flow =  $MV = (F \cdot I)/(I+E)$   
solving for F:  
 $F = MV(1+E/I)$

Expresses the inspiratory flow rate in terms of minute volume and the I:E ratio, which are set on the front panel.

3.  $I+E = 60/R$   
 $I(1+E/I) = 60/R$   
 $I = 60/[R(1+E/I)]$

Expresses the inspiration time in terms of the Rate and the I:E ratio, which are set on the front panel.

4.  $I+E = 60/R$   
 $E = (60/R) - (60/[R(1+E/I)])$   
 $E = 60[1/(1+E/I)]/R$

Expresses the expiration time in terms of the Rate and the I:E ratio, which are set on the front panel.

Consider a numerical example:

MV = 8 L/min  
R = 12 BPM (Breaths Per Minute)  
I:E = 1:2

We have:

$TV = 8/12 = 0.667$  liters  
 $F = MV(1+E/I) = 8(1+2) = 24$  L/min  
 $I = 60/R(1+E/I) = 60/12(1+2) = 1.67$ s  
 $E = 60[1-(1/(1+E/I))]/R = 60[1-(1/(1+2))]/12 = 3.33$ s

The preceding relationships in terms of Minute Volume, Rate, and I:E Ratio are used by the control circuitry of the Ventilator to deliver the appropriate Flow.

### 2.2 Patient Volumes vs. Ventilator Set Volume

Several factors within the breathing system including the patient affect the delivered patient volume. The extent of these variations depend on the type of breathing system used.

1. Compliance of the breathing system reduces the volume from the ventilator that is delivered to the patient. Compliance can be defined as the volume of gas which when added to a closed system produces a unit increase in pressure. The compliance of any circle absorber system can be a significant factor because of its large internal volume. Because of this large volume, it requires more of the ventilator's delivered volume to produce a unit increase in pressure within the system.

An approximate compliance factor for a circle absorber system with the 7000 Anesthesia Ventilator is  $C = 10$  mL/cm  $H_2O$ . This can be used only as an approximate comparison of measured patient volumes and ventilator set volumes.

MVpt = Patient Minute Volume  
TVpt = Patient Tidal Volume  
MVv = Ventilator set Minute Volume  
MVc = Minute Volume lost because of compliance of the system  
 $\Delta P$  = Change in circuit pressure  
C = Compliance of the system  
TVc = Tidal Volume lost because of compliance of the system  
R = Rate, number of breaths per minute

$$MV_{pt} = MV_v - MV_c = MV_v - C \cdot \Delta P \cdot R$$

or:

$$TV_{pt} = \frac{MV_v}{R} - TV_c = \frac{MV_v}{R} - C \cdot \Delta P$$

2. Fresh Gas Flow into the breathing system during inspiration adds to the volume from the 7000 Anesthesia Ventilator that is delivered to the patient.

MVpt = Patient Minute Volume  
TVpt = Patient Tidal Volume  
MVv = Ventilator set Minute Volume  
MVfgf = Minute Volume total Fresh Gas Flow  
fgf = Total Fresh Gas Flow  
R = Rate, number of breaths per minute

## 2/Theory of Operation

TVfgf = Tidal Volume total fresh gas flow  
(I:E) = I:E ratio 1:2 so E/I = 2

$$MV_{pt} = MV_v + MV_{fgf} = MV_v + \frac{fgf}{(1 + E/I)}$$

or:

$$TV_{pt} = \frac{MV_v}{R} + TV_{fgf} = \frac{MV_v}{R} + \frac{fgf}{R(1 + E/I)}$$

3. Leaks in the breathing system during inspiration reduce the volume from the ventilator delivered to the patient. This factor is usually small, however, it should be considered.

MVpt = Patient Minute Volume  
TVpt = Patient Tidal Volume  
MVv = Ventilator set Minute Volume  
MVI = Minute Volume lost to leaks  
TVI = Tidal Volume lost to leaks  
VI = Leak rate at peak inspiratory pressure  
R = Rate, number of breaths per minute  
(I:E) = I:E ratio 1:2 so E/I = 2

$$MV_{pt} = MV_v - MVI = MV_v - \frac{VI}{2(1 + E/I)}$$

or:

$$TV_{pt} = \frac{MV_v}{R} - TVI = \frac{MV_v}{R} - \frac{VI}{2R(1 + E/I)}$$

### Example:

To determine the measured patient Minute Volume or Tidal Volume expected from the 7000 Anesthesia Ventilator attached to a circle absorber breathing system, make the following calculations:

Ventilator Setting: Minute Volume = 8 L/min  
Rate = 10/min  
I:E = 1:2  
Fresh Gas Flow (fgf) = 4 L/min  
Change in Circuit Pressure ( $\Delta P$ ) = 30 cm H<sub>2</sub>O  
Breathing Circuit Leak (V) = 500 mL/min at 60 cm H<sub>2</sub>O

Breathing circuit leakage is assumed to be directly proportional to pressure:

$$VI = \frac{500 \text{ mL/min}}{60 \text{ cm H}_2\text{O}} (30 \text{ cm H}_2\text{O}) = 250 \text{ mL/min}$$

$$MV_{pt} = MV_v - MV_c + MV_{fgf} - MVI$$

$$= MV_v - C \cdot \Delta P \cdot R + \frac{fgf}{(1 + E/I)} - \frac{VI}{2(1 + E/I)}$$

$$= 8 \text{ L/min} - \frac{(10 \text{ mL/cm H}_2\text{O})(30 \text{ cm H}_2\text{O})(10/\text{min})}{(1000 \text{ mL/L})} + \frac{4 \text{ L/min}}{(1 + 2)} - \frac{250 \text{ mL/min}}{2(1 + 2)1000}$$

$$= 8 \text{ L/min} - 3 \text{ L/min} + 1.33 \text{ L/min} - .042 \text{ L/min}$$

$$\text{Patient Minute Volume (MVpt)} = 6.29 \text{ L/min}$$

or:

$$TV_{pt} = \frac{MV_v}{R} - TV_c + TV_{fgf} - TVI$$

$$= 800 \text{ mL} - 300 \text{ mL} + 133 \text{ mL} - 4.2 \text{ mL}$$

$$\text{Patient Tidal Volume (TVpt)} = 629 \text{ mL of each breath.}$$

## 2/Theory of Operation

### 2.3 Pneumatic Operation

(See Figure 2-1)

The driving gas (oxygen at 50 psig nominal) connects to the ventilator enroute to the pressure regulator. The output of the regulator is set for 38 psig  $\pm$  0.50 psig at 24 L/min flow, and connects directly to the flow control solenoid valves.

The flow control valves are electronically controlled during the inspiratory time to direct gas flow through calibrated orifices. The orifices are calibrated for flows of 2, 4, 8, 16 and 32 L/min. The range of flow selection is 4 L/min to 60 L/min, in 2 L/min increments.

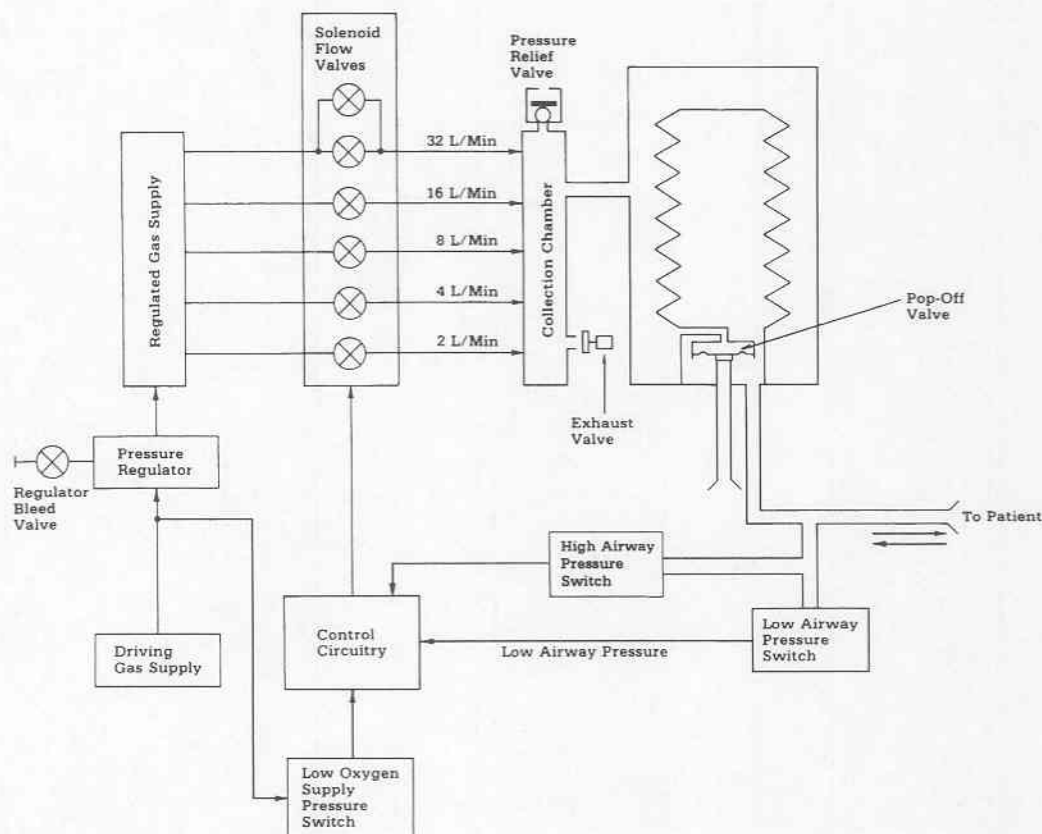
Both the pressure within the patient breathing circuit and the pressure generated from the settings of the control module act upon the bellows. The bellows assembly can be thought of as the interface between the anesthesia gas circuit and the control module driving gas circuit, even though the two circuits are isolated from each other.

Note: The anesthesia machine's oxygen flush valve is used to inflate (extend) the bellows before initiation of patient ventilation. For purposes of discussion, it will be assumed that ventilation begins with the bellows extended.

During the inspiratory phase, the control module delivers its pre-established gas flow into the area between the bellows and the transparent bellows housing. As the volume of gas increases within the bellows housing, pressure is exerted on the bellows which in turn exerts pressure in the patient breathing circuit, including the patient's lungs. When the pre-established gas volume has been delivered into the bellows housing, the process is reversed and the expiratory phase begins.

During the expiratory phase, gas flows from the patient breathing circuit into the inside of the bellows. The flow is a combination of fresh gas flow from the anesthesia machine and patient exhaled gas. The bellows expands, thus exerting pressure on the area between the bellows and the bellows housing.

There are three valves which are of importance during the inspiration-expiration cycle. One of these is the driving gas exhaust valve located in the control module. This valve remains closed during the inspiration phase when gas is being delivered into the bellows housing. It opens, however, during the expiratory phase to pro-



**Figure 2-1**  
Block Diagram



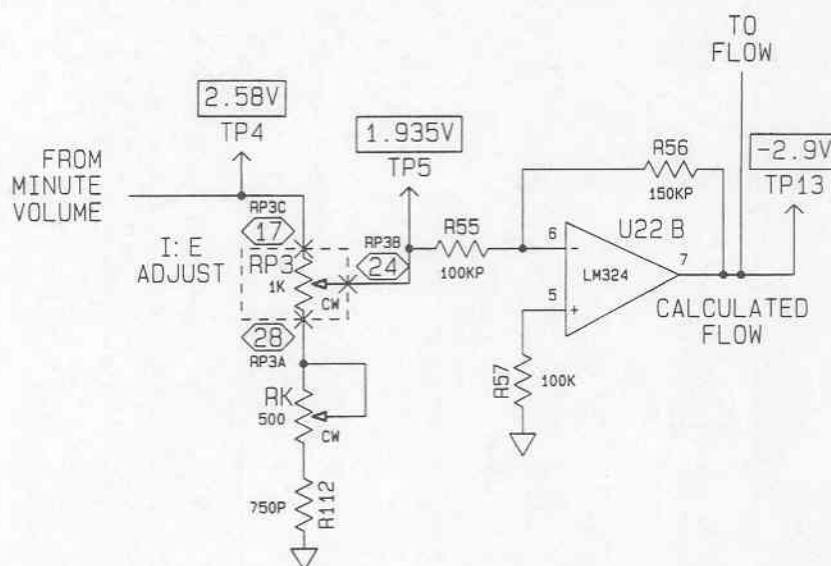


## 2/Theory of Operation

**I:E Ratio:** See Figure 2-3. The flow voltage is produced by multiplying MV by  $(1 + E/I)$ . A series arrangement of I:E potentiometer RP3 with RK, and R112 provides a linear range of I:E from 1:1 to 1:3. The resultant output at TP-13 represents a flow corresponding to the MV and I:E setting.

U22B is an amplifier in an inverting configuration. In the circuit, the (+) input is grounded and the signal is applied to the (-) input through R55, with feedback returned from the output R56. The resistors R55 and R56 determine the gain of the circuit.

Note: Potentiometers RI, RJ, and RK compensate for errors in the control potentiometers.



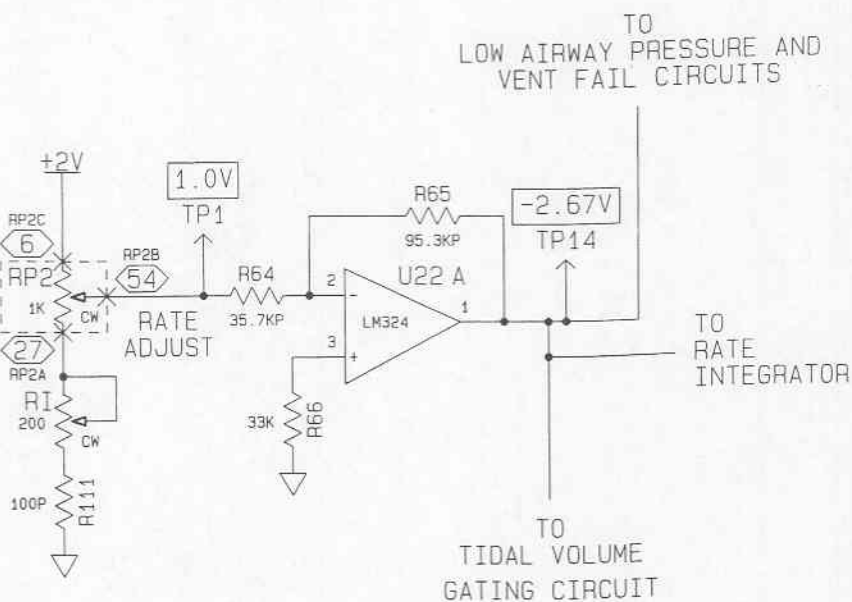
**Figure 2-3**  
I:E Ratio Circuit

## 2/Theory of Operation

**Rate:** See Figures 2-4, 2-5, and 2-6. The Rate Control has a calibrated range from 6-40 BPM. A series arrangement of the Rate potentiometer RP2 with R1, R111, and a reference of 2 volts provides a linear signal scaled to 0.05 V/BPM.

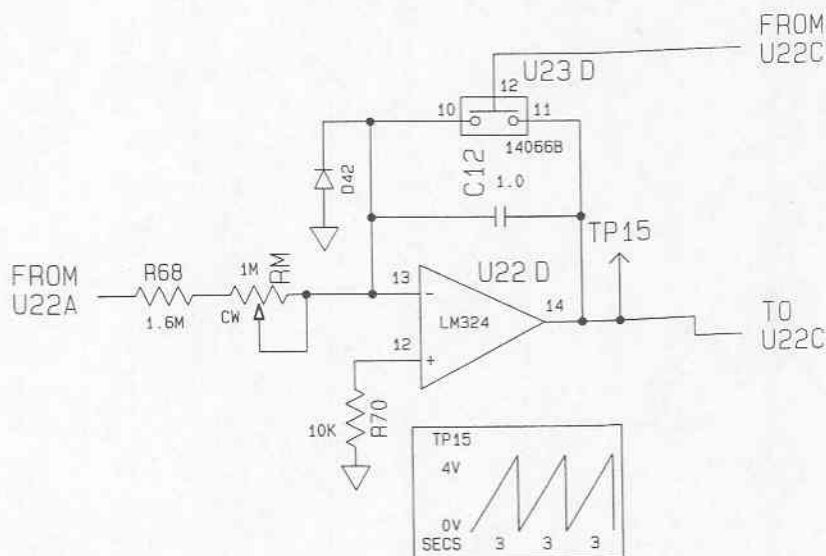
**Note:** Potentiometers R1, R2 and R3 compensate for errors in the control potentiometers.

U22A is a scaler and multiplier in an inverting configuration. In the circuit, the (+) input is grounded and the signal is applied to the (-) input through R64, with feedback returned from the output through R65. The resistors R64 and R65 determine the gain of the circuit.



**Figure 2-4**  
Rate Scaler Circuit

Potentiometer RM calibrates the rate of integration. U23 is a solid state switch that resets the integrator. The voltage is integrated on capacitor C12 in the feedback loop of Op-amp U22D.

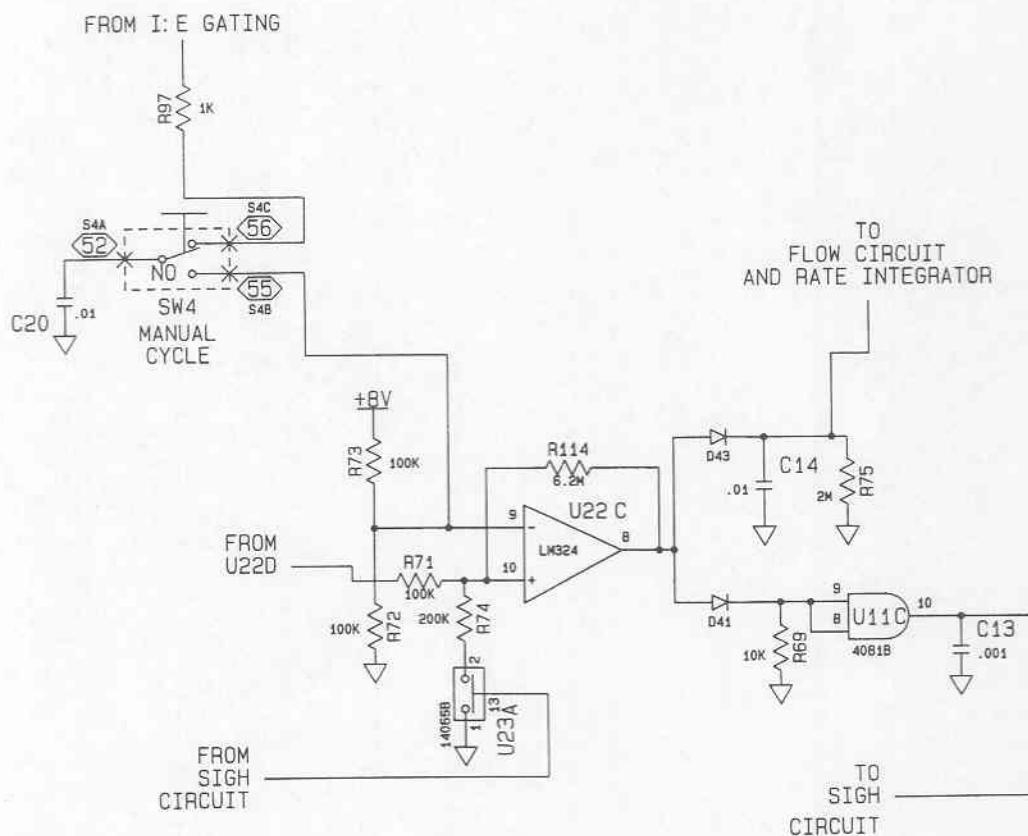


**Figure 2-5**  
Rate Integrator Circuit

## 2/Theory of Operation

U22C compares the ramp voltage from U22D to a fixed voltage of four volts which is set by R73 and R72. When the voltages become equal, the comparator changes state. AND gate U11C adjusts the signal from an analog voltage level to a digital voltage level. The Manual Cycle

function can be initiated only during the expiratory phase. Depressing the front panel Manual Cycle pushbutton (SW4) connects a negative voltage to comparator U22C which resets integrators U22D and U17 starting a new rate and flow ramp.

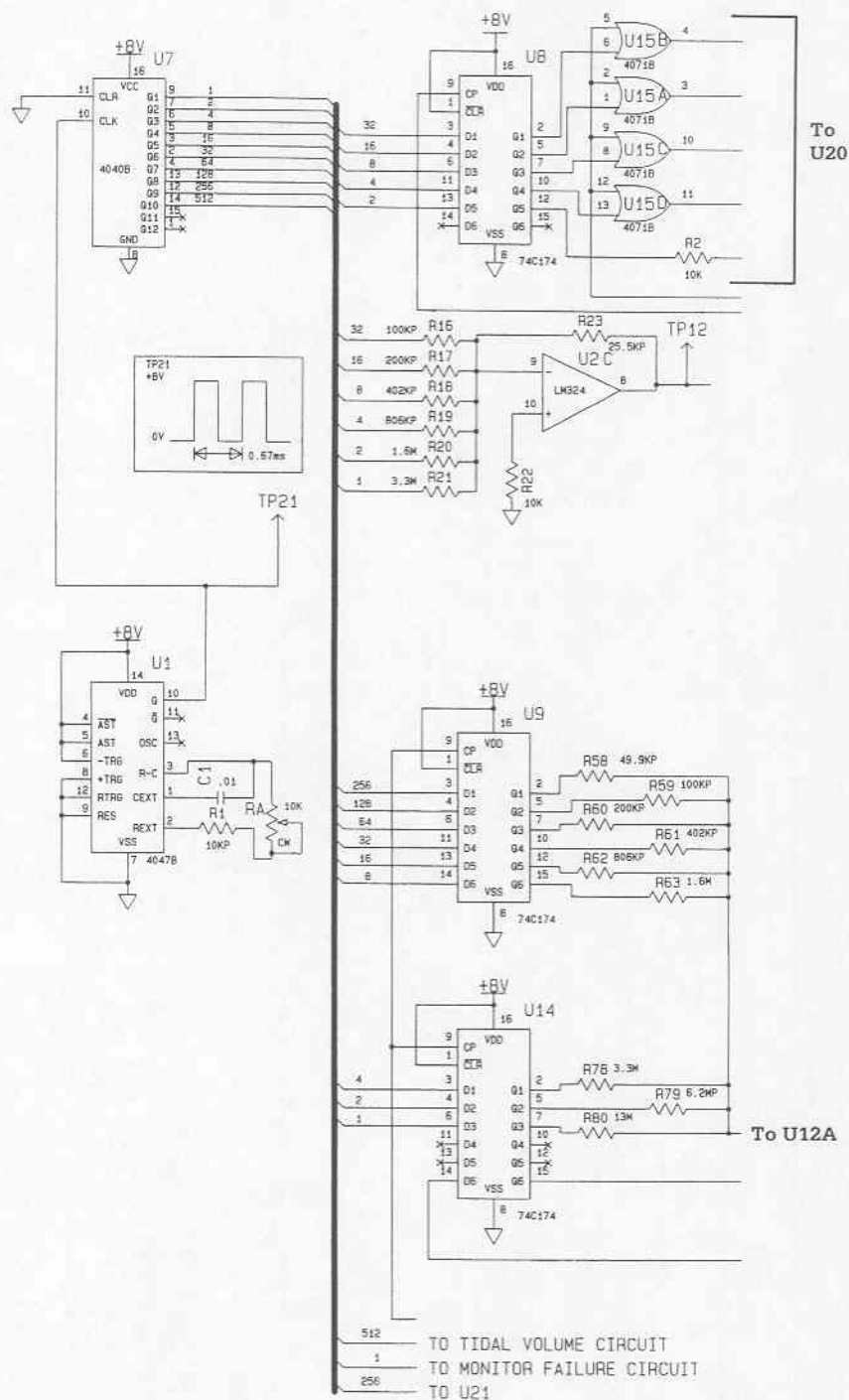


**Figure 2-6**  
Rate Analog to Digital Circuit

## 2/Theory of Operation

**Bus:** The clock U1 oscillates at approximately 1500 Hz and drives an auto-cycling binary counter U7. The frequency of the clock is adjusted by potentiometer RA. Ten of the counter (U7) outputs are used for the timing functions. Five of the outputs (Q1 to Q5) drive the solenoid valves through latch U8 and transistor array U20. These five outputs correspond to binary counts of 2, 4, 8, 16 and 32, which also correspond to the flow values of 2, 4, 8, 16 and 32 L/min. The 6-low outputs (Q1 to Q6; binary 1, 2, 4, 8, 16, 32) drive a digital to analog converter (DAC) U2C. This converter

develops the signal that is used for delivery of the actual flow. The 9 outputs (Q1 to Q9; binary 1, 2, 4, 8, 16, 32, 64, 128, 256) of the counter drive another DAC-U12A (via latch U9 and U14) which is the Tidal Volume generator circuit. Its output is the calculated Tidal Volume. An additional use of the 256th count is to cause the audio and the visual alarms to beep and blink by toggling the alarm pulser/driver circuit U21. The 512th count is used for resetting integrators U5B (Tidal Volume limit check) and U4 (Tidal Volume gating).

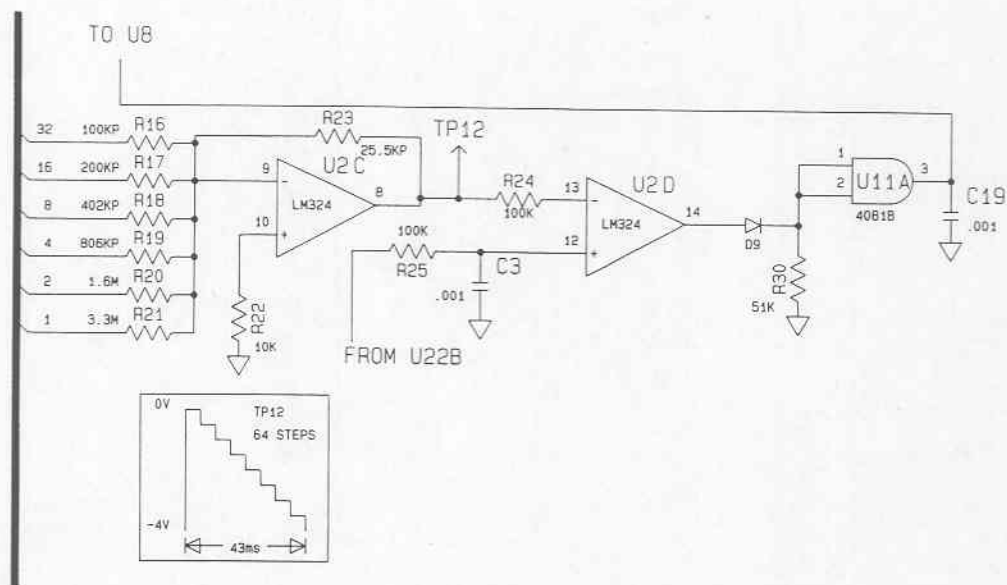


**Figure 2-7**  
Clock Circuit

## 2/Theory of Operation

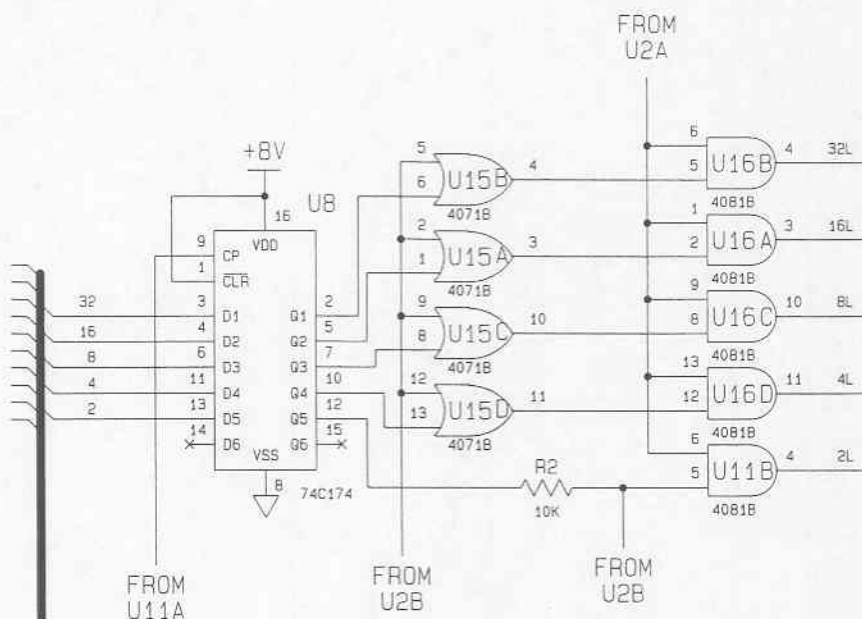
**Flow:** See Figure 2-8. Comparator U2D compares the flow voltage against a staircase voltage from DAC U2C. (The output span of the negative staircase is such that the Flow voltage

is always limited to the equivalent of 63 L/min as a maximum value). When the two voltages at the inputs of U2D are equal the output of the comparator goes high, enabling latch U8.



**Figure 2-8**  
Flow DAC Circuit

See Figure 2-9. (There are 5 AND gates and 5 OR gates. One of the OR gates is made up of R2 and D1.) The valves stay open as long as the AND gates are enabled by U2A during the inspiration phase.

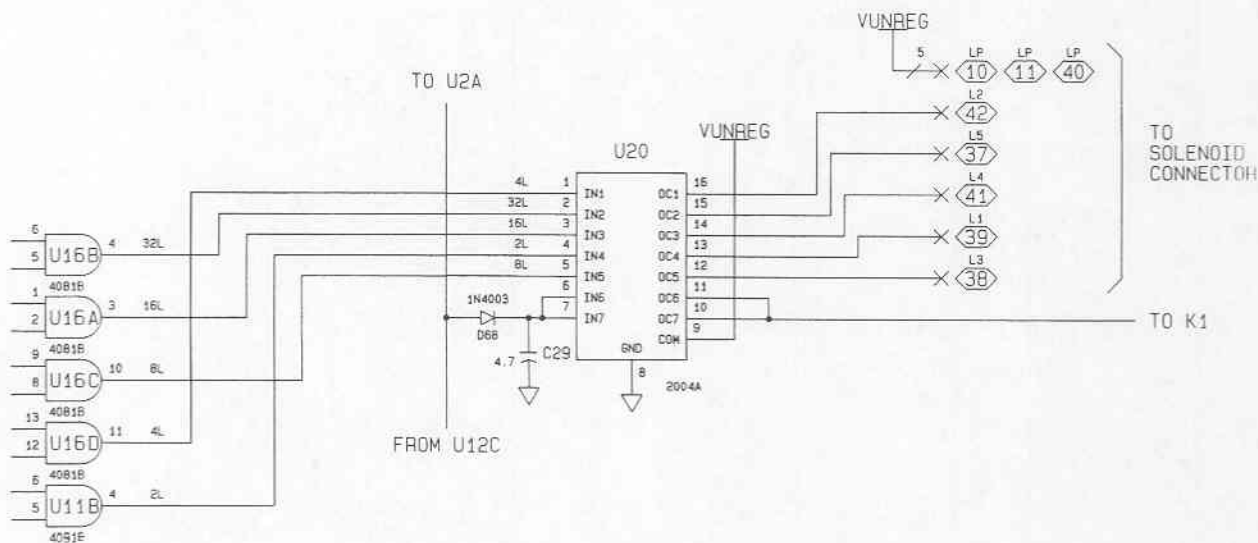


**Figure 2-9**  
Flow Gating Circuit



## 2/Theory of Operation

See Figure 2-10. U20 driver is an array of Darlington pairs that interfaces the low current electronics to the high current solenoid valves. The Darlington Transistor Array has a 10.5 K ohm series input resistor which operates directly from CMOS or PMOS outputs utilizing supply voltages of 6 to 15 V.



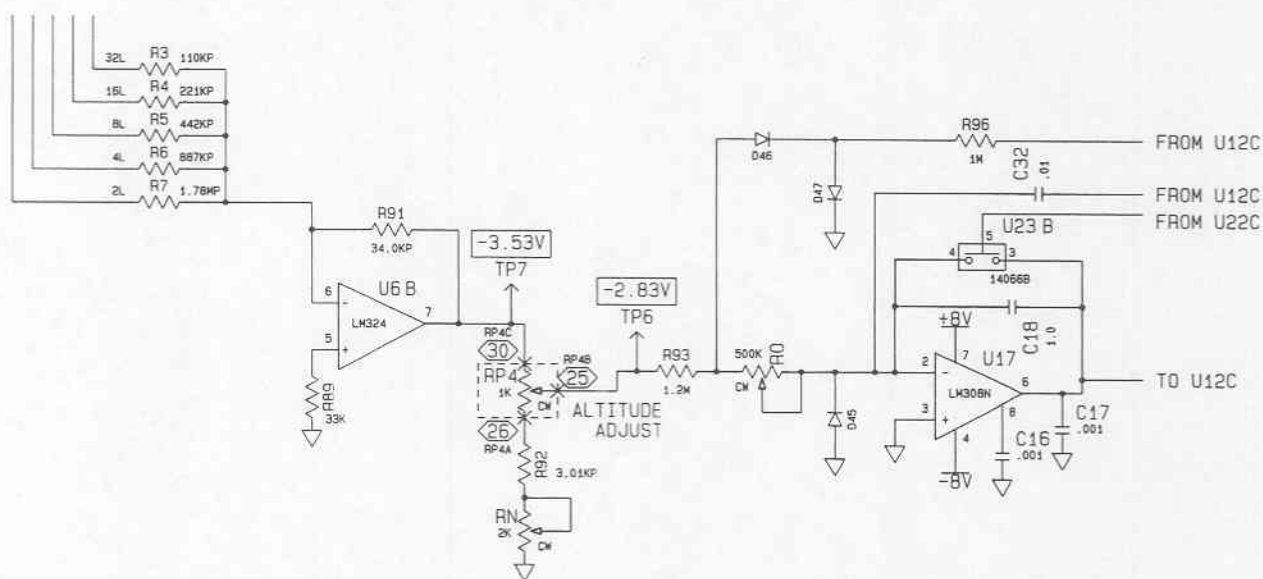
**Figure 2-10**  
Flow Valve Driver Circuit

## 2/Theory of Operation

See Figure 2-11. The ramp rate of the integrator U17 is adjusted by potentiometer RO. For  $MV = 20$ ,  $R = 20$  and  $I:E = 1:1$ , TP-17 (output of comparator U12C) is adjusted for a 50% duty cycle. When the integrated voltage equals the calculated Tidal Volume voltage from DAC U12B, Comparator U12C output goes negative to disable the AND gates and thereby ends the inspiration phase. The output of U12 pin 8 is fed back to U17 as positive feedback to provide hysteresis. When the comparator output switches negative, the positive feedback causes the output of integrator U17 to rise sharply. This ensures that the comparator output will

stay low, thereby eliminating glitches. By this action, valves are opened and closed for a duration which compensates for inaccuracies between the settings of the dials, the valves, and their related binary flow control circuitry. Potentiometer RN compensates for tolerance in the altitude potentiometer. The adjustment is such that the voltage at TP-6 is 80% of the voltage at TP-7 with the altitude dial set at 0 meters.

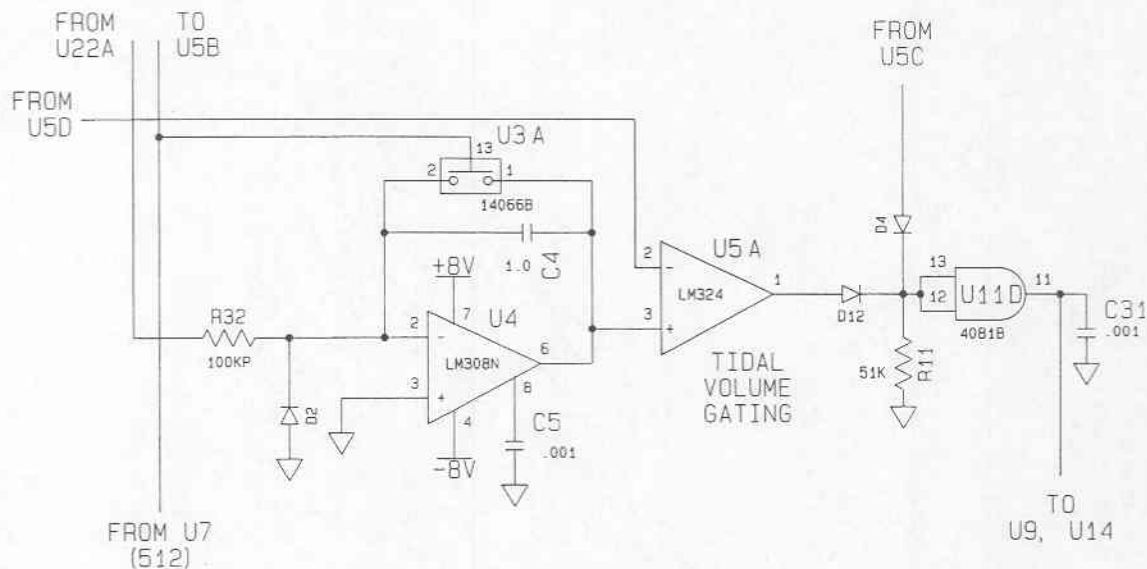
U6B converts the digital flow enabling signals to an analog signal for the altitude compensation scaling.



**Figure 2-11**  
Flow DAC and Altitude Adjust Circuit

## 2/Theory of Operation

**Tidal Volume:** See Figure 2-12. The generation of the Tidal Volume signal is initiated by applying the Rate voltage from U22A pin 1 to integrator U4. The signal is integrated, then compared to the MV voltage from U5D at comparator U5A. When the two voltages are equal, the output U5A goes high. Through D12 and U11D the enables latches U9 and U14 to load the binary count present at their inputs.

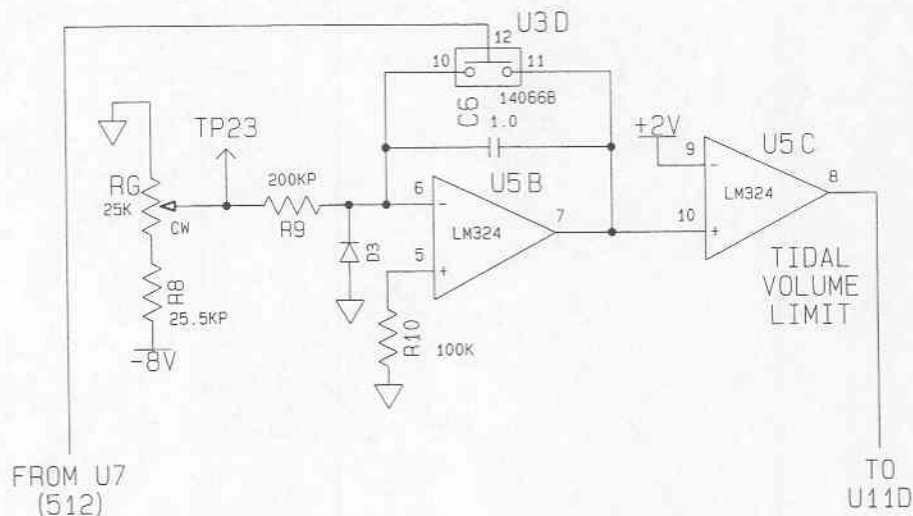


**Figure 2-12**  
Tidal Volume Gating Circuit

See Figure 2-13. Integrator U5B is a free running integrator which is reset by the 512th count of counter U7. The integrator is kept reset until the 1024th count when the line goes low. At this instant a reference voltage begins integrating and is compared at U5C with a second reference voltage. The second reference voltage

level corresponds to a 1.5 Liter Tidal Volume voltage level at U12B.

When the integrated voltage at U5B rises above the second reference voltage at U5C, the comparator output (U5C pin 8) goes high.



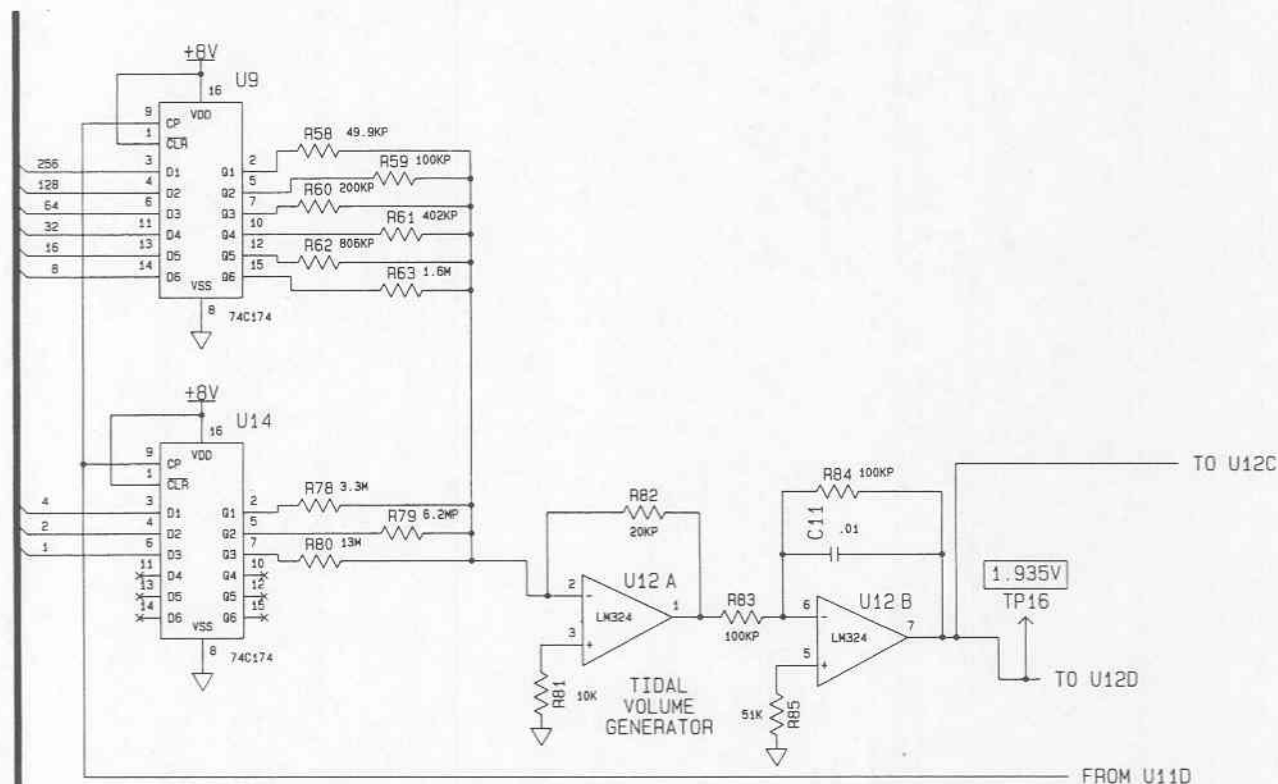
**Figure 2-13**  
Tidal Volume Limit Circuit

## 2/Theory of Operation

See Figure 2-14. If the OR gate (diodes D4, D12) output is not already high, then the binary count from U7 at this instant will be loaded into latches U9 and U14. This count represents the maximum Tidal Volume of 1.5 liters. If the DAC U12A output rises above the reference voltage at comparator U12D an alarm of Set Volume Not Delivered comes on via the alarm pulser/driver U21.

When the two input voltages are equal the comparator U5A output goes high, which through OR gate U11D latches the count from counter U7 into the latch U9 and U14.

This count is a digital representation of the Tidal Volume. The count is converted to an analog signal by the DAC U12A and is used to determine the inspiratory time by comparator U12C.

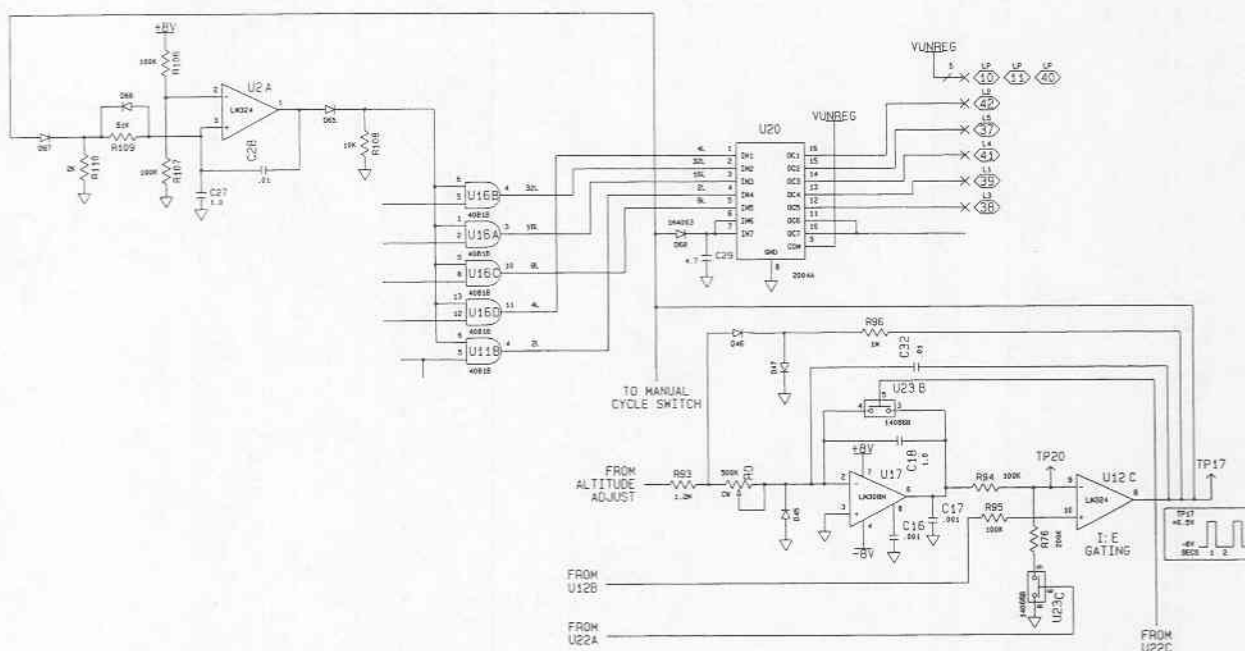


**Figure 2-14**  
Tidal Volume Generator Circuit

## 2/Theory of Operation

See Figure 2-15. If the DAC U12A output rises above the reference voltage at comparator U12D an alarm of Set Volume Not Delivered comes on via the alarm pulser/driver U21. When the two input voltages are equal the output of the comparator U2D enables latch U8. The counts at that instant are latched in and it represents the binary value of the flow rate. This is used to drive the binary weighted valves through the OR gate U15 and AND gate U16. The AND gate is enabled during inspiration time by the output of comparator U12C through level shifter U2A. The binary signal driving the flow valves is also converted to analog signal

through DAC U6B. This "flow" signal is compensated for altitude and integrated by integrator U17. This integrated signal corresponding to the "actual volume" is compared by comparator U12C with the calculated Tidal Volume from DAC U12A and when the two are equal the output of the comparator goes low and disables the AND gate U11C, which shuts off the solenoid valves, ending the inspiratory phase. At this point there is no flow (expiratory phase), which continues until the rate comparator U22C resets the flow integrator U17 and a new respiratory cycle is initiated.



**Figure 2-15**  
I:E Gating Circuit

**Exhaust Valve:** See Figure 2-16. The start of an inhalation is coincident with the start of integration of rate integrator U22D and flow integrator U17. At this time, the output of comparator U12C is at logic 1. Transistor driver U20 inverts this signal to a low and causes the exhaust valve to energize (close) through the closed contacts of Relays K1 and K2. When the actual Tidal Volume voltage equals the calculated Tidal Volume voltage at comparator U12C, the output of U12C goes low. The exhalation period begins, and the exhaust valve de-energizes (opens). The exhaust valve stays open until integrators U22D and U17 are reset. They are reset by the rate integrator U22D

voltage rising above a reference voltage at comparator U22C. This causes a new respiratory cycle to start. During the exhalation phase the output of U20 no longer holds the cathode of zener diode D14 low.

If VUNREG is sufficiently high, approximately 24 V dc or greater, and there is a continuous circuit through the exhaust valve, K1, and K2, integrator U6C is reset by analog switch U3C.

If the reset signal does not appear, the output of integrator U6C continues to increase, causing the output of comparator U6D to go low. When U6D pin 14 goes low, relay K1 de-energizes, opening its contacts and the exhaust valve.

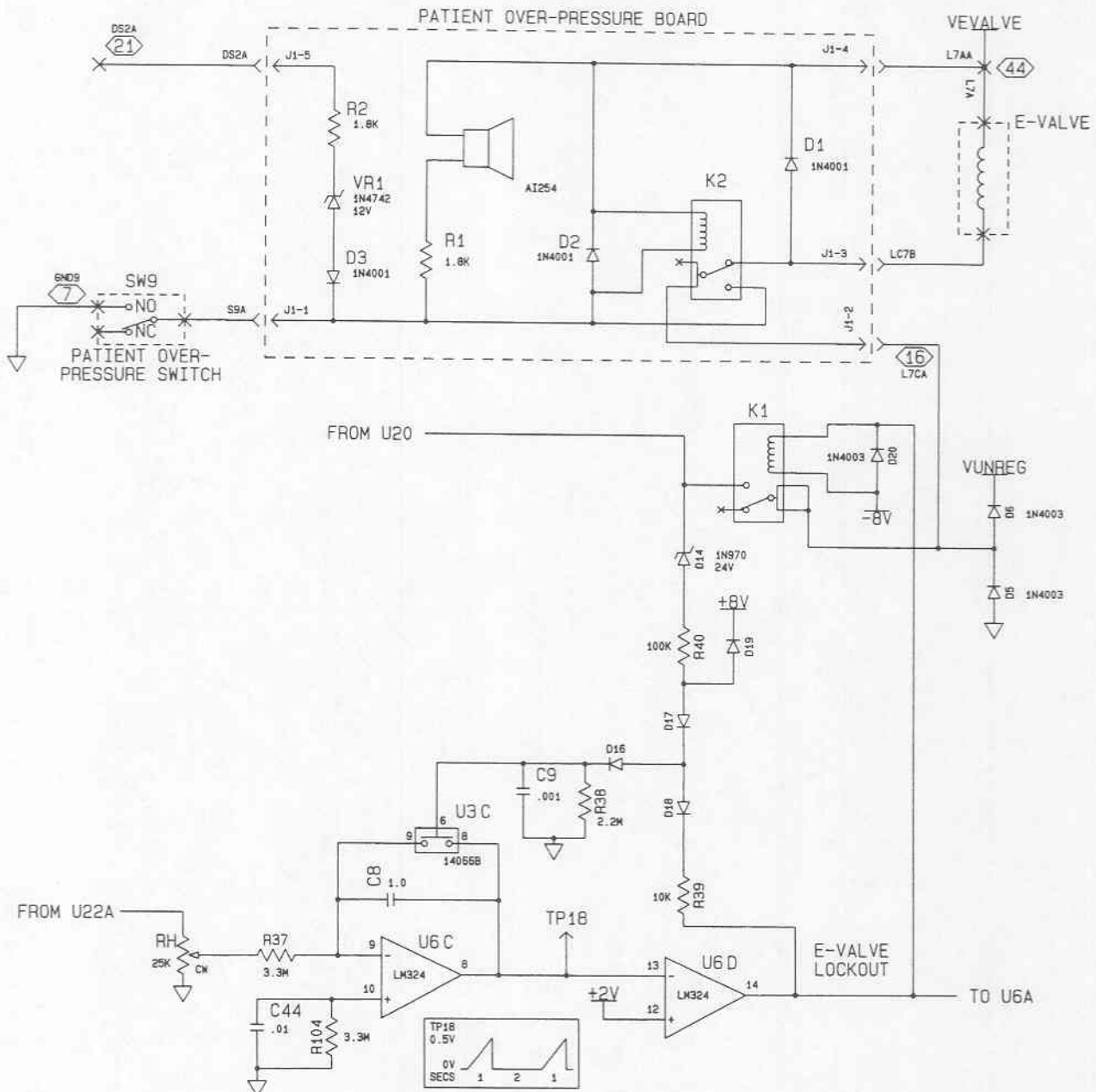


## 2/Theory of Operation

This signal through R39 and D18 inhibits the reset pulses from occurring, and through comparator U6A activates the Ventilator Failure alarm after 2 to 3 breaths. These components form the exhaust valve lockout circuitry. The rate of increase of integrator U6C is adjusted with potentiometer RH. The waveform at TP-18 (output of integrator U6C) has a rate of increase so that the peak voltage equals 0.50 volts for R = 20 BPM.

If a patient circuit pressure greater than approximately 65 cm H<sub>2</sub>O occurs, the contacts of the patient over pressure switch close, energizing the High Pressure Board, the Set Volume

Not Delivered lamp and relay K2. When K2 energizes the normally closed contacts open and interrupt the exhaust valve circuit. The exhaust valve opens to relieve the high pressure condition. When the high pressure condition is relieved, the over pressure switch resets and re-energizes relay K2. This stops the alarm condition and reconnects the exhaust valve circuit. The ventilator will now operate normally for the next breath. However if the pressure is not relieved and the alarm condition remains, the Ventilator Failure Alarm will activate after two to three breaths.

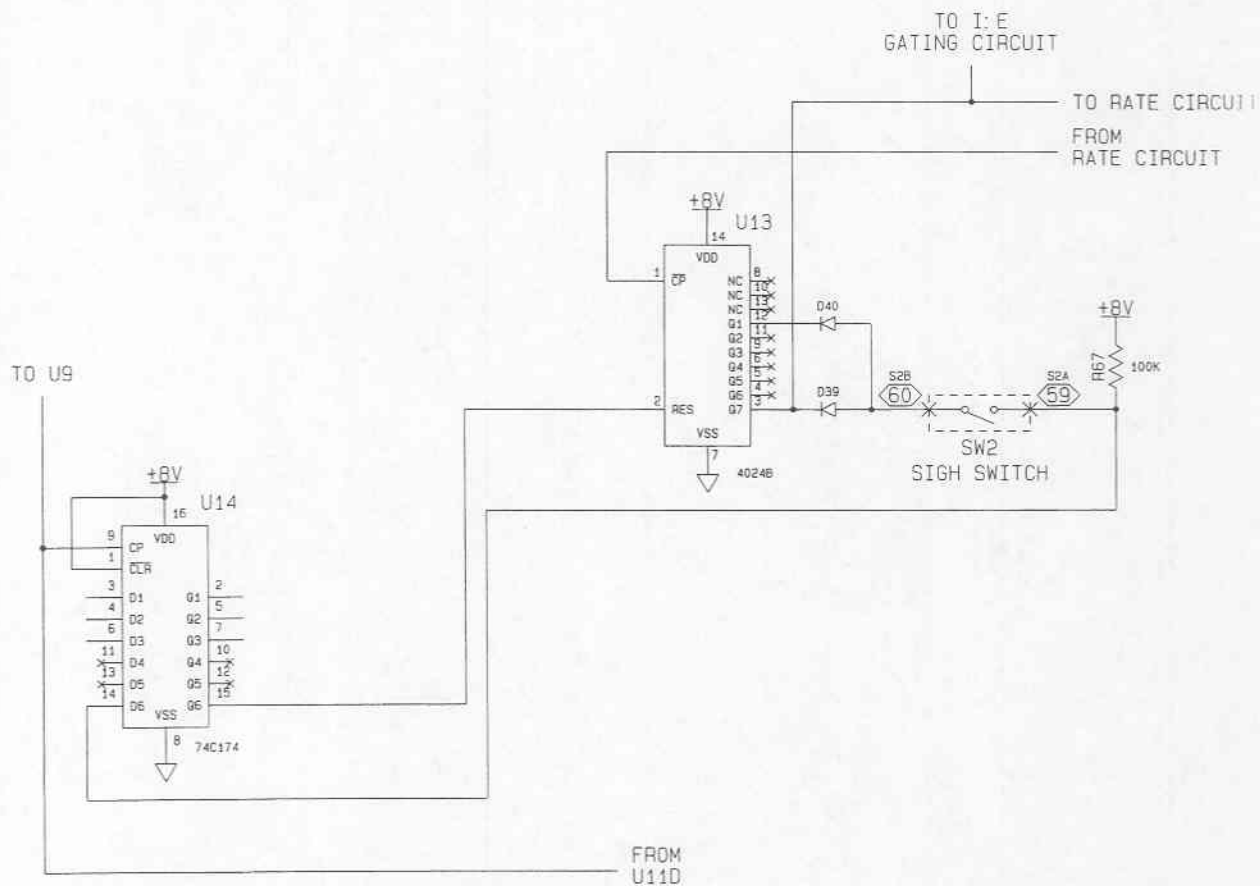


**Figure 2-16**  
Exhaust Valve Lockout Circuit

## 2/Theory of Operation

**Sigh:** See Figure 2-17. This circuit increases the inspiration and expiration times by 50% when selected. The Sigh Switch on the front panel controls the sigh counter (U13). When the Sigh switch is on, the sigh counter U13 counts 64 pulses, corresponding to 64 respiratory cycles. Every time the output of U11C (Rate) goes high to start a new respiratory cycle, the sigh counter is advanced one count. On the 64th count a logic "1" appears at the output of the sigh counter which enables analog switches U23 A and C. With the analog switches closed, the slope of the Rate and Flow ramps at comparators U22C and U12C (respectively) de-

creases to sixty-six percent of the normal values. This causes the Rate and Flow comparators to take longer to change state, effectively increasing the length and Tidal Volume of the respiratory cycle. At the end of the inspiratory phase of the 64th breath, U13 is clocked and the outputs go to binary 65, i.e. outputs Q1 and Q7 are both high and therefore R67 pulls the D6 input of U14 high. When the binary values for the next breath are clocked into U9 and U14, the high signal at D6 of U14 is clocked through to the Q6 output of U14 and U13 is reset. With Rate = 40, the time between two sigh breaths is approximately 1 minute 34 seconds.



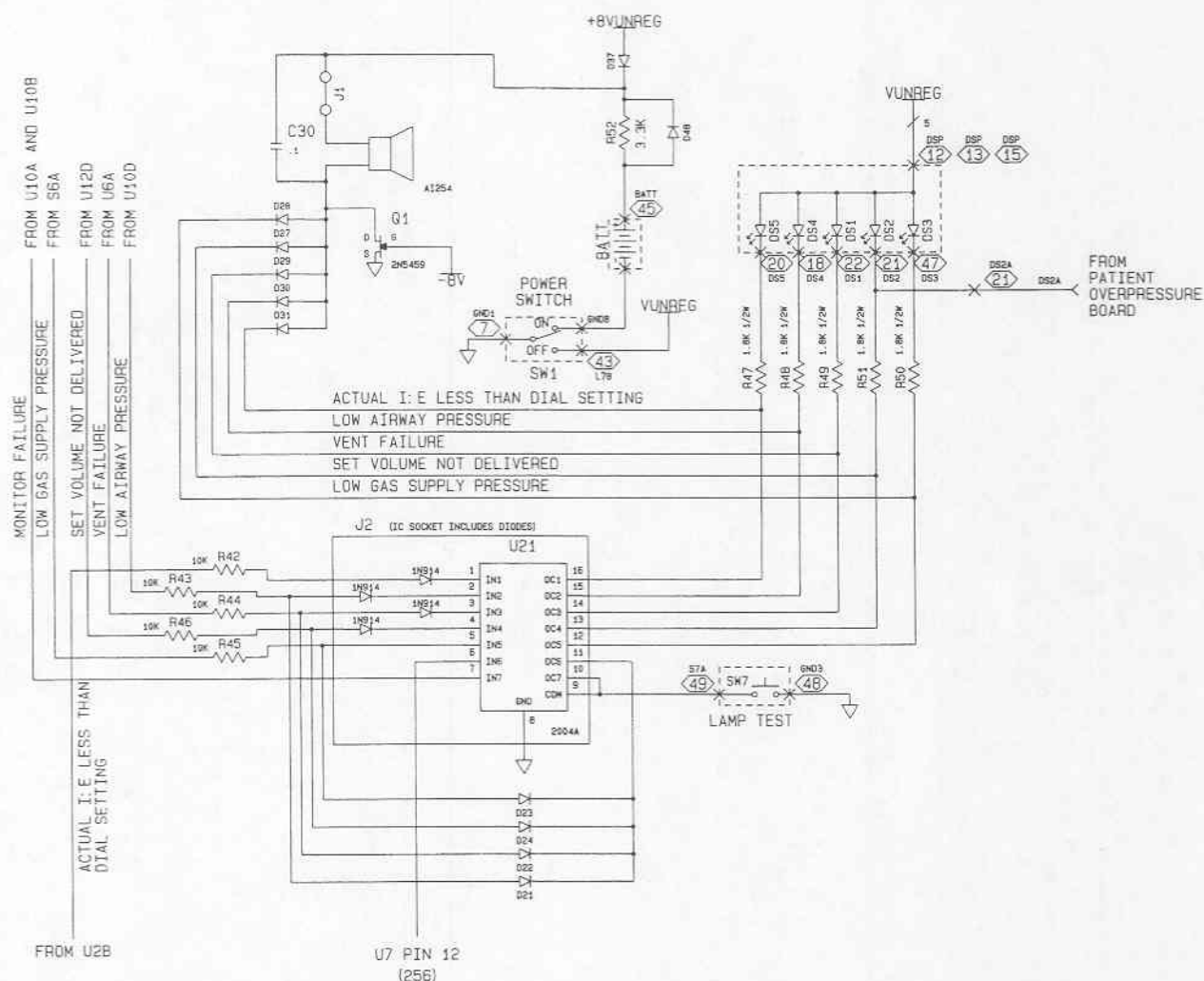
**Figure 2-17**  
Sigh Circuit

## 2/Theory of Operation

## Alarm System

See Figure Z-18. All alarms except Actual I:E Less than Dial Setting Monitor Failure and Power Failure are pulsating alarms whose frequency is dependent on the Q9 output of counter U7. Diodes D21-D24 cause this action, by blanking the inputs to inverter U21 every 256th count.

The 512th count is used for resetting integrators U5B (Tidal Volume limit check) and U4 (Tidal Volume gating).



**Figure 2-18**  
Alarm Driver Circuit

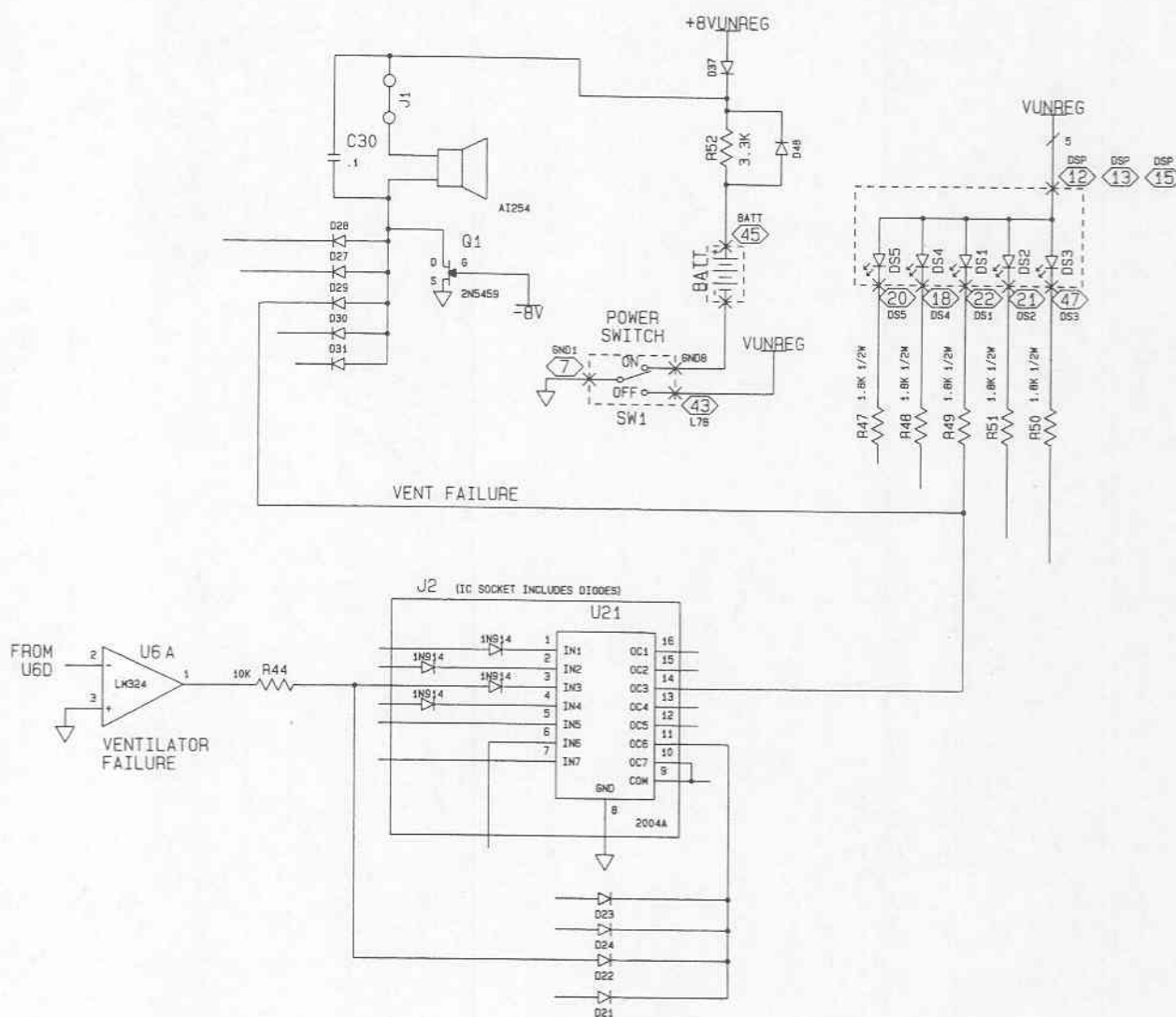
## 2/Theory of Operation

## Ventilator Failure

(Pulsating red lamp and audio tone)

See Figure 2-19. The alarm is activated if the exhaust valve fails to open during the expiratory phase or the exhaust valve is disabled for 2 to 3 breaths due to continuous high pressure conditions.

Note: See exhaust valve description in this section for additional information.



**Figure 2-19**  
Ventilator Failure Alarm Circuit

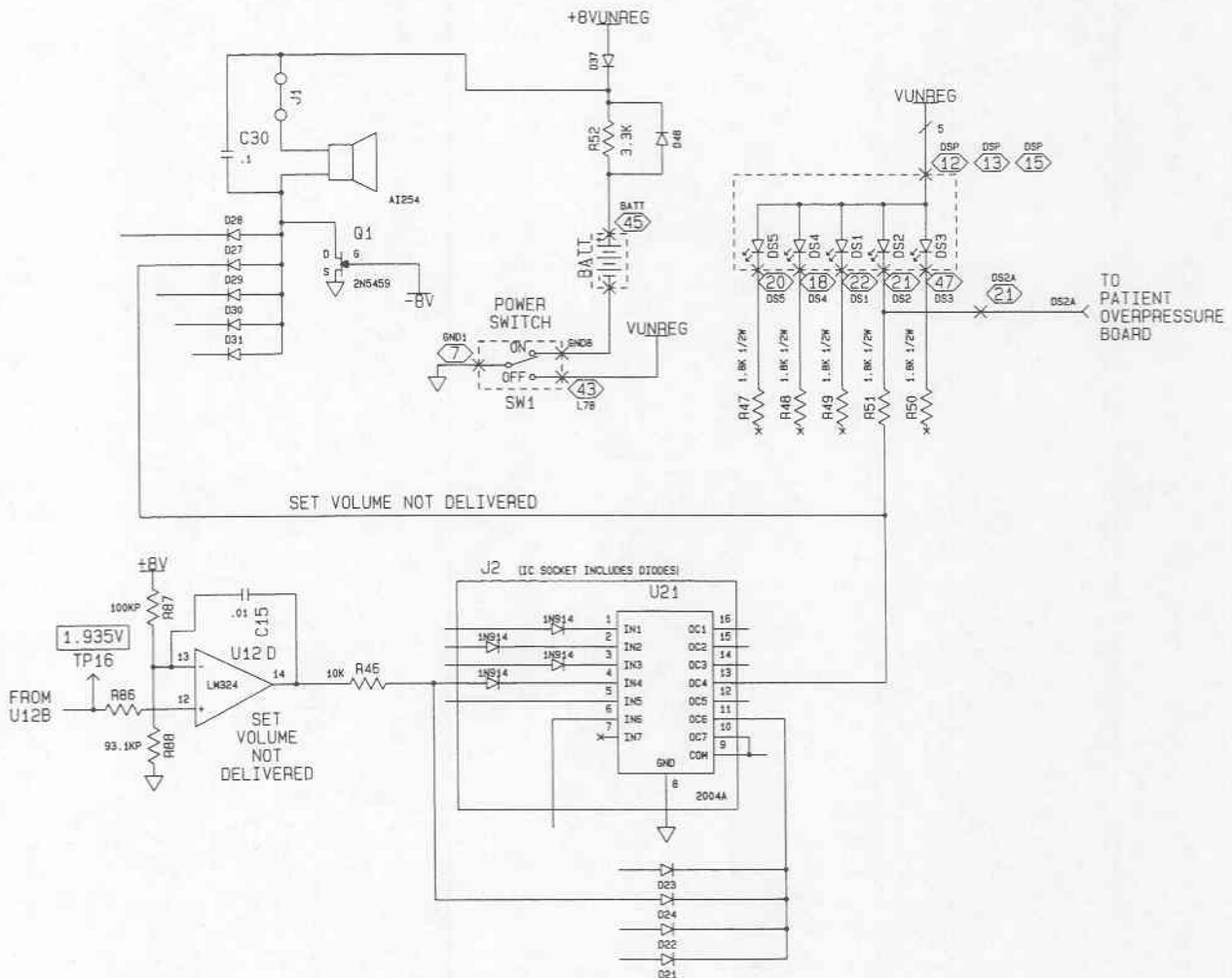
## 2/Theory of Operation

### Set Volume Not Delivered (Pulsating red lamp and audio tone)

See Figure 2-20. The Tidal Volume is limited to 1.5 liters maximum, but when the Minute Volume and Rate settings call for a Tidal Volume greater than 1.5 liters the output of integrator U5B rises above the reference voltage at comparator U5C, causing the output of U5C to go high. If the output of the OR gate formed by D4 and D12 is not high then the count at counter U7 at this instant will be loaded into latches U9 and U14 by the high signal from U5C. This latched count represents the maximum Tidal Volume. Op amp U12A and U12B are

configured as a DAC and convert the count into an analog signal. U12D compares the analog signal with a reference voltage. The output of U12D controls a lamp and audio alarm via pulser/driver U21.

The output of the High Pressure Board also controls the Set Volume Not Delivered Lamp and audio alarm by connecting a low to R51 if a high pressure condition occurs. When this condition is relieved, the high pressure switch resets and the low is removed.

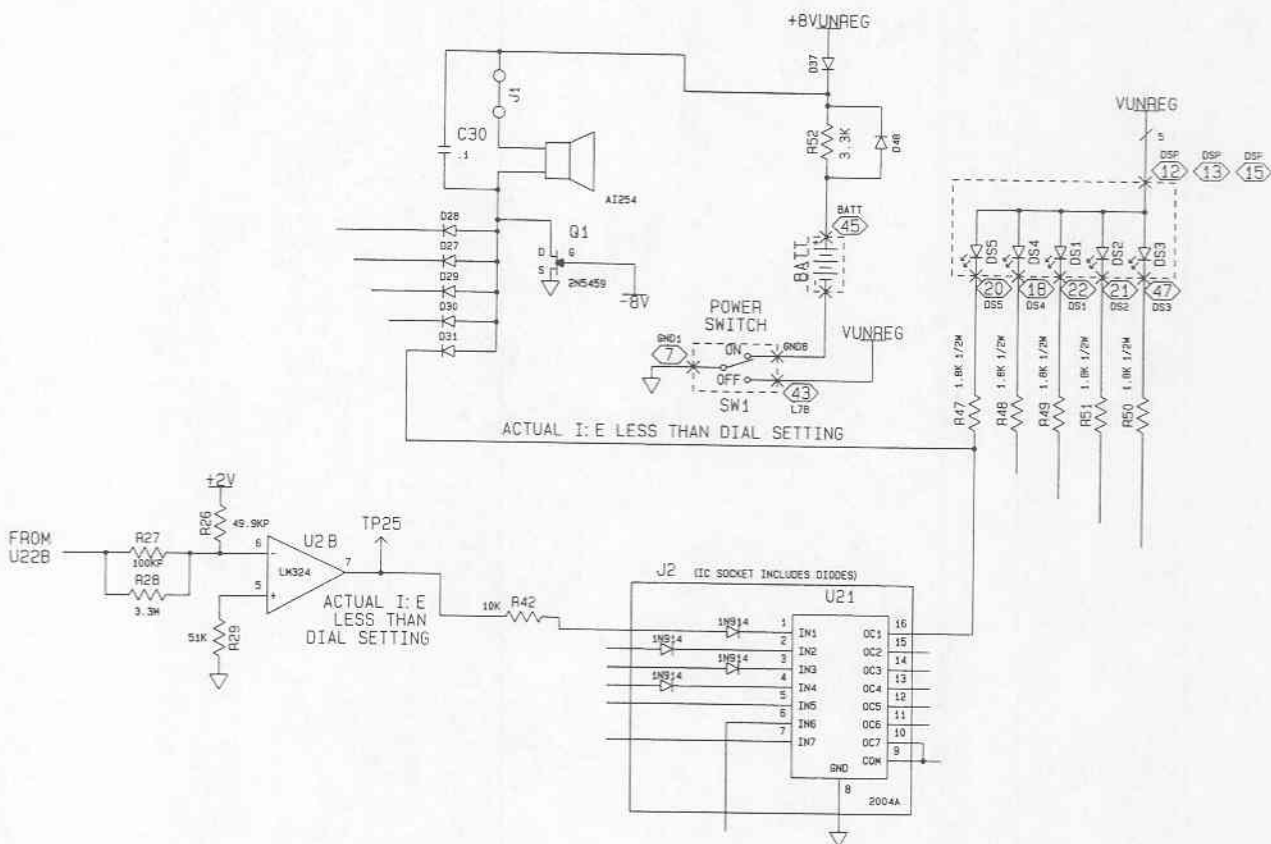


**Figure 2-20**  
Set Volume Not Delivered Alarm Circuit

## 2/Theory of Operation

**Actual I:E Less than Dial Setting**  
(Continuous red lamp and audio tone)

See Figure 2-21. If a flow greater than 60 L/min is called for by the control setting, the calculated flow voltage from U22B will exceed the reference voltage at comparator U2B. The output of this comparator via OR gates U15A, B, C, D, and diodes D10, and D1, turns on all solenoid flow valves. This also activates a lamp and audio alarm via the alarm pulser/driver U21.



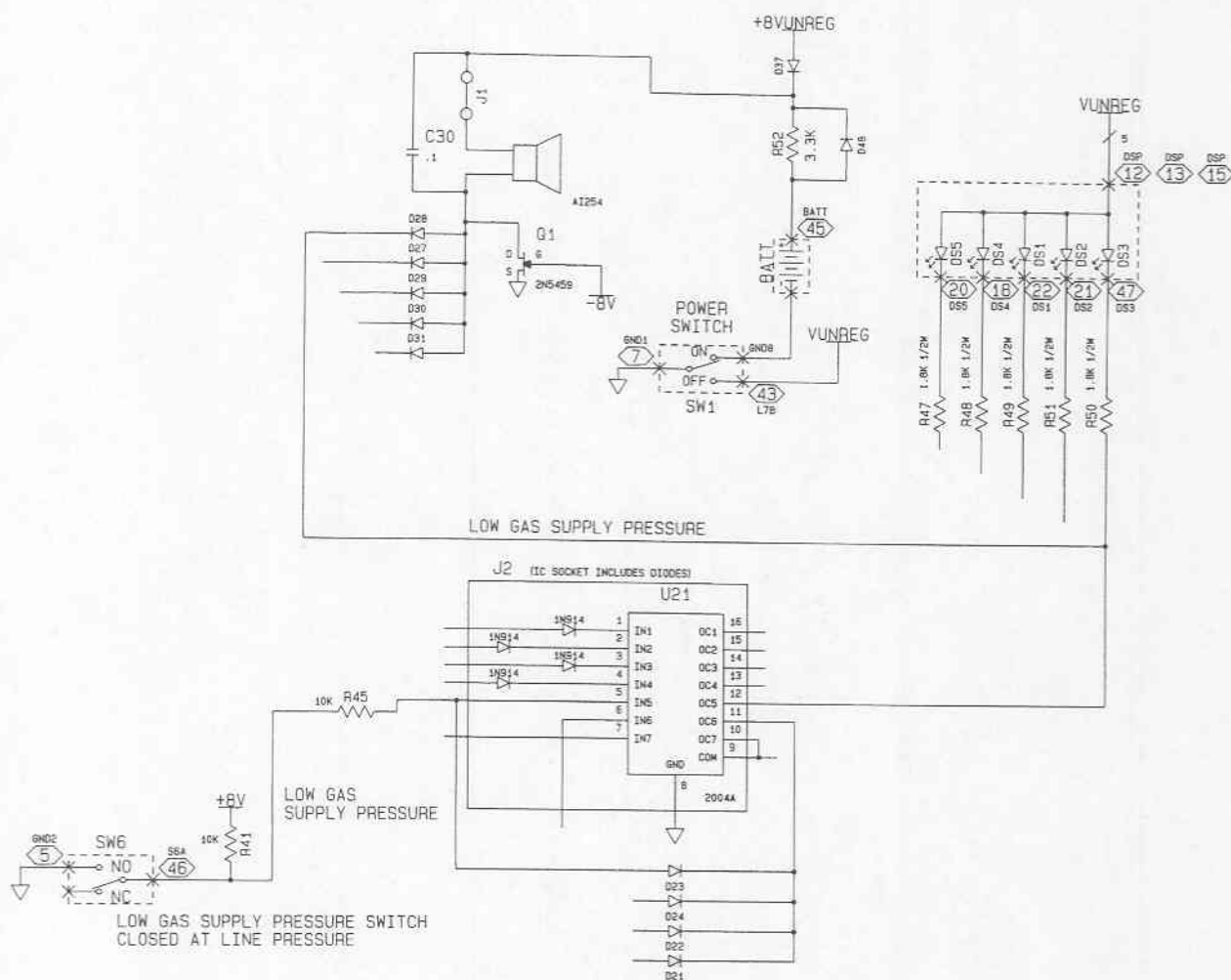
**Figure 2-21**  
Actual I:E Less Than Dial Setting Alarm Circuit



## 2/Theory of Operation

### Low Oxygen Supply Pressure (Pulsating red lamp and audio tone)

See Figure 2-22. The pressure regulator operates from a nominal supply pressure of 50 psig. A supply pressure switch SW6 remains closed at this pressure. If the supply pressure drops below approximately 35 psig, the switch opens and activates the Low Oxygen Supply Pressure alarm via the alarm pulser/driver U21.



**Figure 2-22**  
Low Oxygen Supply Pressure Alarm Circuit

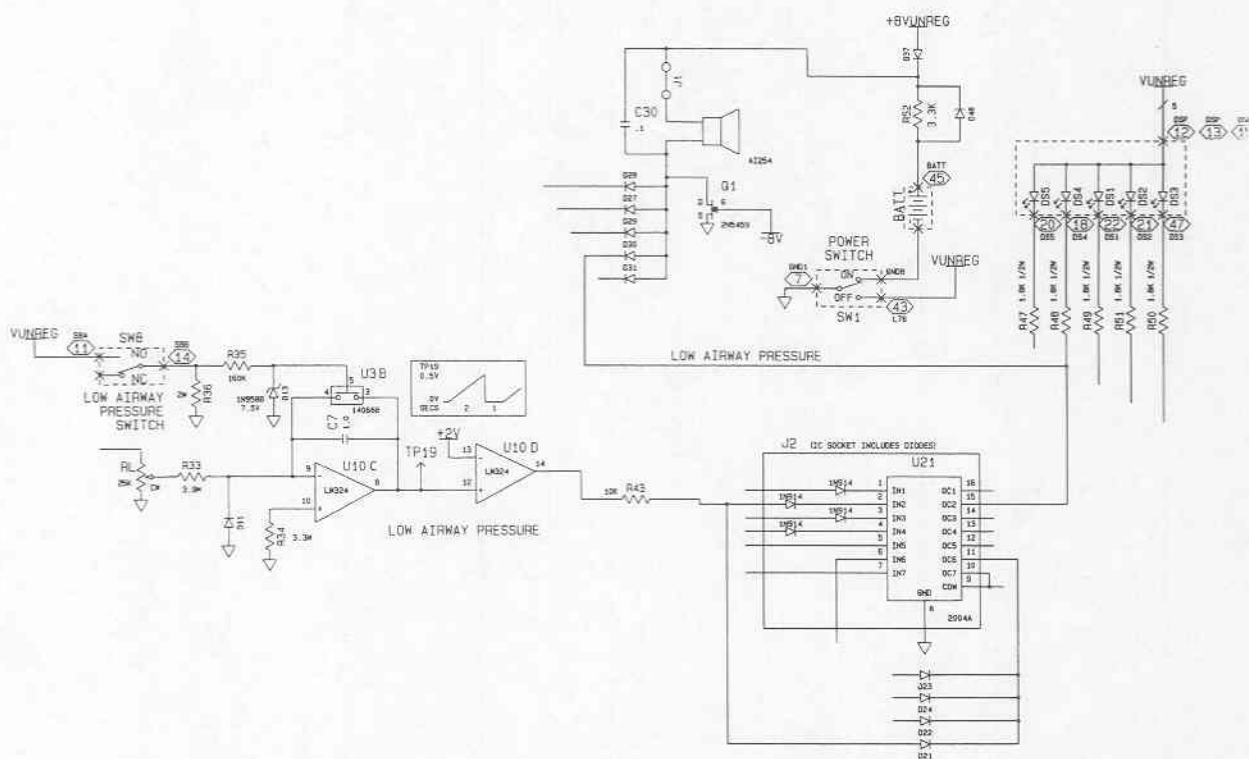
## 2/Theory of Operation

### Low Airway Pressure

(Pulsating red lamp and audio tone)

See Figure 2-23. The pressure is monitored at a distal sensing tee by a pressure switch in the control unit. At pressures below 7 cm H<sub>2</sub>O the switch stays open; otherwise, it is closed and transmits an enable signal to the analog switch U3B which resets integrator U10C. If for two breaths there is no switching action, integrator U10C integrates the Rate voltage to a value

above the reference voltage at comparator U10D. This causes the Low Airway Pressure alarm to activate via the alarm pulser/driver U21. The ramp rate of integrator U10C is adjusted by potentiometer RL. The waveform at TP-19 (output of integrator U10C) for Rate 20 has a voltage of 1.0 V at 3 seconds.



**Figure 2-23**

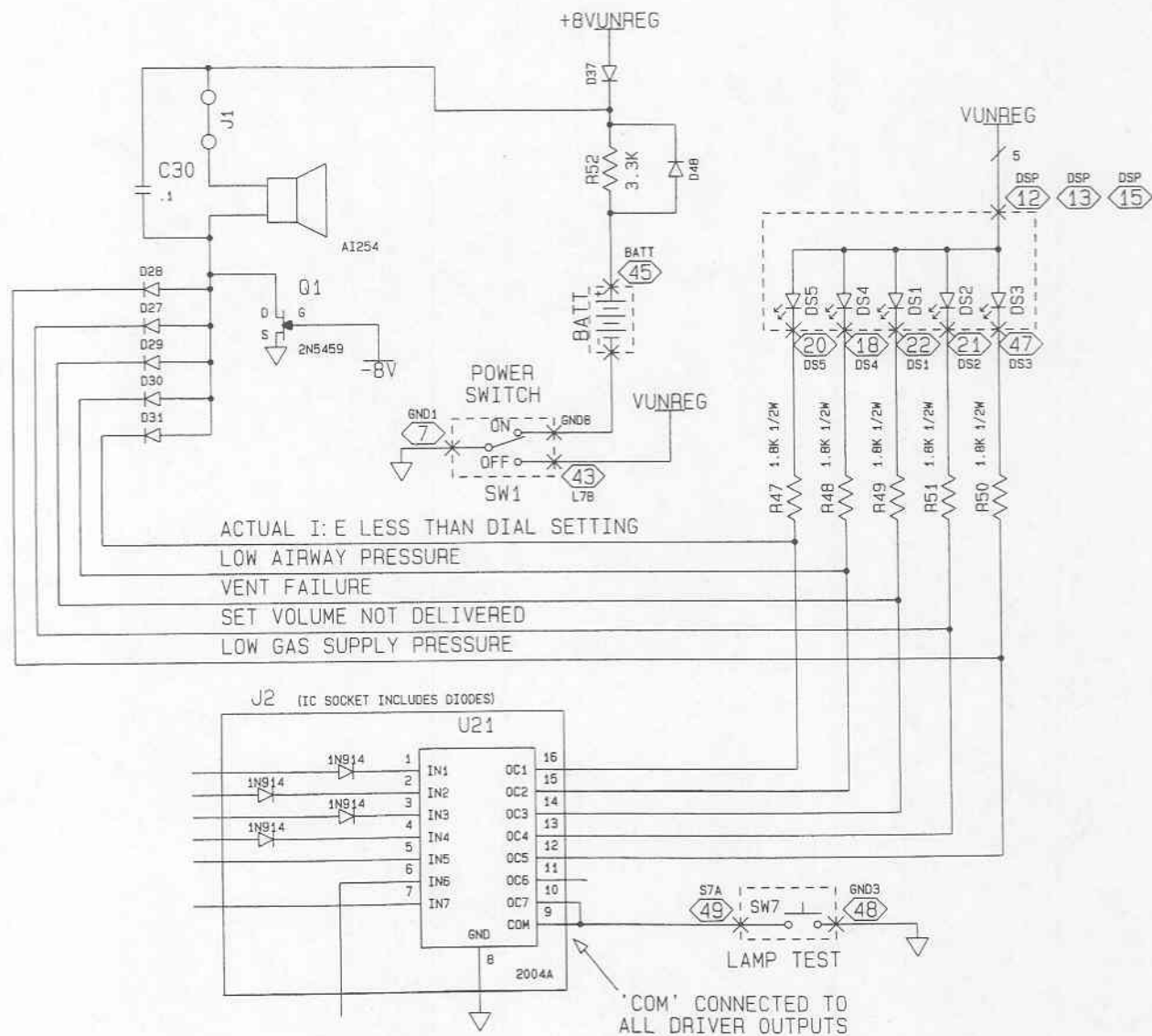
Low Airway Pressure Alarm Circuit

## 2/Theory of Operation

### Lamp Test

(Continuous red lamp and audio tone)

See Figure 2-24. The front panel lamp test switch (when depressed) causes all the lamps and the audio alarm to turn on. All outputs of the alarm pulser/driver U21 are taken low by the switch to accomplish this.



**Figure 2-24**  
Lamp Test Circuit

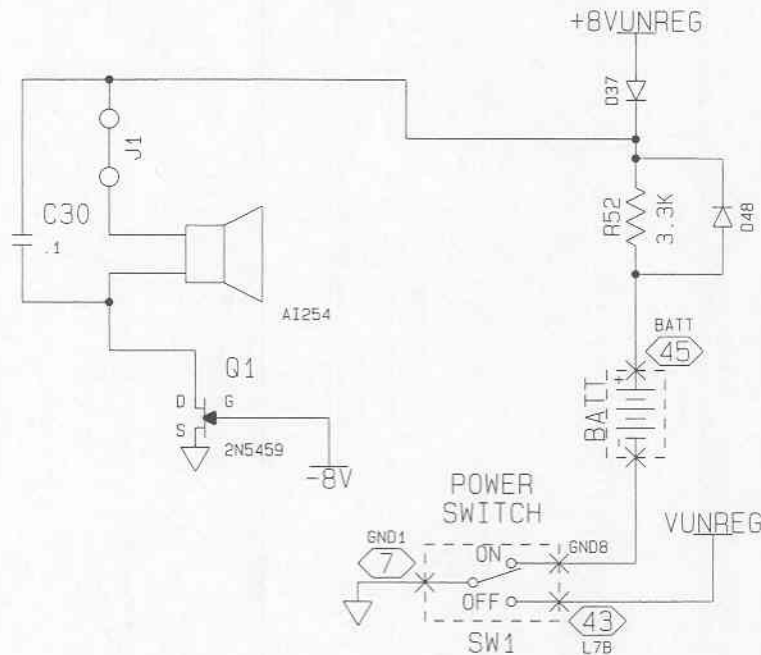


## 2/Theory of Operation

### Power Failure (Continuous audio tone)

See Figure 2-26. In the event of power loss, the -8 V supply will be absent. Transistor Q1 is normally biased off by the negative voltage and if the voltage is absent, Q1 will turn on. This

causes the audible alarm to activate, deriving its power from a rechargeable NiCad battery. When the power is On, the battery is recharged from a +8 V unregulated supply.



**Figure 2-26**  
Power Failure Alarm Circuit

### Power Supply

(Refer to Schematic, Figure 8-4)

Power enters the system through the appliance inlet of the Power Inlet Module where it is filtered for RFI, fused by two fuses on the line and neutral, and routed appropriately by the voltage selector for the transformer T1. The voltage selector can be set for input voltages of 100, 120, 220, or 240 V ac. The transformer provides two AC outputs, 23 V ac at 1.7 A and 27.5 V ac at 100 mA center tapped (CT). The 23 V ac is rectified and filtered to provide 24 V dc unregulated (VUNREG). VUNREG is used to drive the solenoid valves, the exhaust valve, and the LED's. The 27.5 V ac CT is rectified and filtered to provide +8 V dc unregulated (+8

VUNREG) and -8 V dc unregulated (-8 VUNREG). +8 VUNREG is used to drive the audible alarm, charge the NiCd battery, and provide the source for the regulated supplies, +8 V dc and +2.00 V dc. -8 VUNREG is used to provide the source for the -8 V dc regulated supply. Zener diode D57 and potentiometer RP provide regulation to provide the +2.00 V dc reference. The +2.00 V dc reference is amplified by U19 and U18 to provide the +8 V dc and -8 V dc regulated supplies, respectively. The +8 V dc and -8 V dc regulated supplies supply power for the control logic. The bleed valve is driven by +8 VUNREG and -8 V dc regulated.

### 3/Functional Test

**⚠WARNING:** Do not, under any circumstances, perform any testing or maintenance on medical instruments while they are being used to ventilate a patient.

#### 3.1 Bellows Performance Test

Equipment Required:

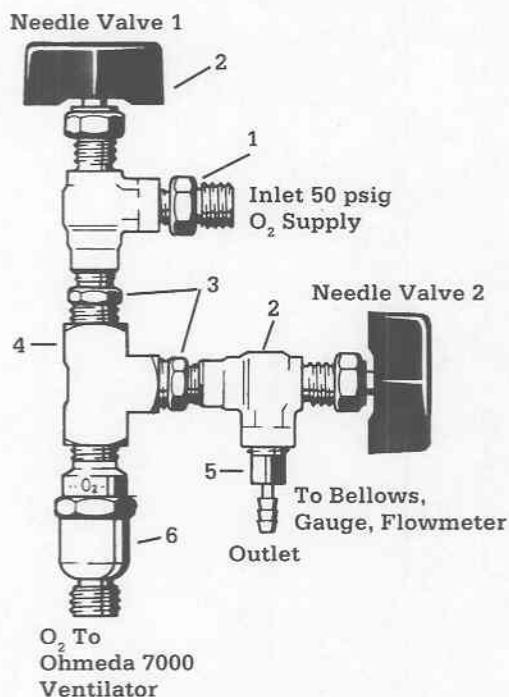
- Pressure Gauge, 0 - 20 cm H<sub>2</sub>O
- Test Fixture
- 2" length of 1/4" OD copper tubing
- #2 rubber stopper w/hole
- Test plug (Stock Number 2900-0001-000)
- Plastic tee
- Flowmeter 0 - 500 mL/min and Needle valve
- Suitable lengths of 1/8" ID tygon or rubber tubing.

1. Connect the test equipment to the bellows assembly as shown in Figure 3-2.
2. Plug the exhaust port on the Bellows Assembly.

3. Close the needle valves on the test fixture then turn on the oxygen supply.
4. Open needle valves 1 and 2 and inflate the bellows to the 100 mL level.
5. If the pressure on the gauge exceeds 1.0 cm H<sub>2</sub>O or the bellows drops at a rate exceeding 50 mL/min, replace the bellows and repeat the above steps.
6. Continue inflating the bellows to the top of the housing.
7. At a pressure value shown on the gauge of 15 cm H<sub>2</sub>O the bellows must still be correctly located, with the base bellows securing lip still covered by the bellows. (See Note).

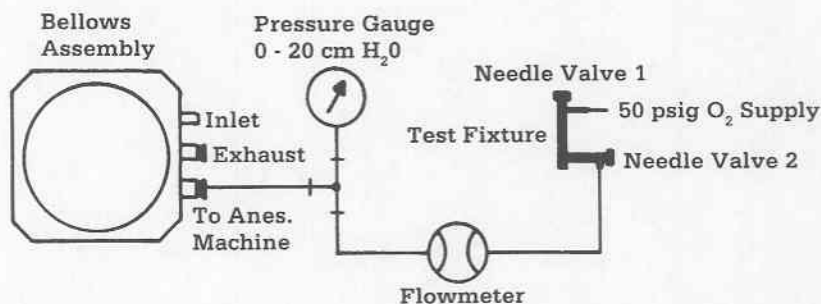
Note: Gas leak is acceptable providing the above conditions are met.

8. If the bellows has slipped off or exposed the securing lip the bellows must be replaced.



Description	Stock Number
1. DISS, O <sub>2</sub> , M x 1/4" NPTM Adapter ..	0204-0490-535
2. Needle Valve, 1/8" NPTF .....	0207-6067-800
3. Reducing Nipple, 1/8" NPTM x 1/4" NPTM .....	0213-5017-335
4. Tee, 1/4" NPTF .....	0213-6115-335
5. Hose Nipple, 1/8" ID x 1/8" NPTM .....	0204-8877-300
6. Check Unit, DISS, O <sub>2</sub> , M x 1/4" NPTM .....	0221-3900-800

**Figure 3-1**  
Test Fixture



**Figure 3-2**  
Bellows Performance Test



## 3/Functional Test

### 3.2 Pop-off Valve Performance Test

Equipment Required:

- Pressure Gauge, 0 - 20 cm H<sub>2</sub>O
- Test Fixture
- 2" length of 1/4" OD copper tubing
- #2 rubber stopper w/hole
- Plastic tee
- Flowmeter 0 - 500 mL/min and Needle valve
- Suitable lengths of 1/8" ID tygon or rubber tubing.

To verify operation of the pop-off valve, perform the following tests.

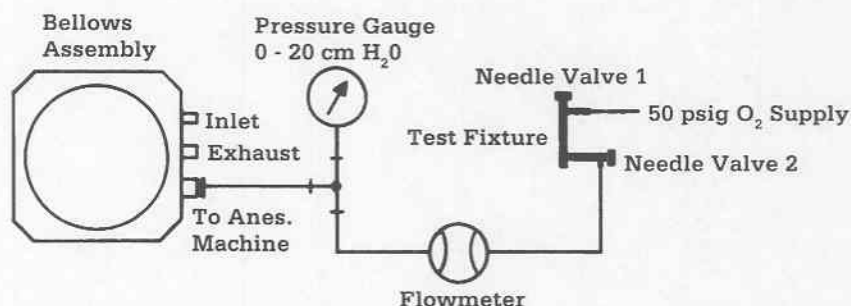
1. Connect the test equipment to the bellows assembly as shown in Figure 3-3.
2. Close the needle valves on the test fixture then turn on the oxygen supply.
3. Open needle valves 1 and 2 to allow the bellows to rise up against the top of the bellows housing.
4. Adjust needle valve 2 to obtain a flow of 5 L/min (indicated on flowmeter). The pressure within the bellows should not exceed 3.5 cm H<sub>2</sub>O.
5. Adjust needle valve 2 to obtain a flow of 200 mL/min. The pressure within the bellows should be at least 1 cm H<sub>2</sub>O and sufficient to hold the bellows at the top of the housing.
6. Close needle valves 1 and 2.
7. Monitor the volume lost by observing the height of the bellows against the volume graduations on the housing. The volume loss should not exceed 100 mL in a one minute period.
8. If the leak rate exceeds the above values replace the pop-off valve.

### 3.3 Bellows Assembly Leak Test

Equipment Required:

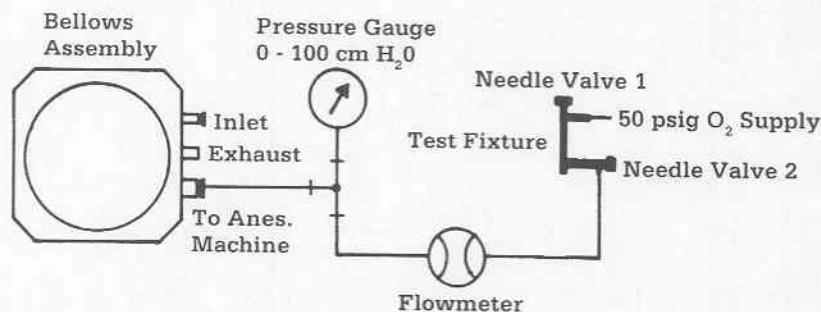
- Pressure Gauge, 0 - 100 cm H<sub>2</sub>O
- Test Fixture
- 2" length of 1/4" OD copper tubing
- #2 rubber stopper w/hole
- Test plug (Stock Number 2900-0001-000)
- Plastic tee
- Flowmeter 0 - 500 mL/min and Needle valve
- Suitable lengths of 1/8" ID tygon or rubber tubing.

1. Connect the test equipment to the bellows assembly as shown in Figure 3-4.
2. Remove the bellows housing
3. Remove the bellows and replace the housing.
4. Close the needle valves on the test fixture then turn on the oxygen supply.
5. Open needle valves 1 and 2. Adjust needle valve 2 to obtain 300 mL/min fresh gas on flowmeter. Do not readjust the flowmeter during this test.
6. Plug the inlet port on the Bellows Assembly.
7. The pressure should rise to 60 cm H<sub>2</sub>O or greater (do not pressurize over approximately 100 cm H<sub>2</sub>O).
8. If 60 cm H<sub>2</sub>O pressure cannot be maintained with a flow of 300 mL/min or less, place a finger tightly over the "Exhaust" port. If this causes the pressure to rise and/or the flow to decrease, a leak exists through the pop-off valve.
9. If sealing the "Exhaust" port has no effect, check the bellows housing, u-cup seal, and the bellows base assembly for leaks.
10. Any leak must be corrected to achieve at least 60 cm H<sub>2</sub>O at 300 mL/min.



**Figure 3-3**  
Pop-off Valve Performance Test

### 3/Functional Test



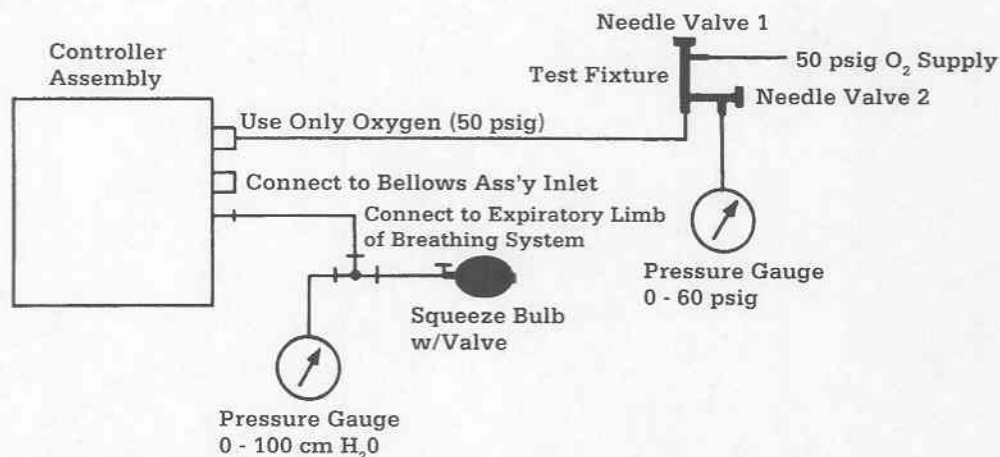
**Figure 3-4**  
Bellows Assembly Leak Test

#### 3.4 Low Oxygen Supply Pressure Alarm Test

##### Equipment Required:

- Pressure Gauge, 0 - 60 psig
- Pressure Gauge, 100 cm H<sub>2</sub>O
- Test Fixture
- Plastic Tee
- Squeeze bulb w/valve
- High pressure O<sub>2</sub> hose, DISS O<sub>2</sub>, Female fitting on both ends
- Suitable length of 1/8" ID tygon or rubber tubing.

1. Connect the test equipment to the controller assembly as shown in Figure 3-5.
2. Close the needle valves on the test fixture then turn on the oxygen supply.
3. Using the squeeze bulb, pressurize the distal sensing port to 10 cm H<sub>2</sub>O. This will eliminate the Low Airway Pressure Alarm so it will not interfere with the test.
4. Set the ventilator controls as follows:  
Minute Volume = 2 L/min  
Rate = 6 BPM  
I:E = 1:1
5. Turn on the controller unit.
6. Open needle valves 1 and 2.
7. Close needle valve 1 slowly so that during the inspiration phase the pressure on the 0 - 60 psig gauge decreases to 35 psig. The Low Oxygen Supply Pressure Alarm should activate at 35 psig or above.
8. Open needle valve 1 slowly so that during the expiration phase the pressure on the 0 - 60 psig gauge increases to 42 psig. The Low Oxygen Supply Pressure Alarm should deactivate at 42 psig or below.
9. Adjust or replace the pressure switch (Section 6.5.B) if it does not meet the specifications.



**Figure 3-5**  
Low Oxygen Supply Pressure Alarm Test

## 3/Functional Test

### 3.5 Low Airway Pressure Alarm Test

Equipment Required:

- Pressure Gauge, 0 - 20 cm H<sub>2</sub>O
- Squeeze bulb w/valve
- Plastic Tee
- Suitable length of 1/8" ID tygon or rubber tubing

Note: A Low Airway Pressure alarm may occur during testing when the ventilator is operating normally. This can happen when the ventilator is equipped with a test lung and small tidal volumes are selected (less than approximately 200 mL Adult; 100 mL Pediatric).

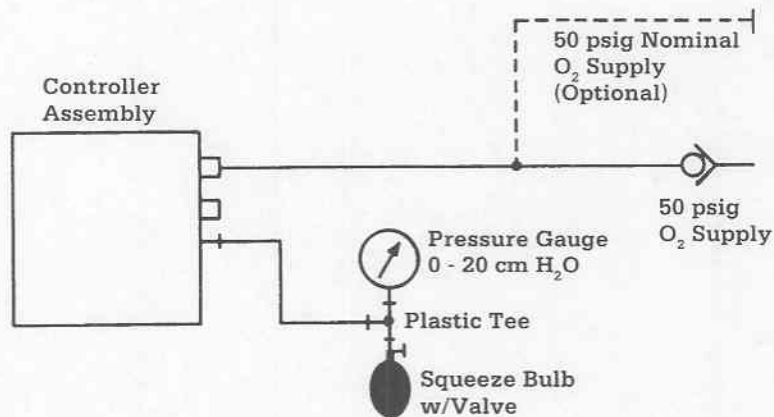
1. Connect the test equipment to the ventilator as shown in Figure 3-6.
2. Lightly pump the squeeze bulb, then open the valve and bleed until 5 cm H<sub>2</sub>O is indicated on the gauge.
3. Set the ventilator controls as follows:  
Minute Volume = 6 L/min  
Rate = 6 BPM  
I:E = 1:1
4. Turn the ventilator on.
5. The "Low Airway Pressure" alarm should activate after the second breath.
6. Lightly squeeze the hand bulb to bring the pressure over 10 cm H<sub>2</sub>O. The alarm must silence.
7. If either of the above alarm conditions do not occur, adjust or replace the Sensor Pressure switch as necessary. If problems remain, perform unit calibration.

### 3.6 Pressure Relief Valve Test

Equipment Required:

- Pressure gauge 0 - 100 cm H<sub>2</sub>O
- Pressure Gauge, 0 - 20 cm H<sub>2</sub>O
- Test Fixture
- Plastic Tee (2 required)
- #2 Rubber Stopper w/hole
- Squeeze bulb w/valve
- High pressure O<sub>2</sub> hose, DISS O<sub>2</sub>, Female fitting on both ends
- Suitable length of 1/8" ID tygon or rubber tubing
- Corrugated driving gas tubing
- #2 length of 1/4" OD copper tubing

1. Connect the test equipment to the bellows and control assembly as shown in Figure 3-7.
2. Close the needle valves on the test fixture then turn on the oxygen supply.
3. Open needle valves 1 and 2 to inflate the bellows to the 500 mL level.
4. Close needle valve 2 when the 500 mL is obtained.
5. Set the ventilator controls to:  
Minute Volume = 10 L/min  
Rate = 10 BPM  
I:E = 1:1
6. Using the squeeze bulb, pressurize the distal sensing port to 10 cm H<sub>2</sub>O. This will eliminate the Low Airway Pressure Alarm so it will not interfere with the test.
7. Turn on the ventilator.
8. The gauge will indicate varying pressures during inspiration and expiration, but the

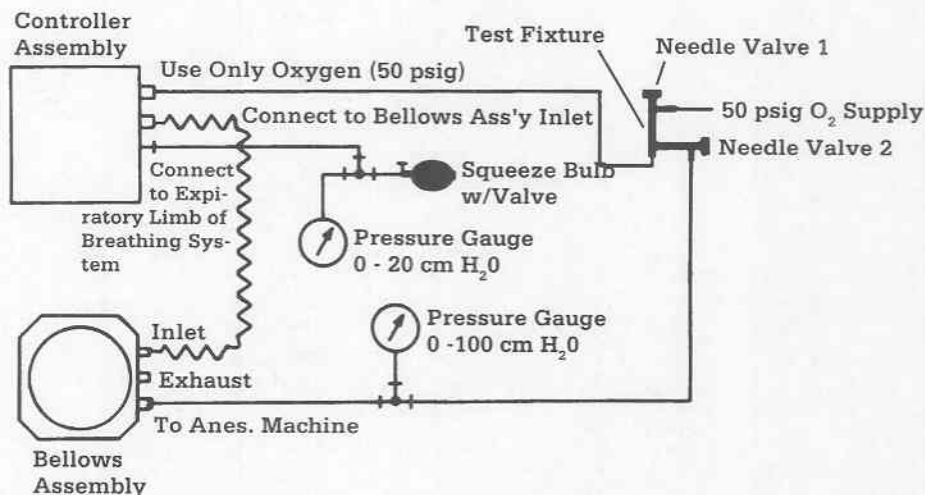


**Figure 3-6**  
Low Airway Pressure Alarm Test

### 3/Functional Test

maximum pressure indicated on the 0 - 100 cm H<sub>2</sub>O gauge must be between 65 and 75 cm H<sub>2</sub>O.

9. If the valve fails, replace the entire flow control unit. This is necessary because the valve cannot be replaced without disturbing the tuned flow tubes.



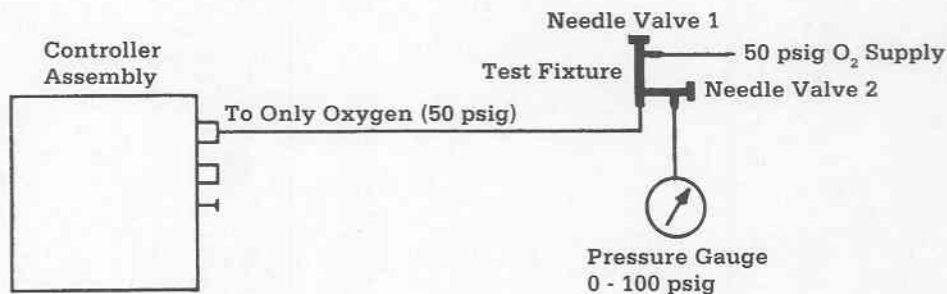
**Figure 3-7**  
Pressure Relief Valve Test

### 3.7 Controller Assembly Leak Test

Equipment Required:

- Pressure Gauge, 0 - 100 psig
  - Test Fixture
  - High pressure O<sub>2</sub>, DISS O<sub>2</sub>, Female fitting on both ends
1. Connect the test equipment to the controller assembly as shown in Figure 3-8.
  2. Close the needle valves 1 and 2 on the test fixture then turn on the oxygen supply.

3. Open needle valve 1 and 2.
4. Pressurize the controller assembly to 50 psig.
5. Close needle valve 1 and monitor the pressure in the controller assembly. The pressure drop should not exceed 1 psig in 90 seconds.
6. If pressure in assembly cannot be maintained check for loose hose fittings or holes in the hoses.



**Figure 3-8**  
Control Assembly Leak Test

## 3/Functional Test

### 3.8 Ground Resistance Checks

Perform a ground resistance check on the ventilator. Use a low range ohmmeter or electrical safety analyzer to measure the resistance between the ground pin on the line cord plug and the controller unit. Tug and flex each end of the power cord during the measurement. The ground resistance must be less than 0.15 ohms. Higher readings may indicate loose or oxidized connections in the power cord or the ventilator grounding circuits.

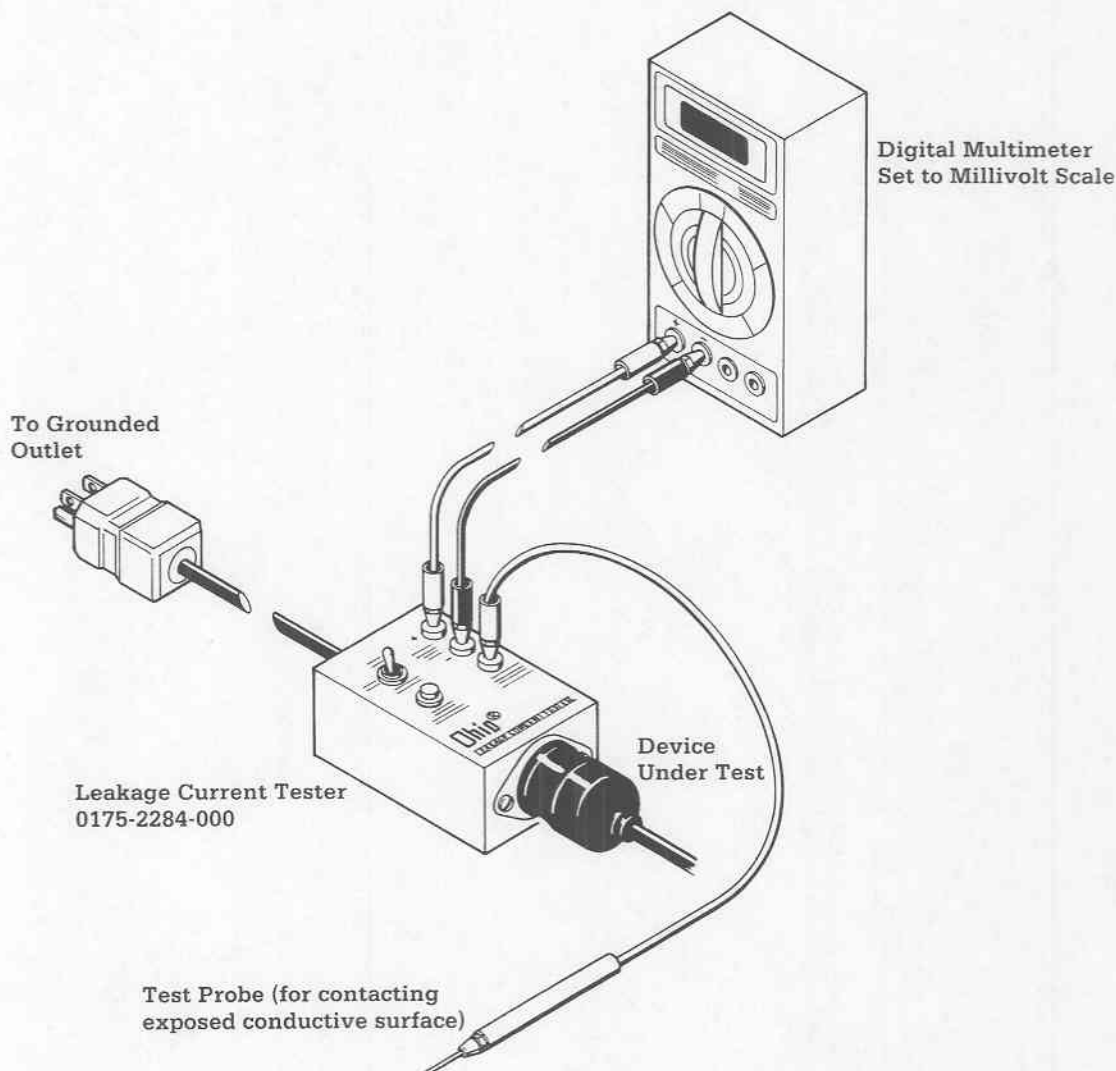
Measure the leakage current in all wiring configurations both On and Off, grounded and ungrounded, and normal and reverse polarities.

Use the leakage current tester Stock No. 0175-2284-000 and digital multimeter (DMM) for the following procedure:

1. Connection (Figure 3-9)

- a. Connect the device under test to the outlet on the leakage current tester.

- b. Make sure the polarity switch on the leakage tester is in the Off Position then plug the line cord into an appropriate grounded mains wall outlet.
- c. Connect the positive lead of the DMM to the positive (+) Meter Out output.
- d. Connect the negative lead of the DMM to the negative (-) Meter Out output.
- e. Set the DMM on the AC millivolt scale.
- f. Connect one end of the test cable (needle probe tip) to contact the External Ground jack on the Leakage Current Tester.
- g. Use the other end of the test cable (needle probe tip) to contact the exposed conductive surface of the device under test.



**Figure 3-9**  
Leakage Current Tester Setup

### 3/Functional Test

#### 2. Normal Polarity Leakage Current Test

- Place the polarity switch of the Leakage Current Tester in the Normal position. (This is in the grounded mode.)
- Switch On the power of the device under test.
- Measure the voltage on the DMM in millivolts. The millivolt reading is directly related to leakage current in microamps (i.e., 100 mV is equivalent to a leakage current of 100 microamps).
- Push the Ground Disconnect switch to measure the ungrounded leakage current.
- Switch the power switch of the device under test Off and then repeat steps 2c through 2d.

#### 3. Reverse Polarity Leakage Current Test

- Place the polarity switch on the Leakage Current Tester in the Reverse position. (This is the grounded mode.)
- Switch On the power of the device under test.
- Measure the voltage on the DMM in millivolts. The millivolt reading is directly related to leakage current in microamps, (i.e., 100 mV is equivalent to a leakage current of 100 microamps).
- Push the Ground Disconnect switch to measure the ungrounded leakage current.
- Switch the power switch of the device under test Off and then repeat steps 2c through 2d.

### 3.9 Leakage Current Test

Use approved equipment and techniques to test the ventilator's leakage current and ground

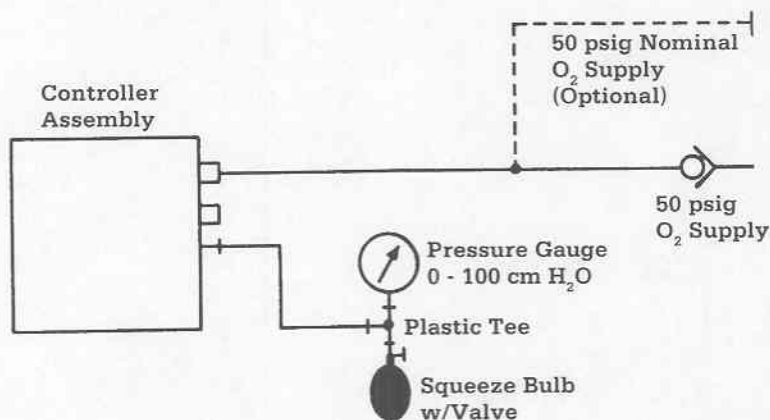
continuity. There must be less than 35 microamps leakage current at 100/120 V ac or less than 70 microamps leakage current at 220/240 V ac under all conditions.

### 3.10 High Airway Pressure Switch Test

Equipment Required:

- Pressure Gauge, 0 - 100 cm H<sub>2</sub>O
- Squeeze bulb w/valve
- Plastic Tee
- Suitable lengths of 1/8" ID tygon or rubber tubing.

- Connect the test equipment to the controller assembly as shown in Figure 3-10.
- Lightly pump the squeeze bulb, then open the valve and bleed until 15 cm H<sub>2</sub>O is indicated on the gauge.
- Set the ventilator controls as follows:  
Minute Volume = 6 L/min  
Rate = 6 BPM  
I:E = 1:1
- Turn on the oxygen supply and the ventilator.
- Slowly Squeeze the hand bulb to bring the pressure above 60 cm H<sub>2</sub>O. The Set Volume Not Delivered alarm must occur between 65 and 75 cm H<sub>2</sub>O as pressure is increased.
- Check that with the pressure maintained at a level to provide a constant alarm, the Ventilator Failure alarm occurs after 2 to 3 breaths.
- If either of the above alarms conditions do not occur, adjust/replace the Pressure Switch or High Pressure board. If problems remain, perform unit calibration.



**Figure 3-10**  
High Airway Pressure Switch Test



## 4/Maintenance

**⚠ WARNING:** Disconnect power before removing the cover panel. Leave the power disconnected unless specifically instructed otherwise.

**⚠ WARNING:** Fire Hazard. Never oil or grease any anesthesia equipment. In general, oils and greases oxidize readily, and in the presence of oxygen they will burn violently.

**⚠ WARNING:** Do not, under any circumstances, perform any testing or maintenance on medical instruments while they are being used to ventilate a patient.

**⚠ WARNING:** The alarm circuit check (section 6.16) must be performed before the ventilator is returned to use after any service procedure.

**⚠ WARNING:** Never use the ventilator if the jumper plug is missing; the audible alarm will malfunction. Always check to be sure that the audible alarm works before returning a unit to operation.

**⚠ WARNING:** Always wear a grounding wrist strap when handling static sensitive assemblies except when working on an energized unit. Otherwise, electrostatic discharges can damage electronic components.

**⚠ WARNING:** Operation must be checked per Section 3 after performing any maintenance procedure.

### 4.1 Scheduled Maintenance

The items listed in the chart must be checked at the specified intervals by a competent technician to help ensure that the ventilator remains in optimum working condition. If these items are not checked, performance may eventually deteriorate and the warranty may be void under the terms of the user's responsibility set forth in the operation manual (1502-0008-000).

Item	Procedure	See Section	Recommended Intervals
Altitude Control	Adjust	4.2	yearly or when relocated
Battery	Replace	4.3	two years
Bellows	Replace	4.4	yearly
Hoses, Internal	Inspect	4.5	yearly
Inspect Unit	Inspect	4.6	six months
Regulator	Check	4.7	yearly
Valve, Exhaust	Inspect	4.10	yearly
Bellows Assembly	Check	4.12	six months
Pop-Off Valve	Check	4.13	six months
Bellows	Check	4.13	six months

## 4/Maintenance

### 4.2 Altitude Adjustments

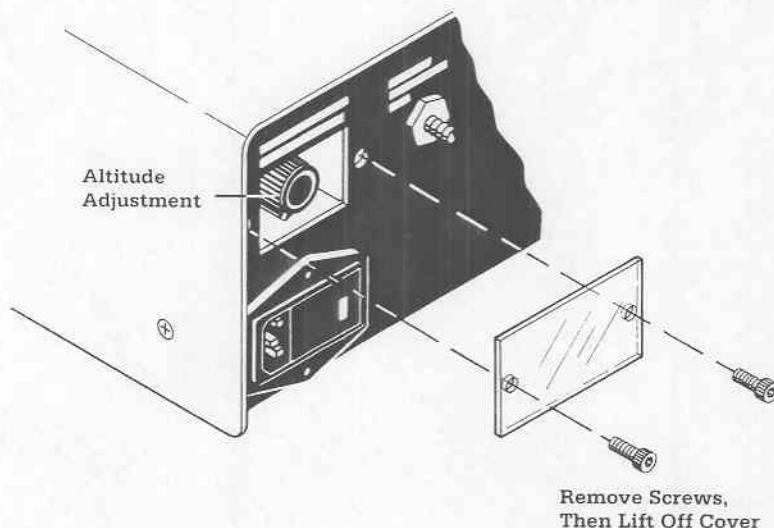
(See Figure 4-1)

Tool Required:

- 3/32 inch hex key wrench.

1. Check the altitude adjustment once a year and whenever the unit is moved to a new location.

2. Determine the location's altitude above sea level.
3. Remove the cover from the altitude adjustment.
4. Set the control to the altitude in meters. Note that the adjustment is set in 50 meter increments.
5. Replace the cover over the control.



**Figure 4-1**  
Altitude Adjustment

Note: When using the Ohmeda 7000 Ventilator at altitudes above the altitude set on the back of the unit, the minute volume delivered will be greater than the setting. At altitudes above 6,000 feet or 1,800 meters the following correction will convert the dial setting of minute volume to the delivered minute volume.

First set the altitude compensation knob to 6,000 feet or 1,800 meters. In the equation, "A" is the altitude in units of the number of feet above 6,000 feet or number of meters above 1,800.

$$\frac{610}{610 - (.02)A} \times \sqrt{\frac{2576 - (.02)A}{2576}} \times \text{Minute Volume Set} = \text{Minute Volume Delivered}$$

For example, assume an altitude of 12,159 feet then:

$$\frac{610}{610 - (.02)6159} \times \sqrt{\frac{2576 - (.02)6159}{2576}} \times \text{MV Setting} = \text{MV Delivered}$$
$$1.19 \times \text{MV Setting} = \text{MV Delivered}$$

Therefore, at an altitude of 12,159 feet with the altitude compensation knob set to 6,000 feet and a set minute volume of 10 L/min, the 7000 will deliver a minute volume of 12.23 L/min.

For ventilators with Altitude Adjustment Control in meters assume an altitude of 3,648 meters then:

$$\frac{610}{610 - (.02)1848} \times \sqrt{\frac{2576 - (.02)1848}{2576}} \times \text{MV Setting} = \text{MV Delivered}$$
$$1.19 \times \text{MV Setting} = \text{MV Delivered}$$

Therefore, at an altitude of 3,648 meters with the altitude compensation knob set to 1,800 meters and a set minute volume of 10 L/min, the 7000 will deliver a minute volume of 10.57 L/min.

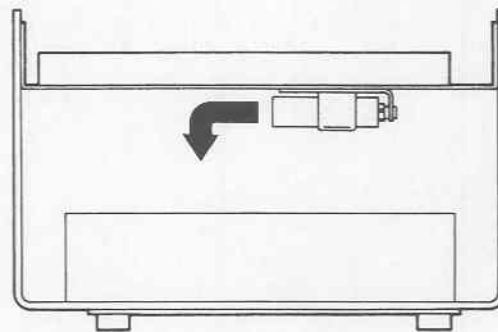
## 4/Maintenance

### 4.3 Battery Replacement

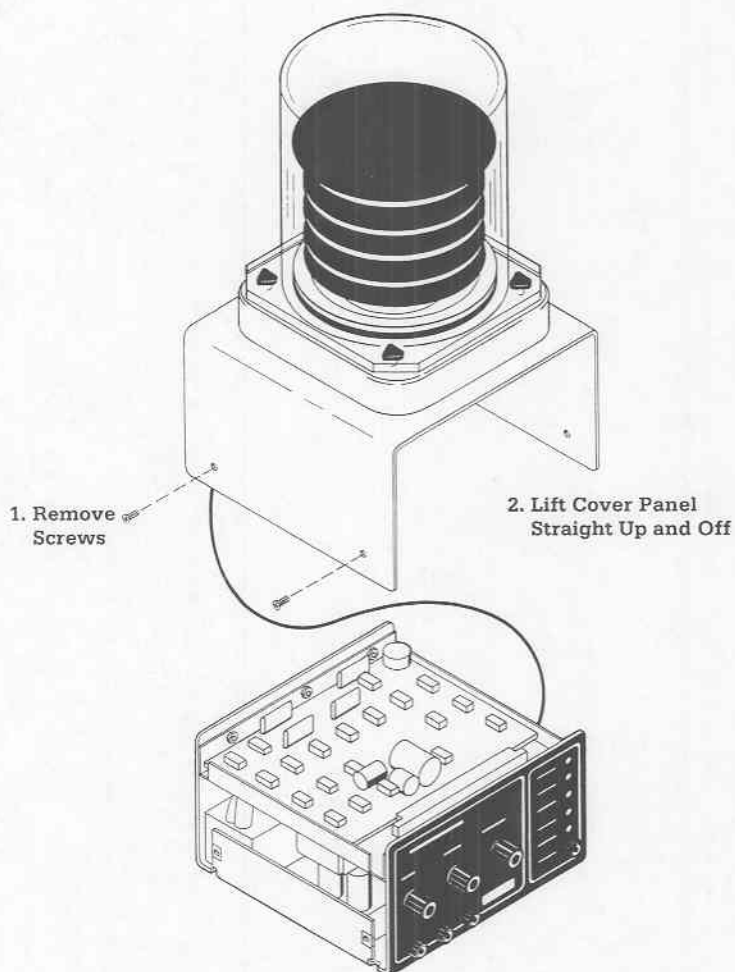
Tools Required:

- #2 Phillips Screwdriver
- 1/8" Flat-tip Screwdriver

1. Unplug the line cord from the electrical outlet.
2. Remove the four screws that fasten the white cover panel in place, and lift off the panel. Do Not unfasten the ground wire between the cover panel and the chassis, (Figure 4-2).
3. The battery mounting clip is located underneath the circuit board plate, (Figure 4-3). Pry the battery out of the clip and install the replacement. Use only a 7.2 V rechargeable battery for a replacement. Stock No. 1502-3016-000.
4. Reassemble the unit.



**Figure 4-3**  
Battery Replacement



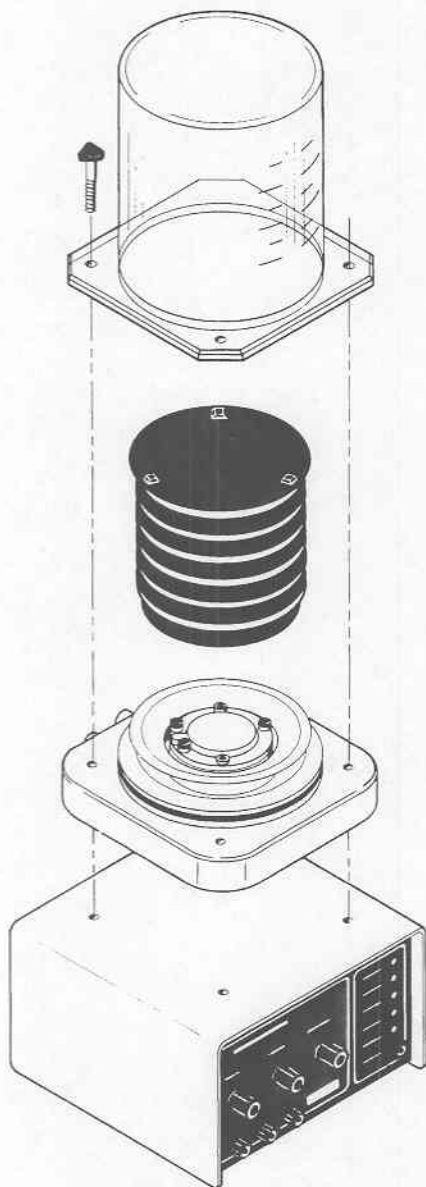
**Figure 4-2**  
Cover Panel Removal

## 4/Maintenance

### 4.4 Bellows Replacement

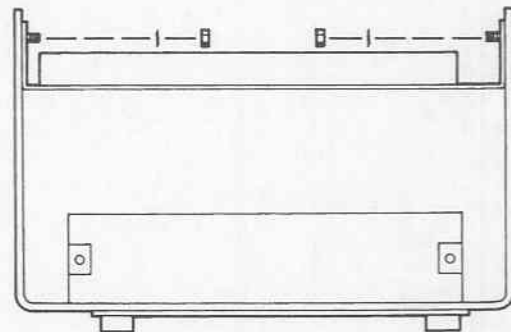
(See Figure 4-4)

1. Remove the four thumbscrews that fasten down the transparent bellows housing.
2. Lift the housing off the bellows assembly.
3. Pull the bellows off its mounting flange.
4. Stretch the replacement bellows over the mounting flange. Remove any wrinkles and make sure of a uniform fit.
5. Replace the bellows cover on the assembly. Be sure the U-cup seal around the base of the assembly does not come out of its groove when the cover is replaced. Otherwise, the assembly will leak.
6. Fasten the cover on with the four thumbscrews.
7. Test the ventilator for correct operation per Section 3.

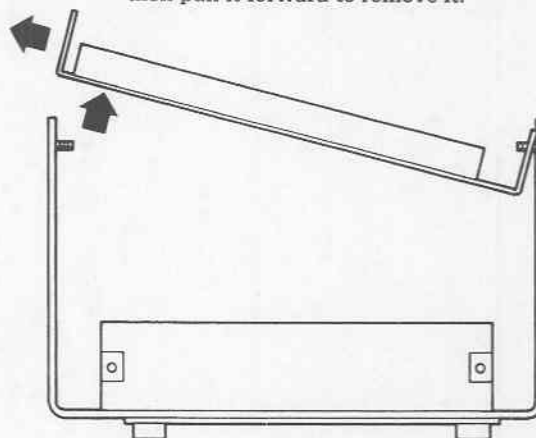


**Figure 4-4**  
Bellows Replacement

1. Unscrew the Mounting Nuts from the Mounting Studs.



2. Lift the Shelf up about an inch, then pull it forward to remove it.



**Figure 4-5**  
Circuit Board Shelf Removal for Maintenance

## 4/Maintenance

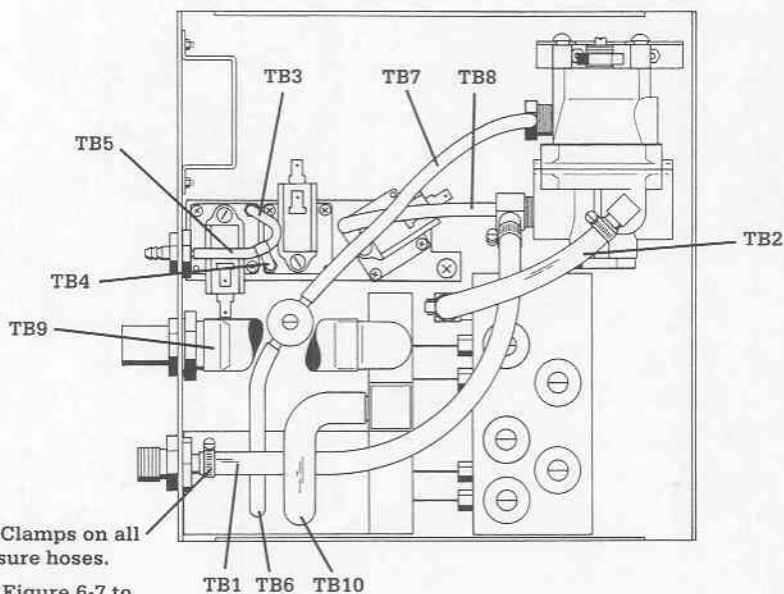
### 4.5 Hose Check and Replacement (Internal)

#### Tools Required:

- #2 Phillips screwdriver
- 5/16" open-end wrench
- 5/16" nut driver
- Needle nose pliers
- Sharp knife

Note: When ordering hose, specify length in units. That is, one unit of 0995-6439-010 would be one foot long, five units would be five feet, etc.

1. Unplug the line cord and remove the four screws that fasten the cover panel in place. Lift off the cover panel (see Figure 4-2).
2. Remove the four nuts that fasten the circuit board mounting plate to the chassis. Tilt the front of the plate up, slide it forward and out of the chassis. Lay it to the side, (Figure 4-5). Inspect the hoses for cracking or general deterioration. If they are OK, reassemble the unit. Otherwise, continue with this procedure to replace all hoses.
3. Loosen the hose clamps and remove all of the hoses attached inside the ventilator.
4. Refer to Figure 4-6 for hose connections throughout the following procedure.
5. Connect TB7 (6 inch length) between the regulator bleed outlet and the solenoid bleed valve inlet.
6. Connect TB6 (6 inch length) between the solenoid bleed valve outlet and the exhaust manifold.
7. Connect TB8 (4 inch length) between the 35 psi pressure switch and the regulator inlet.
8. Connect TB1 (8.25 inch length) between the regulator inlet and the rear panel O<sub>2</sub> supply connection.
9. Connect TB4 (1 inch length) between the middle barb of the Tee fitting and the 7 cm H<sub>2</sub>O pressure switch.
10. Connect TB2 (4.75 inch length) between the regulator outlet and the flow control unit inlet.
11. Connect TB9 (2.75 inch length) between the flow control unit outlet and the rear panel connector.
12. Attach TB3 (1.75 inch length) from the distal sensing connection on the rear panel to the Tee fitting.
13. Connect TB 5 (1.75 inch length) between the Tee fitting and the 65 cm H<sub>2</sub>O pressure switch.
14. Attach TB10 (5 inch length) between the flow control unit relief valve outlet and the exhaust manifold.
15. Test the ventilator for correct operation per Section 3.



**Figure 4-6**  
Internal Hose Connections

## 4/Maintenance

### 4.6 Inspections

#### Equipment Required:

- Leakage Current Tester
- Operational Anesthesia Machine

1. Check that none of the control dials or switches are loose.
2. Plug in the line cord, and switch on the ventilator. Disregard any alarms.
3. Depress the Lamp Test button. All of the alarm lamps must light and the audible alarm must sound.
4. Check the breathing circuit, including the bellows assembly, for cracking or dryness of the rubber. Replace defective items.
5. Set the Altitude dial to the correct elevation (in meters) for the operational location.
6. Inspect the bellows housing for cracks or chips.
7. Using approved equipment and techniques, check that the leakage current is under 35 microamps (70 microamps on 220/240 volts AC). Also test ground continuity to specified values.
8. Examine the physical condition of the unit. Units that appear to have been abused should be tested for correct function per Section 3.
9. Connect the ventilator to an anesthesia machine as if for normal operation. Check that the ventilator's controls function correctly.

### 4.7 Pressure Regulator and Bleed Valve Test and Adjustment

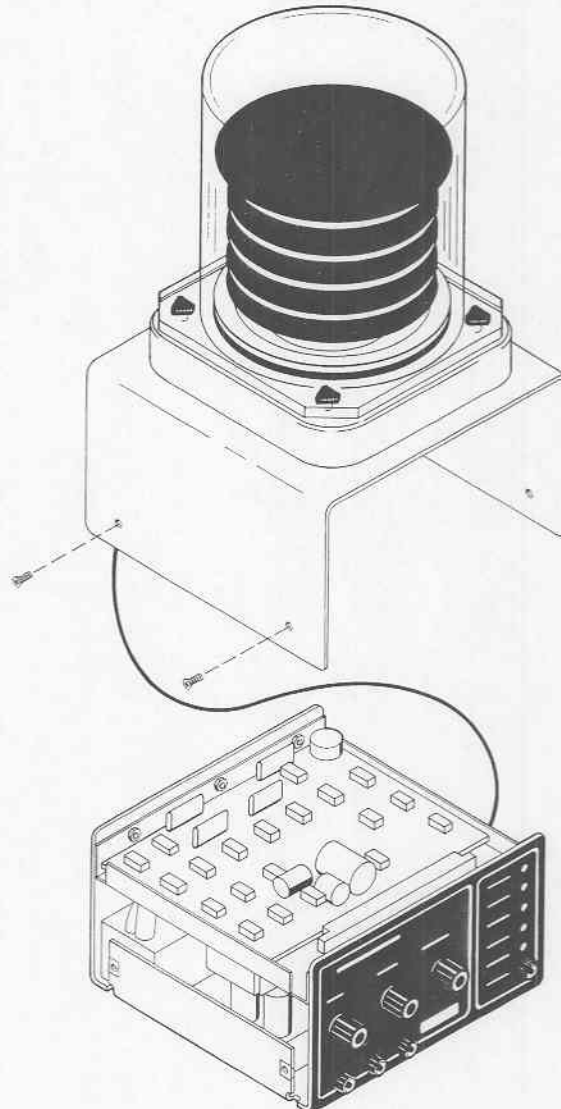
#### Tools Required:

- #2 Phillips screwdriver
- 5/8" open-end wrench
- 7/8" flat-tip screwdriver
- 5/16" open-end wrench
- 5/16" nutdriver
- 0 - 60 psig pressure gauge  $\pm 0.25\%$  full scale accuracy
- $50 \pm 2$  psig oxygen supply
- 5 mm nutdriver

1. Unplug the line cord. Remove the four Phillips-head screws that fasten the cover panel in place, then lift off the cover panel, (Figure 4-7).
2. Remove the four nuts that fasten the circuit board assembly in place. Lift the front of the assembly up an inch and a half, then slide it forward off its mounting studs and out of the unit. Lay it down next to the chassis, (Figure 4-5).

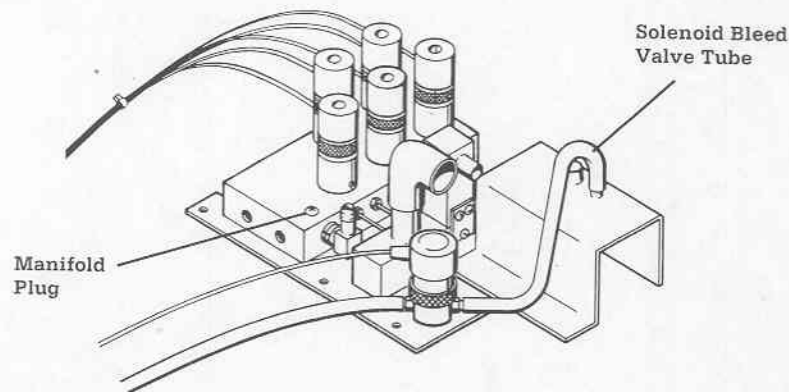
3. Remove the manifold plug, (Figure 4-8). Connect an accurate pressure gauge to the manifold where the plug was. The gauge must have a length of tubing attached between it and the manifold such that the gauge will rest on the table beside the ventilator.

**⚠ WARNING: Electrical Shock Hazard.** Do not touch exposed wires or conductive surfaces while the cover panel is removed from the ventilator unless electrical power is disconnected from the unit. Hazardous voltages are present during normal operation. Never wear a grounding wrist strap when working on an energized ventilator.



**Figure 4-7**  
Cover Panel Removal





**Figure 4-8**  
Manifold Plug Location for Regulator Adjustment

4. Remove the solenoid bleed valve's tube from its connection to the exhaust chamber cover.
5. Connect the 50 psig O<sub>2</sub> supply to the ventilator, connect the line cord to the power source, and switch on the unit in that order. (Disregard any alarms).
6. A maximum gas flow of 3 L/min out of the bleed tube must be observed. If the flow is greater than 3 L/min, replace the regulator.

If there is no flow out of the bleed valve, disconnect the bleed valve tube from the fitting on the regulator. Flow some gas through the bleed valve to verify that it is open. If the bleed valve is not open, check the circuit board and bleed valve solenoid for correct operation.

7. Turn off the ventilator. Then, reconnect the bleed tube to the exhaust chamber cover.
- Note: During this test ignore the Set Volume Not Delivered alarm.
8. Replace the circuit board assembly but do not fasten it in place. Turn the ventilator back on.

9. Set the ventilator controls to:

Minute Volume = 12 L/min  
Rate = 6 BPM  
I:E = 1:1

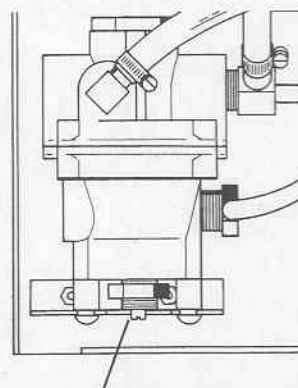
10. Check for  $38 \pm 0.50$  psig during inspiration. If necessary, adjust the regulator using a 5 mm nutdriver, (Figure 4-9).
11. Set the ventilator controls to:  
Minute Volume = 30 L/min  
Rate = 6 BPM  
I:E = 1:1
12. Check that the regulator output pressure is 36.75 psig or higher during inspiration. If not, readjust it and repeat steps 6 through

9. Replace the regulator if it cannot be adjusted to meet the specifications.

13. Set the ventilator controls to:

Minute Volume = 12 L/min  
Rate = 6 BPM  
I:E = 1:1

14. Check for  $38 \pm 0.50$  psig during inspiration. If necessary, adjust the regulator using a 5 mm nutdriver, (Figure 4-9).
15. Check the static pressure during expiration. It must be less than 39 psig; if not, adjust the regulator and repeat steps 6 through 10. Replace the regulator if it cannot be adjusted to meet the specification.
16. Any regulator that develops an oscillation in the output pressure should be replaced.
17. Switch off the ventilator and disconnect the O<sub>2</sub> supply.
18. Reinstall the manifold plug, then reassemble the unit.



Adjust Regulator through access hole in side of chassis. Secure adjustment with thread-locking compound when finished. (Loctite #242).

**Figure 4-9**  
Regulator Adjustment

## 4/Maintenance

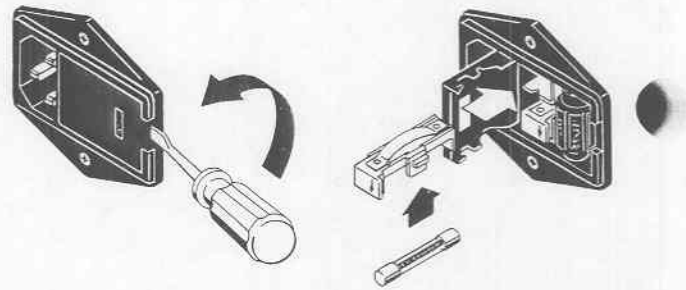
### 4.8 Fuse Replacement

1. Remove the power cord from the AC power source receptacle.
2. Remove the power cord anti-disconnect bracket by removing the two socket head cap screws. Refer to figure 4-11.
3. Remove the power cord plug from the power inlet module.
4. Place the end of a small flat edge screwdriver into the tab on the right hand side of the power inlet module and pry open the cover.
5. Refer to Figure 4-10. Use the end of the screwdriver to lift out the fuse drawers. Replace both of the fuses with fuses of the same type and rating.
6. Check voltage selector drum so that the desired voltage is facing forward.
7. Close the cover and push firmly to snap the module cover into place. Check to insure that the desired voltage is displayed in the window.
8. Reinstall the power cord and the power cord anti-disconnect bracket.

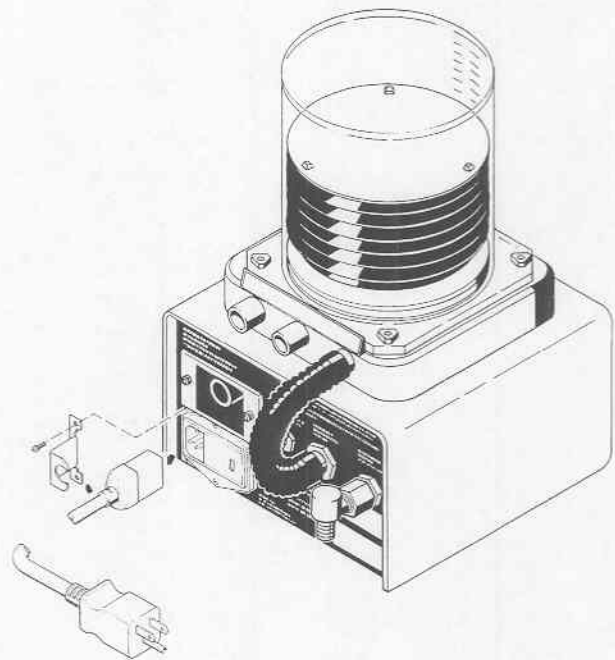
### 4.9 Changing Input Voltage

1. Remove the power cord from the AC power source receptacle.
2. Remove the power cord anti-disconnect bracket by removing the two socket head cap screws. Refer to figure 4-11.
3. Remove the power cord plug from the power inlet module.
4. Refer to Figure 4-12. Place the end of a small flat edge screwdriver into the tab on the right hand side of the power inlet module and pry open the cover.
5. Remove the voltage selector drum and rotate the drum so that the desired voltage faces forward. Reinsert the drum back into the slots in the module.
6. Close the cover and push firmly to snap the module cover into place. Check to insure that the desired voltage is displayed in the window.
7. Reinstall the power cord and the power cord anti-disconnect bracket.

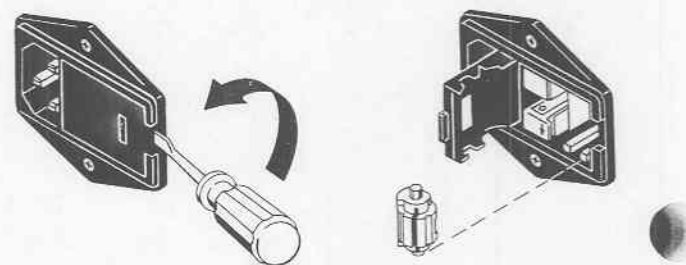
**⚠ CAUTION:** The input voltage to the ventilator from the mains outlet must be the same as that indicated in the window on the power inlet module on the rear panel of the control module. Operating the ventilator with an incorrect input voltage may damage the ventilator or cause it to malfunction.



**Figure 4-10**  
Fuse Replacement



**Figure 4-11**  
Anti-Disconnect Bracket Removal



**Figure 4-12**  
Changing the Input Voltage

## 4/Maintenance

### 4.10 Exhaust Valve Inspections

Tools Required:

- #2 Phillips screwdriver
- 5/16" open-end wrench
- 7/8" open-end wrench
- 5/16" nutdriver

1. Unplug the ventilator's line cord from the wall outlet and disconnect the O<sub>2</sub> power source.
2. Remove the four Phillips head screws that fasten the cover panel in place. Lift off the cover panel, (Figure 4-7).
3. Unbolt the circuit board mounting plate from the chassis (four nuts) and set it to the side, (Figure 4-5).
4. Disconnect the gas hose from the rear panel gas supply inlet connector.

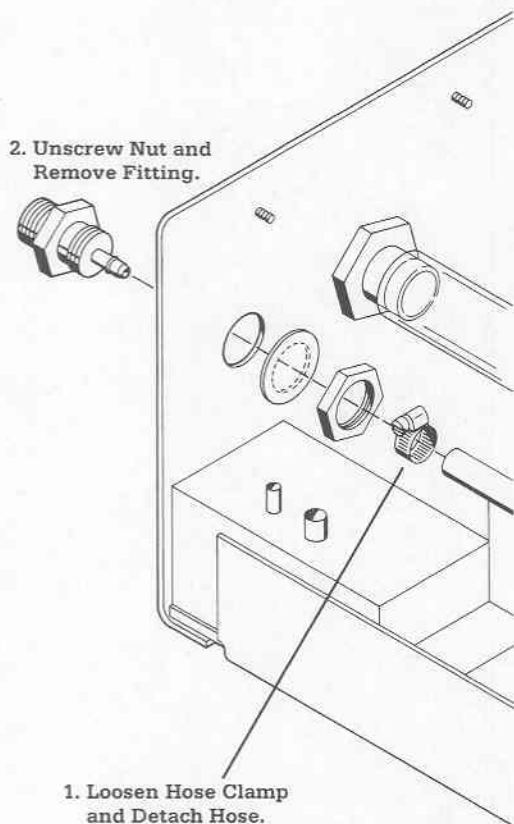
5. Remove the rear panel gas supply inlet connector, (Figure 4-13).
6. Referring to Figure 4-6, disconnect tubes TB6 and TB10.

7. Remove the exhaust valve cover, (Figure 4-14).

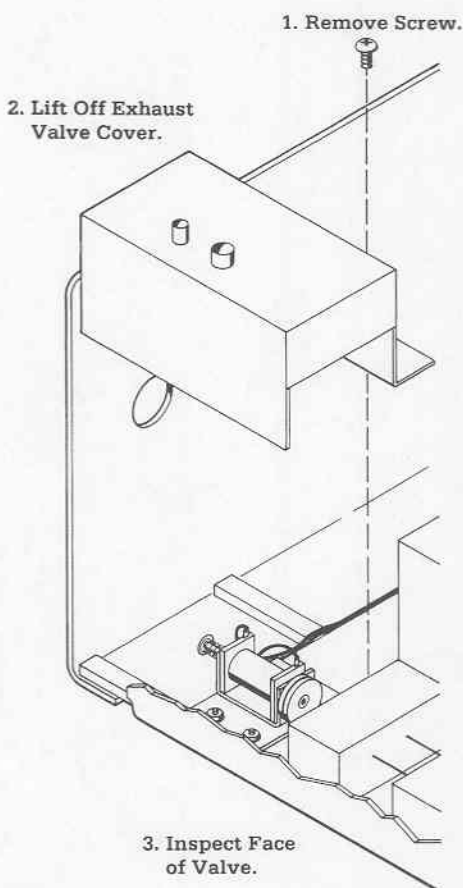
8. Examine the seal on the exhaust valve. If it is deteriorated or worn replace the exhaust valve (refer to Section 6.2A).

Examine the exhaust valve plunger for debris or corrosion. Replace if debris or corrosion is present.

9. Reassemble the unit, then perform all of the tests in Section 3 before returning the unit to operation.



**Figure 4-13**  
Rear Panel Gas Supply Inlet Connector Removal



**Figure 4-14**  
Exhaust Valve Inspection

## 4/Maintenance

### 4.11 Preoperative Checkout Procedures

**⚠ WARNING:** Do not use the ventilator until all the Preoperative Checkout Procedures have been performed and correct operation has been verified.

Perform these procedures after cleaning and sterilizing the bellows assembly and before each case.

1. Verify that the proper hose connections have been made between the bellows assembly and the control module.
2. Verify that the proper hose connections have been made between the bellows assembly and the patient breathing circuit.
3. Verify that the correct driving gas (Oxygen Only) is securely connected to the control module.
4. Verify that the electrical power cord is plugged into a properly grounded outlet.
5. Verify that a properly functioning scavenging system is connected to the ventilator's 19 mm Exhaust port or interface manifold 19 mm connector. Do not connect the ventilator Exhaust directly to a vacuum source.

**⚠ WARNING:** Do not connect the ventilator Exhaust directly to a vacuum source. The vacuum may remove required gases from the patient circuit.

6. Verify that the alarm lamps light and alarm tone sounds when the Lamp Test button is pressed (the Power switch must be On (I)). If not, perform the Functional Tests in Section 3 to isolate the problem.
7. Verify that the Sigh switch is in the desired position.
8. Verify that the low airway pressure sensing tube is properly connected to the barb on the control module back panel labeled Connect to Expiratory Limb of Breathing System and to the pressure sensing tee (or Circuit Pressure fitting secured in the GMS Absorber).
9. Verify that the Low Airway Pressure Alarm and high pressure relief are functioning by doing the following:

#### Verifying Low Airway Pressure

- a. Fit a rebreathing bag onto the Y connector.
- b. Fill the bellows using the anesthesia system's oxygen flush and set a gas flow of 2 L/min. Keep the bellows inflated.
- c. Switch the ventilator on.

- d. Set ventilator control dials so that no alarms activate.
- e. Remove the bag from the Y connector. The Low Airway Pressure Alarm should activate after the second ventilation cycle. If not, perform the Functional Tests in Section 3 to isolate the problem. If the alarm is functional, continue with step f.

#### Verifying High Pressure Relief

- f. Keep the ventilator cycling and set the control dials for a tidal volume of 1 liter.
- g. Plug the Y connector with the test plug.
- h. During the next inspiration phase, the Set Volume Not Delivered Alarm should activate and the bellows should reinflate before the 1 liter tidal volume is reached. If not, perform the Functional Tests in Section 3 to isolate the problem.

Note: An abbreviated version of these procedures is printed on the Preoperative Check List card which slides out from under the control module. Its purpose is to remind the operator of the checks which must be made, not to give instruction. To learn safe operation of the ventilator, read the 7000 Electronic Anesthesia Ventilator's Operation and Maintenance Manual.

### 4.12 Bellows Assembly Leak Test

Perform this procedure after cleaning and sterilizing the bellows assembly and before each case.

1. Perform the leak test recommended for the absorber in use (consult the absorber operation and maintenance manual). The absorber must pass the leak test before performing the following steps.
2. Shut off all fresh gas flow.
3. Plug the Y connector with the test plug.
4. Fill the bellows using the anesthesia system's oxygen flush.
5. Observe the bellows. If it drops more than 100 mL in one minute, it has a leak. Tighten loose patient circuit connections, then repeat the test.

If the leak cannot be corrected, perform the Functional Tests (Section 3) to isolate the problem.

**⚠ WARNING:** Do not use the ventilator if it fails any part of the checkout procedure. Remove for service.



### 4.13 Cleaning and Sterilizing the Bellows Assembly

**⚠ WARNING:** The bellows assembly should be sterilized periodically to minimize the risk of crossinfecting patients. Use a sterilization schedule which complies with the user's infection control and risk management policies.

Note: Because of the temperature difference between exhaled patient gases and the breathing circuit, condensation may form in the circuit. Water droplet formation is particularly noticeable in the bellows and bellows base. This is a normal occurrence. Periodic cleaning and sterilization helps keep the ventilator in proper working order.

Remember to perform the above Preoperative Checkout Procedures and Bellows Assembly Leak Test after cleaning and sterilizing the bellows and before each case.

**To clean and sterilize the bellows assembly do the following:**

#### Disassembly

Perform Step 1 if the bellows assembly is attached to the control module.

Perform Step 2 if the bellows assembly is attached to the GMS Absorber.

1. To detach the bellows assembly from the control module:
  - a. Remove all hose connections from the bellows assembly.
  - b. Remove the four thumbscrews which attach the bellows assembly, and carefully lift the bellows assembly from the control module.
2. To detach the bellows assembly from the GMS Absorber:
  - a. Remove all hose connections from the bellows assembly.
  - b. Loosen the locking knob until the locking rod is released. Hold the entire assembly firmly and pull it free from the absorber.
  - c. Remove the four thumbscrews which attach the bellows assembly to the mounting assembly. Separate the bellows assembly from the mounting assembly.
  - d. Remove the interface manifold from the bellows assembly ports.
3. Use Figure 4-15 as a guide for further disassembly.

#### Cleaning

Except for the control module, those parts shown in Figure 4-15 may be washed with a mild soap and water solution. Make sure to dry the parts thoroughly.

4. To clean the plastic bellows housing, bellows, pressure sensing tube, Pop-off Valve, bellows base and Interface Manifold do the following:
    - a. Wash the plastic bellows housing with mild soap and water solution. Rinse thoroughly with cold water making sure that all soap is removed. Dry thoroughly with a soft cloth.
    - b. Wash the bellows with mild soap and water solution. Rinse thoroughly with cold water making sure that all soap is removed. Remove excess water and hang the bellows up to dry overnight, suspended by its top disc.
- Note: Moisture remaining in the folds of the bellows can cause tackiness and interfere with normal operation.
- Note: Rubber materials deteriorate over a period of time and should be considered an expendable item, subject to periodic replacement. Check rubber parts often for swelling, tackiness, holes or cracking. When any of these conditions are evidence, replace the affected parts.
- c. Wash the pressure sensing tube with mild soap and water solution. Rinse thoroughly with cold water making sure that all soap is removed. Dry thoroughly.
  - d. Do not submerge the Pop-off Valve. Liquids can become trapped within the valve. Clean the exterior surfaces with a soft cloth dampened in a solution of warm water and mild liquid detergent. Do not allow liquid to enter the Drive Gas Port (see Figure 4-15 Port "A"). Rinse the cloth in clean cold water and wipe the valve to remove all soap. Dry thoroughly before use and before sterilization.

**⚠ WARNING:** Liquids or any foreign material trapped within the driving gas circuit of the Pop-off Valve (Port "A", Figure 4-15) and Bellows Base (Port "B" and Ports "C", Figure 4-15) can impair operation of the Pop-off Valve. Do not use the Pop-off Valve or Bellows Base if this is suspected. If complete disassembly is required to remove trapped foreign material, perform Pop-off Valve Perform-

## 4/Maintenance

ance Test (see Section 3.2) and Bellows Assembly Leak Test (see Section 3.3) before reuse.

- e. Do not submerge the Bellows Base. Liquids can become trapped within the base. Clean the exterior surfaces with a soft cloth dampened in a warm water and mild liquid detergent solution. A bottle brush may be used to clean the 22 mm "To Anesthesia Machine" (patient) port and 19 mm "Exhaust" port. The 17 mm "Inlet" port is normally exposed only to the oxygen driving gas and should not require cleaning. Rinse the cloth and bottle brush in clean cold water and repeat cleaning procedure to remove all soap. Dry thoroughly before use and before sterilization.

**⚠ WARNING:** Liquids or any foreign material trapped within the driving gas circuit of the Pop-off Valve (Port "A", Figure 4-15) and Bellows Base (Port "B" and Ports "C", Figure 4-15) can impair operation of the Pop-off Valve. Do not use the Pop-off Valve or Bellows Base if this is suspected. If complete disassembly is required to remove trapped foreign material, perform Pop-off Valve Performance Test (see Section 3.2) and Bellows Assembly Leak Test (see Section 3.3) before reuse.

Note: When disassembling the Bellows Base, remove the retaining screws and carefully separate the individual components. Remove the foreign material and reassemble in reverse order. Do not over-tighten screws.

- f. Wash the Interface Manifold in a solution of warm water and mild liquid detergent. Rinse thoroughly in clean cold water removing all soap. Dry thoroughly before use and before sterilization.

### Sterilization

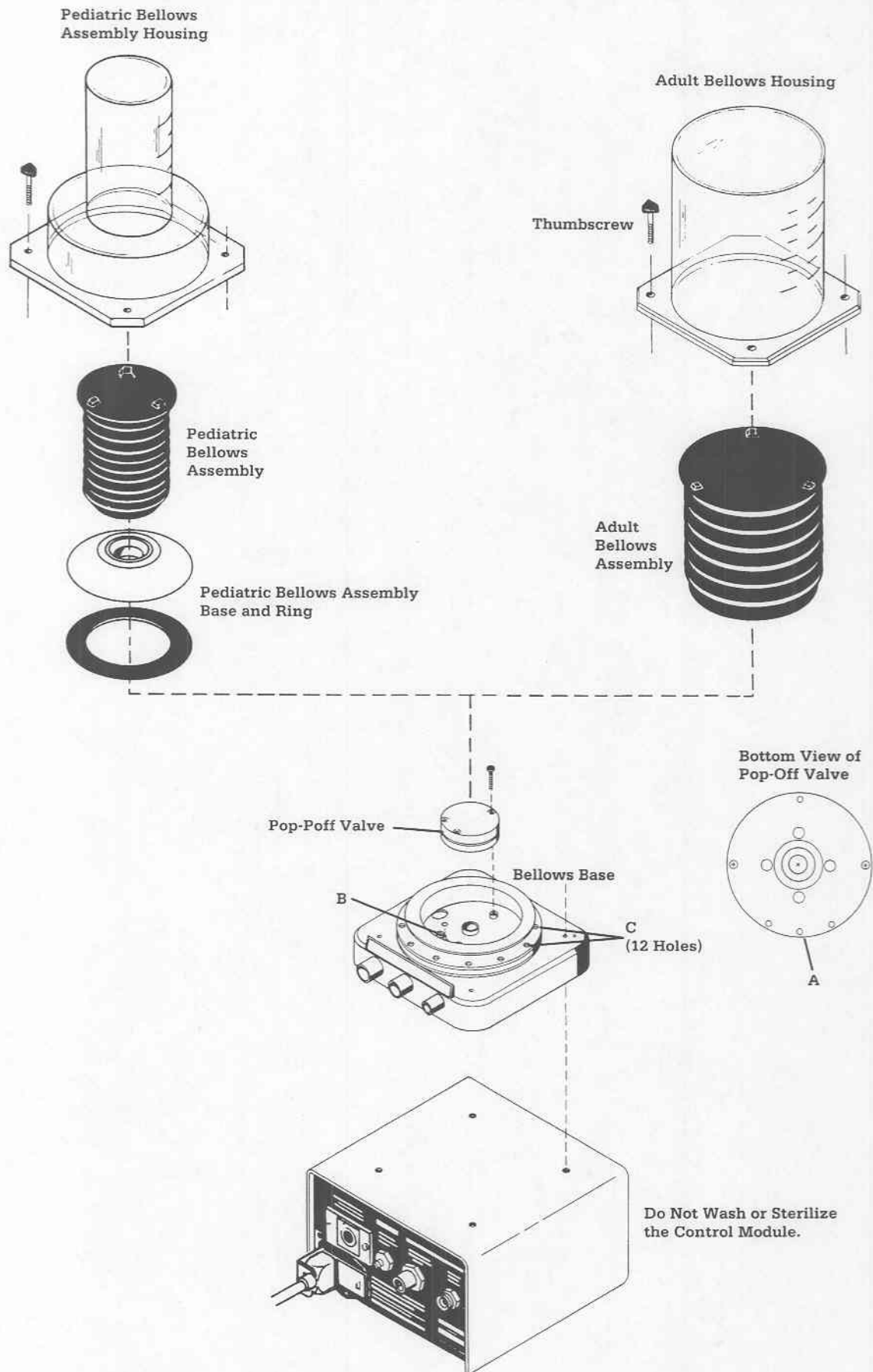
Except for the control module, those parts shown in Figure 4-15 may be washed with a mild soap and water solution. Make sure to dry the parts thoroughly.

Note: The clear plastic bellows housing (adult and pediatric) requires sterilization only if the bellows has torn or leaked. Normally the bellows exterior is exposed to the driving gas only. The control module is exposed to the driving gas only and does not require sterilization.

Ethylene Oxide Sterilization: After cleaning and thorough drying, all components may be sterilized using an ethylene oxide mixture not exceeding 135 degrees Fahrenheit. Follow sterilizer manufacturer's recommendations for sterilization and aeration of rubber and plastic parts.

**⚠ CAUTION:** Those parts suitable for ethylene oxide sterilization should, following sterilization, be quarantined in a well ventilated area to allow dissipation of residual gas absorbed by components. Follow the sterilizer manufacturer's recommendations for special aeration periods required.





**Figure 4-15**  
Bellows Disassembly

# 5/Maintenance

## 5.1 Troubleshooting (Basic)

### Troubleshooting Guide

This troubleshooting guide is intended to isolate the cause of the most basic problems only. If after using this guide, the ventilator continues to malfunction, an Ohmeda Service Representative should be called to repair the unit.

Problem	Probable Cause	Check
Bellows does not expand during ventilation or tends to collapse.	<ol style="list-style-type: none"><li>1. Leak in the breathing circuit.</li><li>2. Bellows not installed properly.</li><li>3. Tear or leak in bellows.</li><li>4. Insufficient fresh gas flow.</li><li>5. Improperly functioning Pop-off valve.</li></ol>	<p>Check breathing circuit and absorber for leaks.</p> <p>Check the bellows to base attachment. Check the entire surface of the bellows. Pay close attention to the angles in the convolutions (see Section 3).</p> <p>Check that settings on flowmeters are adequate.</p> <p>Check Pop-off valve (see Section 3).</p>
Bellows distended and/or slips off base.	<ol style="list-style-type: none"><li>1. Bellows retention problem.</li><li>2. Bellows assembly exhaust restricted.</li><li>3. Ventilator Pop-off valve.</li></ol>	<p>Check bellows (see Section 3).</p> <p>Check the scavenging system for high vacuum or blockage.</p> <p>Control port plugged (see Section 3) or drive gas inlet hose blocked.</p>
Audible power failure alarm activates when turning the ventilator on.	<ol style="list-style-type: none"><li>1. Power cord disconnect or power failure.</li><li>2. Fuse blown.</li></ol>	<p>Check the power cord connection to the wall outlet. Make sure the wall outlet has power.</p> <p>Check fuses.</p>
Set Volume not Delivered alarm activates.	<ol style="list-style-type: none"><li>1. The Minute Volume and/or Rate dials are set to exceed Tidal Volume limits.</li><li>2. High pressure condition in patient circuit.</li></ol>	<p>Check the Minute Volume and Rate dial settings. Make sure they allow function within the ventilator limits. See Section 2.</p> <p>Check patient circuit for obstruction.</p>
Low Oxygen Supply Pressure alarm activates.	<ol style="list-style-type: none"><li>1. High pressure hose connections may be leaking.</li><li>2. Anesthesia machine power outlet circuit pressure may be low.</li><li>3. Hospital oxygen pipeline supply pressure may be low.</li><li>4. Flow restriction in the oxygen supply line.</li></ol>	<p>Check high pressure hose connections at ventilator and oxygen source.</p> <p>Check pressure in power outlet circuit.</p> <p>Check pressure of hospital oxygen pipeline supply.</p> <p>Check oxygen supply line on hose for restrictions.</p>
Ventilator cycles normally but Low Airway Pressure alarm activates.	The tube from the ventilator port labeled Connect to Expiratory Limb of Breathing System to the distal LowPressure Alarm tee or connector is disconnected, plugged or kinked.	Check the connections at the ventilator control module and at the sensing tee or connector.
Actual I:E Ratio Less than Dial Setting alarm activates.	The Minute Volume and I:E Ratio dials are set to exceed ventilator functional limits.	Check the Minute Volume and I:E Ratio dial settings. Make sure they allow function within the ventilator limits. See Section 2.1.

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Problem	Probable Cause	Check
Continuous flow of supply gas before machine is turned on.	1. Valve plate assembly. 2. Internal hose leak. 3. Bleed valve failure.	Manually hold exhaust valve closed and check for gas flow from control unit driving gas outlet. Check hose. Check bleed valve outlet for gas flow.
Bellows does not descend during inspiration.	Failure of exhaust valve.	Check exhaust valve.
Ventilator Failure Alarm activates.	1. High pressure condition in patient circuit. 2. Failure in critical area of control module.	Check patient circuit for obstruction.  Contact Ohmeda Service for ventilator repair.

### 5.2 Troubleshooting (Extended)

This troubleshooting guide is intended to isolate the cause of most problems. If after using this guide, the ventilator continues to malfunction, an Ohmeda Service Representative should be called to repair the unit.

Problem	Probable Cause	Check
Power failure	Transformer, board connector or power switch PC board PC board	a. Check ac to board at cathode D-50. b. Check for $+8 \pm 0.15$ volts at TP8. c. Check for $-8 \pm 0.15$ volts at TP9.
Ventilator failure	PC board  PC board PC board  PC board	a. Check for flow gate TP17, see Figure 7-4. (If present go to C). b. Check for rate at TP15, see Figure 7-3. c. Check junction D16, 17 and 18 for exhaust valve lockout reset pulse. d. Check for ramp at TP18, see Figure 7-5.
Low supply pressure	Pressure switch  Pressure switch or PC board	a. Check supply pressure to SW6 pressure switch to be above 35 psi. b. Check pin 46 for zero volts.
Patient pressure alarm	Bellows not installed properly  Pressure switch or PC board  PC board	a. Check pressure connection from bellows base to control unit. b. Check cathode of D13 for reset pulse each time the bellows is driven. c. Check ramp at T19 see Figure 7-6.
Actual I:E less than setting	PC board PC board	a. Check TP13 for $1.933 \pm 0.10$ volts. b. Check U2 pin 7 for $7.65 \pm 0.5$ volts.
Low Tidal Volume	PC board Leaking in the breathing circuit  Breathing circuit compliance	a. Check TP4 for $0.34 \pm 0.02$ volts. b. Check driving gas to bellows assembly is within 1 L/min of set Flow Rate. c. Perform bellows assembly tests (see Section 3). d. Check breathing system and absorber for leaks. e. See Section 2 on compliance.

## 6/Repairs and Parts

**⚠ WARNING:** Fire Hazard. Never oil or grease any anesthesia equipment. In general, oils and greases oxidize readily, and in the presence of oxygen they will burn violently.

**⚠ WARNING:** The alarm circuit check (section 7-16) must be performed before the ventilator is returned to use after any service procedure.

**⚠ WARNING:** Disconnect power before removing the cover panel. Leave the power disconnected unless specifically instructed otherwise.

**⚠ WARNING:** Electrical Shock Hazard. Do not touch exposed wires or conductive surfaces while the cover panel is removed from the ventilator unless electrical power is disconnected from the unit. Hazardous voltages are present during normal operation. Never wear a grounding wrist strap when working on an energized ventilator.

**⚠ CAUTION:** Always wear a grounding wrist strap when handling static sensitive assemblies except when working on an energized unit. Otherwise, electrostatic discharges can damage electronic components.

Note: Check operation of the unit after any service procedure is performed.

Note: Assembly is the reverse of disassembly except where noted.

### 6.1 Circuit Board Assembly

**⚠ CAUTION:** Only control boards with assembly revision 14 or higher can be used with this version of the 7000 Electronic Ventilator. Use of earlier version boards will result in malfunction of the ventilator.

Tools Required:

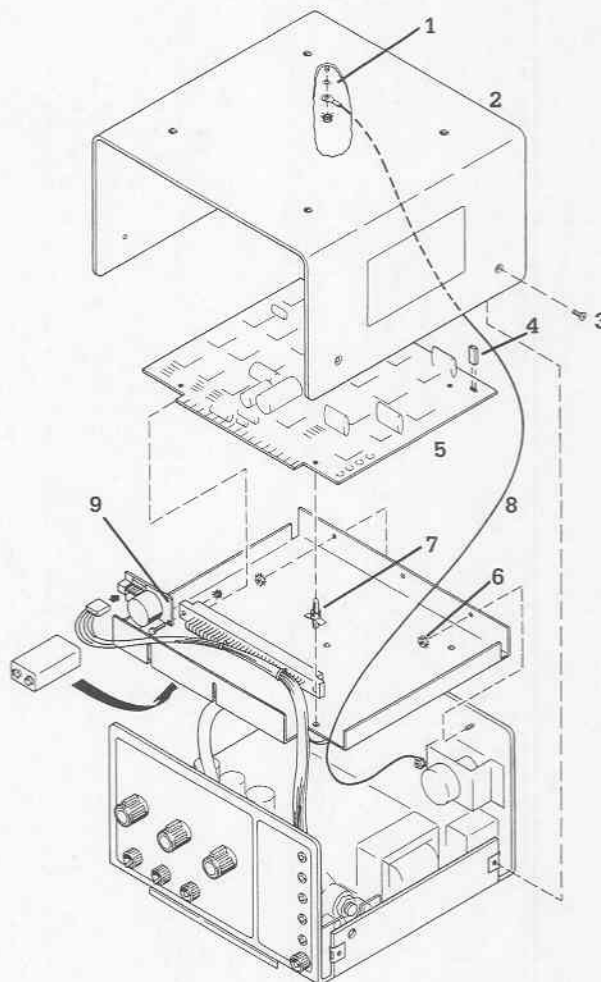
- #2 Phillips screwdriver
- 5/16" open-end wrench
- 5/16" nutdriver
- Solder gun and solder
- needle nose pliers
- 1/8" flat-tip screwdriver
- wire cutting/stripping tool
- 5 mm nutdriver

1. Unplug the ventilator's line cord from the wall outlet and disconnect the O<sub>2</sub> power source.

Description	Stock Number
1. Washer .....	0202-3200-300
2. Cover Panel .....	0229-1001-710
3. Screw .....	0140-6224-106
4. Alarm Jumper Plug .....	0690-1563-315
5. Circuit Board (Calibrated) .....	0208-6349-700
6. Nut .....	0202-1130-300
7. Stand-off, Circuit Board mtg .....	0602-2088-300
8. Wire, Grounding, Cover Panel .....	1502-7016-000
9. Over Pressure PC Board .....	0208-6341-300

Not Shown

Audio Alarm ..... 0690-1100-301



**Figure 6-1**  
Circuit Board Assembly Removal

## 6/Repairs and Parts

2. Remove four screws fastening the cover panel onto the chassis then set the panel aside, (Figure 6-1).
3. Gently lift the circuit board while releasing it from its five mounting pegs.

**⚠CAUTION:** Do not apply excessive force to the circuit board when removing it. Over-stressing may damage the printed circuit board.

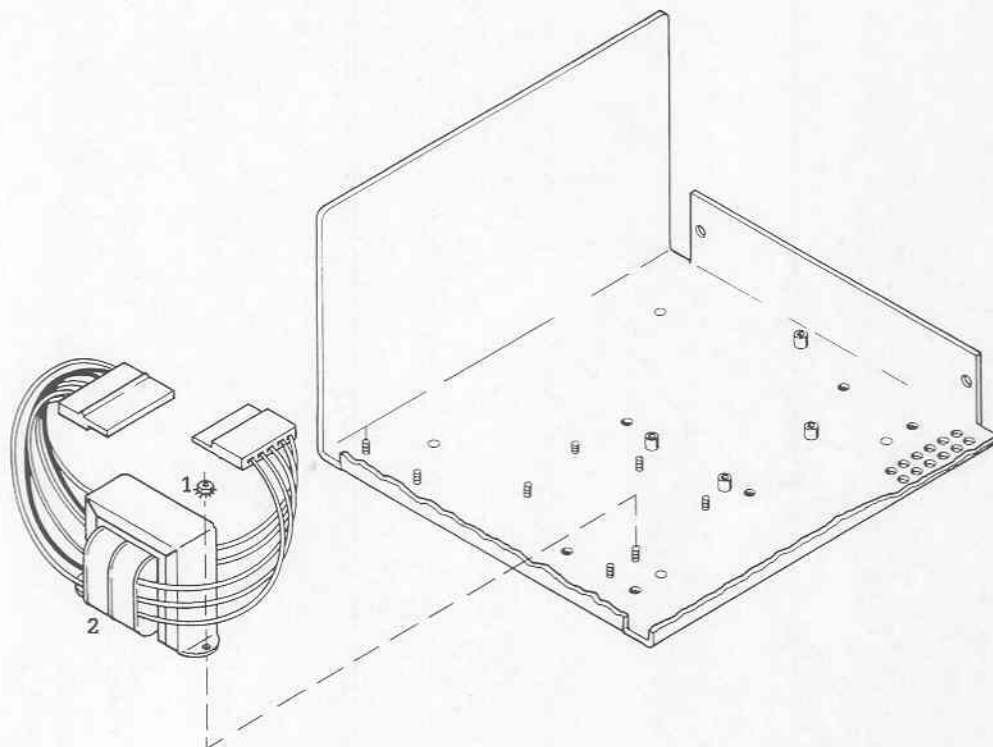
4. Unplug the circuit board from the harness connector to replace it.
5. Unplug the connector from the over pressure board.
6. Remove the four nuts that fasten the circuit board mounting plate into position.

7. Lift the front of the circuit board mounting plate about an inch and a half then slide it forward off the rear panel mounting studs.
8. Any of the following components can now be replaced.

### A. Transformer

(See Figure 6-2)

1. Disconnect the two connectors from the transformer from their mating connectors.
2. Remove the two nuts retaining the transformer and remove the old transformer.
3. Mount the new transformer onto the main-frame of the ventilator.
4. Connect the two connectors from the transformer to the mating connectors.



Description	Stock Number
1. Nut .....	0202-1130-300
2. Transformer .....	1502-3000-000

**Figure 6-2**  
Transformer

## 6/Repairs and Parts

### B. Battery Clip

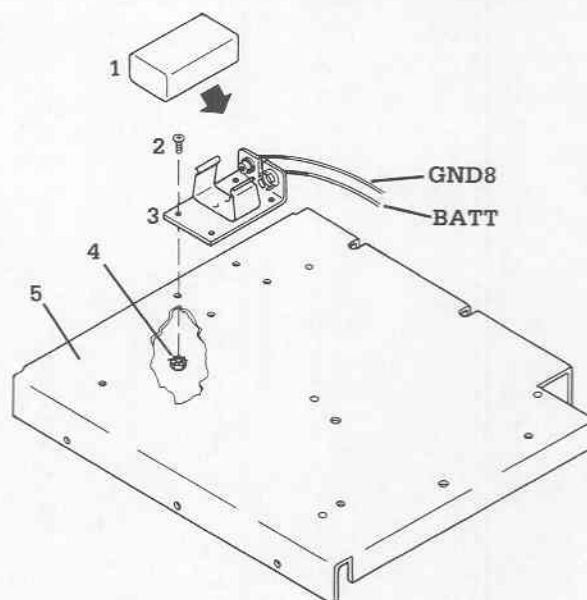
(See Figure 6-3)

1. Pry the battery out of the clip.
2. Unfasten the old battery clip then install the replacement.
3. Transfer the wire connections from the old clip to the replacement, working one wire at a time. Use shrink wrap insulation over both solder joints.
4. Fasten the battery to the clip.

### C. Board Mounting Plate

(See Figure 6-3)

1. Remove the battery and unfasten the battery clip from the plate.
2. Install the battery clip on the new mounting plate. Orient the component as shown in Figure 6-3.



## 6.2 Flow Control Unit

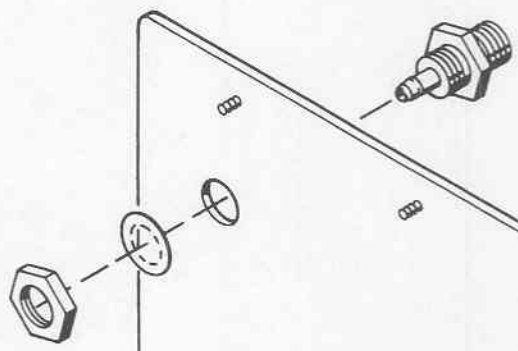
**⚠ WARNING:** Never tamper with or disassemble the flow control solenoid valves. Such actions will compromise the calibration of the Flow Control Unit, which must then be replaced as an assembly.

Tools Required:

- 5/16" nutdriver
  - 5/16" open-end wrench
  - #2 Phillips screwdriver
  - needle nose pliers
  - 7/8" open-end wrench
  - Pin extractor (Molex #11-03-002) (Ohmeda #0175-2355-000)
  - 1/4" open-end wrench
1. Unplug the ventilator's line cord from the wall outlet and disconnect the O<sub>2</sub> power source.
  2. Remove the Circuit Board Assembly per Section 6.1. Disregard steps 3 through 5 of Section 6.1 as the circuit board itself is not being replaced.
  3. Disconnect all internal hoses. See Figure 6-7 for internal hose connections.
  4. Remove the pressure regulator per Section 6.5.  
  
Note: It may also be necessary to remove the Lamp Test switch in order to remove the regulator. (See Section 6.3C).
  5. Take off the rear panel oxygen supply connector. (See Figure 6-4).
- See Figure 6-5.
6. Unplug both wiring harness connections to the solenoid valves.

Description	Stock Number
1. Battery .....	1502-3016-000
2. Screw .....	0140-6617-103
3. Clip, Battery .....	1502-3015-000
4. Nut .....	0144-3717-312
5. Board Mounting Plate .....	0234-0210-500

**Figure 6-3**  
Battery Clip and Shelf



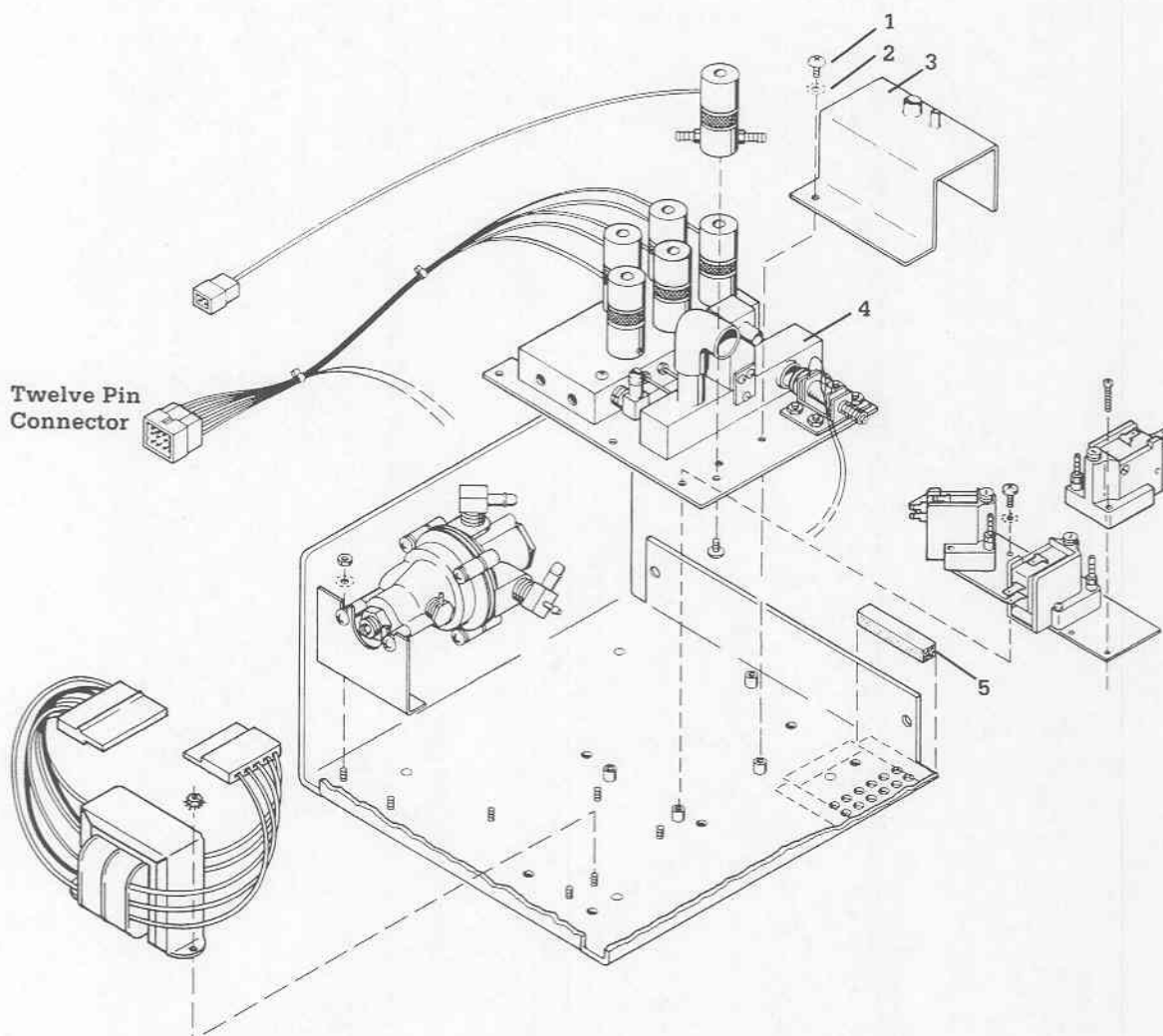
**Figure 6-4**  
Removing the Rear Panel Gas Supply Connector Before Removing the Flow Control Unit



## 6/Repairs and Parts

7. Remove all five mounting screws from the flow control unit, then lift it out of the chassis.

8. With the Flow Control Unit removed from the chassis, any of the following components can be replaced.



Description	Stock Number
1. Screw .....	0140-6124-105
2. Washer .....	0202-3200-300
3. Cover, Exhaust .....	0229-1000-742
4. Flow Control Unit, Calibrated, Less Regulator Bleed Valve .....	1502-8001-000
5. Seal, Exhaust (1 Section Required; Cut to Length) .....	0999-1116-010

**Figure 6-5**  
Flow Control Unit

## 6/Repairs and Parts

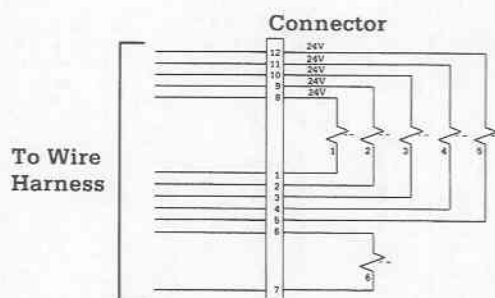
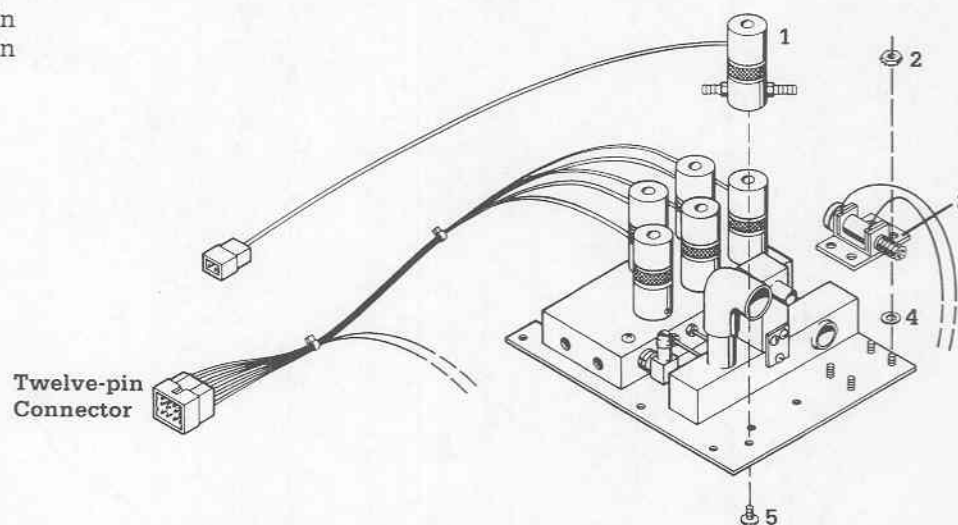
### A. Exhaust Valve

1. Unbolt the old exhaust valve.
2. Referring to Figure 6-6, locate the exhaust valve wiring connections to the valve wire connector.
3. Using a pin extractor, transfer the wire connections of the replacement valve to the connector.
4. Loosely screw the replacement valve into position.
5. Manually extend the valve stem as far as it will go. Slide the assembly in the slots until the pad is compressed about 1/32 of an inch against the low pressure manifold seat. Tighten the exhaust valve assembly (4 places).
6. Reconnect the gas hose to the rear panel gas supply inlet connector.
7. Connect 50 psig O<sub>2</sub> supply to the ventilator.
8. Set front panel controls as follows:

MV 30 L/min  
Rate 6 B/min  
I:E 1:1

9. (Disregard any alarms; jumper TJ1 maybe removed to silence alarms). Apply power to the ventilator.
10. Occlude the bellows assembly inlet port at rear of chassis.
11. Visually watch to see that the exhaust valve seats properly and that there are no leaks or blow by. A small amount of water maybe used to check for leaks. Drive Gas (O<sub>2</sub>) should only be relieving through the pressure relief valve.
12. Remove power from the ventilator.
13. Reassemble the unit then test it for leaks and correct operation (Section 3). See Figure 6-7 for hose connections.

If exhaust valve functions properly reassemble the unit then test it for leaks and correct operation. See Service Manual, Section 3. If proper operation is not achieved, readjust the exhaust valve assembly or if necessary replace it and retest.



Valve Number	Flow
1	2 L/min
2	4 L/min
3	8 L/min
4	16 L/min
5	32 L/min

Wiring Schematic

Description	Stock Number
1. Valve, Bleed, Regulator .....	0229-1034-700
2. Nut .....	0202-1130-300
3. Valve, Exhaust .....	0229-1014-700
4. Spacer .....	0144-1006-131
5. Screw .....	0140-6124-104

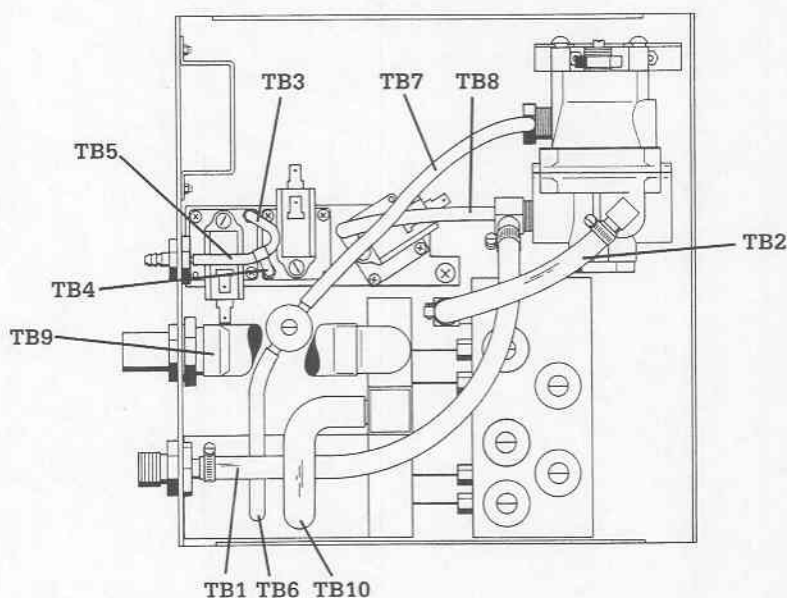
**Figure 6-6**  
Exhaust Valve Regulator Bleed Valve

## 6/Repairs and Parts

### B. Regulator Bleed Valve

(See Figure 6-6)

1. Remove the two valve mounting screws from underneath the flow plate.
2. Fasten the replacement valve into position. Orient it with the valve outlet towards the exhaust valve.
3. Reassemble the ventilator. (See Figure 6-7 for internal hose connections.) Check that the valve opens to bleed the regulator when the ventilator is switched on, and closes to prevent the regulator from leaking when the ventilator is switched off.



Description	Stock Number
1. Tee .....	0204-8847-300
2. Hose Clamp .....	0690-1240-322

#### Tubing No.

TB 1 .....	0995-6439-010
TB 2 .....	0995-6439-010
TB 3 .....	0994-6370-010
TB 4 .....	0994-6370-010
TB 5 .....	0994-6370-010
TB 6 .....	0994-6370-010
TB 7 .....	0994-6374-010
TB 8 .....	0994-6374-010
TB 9 .....	0994-6499-010
TB 10 .....	0994-6435-010

**Figure 6-7**  
Internal Hose Connections

## 6/Repairs and Parts

### 6.3 Front Panel Components

#### Tools Required:

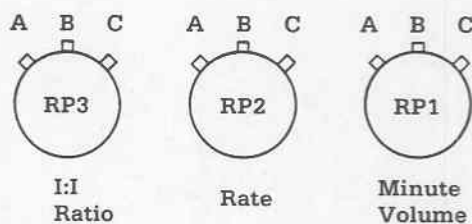
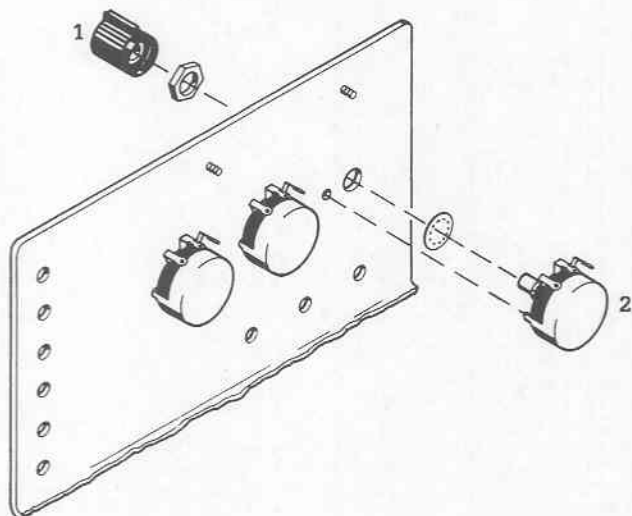
- #2 Phillips screwdriver
- 5/16" open-end wrench
- 1/2" open-end wrench
- 5/16" nutdriver
- 1/16" hex key wrench
- soldering tool and solder
- needle nose pliers
- wire cutting/stripping tool
- ordinary pliers
- pin extractor

1. Remove the Circuit Board assembly per Section 6.1. Disregard steps 3 through 5 of Section 6.1 as the circuit board itself is not being replaced.
2. With the chassis exposed, any of the following front panel components can be replaced. Reassembly is the reverse of disassembly except as noted.

#### A. Potentiometer Replacement

(See Figure 6-8)

1. Use a hex key wrench to remove the control knob from the old pot.
2. Remove the mounting nut from the front of the old pot.
3. Remove the old pot and insert the replacement in the front panel.
4. Fasten the replacement in position with the mounting nut. The tab on the face of the pot must set into the alignment hole provided in the front panel.
5. Working one wire at a time, transfer the electrical connections from the old pot to the replacement. Insulate all solder joints with heat-shrink tubing.
6. Reassemble the ventilator, leaving the cover panel off. Calibrate the potentiometer per Section 7.6.



Description	Stock Number
1. Knob, Control .....	0212-1945-300
2. Potentiometer, w/Mounting Hardware .....	0681-0800-000

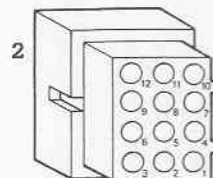
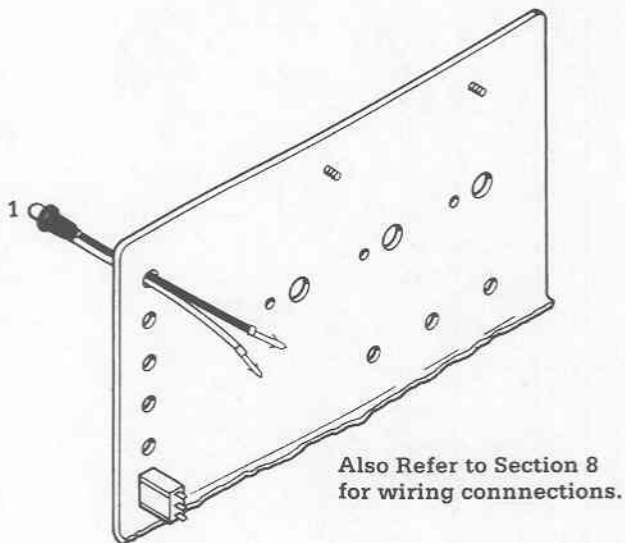
**Figure 6-8**  
Potentiometers

## 6/Repairs and Parts

### B. Alarm Lamps

(See Figure 6-9)

1. Extract the wires of the burned out lamp from the wiring harness connector. Note which sockets the wires came out of.
2. Push the old lamp forward, out of the front panel.
3. Feed the wires of the replacement lamp through the front panel hole from the front. Press the lamp into place.
4. Insert the wires from the replacement lamp into the wiring harness connector. Make sure the wires go into the correct sockets.



Pin	Name	Color
1	DS1	Blk
2	DS2	Blk
3	DS3	Blk
4	DS4	Blk
5	DS5	Blk
6	NC	Blk
7	DSP2	Blk
8	DSP1	Blk
9	NC	Blk
11	DSP3	Blk
12	DSP5	Blk
13	DSP4	Blk

#### Description

#### Stock Number

- |                         |               |
|-------------------------|---------------|
| 1. Lamp .....           | 0683-9017-700 |
| 2. Socket, Wiring ..... | 0690-1565-306 |

**Figure 6-9**

Indicator Lamp Replacement

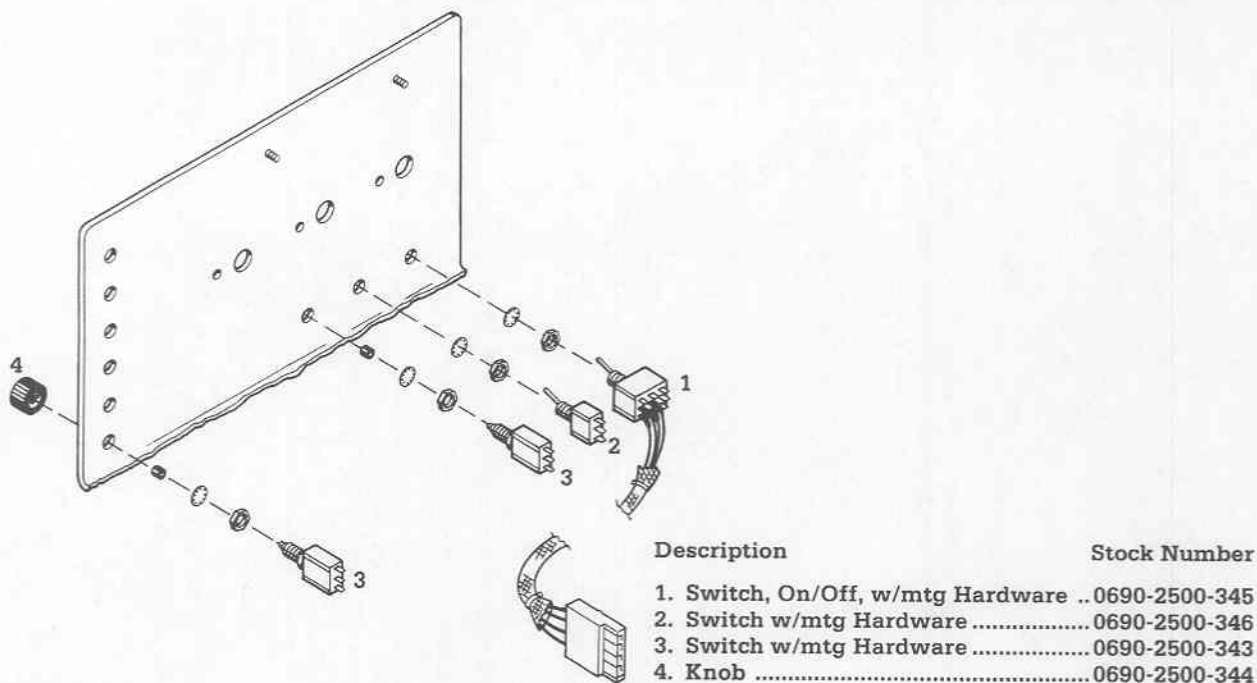
### C. Switches

(See Figure 6-10)

1. Remove the bezel nut from the switch that is to be replaced.
2. Slide the switch back out of the front panel. If necessary, cut some of the harness ties to allow the switch to be moved into a position where its terminals are readily accessible.
3. Working one wire at a time, transfer the control harness wires from the old switch to the replacement. Cover all solder joints with heatshrink.
  - a. Disconnect the four wire harness of the old switch from the four pin connector from the power inlet module.
  - b. Route the four wire harness of the new switch s/a along the bottom in the front and right side of the chassis. Connect the switch s/a harness to the four pin connector from the power inlet module.
4. Insert the replacement switch in the front panel and fasten it into position with the bezel nut. Use medium strength thread-locking compound on the nut. (Loctite #242).
5. Check the switch for correct operation.

For power switch only (a. and b.):

- a. Disconnect the four wire harness of the old switch from the four pin connector from the power inlet module.

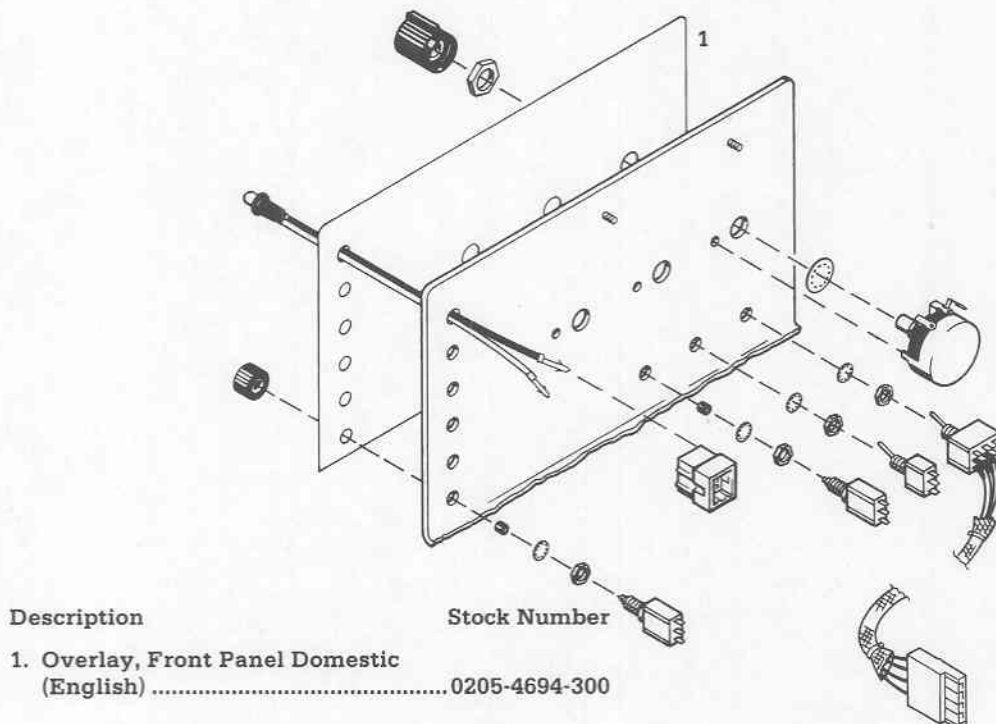


**Figure 6-10**  
Front Panel Switches

## D. Front Panel Overlay

(See Figure 6-11)

1. Remove the bezel nuts from all four of the switches and push them back out of the panel.
2. Remove the alarm lamp wire connections from their wiring harness connector.
3. Push all five of the lamps forward out of the front panel.
4. Remove the knobs and mounting nuts from the potentiometers. Push the potentiometers back out of the front panel.



**Figure 6-11**  
Front Panel Overlay



## 6/Repairs and Parts

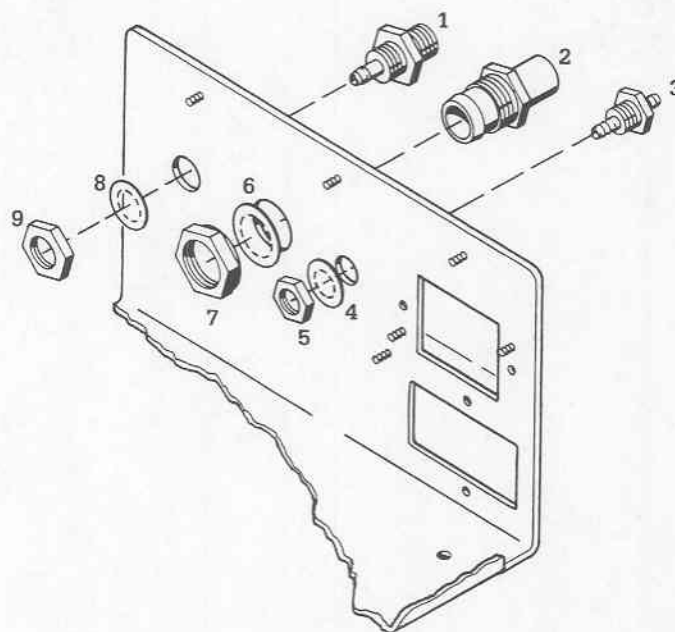
5. Insert a sharp knife into the crack between the front panel and the overlay. Peel off the overlay.
6. Clean the surface of the front panel with a suitable solvent or rubbing alcohol.
7. Remove the backing from the new panel overlay. Position the overlay carefully then press it into place.
8. Reassemble the ventilator leaving the cover panel off. Refer to Figure 6-9 when inserting the alarm lamp wire connections into the wiring harness connector. Calibrate all three potentiometers per Section 7.6.

### 6.4 Rear Panel Components

#### Tools Required:

- #2 Phillips screwdriver
- 5/16" open-end wrench
- 5/16" nutdriver
- 7/8" open-end wrench
- 1/2" open-end wrench
- needle nose pliers
- 1/16" hex key wrench
- soldering tool and solder
- wire cutting/stripping tool

1. Remove the Circuit Board assembly per Section 6.1. Disregard steps 3 through 5 of Section 6.1 as the circuit board itself is not being replaced.
2. With the chassis exposed, any of the rear panel gas connectors can be disengaged from the internal hoses and replaced. (Figure 6-12).



Description	Stock Number
1. Adapter, Inlet, O <sub>2</sub> DISS .....	0229-0004-535
2. Connector, 15 mm .....	0229-0005-535
3. Connector, 1/8 inch barbed hose ....	0229-0006-535
4. Washer .....	0202-3422-340
5. Nut .....	0402-1683-535
6. Washer .....	0202-3432-300
7. Nut .....	0402-1779-535
8. Washer .....	0144-1126-131
9. Nut .....	0402-1544-535

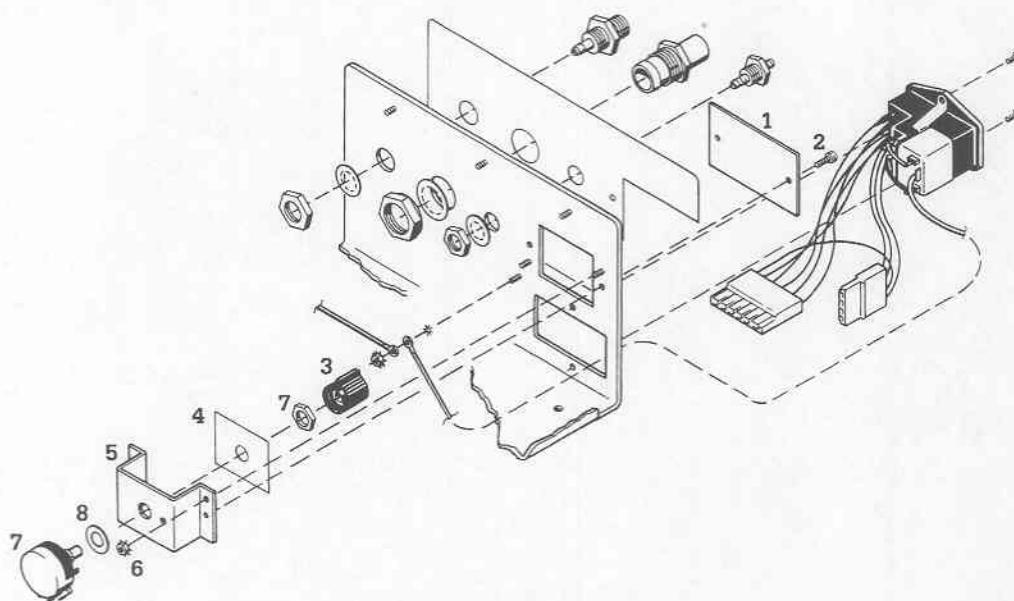
**Figure 6-12**  
Rear Panel Connectors

## 6/Repairs and Parts

### A. Altitude Adjustment Potentiometer Replacement

(See Figure 6-13)

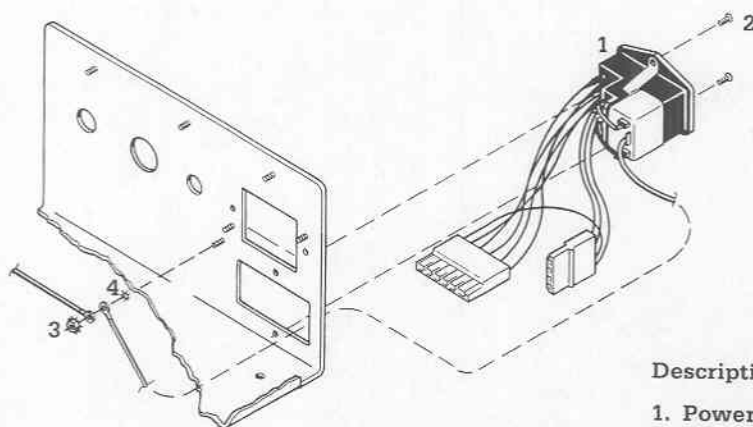
1. Remove the adjustment cover panel.
2. Remove the knob from the pot.
3. Remove the pot from the mounting bracket.
4. Working one wire at a time, transfer the wire connections from the old pot to the replacement. Cover all solder joints with heat-shrink insulation.
5. Mount the replacement pot on the mounting bracket. Orient the pot with the alignment tab in the alignment hole provided in the bracket.
6. Calibrate the control per Section 7.6 then reassemble the ventilator.



Description	Stock Number
1. Plate .....	0229-0029-300
2. Screw .....	0144-2124-206
3. Knob .....	0212-1945-300
4. Label .....	0205-4696-300
5. Bracket, mtg .....	1502-5000-000
6. Nut .....	0202-1130-300
7. Potentiometer (Includes Bezel Nut) .....	0681-0800-000
8. Washer .....	0402-6224-105

**Figure 6-13**  
Altitude Adjustment Potentiometer Replacement

## 6/Repairs and Parts



Description	Stock Number
1. Power Entry Module S/A .....	1502-7002-000
2. Screw .....	0400-3153-300
3. Nut .....	0202-1130-300
4. Washer .....	0202-3200-300

**Figure 6-14**

Power Entry Module Replacement

### B. Power Entry Module Replacement

(See Figure 6-14)

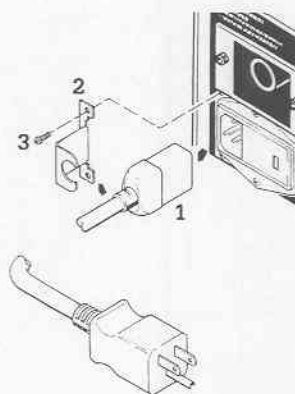
1. Remove the power cord from the AC power source.
2. Remove the two socket head screws and remove the power cord anti-disconnect bracket. See figure 6-15.
3. Disconnect the six position connector of the transformer from the mating connector of the power entry module.
4. Disconnect the four position connector of the On/Off switch from the mating connector of the power entry module.
5. Disconnect the ground wires to the chassis.
6. To remove the power entry module, remove the two phillips mounting screws and pull the module out from the chassis.
7. Place the new power entry module into the chassis and secure with the mounting screws.
8. Connect the ground wires from the power entry module and from the cover to the chassis ground stud.
9. Connect the four position connector to the mating connector from the On/Off switch.
10. Connect the six position connector to the mating connector from the transformer.
11. Install the fuses and set the input voltage as per sections 4.8 and 4.9.
12. Reinstall the power cord and the power cord anti-disconnect bracket.

### C. Anti-Disconnect Bracket and Power Cord Plug Removal

(See Figure 6-15)

To remove the anti-disconnect bracket and the power cord plug from the ventilator control module:

1. Remove the power cord from the ac power source.
2. Remove the two socket head screws and remove the power cord anti-disconnect bracket. The power cord plug can now be disconnected.



Description	Stock Number
1. Power Cord .....	1502-3020-000
2. Anti-Disconnect Bracket .....	1502-5000-000
3. Screw, Socket Head Cap .....	0144-2124-206

**Figure 6-15**

Anti-Disconnect Bracket and Power Cord Plug Removal

## 6/Repairs and Parts

### 6.5 Chassis Components

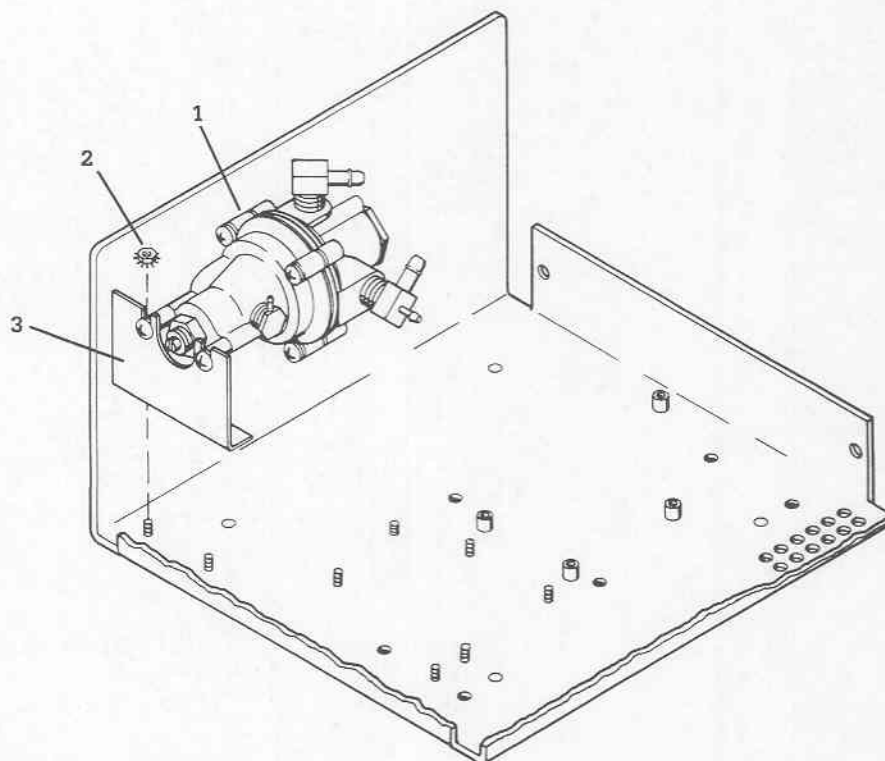
Tools Required:

- #2 Phillips screwdriver
  - #1 Phillips screwdriver
  - 1/8" flat tip screwdriver
  - 5/16" open-end wrench
  - 5/8" open-end wrench
  - 5/16" nutdriver
  - needle nose pliers
  - soldering tool and solder
  - wire cutting/stripping tool
  - 5 mm nutdriver
1. Remove the Circuit Board assembly per Section 6.1. Disregard steps 3 through 5 of Section 6.1, as the circuit board itself is not being replaced.
  2. With the chassis exposed, the following components can be replaced.

#### A. Regulator Replacement

(See Figure 6-16)

1. Remove the Lamp Test switch from the front panel (See Section 6.3 C).
2. Unclamp and disconnect the high pressure hoses from the regulator.
3. Disconnect the bleed valve tube from the regulator.
4. Unbolt the regulator mounting bracket from the chassis.
5. Lift the regulator out of the chassis.
6. Install the replacement regulator. Adjust the regulator per Section 4.9 before placing the cover panel on the unit.



Description	Stock Number
1. Regulator, w/mtg Bracket, Hose Connections .....	0306-0618-800
2. Nut .....	0202-1130-300
3. Bracket, Regulator mtg (*) .....	0234-0202-500
(*) Included with Regulator Kit .....	
	0306-0618-800

**Figure 6-16**  
Regulator Replacement

## 6/Repairs and Parts

### B. Low Supply Pressure Switch

(See Figure 6-17)

#### Adjustment Procedure

1. To adjust the Low Supply Pressure switch, connect the ventilator to the test equipment specified in section 3.4.
2. Perform the test in section 3.4.
3. Adjust the switch. Turning the adjustment screw counterclockwise reduces the pressure trip point.
4. Repeat the test from section 3.5. Repeat adjustments and tests until the switch trips at the specified points or clearly cannot be made to do so.
5. Replace the switch if it is defective.

### C. High and Low Airway Pressure Switches

#### Adjustment Procedure

(See Figure 6-17)

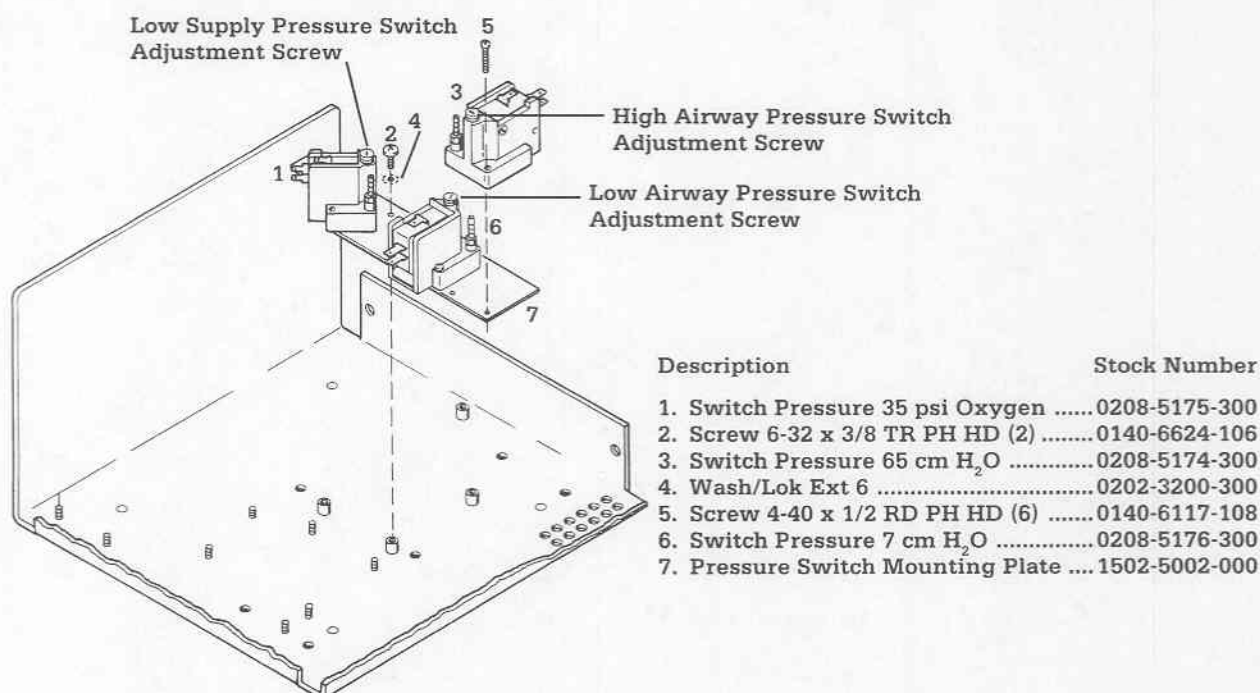
1. To adjust the Low and High Airway Pressure switches, connect the ventilator to the test equipment specified in Section 3.5 or 3.10 as required.

2. Perform the test in Sections 3.5 or 3.10 as required.
3. Adjust the pressure switches. Turning the adjustment screw counterclockwise to reduce the pressure trip point.
4. Repeat the test from Section 3.5 or 3.10 as required. Repeat adjustments and tests until the switch trips and the alarm is silenced at the specified points or clearly cannot be made to do so.
5. Replace the switch if it is defective.

### D. Pressure Switch Replacement

(See Figure 6-17)

1. Unscrew the switch that is to be replaced from the mounting plate.
2. Disconnect the hose from the switch that is to be replaced.
3. Transfer the electrical connections from the old switch to the replacement, working one wire at a time.
4. After reassembling the ventilator, check the operation of the replaced switch per Section 3.



**Figure 6-17**  
Pressure Switches

## 6/Repairs and Parts

### E. Preoperative Checklist Card Replacement

(See Figure 6-18)

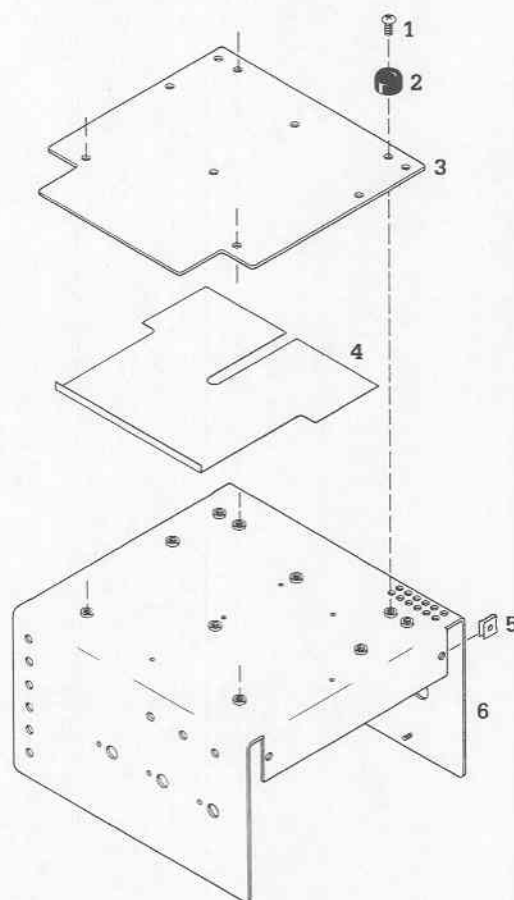
To replace the Preoperative Checklist Card from the ventilator control module:

1. Remove the power cord from the ac power source.
2. Remove the mounting screws for the two front rubber feet on the control module. The Preoperative Checklist Card can now be pulled forward and out.
3. Install the replacement Preoperative Checklist Card (in the correct orientation), the two rubber feet and the mounting screws.

### 6.6 Bellows Unit Disassembly

(See Figure 6-19)

1. Remove the four thumbscrews that fasten the bellows assembly to the control unit.
2. Lift off the transparent bellows cover.
3. Pull the bellows off the base unit.
4. (Pediatric bellows only) Stretch the retaining ring and remove the pediatric bellows mounting ring.
5. Remove the three thumbscrews that fasten the popoff valve into the base unit and lift off the valve.



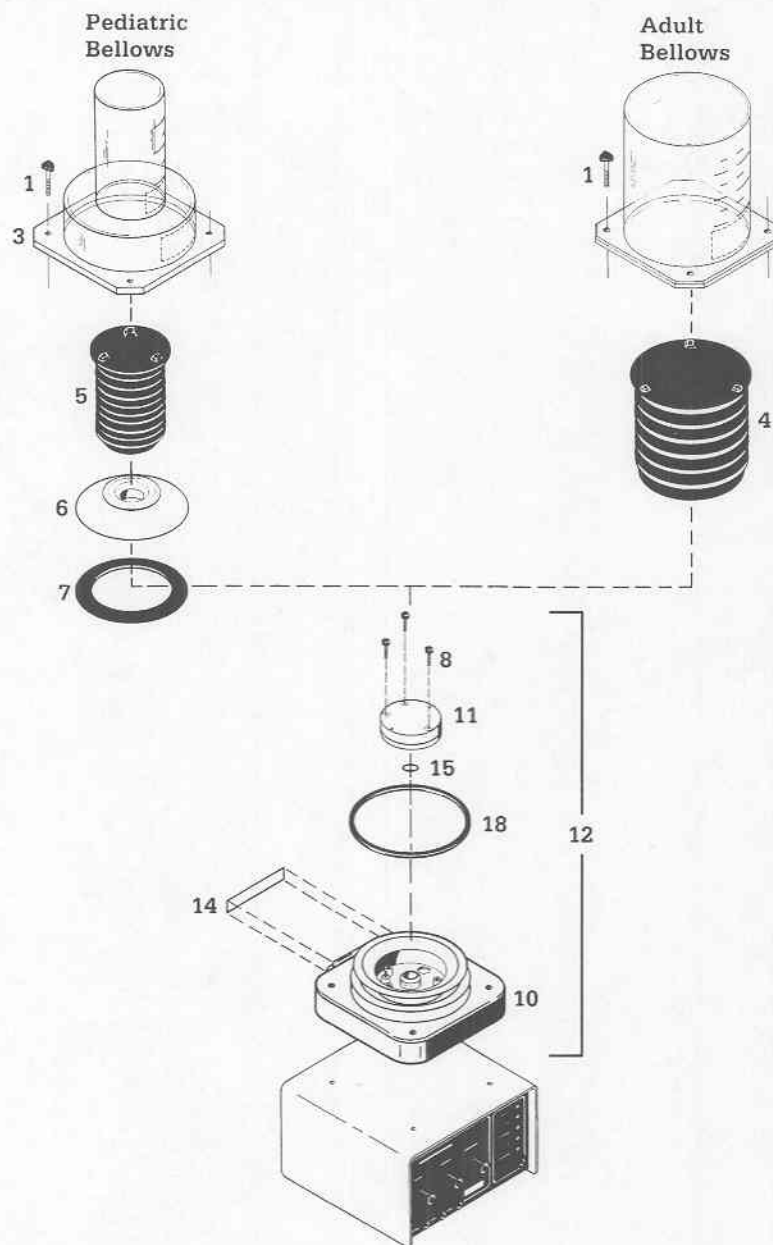
Description	Stock Number
1. Screw .....	0140-6531-106
2. Foot, Rubber .....	0411-1959-100
3. Plate .....	0234-0214-552
4. Card, Preoperative Checklist Domestic (English) .....	1502-3025-000
5. Nut .....	1502-3018-000
6. Chassis .....	1502-7000-000

**Figure 6-18**

Preoperative Checklist Card Replacement



## 6/Repairs and Parts

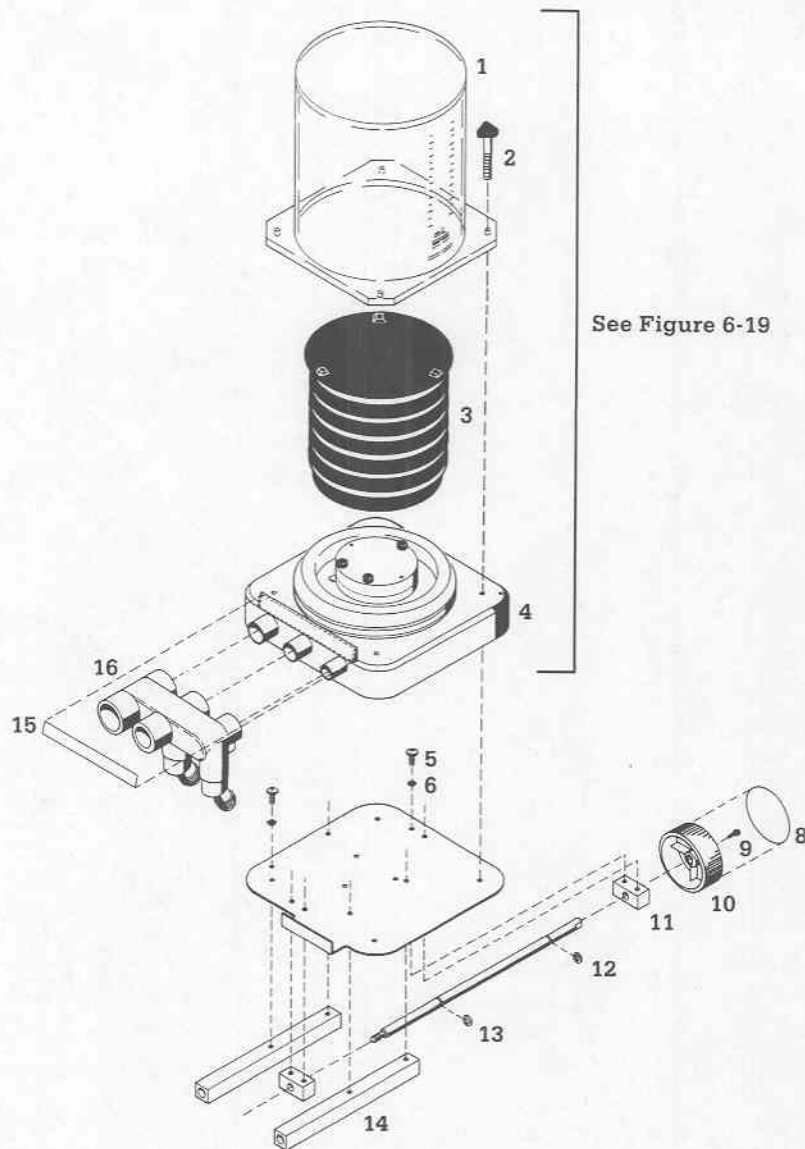


Description	Stock Number
1. Thumbscrew 10-32 x 2.25" .....	0400-3524-300
2. Housing, Bellows, Adult .....	0229-0014-300
3. Housing, Bellows, Pediatric .....	0229-0034-300
4. Bellows, Adult .....	0229-1013-700
5. Bellows, Pediatric .....	0229-1018-700
6. Ring, Ped. Bellows Mounting (Includes #7) .....	0229-1023-700
7. Ring, Retaining, Ped. Bellows .....	0229-0036-300
8. Thumbscrew, 6-32 x 1.19" .....	0400-3507-300
9. Seal, U-cup, 6.00" OD x 5.44" ID ....	0210-0784-300
10. Base (Not Sold Separately)	
11. Pop-Off Valve Assembly* .....	0229-1029-800
12. Base Assembly (English) .....	0229-1032-880

13. Complete Pediatric Bellows  
Attachment Kit  
(Includes Items 1, 3, 5, 6, 7 & 12) ... 0219-7520-871
14. Label, Port ID/ English .....
15. O-ring .....

\* **WARNING:** Only use the new style Pop-off Valve Assembly as a replacement part for a Base Assembly previously fitted with the new style Pop-off Valve. Do Not use the new style Pop-off Valve on bases that Do Not have a raised identification mark on the left front corner of the Base Assembly.

**Figure 6-19**  
Bellows Assembly Components



Description	Stock Number
1. Housing .....	See Fig. 6-19
2. Thumbscrew .....	See Fig. 6-19
3. Bellows .....	See Fig. 6-19
4. Base* .....	See Fig. 6-19
5. Screw 10-32 x 1/2 (Qty. 8) .....	0140-6631-108
6. Lock Washer Ext. #10 (Qty. 8) .....	0202-3210-300
7. Bellows Mtg. Plate .....	0234-1078-700
8. Knob Label .....	0205-4903-300
9. Screw 8-32 x 3/8 .....	0144-2127-206
10. Selector Knob .....	0212-1954-100
11. Lock Support (Qty. 2) .....	0236-0453-552
12. Truarc Ring .375 Shaft (Qty. 2) .....	0203-5314-300
13. Locking Bellows Rod .....	0236-0450-500
14. Bellows Support Guide (Qty. 2) .....	0236-0451-552
15. Label .....	See Fig. 6-22
16. Manifold .....	0236-0478-700

\* The revised Bellows Base Assembly has a raised identification mark on the left front corner of the Base Assembly.

**Figure 6-20**  
Bellows Assembly w/Manifold and Mounting for GMS Absorber

## 7/Calibration

**⚠ WARNING:** Do not, under any circumstances, perform any testing or maintenance on medical instruments while they are being used to ventilate a patient.

**⚠ WARNING:** The alarm circuit check (section 7.16) must be performed before the ventilator is returned to use after any service procedure.

Tools Required:

- #2 Phillips screwdriver
- 5/16" open-end wrench
- 5/16" nutdriver
- 1/8" flat-tip screwdriver
- variac (0 - 240 volts ac)
- digital voltmeter (DVM) 4 digit
- oscilloscope, storage type
- jumper wire (12 inches long)
- 50 psig oxygen supply (nominal)
- test lung
- stop watch
- 3/32" hex key wrench
- 1/16" hex key wrench
- pneumatic tester  $\pm 1\%$  accurate, capable of measuring Minute Volume, Tidal Volume, Flow Rate, Breath Rate and I:E Ratio

Note: Failure in any step is cause for rejection. Ignore all visible and audible alarms until mentioned. For convenience, a jumper plug has been provided (TJ1) on the circuit board which, when removed, disables the audible alarm. Make sure the jumper plug is reinstalled before returning the ventilator to operation. If the plug is lost, order Stock No. 0690-1563-315 for a replacement.

**⚠ WARNING:** An Electrical Shock Hazard exists at the fuse receptacle under the circuit board shelf.

**⚠ WARNING:** Never use the ventilator if the jumper plug is missing; the audible alarm will malfunction. Always check to be sure that the audible alarm works before returning a unit to operation.

**⚠ WARNING:** Electrical Shock Hazard. Do not touch exposed wires or conductive surfaces while the cover panel is removed from the ventilator unless electrical power is disconnected from the unit. Hazardous voltages are present during normal operation. Never wear a grounding wrist strap when working on an energized unit.

**⚠ CAUTION:** Perform all calibration steps in the order given.

### 7.1 Setup

1. Turn off the power switch.
2. Turn off the sigh switch.
3. Remove the cover panel.
4. Remove the printed circuit board. (See Section 6.1)
5. Connect the power cord to a variac set at 0 V.

### 7.2 Wiring Checks

1. Set the variac voltage according to the voltage selected on the power entry module on the rear panel of the ventilator:  
  
120 volts ac - set variac voltage to 120 volts ac at 60 Hz.  
  
100 volts ac - set variac voltage to 100 volts ac at 50 Hz.  
  
220 volts ac - set variac voltage to 220 volts ac at 50 Hz.  
  
240 volts ac - set variac voltage to 240 volts ac at 50 Hz.
2. Turn on the power switch.
3. Test the leakage current. It must be less than 35 microamps at 100/120 V ac or less than 70 microamps at 220/240 V ac.
4. Set a voltmeter to read volts ac rms and perform the following voltage checks. All pins are referenced to the 60 pin wire harness connector. All voltages should be taken during expiration.
  - a. The voltage between pins 9 and 35 should read  $15.7 \pm 0.5$  V ac
  - b. The voltage between pins 4 and 9 should read  $26.5 \pm 1.0$  V ac.
  - c. The voltage between pins 4 and 35 should read  $15.7 \pm 0.5$  V ac.
  - d. The voltage between pins 3 and 8 should read  $31.5 \pm 1.0$  V ac.
5. If these readings are incorrect, the transformer, its associated components, and the wiring should be checked.
6. Turn off the power switch.

## 7.3 DC Power Supply

Note: To help service personnel locate test points on the circuit board, all test points are labeled. Refer to the component diagram (Figure 8-1) for the circuit board.

1. Connect the printed circuit board.
2. Record the variac setting.
3. Connect a Digital Volt Meter (DVM) between TP-2 and ground.

Note: Use only TP26, TP27, TP28 or the negative side of capacitor C21 as a ground.

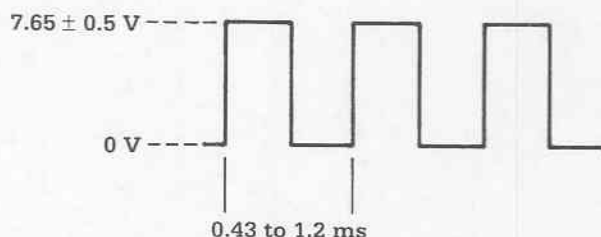
4. Turn on the power switch.
  5. Adjust potentiometer RP until the DVM indicates  $+2 \pm 0.005$  V dc.
  6. Vary the variac  $\pm 10\%$ . The voltage at TP-2 should remain  $+2 \pm 0.005$  V dc.
  7. Return the variac setting to that recorded in step 2.
  8. Connect the DVM between TP-8 and ground; it should read  $+8 \pm 0.15$  V dc.
  9. Connect the DVM between TP-9 and ground; it should read  $-8 \pm 0.15$  V dc.
- Note: If the unit fails step 8 or step 9, go back and repeat steps 5 thru 9. If recalibration of potentiometer RP doesn't work, the circuit board must be replaced (Section 6.1).
10. In Steps 11 and 12, the voltages are loaded voltages. Take measurements with the rate control fully counterclockwise, minute volume fully clockwise, I:E ratio fully counterclockwise, and when the solenoids are on (inhalation).
  11. Connect the DVM between TP-10 and ground. The voltage should be  $+32 \pm 3$  V dc.
  12. Connect the DVM between TP-11 and ground. The voltage should be  $+28 \pm 3$  V dc.
  13. If the readings cannot be obtained, the circuit board, LED's, solenoids, and transformer should be checked out.

## 7.4 Lamp Test

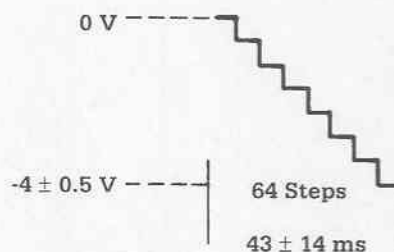
1. Press the Lamp Test button. All lamps shall light and the audio alarm must sound.
2. If this does not happen, check the LED's, circuit board, wiring, and power supply.

## 7.5 Monitor Circuit

1. Connect an oscilloscope between TP-21 (U1 pin 10) and ground. Adjust the oscilloscope for 2 V/division vertical scale and 0.2 ms/division horizontal scale. There must be a square wave of approximately 850 to 2300 Hz (time period of 0.43 to 1.2/ms). The waveform should look like Figure 7-1. Adjust potentiometer RA if necessary to obtain the specified time period.
2. Connect a DVM to TP-22 (U10 pin 6). Check for  $+3.8 \pm 0.8$  V dc.
3. Connect the oscilloscope to TP-12 and set it for 1 V/division vertical scale and 5 ms/division horizontal scale. Check for a negative staircase waveform having 64 steps. The waveform should look like Figure 7-2.
4. Replace the circuit board if these adjustments cannot be made or the proper waveforms cannot be obtained.



**Figure 7-1**  
Oscillator Waveform



**Figure 7-2**  
Staircase Waveform

### 7.6 Mounting and Calibrating the Control Dials, Front and Rear Panel

1. Remove the front and rear panel dials if installed.
2. Turn the Minute Volume, Rate, I:E Ratio and Altitude Adjustment potentiometer shafts fully counterclockwise.
3. If any of these adjustments cannot be made, the circuit board wiring and potentiometers should be checked, recalibrated, and replaced if necessary.
4. For correct positioning of the dials, the potentiometers first have to be moved out of their dead band area by moving their shafts as follows:

#### A. Mounting the Minute Volume Dial

1. Connect the DVM between TP-3 and ground. (A convenient ground is TP28.)
2. Move the Minute Volume potentiometer shaft slightly to produce about 4 to 15 mV voltage change.
3. Place the dial on the potentiometer shaft, with the pointer set to the 2 L/min position, and tighten the dial into place.
4. Adjust potentiometer RJ to obtain  $0.133 \pm 0.003$  V.
5. Check for  $0.340 \pm 0.020$  V at TP-4.

#### B. Mounting the Rate Dial

1. Connect the DVM between TP-1 and ground.
2. Move the RATE potentiometer shaft slightly clockwise to produce about 2 to 5 mV voltage change.
3. Place the dial on the shaft with the pointer set to the 6 BPM position, and tighten the dial into place.
4. Adjust potentiometer RI until the DVM indicates  $0.3 \pm 0.003$  V.

#### C. Mounting the I:E Dial:

1. Connect the DVM between TP-5 and ground.
2. Move the I:E Ratio potentiometer shaft slightly clockwise to produce about 4 to 15 mV voltage change.
3. Place the dial on the shaft, with the pointer set to the 1:1 position, and tighten the dial in place.
4. Make sure the Minute Volume dial is set to 2 L/min. Record the voltage at TP-4.

5. Connect a DVM to TP-5 and adjust potentiometer RK until the voltage at TP-5 is one-half the voltage at TP-4 (within  $\pm 0.003$  V).

#### D. Mounting the Altitude Adjustment Dial, Rear Panel:

**⚠ CAUTION:** Connecting TP-20 to ground places the ventilator in a continuous gas delivery phase where the exhaust valve is continuously on (closed). If the ventilator is left on in this condition for more than one minute, overheating of the exhaust valve may occur.

1. Using a jumper wire, connect TP-20 to ground.
2. Connect the DVM between TP-6 and ground.
3. Move the Altitude potentiometer shaft slightly clockwise to produce about 1 to 4 mV change in voltage at TP-6.
4. Place the dial on the pot shaft with the pointer set to the 0 meters position, and tighten the dial in place.
5. Set the ventilator controls to read:  
Minute Volume = 25 L/min  
Rate = 10 BPM  
I:E Ratio = 1:2
6. Measure the voltage at TP-7. It should be  $-4.76 \pm 0.20$  V. Record this voltage for use in the next step.
7. Connect a DVM to TP-6 and adjust potentiometer RN until the voltage at TP-6 is 0.8 of the voltage at TP-7 (within  $\pm 0.006$  V).
8. Remove the jumper wire between TP-20 and ground. Turn off the unit, then turn it back on to reinitialize it.

### 7.7 Multiplier and Scaler Circuits

Note: The dials may be turned one half division from the specified settings to meet specification in this procedure.

1. Set the ventilator controls to:  
Minute Volume = 10 L/min  
Rate = 20 BPM  
I:E = 1:2
2. Connect a DVM to TP-13. Check for  $1.933 \pm 0.10$  V.
3. Check for  $2.66 \pm 0.08$  V at TP-14.
4. Set the ventilator controls to:  
Minute Volume = 15 L/min  
I:E = 1:1



## 7/Calibration

5. Check U8 pin 2 for 0 to +0.05 V and U8 pins 5, 7, 10 and 12 for  $7.65 \pm 0.5$  V. This corresponds to the flow valves for 2, 4, 8 and 16 L/min being open.
6. As the minute volume is varied between 15 and 16 L/min only U8 pin 2 should be high ( $7.65 \pm 0.5$  V). All other output pins 5, 7, 10 and 12 should be low (0 to  $\pm 0.05$  V). This corresponds to the flow valve for 32 L/min being open.
7. If these readings cannot be obtained, recalibrate the ventilator's controls (section 7.6) and replace the potentiometers or circuit board as necessary.

### 7.8 Flow Limit Circuits

1. Set the ventilator controls to:

Minute Volume = 19 L/min

I:E = 1:2

2. Connect a DVM to TP-25 (U2 pin 7). Check for  $-7.65 \pm 0.5$  V. Increasing the Minute Volume to  $20 \pm 1.5$  L/min must change the voltage to  $6.8 \pm 0.5$  V.
3. If these readings cannot be obtained, recalibrate the ventilator's controls (Section 7.6) and replace the potentiometers or circuit board as necessary.

### 7.9 Rate Circuits

1. Set the Rate control to 30 BPM.
2. Connect an oscilloscope to TP-15 and set it for 1 V/division vertical scale and 0.5 s/division horizontal scale. Adjust potentiometer RM until the oscilloscope displays a sawtooth waveform having a  $2 \pm 0.04$  second ramp. The waveform should look like Figure 7-3.
3. If these readings cannot be obtained, recalibrate the ventilator's controls (section 6.6) and replace the potentiometers or circuit board as necessary.

### 7.10 Tidal Volume Limit Circuits

1. Connect a DVM to TP-23 and adjust potentiometer RG counterclockwise until the DVM indicates 0 V.
2. Set the ventilator controls to:  
Minute Volume = 20 L/min  
Rate = 20 BPM
3. Connect a DVM to TP-16 and adjust potentiometer RA until the DVM indicates 2.58 V (2.55 to 2.60 V). This calibrates the oscillator.

4. Set the front panel controls to:

Minute Volume = 16 L/min

Rate = 10 BPM

5. Record the voltage at TP-16. It should be  $4 \pm 0.2$  V.
6. Set the Minute Volume control to 25 L/min.
7. Adjust potentiometer RG to obtain at TP-16 the voltage recorded in Step 5. Set the voltage to within  $\pm 0.02$  V.
8. If these readings cannot be obtained, recalibrate the ventilator's controls (section 7.6) and replace the potentiometers or circuit board as necessary.

### 7.11 Inspiration/Expiration Time Circuit

1. Set the ventilator controls to:

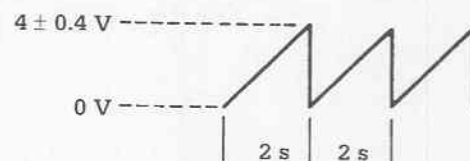
Minute Volume = 20 L/min

Rate = 20 BPM

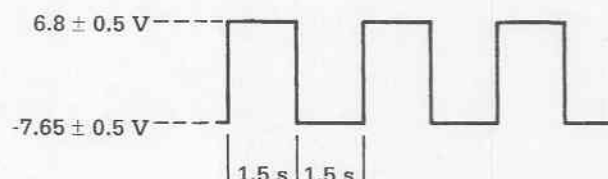
I:E = 1:1

Altitude Adjustment = 0

2. Connect an oscilloscope to TP-17 and set it for 5 V/division vertical scale and 0.5 s/division horizontal scale. Adjust potentiometer RO until the displayed waveform has a 50% duty cycle. The waveform should look like Figure 7-4.
3. If these readings cannot be obtained, recalibrate the ventilator's controls (section 7.6) and replace the potentiometers or circuit board as necessary.



**Figure 7-3**  
Rate Circuit Waveform



**Figure 7-4**  
I:E Circuit Waveform



## 7/Calibration

### 7.12 Manual Cycle Circuit

1. Connect an oscilloscope to TP-17 and set it for 5 V/division vertical scale and 0.5 s/division horizontal scale. Press the Manual Cycle pushbutton when the square wave of Step 7.11-2 is high (7 V nominal). There should be no change in the waveform.
2. Repeat Step 1, but this time depress Manual Cycle when the square wave is low (-8 V nominal). On pressing the switch, there should be a positive transition to +7 V nominal.
3. Check for a defective switch or circuit board if the correct results are not observed. Replace the Manual Cycle switch or circuit board if defective.

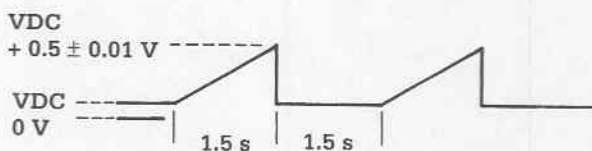
### 7.13 Exhaust Valve Circuit

**⚠ CAUTION:** Connecting TP-20 to ground places the ventilator in a continuous gas delivery phase where the exhaust valve is continuously on (closed). If the ventilator is left on in this condition for more than one minute, overheating of the exhaust valve may occur.

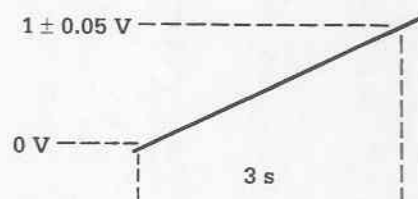
1. Set the ventilator controls to:  
Rate = 20 BPM  
I:E = 1:1
2. Connect an oscilloscope to TP-18 and adjust potentiometer RH until the displayed waveform has a peak ramp voltage of 0.5 V. The waveform should look like Figure 7-5.
3. Connect TP-20 to ground. The Ventilator Failure alarm must activate within 3 to 7.5 seconds and the exhaust valve must remain open. (Listen for a click, indicating that the valve might have closed, signifying malfunction.) The alarm is a blinking LED and an intermittent audible tone. The voltage at the cathode of D14 should stay at less than 1 V.
4. Remove the short between TP-20 and ground. The alarm should stay on and the exhaust valve should remain open. The voltage at the cathode of D14 should stay at less than 1 V.
5. Turn the unit Off, then On. There should be no Ventilator Failure alarm and the exhaust valve should function normally. The voltage at the cathode of D14 should alternate between 0 and 32 volts (nominal).
6. If these results cannot be obtained, recalibrate or replace the controls, circuit board, and exhaust valve as necessary.

### 7.14 Low Airway Pressure Alarm Circuit

1. Set the ventilator controls to:  
Rate = 20 BPM  
I:E = 1:1
2. Connect an oscilloscope to TP-19 and set it for 0.2 V/division vertical scale and 0.5 s/division horizontal scale. Adjust potentiometer RL until the displayed waveform reaches a ramp voltage of 1.0 V at 3 seconds. For this adjustment the ventilator will have to be turned Off and On. When the ventilator is turned On measure the ramp and adjust RL for a  $1 \pm 0.05$  V ramp at 3 seconds. The waveform should look like Figure 7-6.
3. Check the low airway pressure switch, and the circuit board if the correct results are not observed.



**Figure 7-5**  
Exhaust Valve Ramp Waveform



**Figure 7-6**  
Low Airway Pressure Alarm Ramp Waveform

## 7/Calibration

### 7.15 Sigh Circuit

1. Connect the bellows assembly Inlet port to the port labeled Connect To Bellows Ass'y. Inlet at the back of the ventilator.
2. Connect the To Anesthesia Machine outlet port of the bellows assembly to a test lung.
3. Connect the Connect To Expiratory Limb of the Breathing System port at the back of the ventilator to the test lung using a tee connector.
4. Connect a 50 psig oxygen supply line to the back of the ventilator. Inflate bellows to top of housing.
5. Set the front panel controls to:  
Minute Volume = 30 L/min  
Rate = 40 BPM
6. Turn On the Sigh Switch and count the number of breaths, starting when the first sigh is detected. On the 64th breath ( $\pm 2$  breaths) or in approximately 1 minute 36.5 seconds, a larger breath must be delivered which should be  $150\% \pm 15\%$  of the normal breath.

Note: When the sigh breath is delivered there is a high logic level voltage that is delivered across pin 3 of U-13.

7. In case of malfunction, check and replace the circuit board or switch as necessary.

### 7.16 Alarm Circuit Check

**⚠ WARNING:** The alarm circuit check (Section 7.16) must be performed before the ventilator is returned to use after any service procedure.

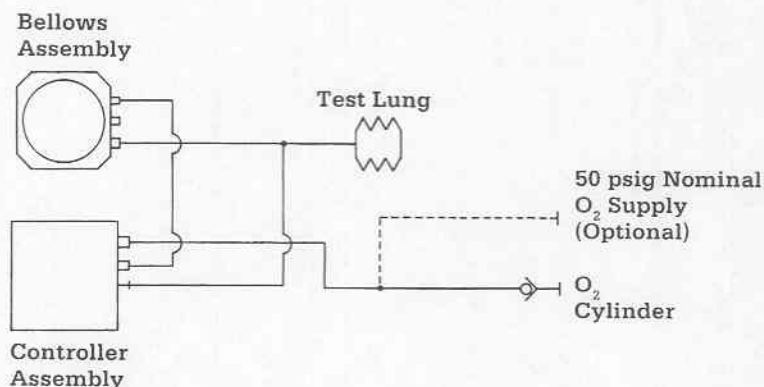
Note: Jumper plug TJ1 must be in place on the circuit board during this test.

1. Set up the unit as in Section 7.15, Figure 7-7. Set the ventilator controls to:

Minute Volume = 14 L/min  
Rate = 10 BPM

2. Increase the Minute Volume; the Set Volume Not Delivered alarm must activate when the Minute Volume reaches 15 breaths/minute  $\pm 1$  breath. The alarm is a blinking light and an intermittent audible tone.
3. Set the ventilator controls to:  
Minute Volume = 20 L/min  
Rate = 15 BPM  
I:E = 1:1
4. Increase the I:E ratio; the Actual I:E Less Than Dial Setting alarm must activate at an I:E of approximately  $1:2 \pm 0.2$ . The alarm is a continuous light and audible tone.
5. Set the Rate control to 6 breaths/minute and the Minute Volume dial to 10 L/min.
6. Remove the patient circuit connection between the test lung and the distal sensing tee. The Low Airway Pressure alarm must activate in 18.5 to 30 seconds. The alarm is a blinking light and an intermittent audible tone.
7. Shut off the oxygen supply line. The Low Oxygen Supply alarm shall activate. The alarm is a blinking light and an intermittent audible tone.
8. Pull the power plug from the variac. A continuous audible alarm shall activate.
9. Reconnect the power plug to the variac.
10. Turn the ventilator Off.
11. Remove all external pneumatic connections except line pressure.
12. Consult the appropriate calibration or maintenance section if any of these tests fail.

Note: If the power disconnect alarm does not sound, try recharging the battery (leave unit on for 21 hours to fully recharge the battery). If the alarm still malfunctions do not use the ventilator until it has been repaired.



**Figure 7-7**  
Sigh and Alarm Circuit Check

## 7/Calibration

### 7.17 Valve Assembly Calibration Check

**⚠ CAUTION:** Connecting TP-20 to ground places the ventilator in a continuous gas delivery phase, where the exhaust valve is continuously on (closed). If the ventilator is left in this condition for more than one minute, overheating of the exhaust valve may occur.

Note: The pressure regulator must be checked and adjusted per section 4.7 before attempting valve assembly calibration.

1. Place a short across capacitor C8.
2. Connect TP-20 (U-12 pin 9) to ground.
3. Connect TP-24 (Minute Volume potentiometer) to ground.
4. Connect the port labeled connect To Bellows Ass'y Inlet port at the back of the ventilator to a flow measuring device (Figure 7-8).
5. Turn on the ventilator and set its controls to:  
Minute Volume = 2 L/min  
Rate = 6 BPM  
I:E = 1:1
6. Vary the Minute Volume control dial from its low to high settings and observe that the solenoids operate in a binary sequence. Record the flow when only the 2 L/min valve is On. Record the same when the 4, 8, 16 and 32 L/min valves are On.

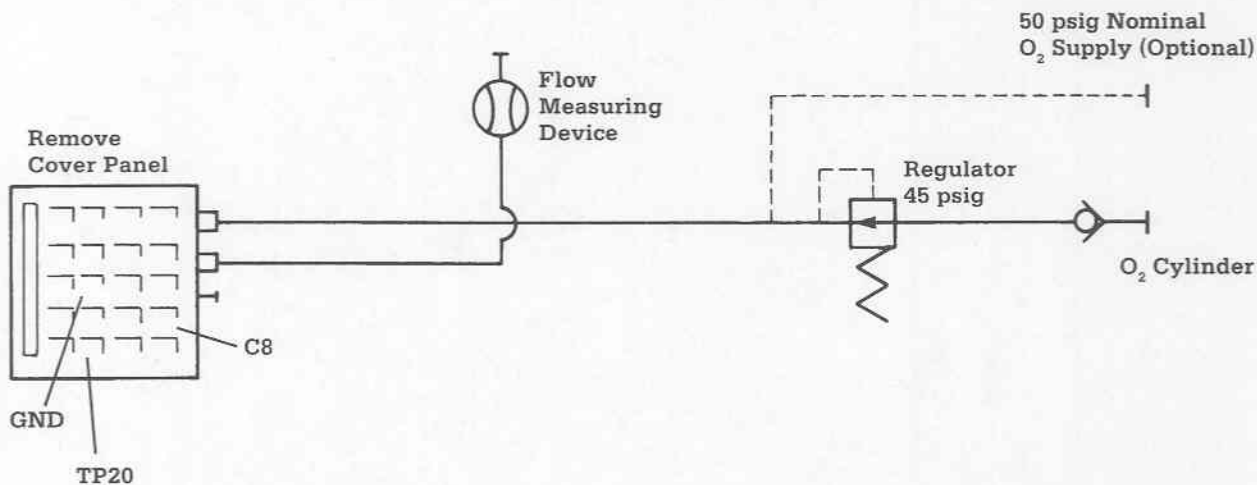
7. Compare the flows recorded in the previous step with the following limits:

Note: Normalize all flow readings to a barometric pressure of 730 mm Hg. Otherwise, test specifications will not be met.

Flow L/Min	Maximum Allowable	Minimum Allowable
2	2.10	1.90
4	4.20	3.80
8	8.40	7.60
16	16.80	15.20
32	33.60	30.40

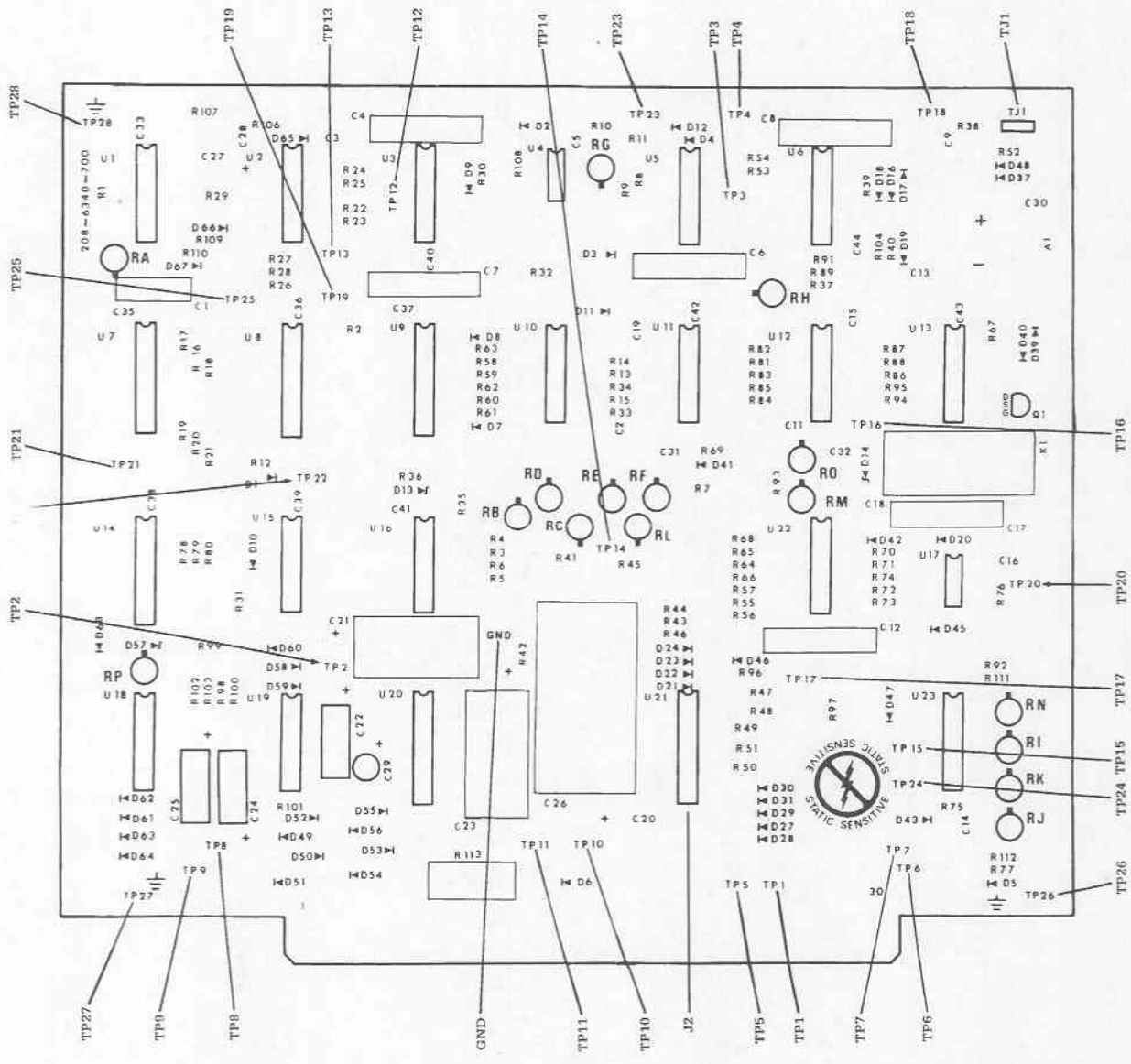
8. Turn Off the ventilator.
9. Remove the connections made in Steps 1 through 5.

Note: The components of the Flow Control Unit are matched and calibrated as an assembly and must not be replaced on an individual basis. Malfunctioning flow units must be replaced as an assembly except where otherwise noted in this manual.

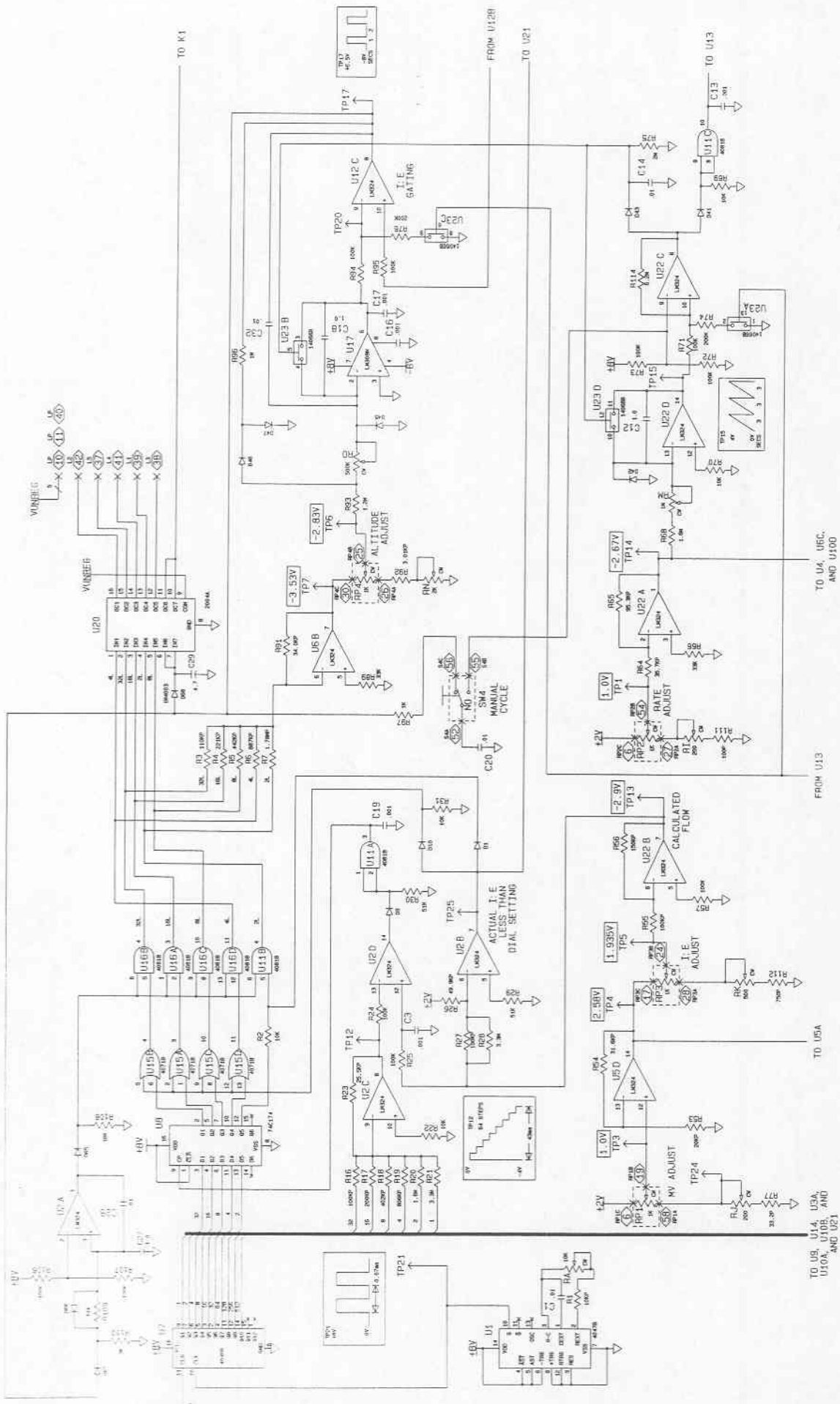


(Connect with jumper wire during test)

**Figure 7-8**  
Valve Assembly Calibration Check



**Figure 8-1**  
Circuit Board Component Layout



**Note:** The letter "p" after the resistor value indicates  $\pm 1\%$  precision.

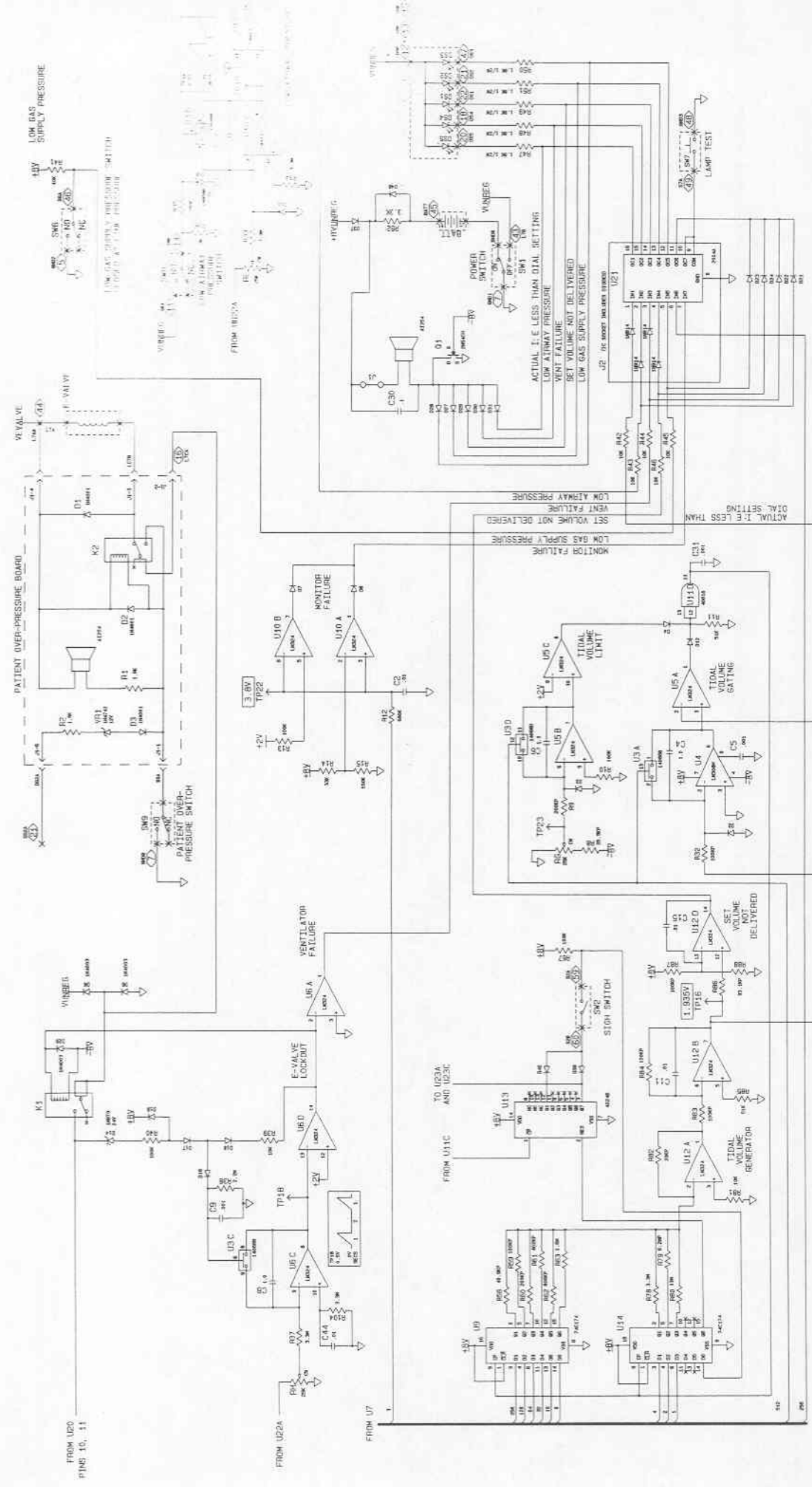
Rate = 20  
MV = 15  
IE = 1:2  
Alt. Adj. = 0

**Figure 8-2A**  
Schematic Diagram of the Electronic Control Circuitry



**Figure 8-6**  
Wiring Harness 1502-7005-000

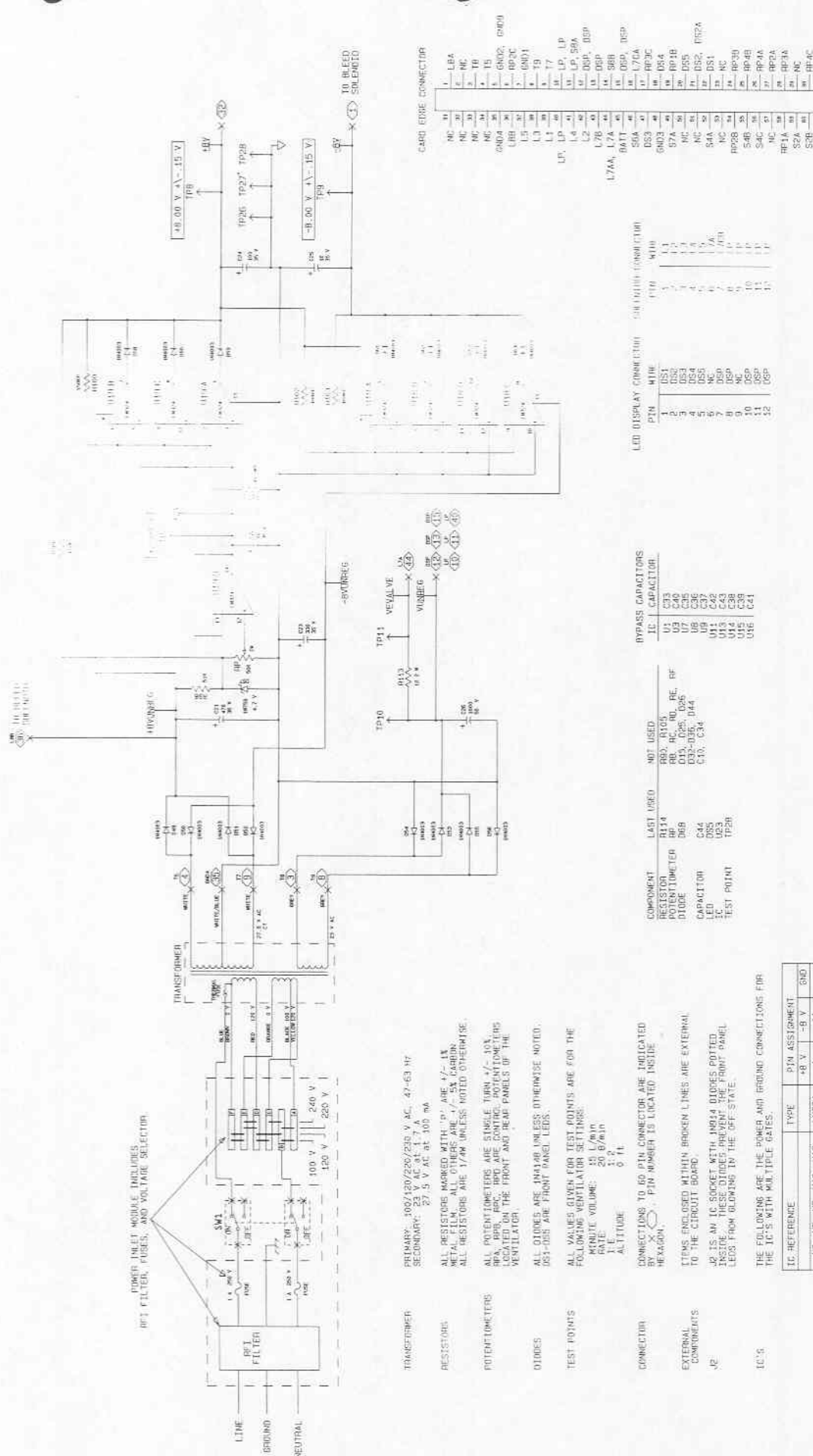




Note: The letter "p" after the resistor value indicates  $\pm 1\%$  precision.

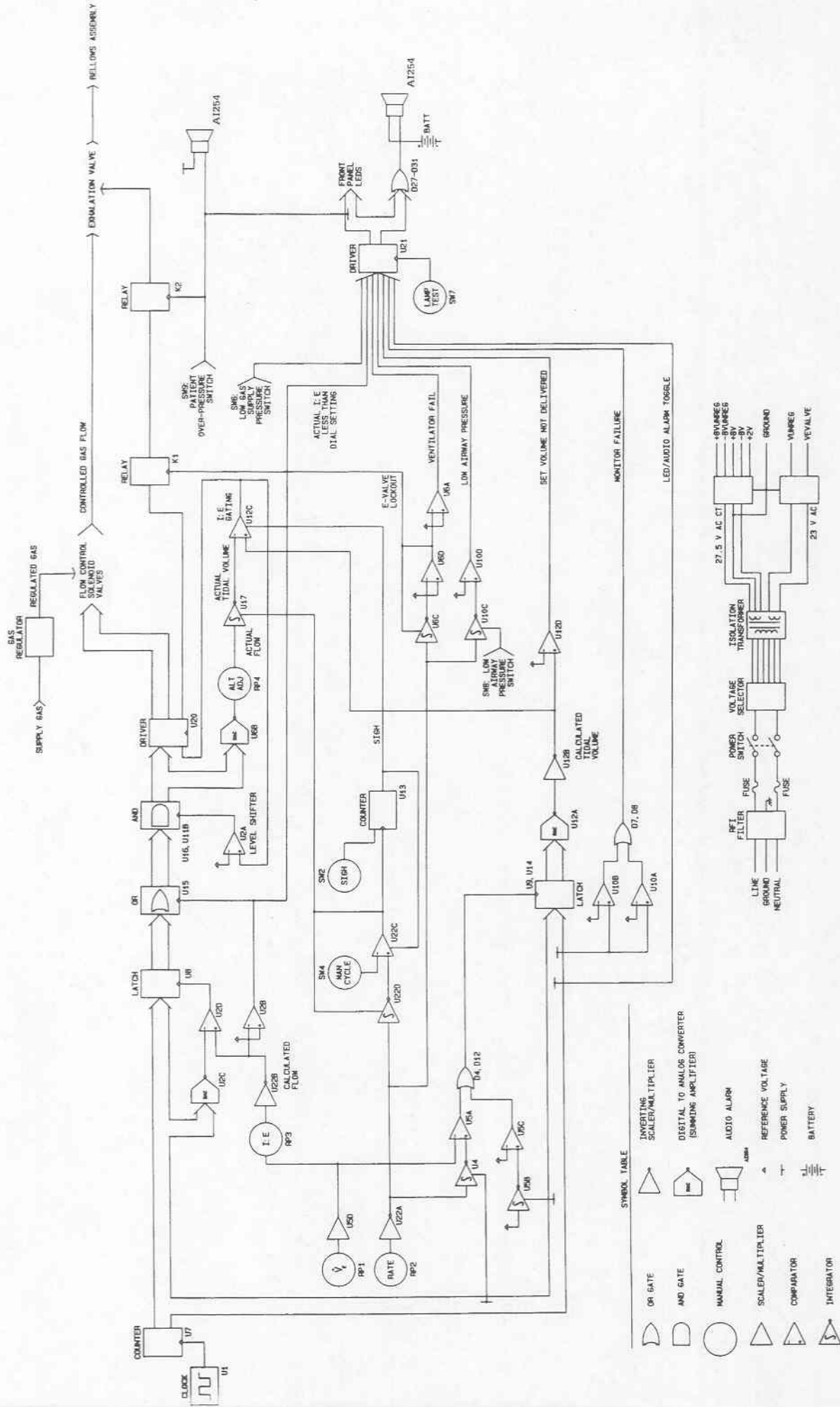
Voltage and Wave shapes valid for the condition  
 Rate = 20  
 MV = 15  
 IE = 1.2  
 Alt. Adj. = 0

**Figure 8-2B**  
 Schematic Diagram of the Electronic Control Circuitry

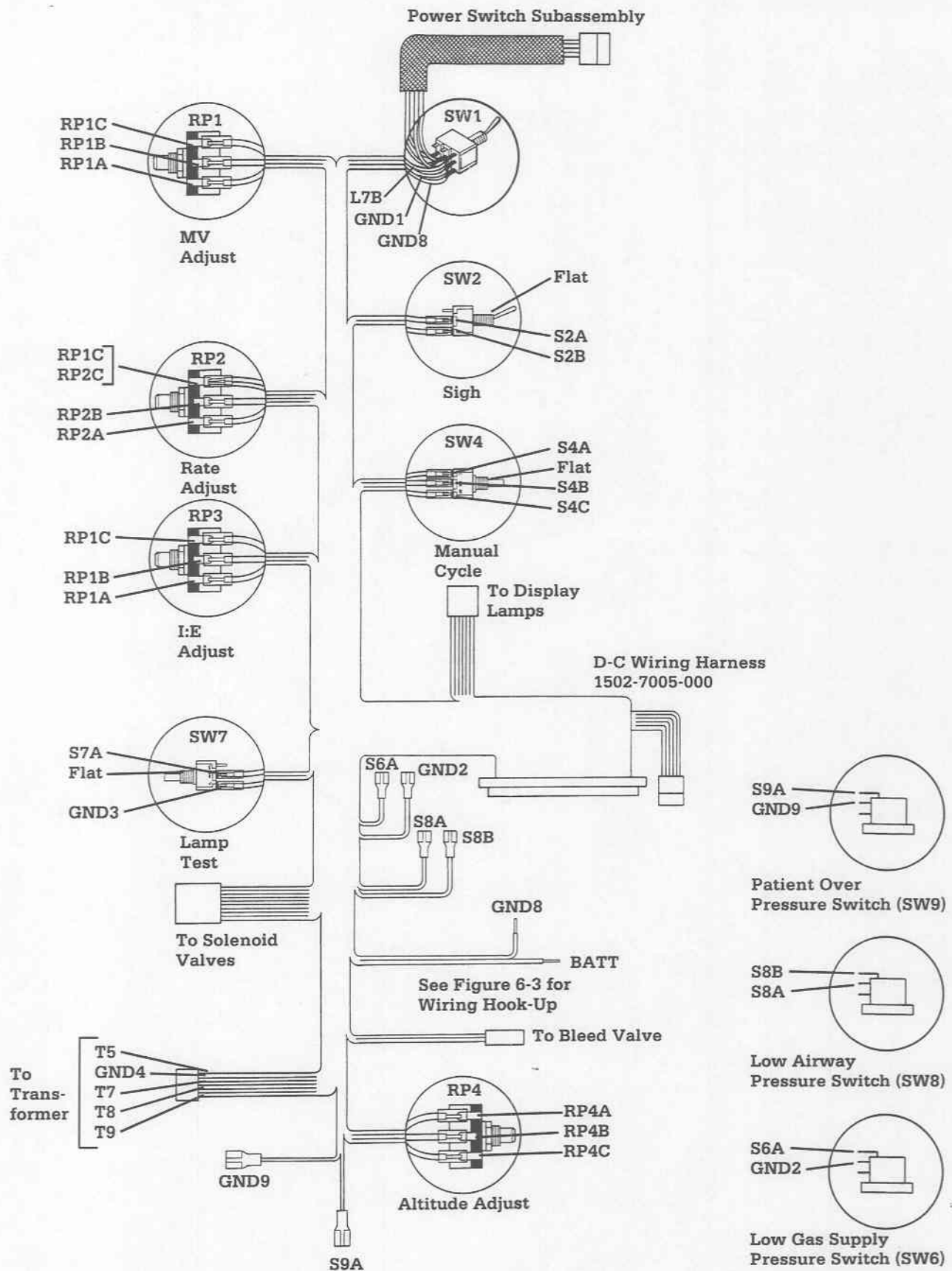


Note: The letter "p" after the resistor value indicates  $\pm 1\%$  precision.

**Figure 8-3**  
Power Supply Schematic



**Figure 8-4**  
Block Diagram of the Electronic Control Circuitry



**Figure 8-5**  
DC Wiring Diagram

## 8-7





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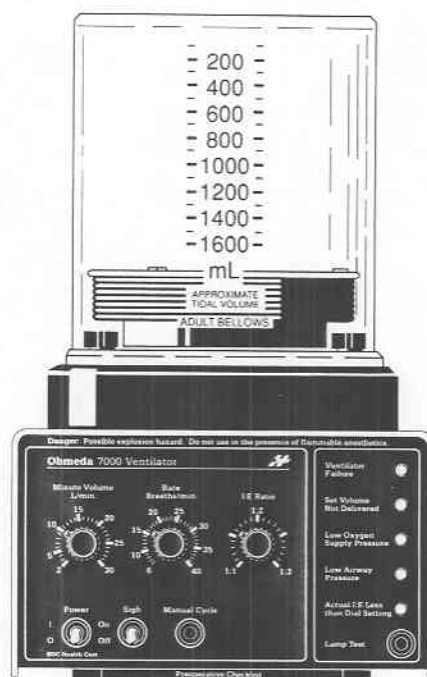
Military Addendum to the:

Ohmeda 7000 Anesthesia Ventilator

(Multi-Voltage Electronic)

Service Manual: Ohmeda stock number 1502-0009-000

Date code 07 90 0



This addendum to the Ohmeda 7000 Anesthesia Ventilator (Multi-Voltage Electronic) Service Manual provides additional information on:

- servicing and storing the ventilator
- connecting the ventilator to the 885A Military Field Anesthesia Machine

When performing the procedures in this addendum, refer to the Service Manual for details on assembly, disassembly and test equipment setup.

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

Note: All stock numbers provided in this Addendum, in the Operation and Maintenance Manual, and in the Service Manual, are Ohmeda stock numbers.

This Addendum is Ohmeda stock number 0397 2130 063 07 90 0.

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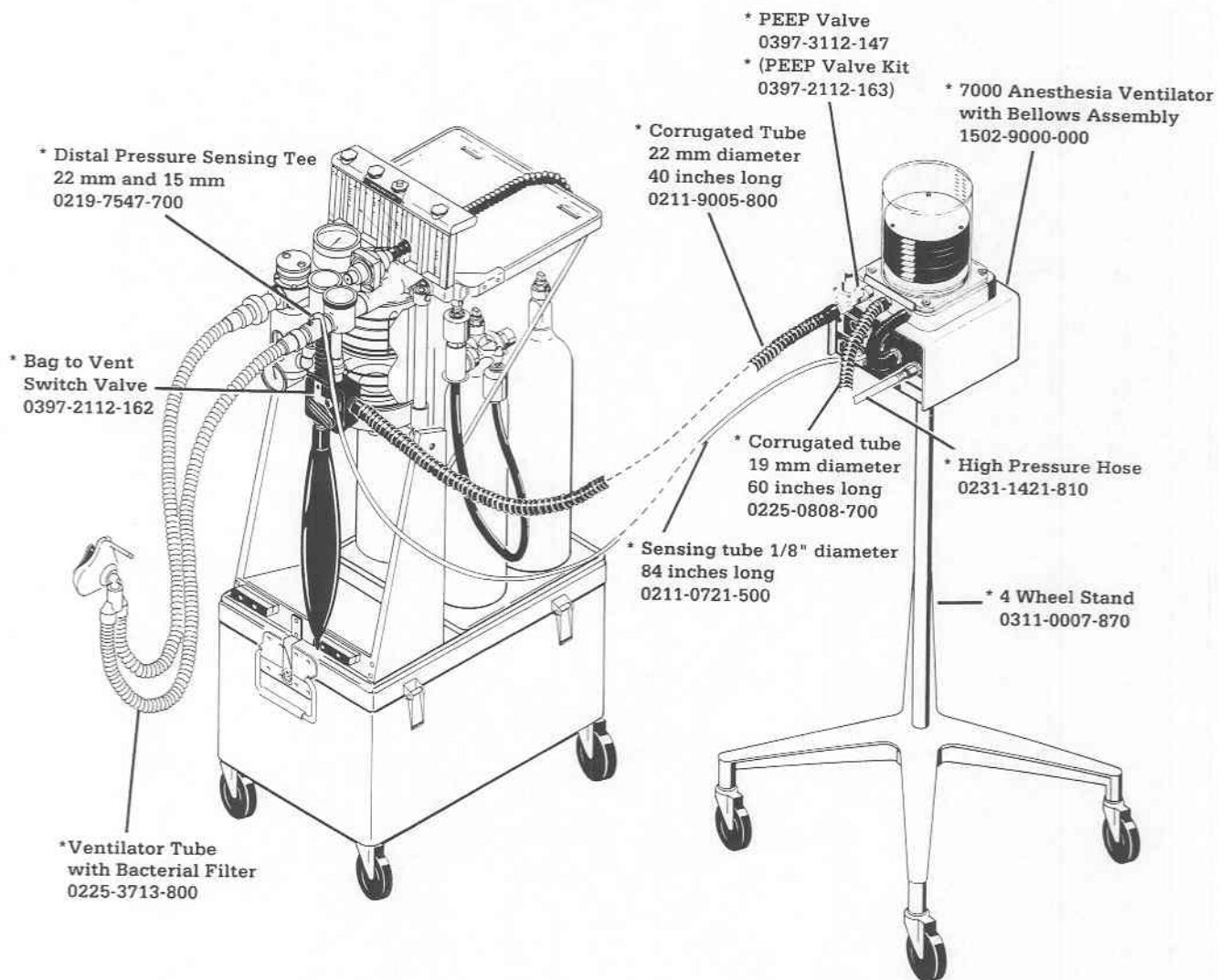
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## List of supplied equipment

Description:	Ohmeda stock number:
7000 Anesthesia Ventilator, Multi-Voltage Electronic with Bellows Assembly.....	1502-9000-000
Operation and Maintenance Manual, 7000 Anesthesia Ventilator.....	1502-0008-000
Addendum, O&M manual, 7000 Anesthesia Ventilator .....	0397-2130-062
Service Manual, 7000 Anesthesia Ventilator .....	1502-0009-000
Addendum, Service Manual, 7000 Anesthesia Ventilator .....	0397-2130-063
Kit, PEEP Valve.....	0397-2112-163
Kit, Low Pressure Alarm Tee .....	0219-7582-800
Switch Valve, Bag to Ventilator .....	0397-2112-162
Stand, 4 wheel.....	0311-0007-870
High Pressure Hose with female oxygen DISS and male Schrader fittings.....	0231-1421-810

## Included with the above items:

Description:	Ohmeda stock number:
Operation and Maintenance Manual, Bag to Ventilator Switch Valve.....	0397-2112-164
PEEP Valve .....	0397-2112-147
Operation and Maintenance Manual, PEEP Valve .....	0397-2112-161
Distal Pressure Sensing Tee, 22 mm and 15 mm.....	0219-7547-700
Sensing Tube, 1/8 inch 84 inches long.....	0211-0721-500
Corrugated Tube, 22 mm diameter, 40 inches long.....	0211-9005-800
Corrugated Tube, 15 mm diameter, 10 inches long.....	0211-0118-300
Ventilator Tube, with Bacterial Filter, disposable, 52 inches long .....	0225-3713-800
Corrugated Tube, 19 mm, 60 inches long .....	0225-0808-700



\* Items designated with an asterisk (\*) are included under NSN 6515-01-204-2663

**Figure 1**

Typical setup with 885A Field Anesthesia Machine

## Arrival inspection

Upon receiving the ventilator, inspect it and its accessories for signs of damage which may have occurred during shipment. If damage is found, notify the transportation company and file a damage claim immediately.

Store the original shipping container in an accessible place and use it if you need to reship the ventilator.

## Storage requirements

### Short term storage requirements (less than 6 months)

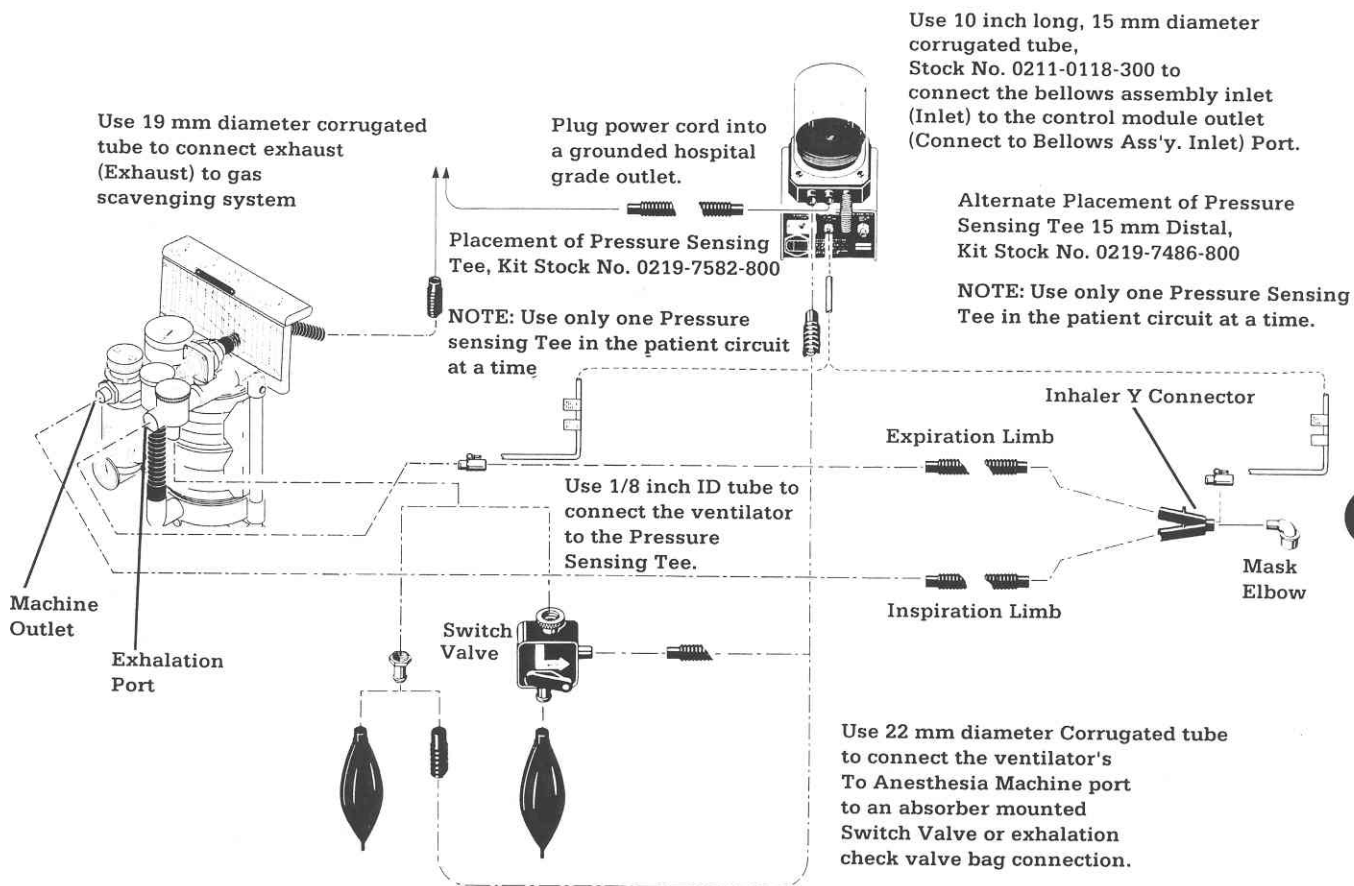
1. Indoor storage only.
2. Non-corrosive environment.
3. Storage temperature between -56.7 and 65.6 °C (-70 and 150 °F).
4. Relative humidity 0 to 100% non-condensing.
5. After storage, the periodic maintenance and inspection must be performed before the ventilator is placed into service.

### Long term storage requirements (greater than 6 months)

1. Indoor storage only.
2. Non-corrosive environment.
3. Storage temperature between -56.7 and 65.6 °C (-70 and 150 °F).
4. Absolute humidity must not exceed 13 grains per cubic foot.
5. After storage, the annual maintenance and inspection must be performed before the ventilator is placed into service.

## Unpacking and assembly

1. Remove the major assemblies and kits from the packing boxes.
2. Assemble the 4 wheel stand per the instructions (Ohmeda stock number 0176-1297-000) included with the stand.
3. Attach the 7000 Ventilator to the four-wheel stand per the instructions (Ohmeda stock number 0176-1297-000) included with the stand.



**Figure 2**

Bellows assembly attached to Control Module with 885A Field Anesthesia Machine



## Installation

**⚠ WARNING:** Before assembly, the following manuals should be read:

1.	Bag to Ventilator Switch Valve Operation and Maintenance Manual	Ohmeda stock number 0397-2112-164
2.	PEEP Valve Operation and Maintenance Manual	Ohmeda stock number 0397-2112-161
3.	7000 Anesthesia Ventilator (Multi-voltage Electronic) Operation and Maintenance Manual	Ohmeda stock number 1502-0008-000
4.	Addendum 7000 Anesthesia Ventilator (Multi-voltage Electronic), Operation and Maintenance Manual	Ohmeda stock number 0397-2130-062
5.	7000 Anesthesia Ventilator Multi-voltage Electronic, Service Manual	Ohmeda stock number 1502-0007-000

## Ventilator connections to 885A Field Anesthesia Machine

See Figure 2.

1. Make sure the Bellows Assembly to Control Module connection is made with the 15 mm diameter, 10 inch long corrugated tubing.
2. Connect the "Ventilator Connection" port of the PEEP valve to the bellows port labeled "To Anesthesia Machine".
3. Fit one end of the 1/8 inch ID pressure sensing tube (from the 22 mm Low Pressure Alarm Tee Kit, Ohmeda stock number 0219-7582-800) on the control module's barbed connector labeled "Connect to Expiratory Limb of Breathing System".
4. Fit the other end of the sensing tube onto the barbed fitting of the Distal Sensing Tee (included in 22 mm Low Pressure Alarm Tee Kit, Ohmeda stock number 0219-7582-800). Install the warning labels, Ohmeda stock numbers 0205-4982-300 and 0205-7493-300, on the sensing tube near the end which connects to the Distal Sensing Tee.

**⚠ WARNING:** Proper placement of the pressure sensing tee is very important. The tee must be placed in the Expiratory limb of the patient circuit, and must be installed with the tee nipple pointing upward. Improper placement could result in accumulation of condensate in the pressure sensing line and inaccurate pressure readings.

5. Install the Bag to Ventilator Switch Valve per the mounting instructions in the Bag to Ventilator Switch Valve Operation and Maintenance Manual, Ohmeda stock number 0397-2112-164.

6. Connect the Distal Sensing Tee to the patient exhalation port on the exhalation valve body.

**⚠ WARNING:** Proper placement of the pressure sensing tube is very important. The tube must be placed in the expiratory limb of the patient circuit. To help ensure proper functioning of the ventilator Low Airway Pressure Alarm, clear accumulated condensate from the pressure sensing tube immediately.

7. Use the 19 mm diameter corrugated tube to connect the bellows assembly Exhaust port to an appropriate gas scavenging system.

**⚠ WARNING:** Do not connect the ventilator Exhaust directly to a vacuum source. The vacuum may remove required gases from the patient circuit.

8. Use the 22 mm diameter corrugated tube to connect the port on the PEEP Valve labeled "Absorber Connection" to the port labeled "Vent" on the Bag to Ventilator Switch Valve.
9. Connect the breathing bag to the switch valve port labeled "Bag".
10. Connect the female DISS connector of the high pressure hose to the ventilator inlet, labeled "Use Only Oxygen 50-70 psig (345-483 kPa) Nominal". Connect the Schrader connector to an appropriate high pressure oxygen source.
11. Remove the access plate over the Altitude Adjustment Control by removing the two socket head cap screws. Set the dial to the altitude at which the ventilator is being used. Replace the access plate.
12. Check that the voltage selected on the power inlet module is the the voltage required. If not see Service Manual for changing the input voltage.
13. Plug the power cord into a properly grounded hospital grade outlet.

### Maintenance and inspection procedure

This procedure is comprised of:

1. Annual maintenance and inspection
2. Periodic maintenance and inspection

The annual maintenance and inspection must be performed annually on units which are in service and on units which are to be placed into service after storage periods of six months or more.

For storage periods of less than six months, the periodic maintenance and inspection must be performed before placing the unit into service.

The periodic maintenance and inspection must be performed every three months on units which have been placed into service.

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If inspection indicates that replacement or servicing is necessary, refer to the appropriate section of the Service Manual.

**⚠ WARNING:** This procedure contains limited warnings and cautions. Refer to the product Service Manual for a full listing of precautions.

## Test equipment and tools required for the inspection procedure

Ohmeda RM 121 Respirometer or Ohmeda 5400 Volume Monitor, or equivalent  
RT-200 Gauge & Bulb Assembly (Ohmeda stock number 0175-2288-000), or equivalent

Pressure Gauge (Ohmeda stock number 0175-2359-000) (0-60 psig  $\pm 0.25\%$ , with case), or equivalent

Zero to four Liter/min flowmeter

Stop watch (Ohmeda stock number 0175-1629-000), or equivalent

Test Lung (Ohmeda stock number 0219-7210-300), or equivalent

Leakage current tester (Ohmeda stock number 0175-2284-000), or equivalent

#2 Phillips screwdriver

5/8 inch open-end wrench

7/8 inch open-end Wrench

7/8 inch flat-tip screwdrivers

5/16 inch open-end wrench

5/16 inch nut driver

5 mm nut driver

50  $\pm$  2 psig oxygen supply

**⚠ WARNING:** This ventilator is designed to be powered by oxygen. All calibration and testing must be performed using oxygen as the supply gas.

**⚠ WARNING:** This ventilator is designed to be powered by oxygen. Medically pure air may be used to power the ventilator. When medically pure air is used, the ventilator's Minute Volume output will be slightly higher than the control setting. The difference in output from the setting will vary from approximately 10% higher at the 2 L/min Minute Volume setting to approximately 5% higher at the 30 L/min Minute Volume setting.

## Annual maintenance and inspection

### A. Visual check

**⚠ WARNING: Electrical Shock Hazard.** Do not touch exposed wires or conductive surfaces while the cover panel is removed from the ventilator unless the electrical power is disconnected from the unit. Hazardous voltages are present during normal operation. Never wear a grounding wrist strap when working on an energized ventilator.

**⚠ WARNING: Do not use the ventilator until all the Preoperative Checkout Procedures have been performed and correct operation has been verified.**

1. Unplug the ventilator's line cord from the power outlet and disconnect the oxygen power source.
2. Remove the four screws fastening the cover panel onto the chassis, then set the panel aside.
3. Check the interior of the control unit for cleanliness (no dust, etc.)
4. Check that all four panel-mounting tinnerman nuts are present and are functioning properly.
5. Check for possible damage to the valve plate assembly, pressure regulator and the On/Off switch caused by incorrect length mounting screws.
6. Check that the fuses installed are of the correct value: 1A 250 V fast-blow.
7. Check all internal tubing for tightness and deterioration.
8. Check the battery; clean its terminals; replace the battery every two years or as necessary. Record the battery change date on a sticker and affix the sticker to the underside of the control unit cover for future reference.

Note: After storage periods greater than two months, the ventilator battery may be discharged resulting in malfunctioning of the power failure alarm. Before testing and placing the ventilator into service, the battery should be replaced with a fully charged battery or the ventilator should be powered up for a period of 21 hours to charge the battery. In either case, the proper functioning of the power failure alarm should be verified before the ventilator is placed into service. (Refer to the periodic maintenance and inspection for the power failure audio alarm and battery condition check.)

### B. Exhaust valve inspection

1. Unbolt the circuit board mounting plate from the chassis (4 nuts) and set it to the side.
2. Disconnect the gas hose TB1 from the rear panel supply gas inlet connector.
3. Remove the gas supply inlet connector from the rear panel.

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4. Disconnect tubes TB10 and TB11.
5. Remove the exhaust valve cover.
6. Examine the seal (pad) on the exhaust valve. If it is deteriorated or worn, replace the exhaust valve (Ohmeda stock number 0229-1014-700). Refer to the procedures in the Service Manual.
7. Inspect the valve stem and the solenoid plunger. If corrosion or debris is present, replace the exhaust valve.
8. Reinstall the exhaust valve cover and the rear panel gas supply inlet connector.
9. Reconnect the gas hoses.

### C. Pressure regulator and bleed valve test/adjustment

1. Remove the solenoid bleed valve's tube from its connection to the exhaust chamber cover and connect to a 0 to 4 Liter/min flowmeter.
2. Connect the 50 ( $\pm 2$  psig) oxygen gas supply to the ventilator, plug the line cord into the power outlet and then switch on the unit. (Disregard any alarms.)
3. A maximum gas flow of 3 L/min out of the bleed tube must be observed. If the flow is greater than 3 L/min, replace the regulator.
4. If there is no flow out of the bleed valve, disconnect the bleed valve tube from the fitting on the regulator. Flow some gas through the bleed valve to verify that it is open. If the bleed valve is not open, check the circuit board and bleed valve solenoid for correct operation.
5. Switch off the ventilator. Then, reconnect the bleed tubes to the exhaust chamber cover and regulator.
6. Remove the manifold plug. Connect a pressure gauge (Ohmeda stock number 0175-2359-000) to the manifold where the plug was removed. The gauge must have a length of tubing attached between it and the manifold, such that the gauge will rest on the table beside the ventilator.

**Note:** During this test, ignore the Set-Volume-Not-Delivered alarm.

7. Replace the circuit board assembly, but do not fasten it in place. Switch the ventilator back on.
8. Set the ventilator controls to:

Minute Volume = 12 L/min

Rate = 6 BPM

I:E = 1:1

**Note:** Be sure to hold the gauge vertical for all readings.

**Note:** Be sure the gas supply pressure to the ventilator is  $50 \pm 2$  psig.

9. Check for  $38 \pm 0.50$  psig during inspiration. If necessary, adjust the regulator using a 5 mm nutdriver.
10. Set the ventilator controls to:



Minute Volume = 30 L/min

Rate = 6 BPM

I:E = 1:1

11. Check that the regulator output pressure is 36.75 psig or higher during inspiration. If not, readjust it and repeat steps 8 and 9. Replace the regulator if it cannot be adjusted to meet the specifications.
12. Set the ventilator controls to:

Minute Volume = 12 L/min

Rate = 6 BPM

I:E = 1:1

13. Check for  $38 \pm 0.50$  psig during inspiration. If necessary, adjust the regulator using a 5 mm nutdriver.
14. Check the static pressure during expiration. It must be less than 39 psi; if not, adjust the regulator and repeat steps 8 through 13. Replace the regulator if it cannot be adjusted to meet the specification.
15. Any regulator that develops an oscillation in the output pressure that does not dampen out to  $\pm 5$  psig or less within 5 seconds should be replaced.
16. Switch off the ventilator and disconnect the oxygen supply.
17. Reinstall the manifold plug.
18. Secure the circuit board mounting plate to the chassis.

## D. Exhaust valve circuit test

**⚠ CAUTION:** Connecting TP-20 to ground places the ventilator in a continuous gas delivery phase where the exhaust valve is continuously On (closed). If the ventilator is left in this condition longer than one minute, overheating-failure of the exhaust valve may occur. If an IC test clip was placed on the valve driver IC (U20), that test clip must be removed to perform the following test.

1. Set the ventilator controls to:

RATE = 20 BPM

I:E = 1:1

2. Switch the ventilator On.
3. Connect TP-20 to ground (TP 26, 27 or 28). The Ventilator Failure alarm must activate within 3 to 7.5 seconds. The exhaust valve must remain open. (If a click occurs, indicating that the valve closed, it is a malfunction, refer to the Service Manual).
4. Remove test link, TP-20 to ground. The alarm must stay on and the exhaust valve must remain open.
5. Switch the unit Off, then On. There must be no Ventilator Failure alarm. The exhaust valve must function correctly.



## **E. Periodic check**

As part of the annual maintenance and inspection, perform the following Periodic maintenance and inspection.

## **Periodic maintenance and inspection**

### **A. External inspection - Control Unit and Bellows Housing**

1. Check the general condition of the unit.
2. Check that the Preoperative Checklist is present and its lettering is legible.
3. Check that the front and rear panel labels are legible and secure on chassis.
4. Check that four cover mounting screws are present.
5. Check the power cord for wear, cracks or damage. Check that the anti-disconnect bracket holds the cord securely.
6. Check that all rear panel connectors are damage-free and mounted securely.
7. Check the bellows housing for cracks, chips or other damage. Also check the condition of the housing lettering.
8. Check the four potentiometer controls (including altitude adj. pot.) for looseness or damage. Check for free and smooth rotation throughout the adjustment range. Reset the altitude adjustment for the proper elevation.
9. Check that the control knobs are firmly affixed.
10. Check the oxygen driving gas tube for deterioration.
11. Check for secure mounting and correct action of all the switches.

### **B. Internal inspection - Bellows Assembly**

1. Check the bellows and "U" cup seal for deterioration, such as dryness, cracking, brittleness, etc; replace them as necessary.
2. Check the condition of the pop-off valve sealing "O" Ring (Ohmeda stock number 0210-0463-300) and the drive gas nipple "O" ring (Ohmeda stock number 0210-0593-300); replace them as necessary.

### **C. Functional tests**

#### **1. Pop-Off Valve Test:**

- a. Set the absorber selector switch to Ventilator.

- b. Check or adjust the absorber pressure gauge for zero indication.
- c. Interconnect the absorber inhalation-exhalation ports with a patient hose.
- d. Fill the bellows, using oxygen flush.
- e. Adjust the oxygen flow rate to 5 L/min. Observe the gauge. When the flow rate has stabilized, the bellows internal pressure must not exceed 3 cm H<sub>2</sub>O. Otherwise, replace the pop-off valve.
- f. Operate the oxygen flush control; ensure that the bellows remains correctly retained on the bellows base lip.

## 2. Bellows Pull-Off Test:

- a. Remove the hose from the bellows base "Exhaust" port.
- b. Plug the bellows base "Exhaust" port with the palm of your hand.
- c. Using the oxygen flow from the anesthesia machine, inflate the bellows to the top of the canister. Continue the flowing until the absorber gauge indicates 8 mm Hg (11 cm H<sub>2</sub>O).
- d. Observe the bellows for correct retention on the bellows base lip. If the bellows has partly or has completely slipped off, immediately replace it.
- e. When the test is completed, reattach the hose to the "Exhaust" port.

## 3. Bellows Assembly Leak Test:

Initial condition: the absorber has passed the leak test.

- a. Set the bag-ventilator switch to the ventilator position.
- b. Inflate the bellows to top of the bellows housing.
- c. Set the bag-ventilator switch to the bag position.
- d. Inflate the bellows to the top of the bellows housing.

**Note:** For units without a bag-ventilator switch valve, inflate the bellows using the squeeze-bulb, gauge assembly (Ohmeda stock number 0175-2288-300) through the port labeled "To Anesthesia Machine." Perform the test in step e.

- e. Observe the bellows position against the housing tidal volume scale. The observed bellows drop (leak rate) must not exceed 100 ml in 1 minute.

- f. Otherwise, check the bellows for a correct retention on the bellows base/leaks; then repeat the above test. Replace the pop-off valve if the test failure reoccurs.

## 4. Flow Delivery Test:

- a. Disconnect the drive gas hose (15 mm diameter, 10 inch long corrugated tubing) from the bellows base.
- b. Connect the volume monitor/respirometer to the bellows drive gas hose on the control unit. (Use hoses/adapters as required)
- c. Check the altitude compensation setting. (Set to the local altitude in meters; 1 foot = 0.305 meters).
- d. Turn the oxygen supply on. Switch the ventilator power switch On.
- e. Pressurize the  $\frac{1}{8}$  inch ID pressure sensing tube to 20 cm H<sub>2</sub>O; clamp the tubing to retain pressure and prevent a low airway pressure alarm.
- f. Set the ventilator controls as in Table 1 on page 19; allow three cycles to occur. Re-zero the volume monitor or respirometer between readings.
- g. Compare the volume monitor or respirometer readings with the tidal volume limits and check the Respiratory Rate with a stop watch.

**Note:** For the following tests and operation check, connect the ventilator to the anesthesia machine absorber with a patient circuit and test lung (Ohmeda stock number 0219-7210-300) and maintain a sufficient fresh gas flow so that the bellows remains fully extended.

## 5. Manual Ventilation Test:

- a. Set the controls to:

Minute Volume = 6 L/min

Rate = 6 BPM

I:E = 1:2

- b. Press the manual cycle button between each cycle to verify that the ventilator cycles.

## 6. Sigh Test:

- a. Set the controls to:

Minute Volume = 30 L/min

Rate = 40 BPM

I:E = 1:1

- b. Switch the sigh switch On and count the number of breaths, starting when the first sigh is detected. On the 64th  $\pm$ 2 breaths, a larger breath must be delivered; 150% of a normal breath.

- c. Reset the sigh switch to its original position.

## 7. Alarm Check Test:

- a. Push the lamp test button. All the lamps must light and the audio alarm must sound.

- b. Set the controls to:

Minute Volume = 15 L/min

Rate = 15 BPM

I:E = 1:2.5

and vary the MV control as indicated; verify the alarm condition:

MV:	Alarm Condition:
15 L/M	None
20 L/M	Actual I:E Less than dial setting
25 L/M	Actual I:E Less than dial setting and set vol. not delivered

- c. Set the controls to:

Minute Volume = 6 L/min

Rate = 6 BPM

I:E = 1:1

and disconnect the test lung with the ventilator On (I). The low airway alarm must activate between 19 and 30 seconds elapsed time.

- d. Disconnect the oxygen supply; verify that the low oxygen supply pressure alarm activates.

## 8. Power Failure Audio Alarm and Battery Condition Check:

Note: After storage periods greater than two months, the ventilator battery may be discharged resulting in malfunctioning of the power failure alarm. Before testing and placing the ventilator into service, the battery should be replaced with a fully charged battery or the ventilator should be powered up for a

period of 21 hours to charge the battery. In either case, the proper functioning of the power failure alarm should be verified before the ventilator is placed into service.

- a. With the ventilator power switch On, remove the power plug from the power socket. The power failure audio alarm should sound.
- b. The power failure audio alarm should remain fully audible for a complete two minute period to indicate an adequate battery.
- c. If the power failure audio alarm does not sound or does not sound for the complete two minutes, charge the ventilator's battery by leaving the ventilator plugged in and switched On for 21 hours.
- d. After charging the battery, repeat steps a and b.
- e. If the power failure audio alarm still does not sound for a complete two minute period, install a new battery and charge it as in step c.
- f. Repeat test steps a and b to verify the proper functioning of the alarm with the new battery.
- g. Reconnect the power plug.

## 9. High Pressure Relief Valves, Safety Tests:

### a. Mechanical relief valve test; *all units*.

#### 1) Set the controls to:

Minute Volume = 5 L/min

Rate = 10 BPM

I:E = 1:2

#### 2) At the control unit, disconnect the system hose from the port labeled "Connect to Bellows Ass'y Inlet"; occlude that port.

#### 3) Switch the unit On. Listen for a "clicking" sound, indicating that the mechanical relief valve is operating.

#### 4) If a clicking sound is not heard, clean or replace the mechanical relief valve.

#### 5) Reconnect the system hose.

**Note:** Disregard the low pressure alarm during the following test.

### b. Electronic high pressure relief system.

#### 1) Switch the unit On (I).

- 2) Connect the gauge and the bulb assembly to the control unit port labeled "Connect to Expiratory Limb of Breathing System".
- 3) Apply a pressure greater than 65 cm H<sub>2</sub>O (approx. 48 mm Hg) to the port labeled "Connect to Expiratory Limb of Breathing System".
- 4) When the inlet pressure is 65-70 cm H<sub>2</sub>O, the "Set Volume Not Delivered" alarm must light and an audio alarm must sound.
- 5) If this condition is not satisfied, replace or adjust the over-pressure switch as necessary.
- 6) If this over-pressure condition is sensed during the inspiration phase, the driving oxygen is vented from the control unit base until the inspiratory phase is complete.
- 7) Maintain the over-pressure condition and ensure that after 2-3 breaths, the ventilator goes into the "ventilator failure" mode and will not function. Switch the unit Off then On to reset.

### D. Electrical safety tests

1. With the power cord disconnected from the power source, test the ground continuity by measuring the resistance from the power plug ground pin to a cover panel screw. The resistance must be less than 0.15 ohm. Flex the power cord gently while measuring the resistance to check for loose or broken connections. Repair or replace as necessary.
2. Using approved techniques and equipment (such as the Ohmeda leakage current tester, Ohmeda stock number 0175-2284-000), perform a full leakage current test. The maximum leakage current must be less than 35 µA for 100/120 Vac or less than 70 µA for 220/240 Vac under all conditions. Refer also to the Functional Test section in the Service Manual.

### E. Final operational check

1. Connect the ventilator to the anesthesia machine-absorber with a patient circuit and test lung (Ohmeda stock number 0219-7210-300).
2. Install the volume monitor/respirometer into the exhalation side of the patient circuit.
3. Flow approximately 3 liters per minute of fresh gas so that the bellows remains fully extended.
4. Switch the ventilator On, repeat the test settings in lines 1, 3 and 6 of Table 1. Ensure the ventilator cycles correctly and that the volumes measured approximate the values in Table 1.



Table 1 - Test table

Line number:	Control settings:			Limits:		
				min:	actual:	max:
Line 1	MV	5	TV	360 ml	500 ml	690 ml
	R	10	I <sub>t</sub>		2 sec.	
	I:E	1:2	E <sub>t</sub>		4 sec.	
Line 2	MV	10	TV	770 ml	1000 ml	1310 ml
	R	10	I <sub>t</sub>		3 sec.	
	I:E	1:1	E <sub>t</sub>		3 sec	
Line 3	MV	10	TV	400 ml	500 ml	620 ml
	R	20	I <sub>t</sub>		0.75 sec.	
	I:E	1:3	E <sub>t</sub>		2.25 sec.	
Line 4	MV	20	TV	840 ml	1000 ml	1200 ml
	R	20	I <sub>t</sub>		1.5 sec.	
	I:E	1:1	E <sub>t</sub>		1.5 sec.	
Line 5	MV	30	TV	860 ml	1000 ml	1170 ml
	R	30	I <sub>t</sub>		1 sec.	
	I:E	1:1	E <sub>t</sub>		1 sec.	
Line 6	MV	20	TV	430 ml	500 ml	580 ml
	R	40	I <sub>t</sub>		1.5 sec.	
	I:E	1:1	E <sub>t</sub>		total	
Line 7	MV	6	TV	160 ml	200 ml	250 ml
	R	30	I <sub>t</sub>		2 sec.	
	I:E	1:2	E <sub>t</sub>		total	
Line 8	MV	25	TV	1190 ml	1500 ml	1920 ml *
	R	10	I <sub>t</sub>		2 sec.	
	I:E	1:2	E <sub>t</sub>		4 sec.	

\* limited to 1550 ml if bellows assembly is fitted

Notes for Table 1:

1. Control setting accuracy is very important to ensure accuracy of results.
2. Limits calculated using TV = MV/Rate.
3. Minute volume accuracy  $\pm 5\%$ , dial setting  $\pm 2\%$  full scale.
4. Rate accuracy  $\pm 5\%$ , dial setting  $\pm 1$  breath.
5. I:E accuracy =  $\pm 20\%$



### Circuit board components

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## Control circuit board components and Ohmeda stock numbers

Refer to Figure 3.

Designator:	Description:	Ohmeda Stock Number:
A1	Alarm, Audio	0690-1100-308
C1	Capacitor, .01 $\mu$ F, mylar	0682-4170-301
C2,11,14,15,20,28,30, 32,33,35-44	Capacitor, .01 $\mu$ F, ceramic	0682-1170-312
C3,5,9,13,16,17,19,31	Cap, .001 $\mu$ F, ceramic	0682-1150-304
C4,6-8,12,18	Capacitor, 1.0 $\mu$ F, polyester	0682-4203-309
C21	Capacitor, 470 $\mu$ F, electrolytic	0682-7118-300
C22,25	Capacitor, 10 $\mu$ F, electrolytic	0682-7018-306
C23	Capacitor, 330 $\mu$ F, electrolytic	0682-7112-300
C24	Capacitor, 100 $\mu$ F, electrolytic	0682-7080-307
C26	Capacitor, 1000 $\mu$ F, electrolytic	0682-7140-304
C27	Capacitor, 1.0 $\mu$ F, tantalum	0682-2295-302
C29	Capacitor, 4.7 $\mu$ F, tantalum	0682-2300-302
C30	Capacitor, .1 $\mu$ F, ceramic	0682-1189-317
D1-4,7-12,16-19,21-24, 27-31,37,39-43,35,36, 47,48, 65-67	Diode, signal, 1N4148	0683-0042-300
D5,6,20,49,50,51-56, 58-64,68	Diode, 1N4003	0683-0500-001
D13	Diode, zener, 1N958B	0683-0099-300
D14	Diode, zener, 1N970	0683-0098-300
D57	Diode, zener, 1N750	0683-0016-300
J1	Socket, IC, 14 pin	0686-9000-424
J2	Socket, IC w/1N914B diodes	1502-3002-000
K1	Relay	0690-2350-332
Q1	Transistor, FET 2N5459	0685-0108-300
R1	Resistor, 10K ohm, 1/4 W, 1%	0680-3401-300
R2,22,31,39,41-46,69, 70,81,108	Resistor, 10K ohm, 1/4 W, 5%	1300-3003-000
R3	Resistor, 110K ohm, 1/4 W, 1%	0680-3915-317
R4	Resistor, 221K ohm, 1/4 W, 1%	0680-0250-324
R5	Resistor, 442K ohm, 1/4 W, 1%	0680-3915-318
R6	Resistor, 887K ohm, 1/4 W, 1%	0680-3915-319
R7	Resistor, 1.78M ohm, 1/4 W, 1%	0680-3915-320

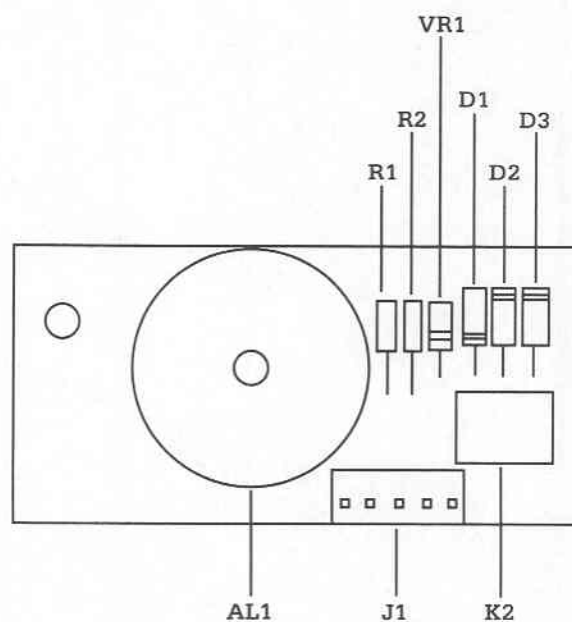
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R8,23	Resistor, 25.5K ohm, 1/4 W, 1%	0680-0250-313
R9,17,60	Resistor, 200K ohm, 1/4 W, 1%	0680-0250-323
R10,13,15,24,25,40,57,6 7,71-73,86,94,95,106, 107	Resistor, 100K ohm, 1/4 W, 5%	0680-0521-300
R11,29,30,85,98,109	Resistor, 51K ohm, 1/4 W, 5%	0680-0514-300
R12	Resistor, 680K ohm, 1/4 W, 5%	0680-0540-300
R14,66,89	Resistor, 33K ohm, 1/4 W, 5%	0680-0509-300
R16,27,32,55,59,83,84,8 7,102,103	Resistor, 100K ohm, 1/4 W, 1%	0680-0250-321
R18,61	Resistor, 402K ohm, 1/4 W, 1%	0680-0250-318
R19,62	Resistor, 806K ohm, 1/4 W, 1%	0680-0250-319
R20,63,68	Resistor, 1.6M ohm, 1/4 W, 5%	0680-0549-300
R21,28,34,37,78,104	Resistor, 3.3M ohm, 1/4 W, 5%	0680-0557-300
R26,58,101	Resistor, 49.9K ohm, 1/4 W, 1%	0680-3915-316
R33	Resistor, 3.9M ohm, 1/4 W, 5%	0680-0559-300
R35	Resistor, 160K ohm, 1/4 W, 5%	0680-0526-300
R36,75	Resistor, 2.0M ohm, 1/4 W, 5%	0680-0552-300
R38	Resistor, 2.2M ohm, 1/4 W, 5%	0680-0553-300
R46,100	Resistor, 150K ohm, 1/4 W, 1%	0680-0250-322
R52	Resistor, 3.3K ohm, 1/4 W, 5%	0680-0485-300
R53,82	Resistor, 20K ohm, 1/4 W, 1%	0680-0250-320
R54	Resistor, 31.6K ohm, 1/4 W, 1%	0680-0250-314
R64	Resistor, 35.7K ohm, 1/4 W, 1%	0680-0250-315
R65	Resistor, 95.3K ohm, 1/4 W, 1%	0680-0250-317
R74,76	Resistor, 200K ohm, 1/4 W, 5%	0680-0528-300
R77	Resistor, 33.2 ohm, 1/4 W, 1%	0680-0250-309
R79,114	Resistor, 6.2M ohm, 1/4 W, 5%	0680-0564-300
R88	Resistor, 93.1K ohm, 1/4 W, 1%	0680-0250-316
R91	Resistor, 34.0K ohm, 1/4 W, 1%	0680-3452-300
R92	Resistor, 3.01K ohm, 1/4 W, 1%	0680-0250-312
R93	Resistor, 1.2M ohm, 1/4 W, 5%	0680-0546-300
R96	Resistor, 1.0M ohm, 1/4 W, 5%	0680-0544-300
R97	Resistor, 1.0K ohm, 1/4 W, 5%	0680-0473-300
R99	Resistor, 1.2K ohm, 1/4 W, 5%	0680-0475-300
R110	Resistor, 2.0K ohm, 1/4 W, 5%	0680-0480-300
R111	Resistor, 100 ohm, 1/4 W, 1%	0680-2050-310
R112	Resistor, 750 ohm, 1/4 W, 1%	0680-0250-311
RA	Resistor, variable, 10K ohm, 1 turn	0681-0900-000
RG, RH, RL	Resistor, variable, 25K ohm, 1 turn	0681-0950-000
RI, RJ	Resistor, variable, 200 ohm, 1 turn	0681-0725-000

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RK	Resistor, variable, 500 ohm, 1 turn	0681-0775-000
RM	Resistor, variable, 1.0M ohm, 1 turn	0681-1100-000
RN	Resistor, variable, 2.0K ohm, 1 turn	0681-0825-000
RO	Resistor, variable, 500K ohm, 1 turn	0681-1075-000
RP	Resistor, variable, 50K ohm, 1 turn	0681-0975-000
TJ1	Header, straight, 2-position	0690-1563-315
TP1-28	Terminal, auto-splice	0690-2600-370
U1	IC, CMOS, 4047B, multivibrator	0684-0400-019
U2,5,6,10,12,18,19,22	IC, linear, LM324N, quad op amp	0684-0600-009
U3,23	IC, CMOS, 14066B, quad bilat switch	0684-0400-018
U4,17	IC, linear, LM308N, op amp	0684-0600-016
U7	IC, CMOS, 4040BC, bin count 12-stage	0684-0400-021
U8,9,14	IC, CMOS, MM74C174B, hex D flip-flop	0684-0400-017
U11,16	IC, CMOS, CD4081BM, quad AND	0684-0400-022
U13	IC, CMOS, 4024B, bin count 7-stage	0684-0400-020
U15	IC, CMOS, CD4071BE, quad OR gate	0684-0191-300
U20,21	IC, linear, ULN2004A, darlington driver	0684-0700-005



**Figure 4**

Patient Overpressure circuit board



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## Patient Overpressure circuit board components and Ohmeda stock numbers

Refer to Figure 4.

Designator:	Description:	Ohmeda Stock Number:
AL1	Alarm, audio	0690-1100-308
J1	Connector Header 5 Pos, .100 ctr	1502-3024-000
D1, D2, D3	Diode, 50 V, 1A, 1N4001	0683-0035-300
VR1	Diode, Zener 1A, 12V 1N4742	1502-3022-000
K2	Relay, SPDT, 24V, Micro-min PC mnt.	1502-3023-000
R1,2	Resistor, 1.8K ohm 1/2 W 5%	0680-0605-351