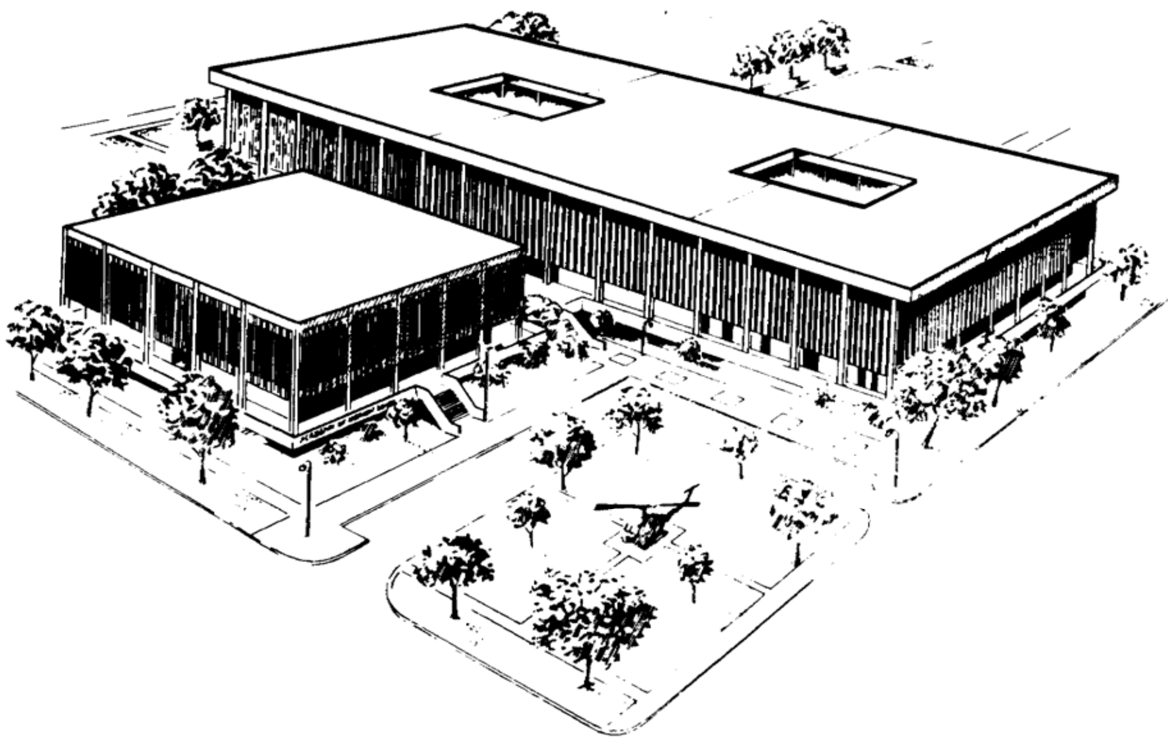
U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL
FORT SAM HOUSTON, TEXAS 78234-6100



PORTABLE VENTILATOR

SUBCOURSE MD0355 EDITION 100

DEVELOPMENT

This subcourse is approved for resident and correspondence course instruction. It reflects the current thought of the Academy of Health Sciences and conforms to printed Department of the Army doctrine as closely as currently possible. Development and progress render such doctrine continuously subject to change.

ADMINISTRATION

Students who desire credit hours for this correspondence subcourse must enroll in the subcourse. Application for enrollment should be made at the Internet website: http://www.atrrs.army.mil. You can access the course catalog in the upper right corner. Enter School Code 555 for medical correspondence courses. Copy down the course number and title. To apply for enrollment, return to the main ATRRS screen and scroll down the right side for ATRRS Channels. Click on SELF DEVELOPMENT to open the application; then follow the on-screen instructions.

For comments or questions regarding enrollment, student records, or examination shipments, contact the Nonresident Instruction Branch at DSN 471-5877, commercial (210) 221-5877, toll-free 1-800-344-2380; fax: 210-221-4012 or DSN 471-4012, e-mail accp@amedd.army.mil, or write to:

NONRESIDENT INSTRUCTION BRANCH
AMEDDC&S
ATTN: MCCS-HSN
2105 11TH STREET SUITE 4191
FORT SAM HOUSTON TX 78234-5064

Be sure your social security number is on all correspondence sent to the Academy of Health Sciences.

CLARIFICATION OF TERMINOLOGY

When used in this publication, words such as "he," "him," "his," and "men" 'are intended to include both the masculine and feminine genders, unless specifically stated otherwise or when obvious in context.

USE OF PROPRIETARY NAMES

The initial letters of the names of some products may be capitalized in this subcourse. Such names are proprietary names, that is, brand names or trademarks. Proprietary names have been used in this subcourse only to make it a more effective learning aid. The use of any name, proprietary or otherwise, should not be interpreted as endorsement, deprecation, or criticism of a product; nor should such use be considered to interpret the validity of proprietary rights in a name, whether it is registered or not.

TABLE OF CONTENTS

**CORRESPONDENCE COURSE OF
THE U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL**

SUBCOURSE MD0355

PORTABLE VENTILATOR

INTRODUCTION

Most of the respirators and ventilators available on the market are designed for use with adults and provide volumes and pressures compatible with large, well developed lungs. When treating respiratory problems in children and infants, these units are too powerful, and it is difficult to adjust them for the volumes and pressures suitable for small, weak, or malformed lungs. To treat infant respiratory distress syndrome and other disorders in newborns, physicians needed a volume limited positive/negative pressure ventilator. The Babybird 5900 Pediatric Ventilator was developed to meet that need. Like any other pulmonary assistance device, the Babybird demands careful preventive maintenance and checks (PMCS) for accuracy and dependability.

Subcourse Components:

This subcourse consists of two lessons. They are

- Lesson 1. Operation and General Maintenance Procedures.
- Lesson 2, Locating and Replacing Defective Components.

Here are some suggestions that may be helpful to you in completing this subcourse:

--Read and study each lesson carefully.

--Complete the subcourse lesson by lesson. After completing each lesson, work the exercises at the end of the lesson, marking your answers in this booklet.

--After completing each set of lesson exercises, compare your answers with those on the solution sheet that follows the exercises. If you have answered an exercise incorrectly, check the reference cited after the answer on the solution sheet to determine why your response was not the correct one.

Credit Awarded:

Upon successful completion of the examination for this subcourse, you will be awarded 5 credit hours.

To receive credit hours, you must be officially enrolled and complete an examination furnished by the Nonresident Instruction Branch at Fort Sam Houston, Texas.

You can enroll by going to the web site http://atrrs.army.mil and enrolling under "Self Development" (School Code 555).

A listing of correspondence courses and subcourses available through the Nonresident Instruction Section is found in Chapter 4 of DA Pamphlet 350-59, Army Correspondence Course Program Catalog. The DA PAM is available at the following website: http://www.usapa.army.mil/pdffiles/p350-59.pdf.

LESSON ASSIGNMENT

LESSON 1	Operation and General Maintenance Procedures.
TEXT ASSIGNMENT	Paragraphs 1-1 through 1-7.
TASKS TAUGHT	Perform PMCS on the Portable Ventilator.
LESSON OBJECTIVES	When you have completed this lesson, you should be able to: 1-1. Identify the purpose of components. 1-2. Identify how to operate the ventilator in the spontaneous breathing and controlled intermittent mandatory breathing modes. 1-3. Identify procedures for performing preventive maintenance checks and services.
SUGGESTION	Work the lesson exercises at the end of this lesson before beginning the next lesson. These exercises will help you accomplish the lesson objectives.

LESSON 1

OPERATION AND GENERAL MAINTENANCE PROCEDURES

Section I. GENERAL FEATURES

1-1. GENERAL

a. **Capabilities.** The Babybird ventilator (figure 1-1) has established design and performance standards for neonatal and pediatric ventilators. It functions as a pneumatically powered, time cycled, pressure limited, constant flow controller. It operates on source-gas pressure of 45 to 55 pounds per square inch (psi). The Babybird ventilator has two clinical capabilities.

(1) Continuous positive airway pressure (CPAP) or spontaneous breathing.

(2) Controlled intermittent mandatory ventilation (IMV).

b. **Functional Features**. Functional features of the ventilator include a Bird oxygen blender which precisely controls the flow and percentage of oxygen delivered to the patient. Airway pressures are monitored by a dual gauge manometer calibrated in centimeters of water (cmH_2O)/millimeters of mercury (mmHg) or in cmH_2O/kilogram-Pascal (kpa). Source-gas pressures are constantly monitored by a pressure gauge. Gas flows to the patient are adjustable in liter per minute (lpm) gradations and visually monitored by a flowmeter readout. Humidification/ nebulization is normally controlled by a knob on the front panel. The Babybird ventilator is time cycled with independently adjustable inspiratory (inhaling) and expiratory (exhaling) time intervals which allow controlled intermittent mandatory ventilation (breathing). Expiratory flow from the patient is manually adjustable to decrease expiratory resistance.

c. **Safety Features**. Safety features include an audible alarm system for quick identification of source-gas failure and an automatic inspiratory lockout with an alarm if inspiration exceeds a preset time limit. The low pressure alarm alerts the clinician if the internal operating pressure falls below 43psi. The inspiratory lockout interrupts the controlled inspiratory phase after a preset period of inspiratory time and interrupts the expiratory venturi jet during the inspiratory phase of controlled ventilation.

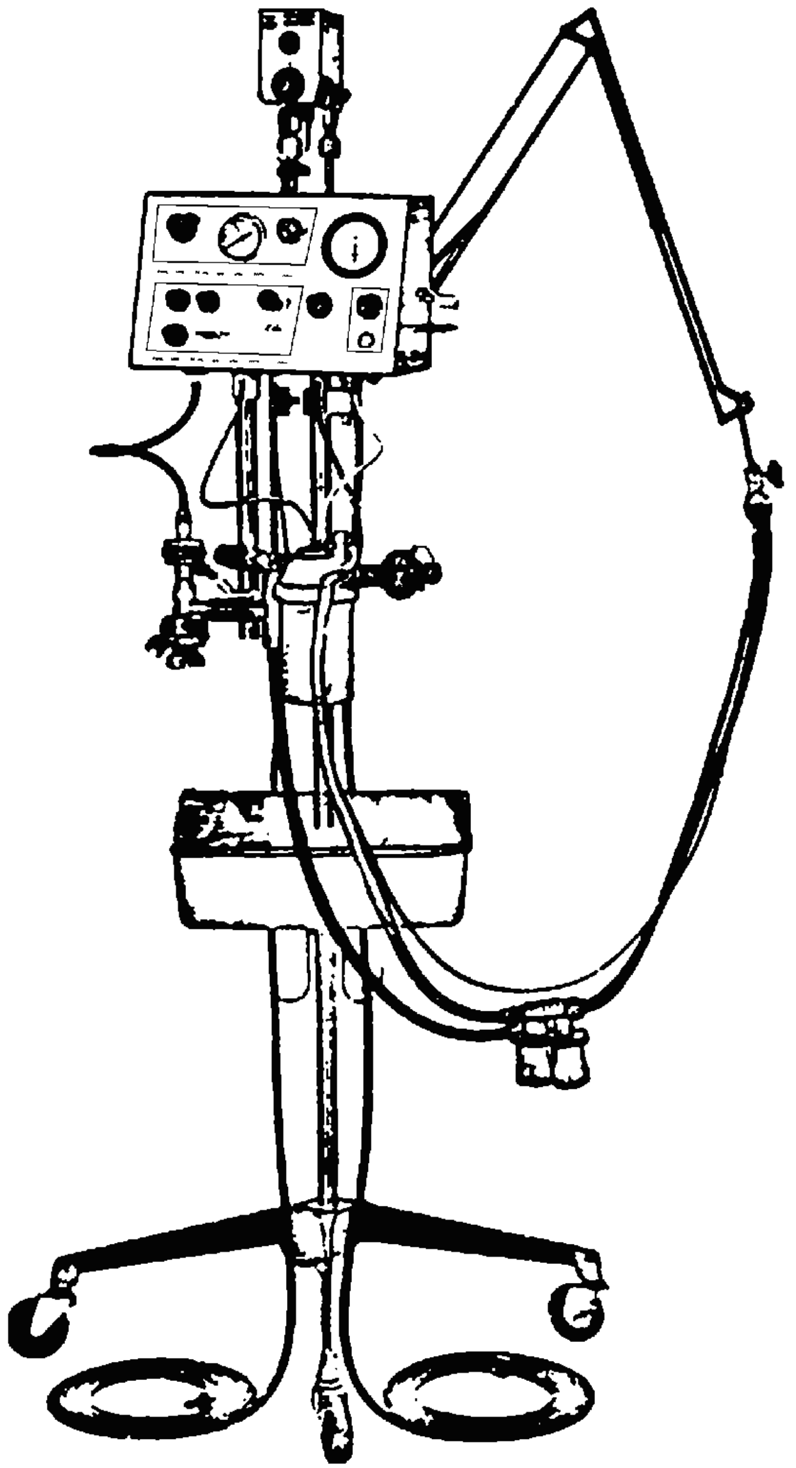


Figure 1-1. Babybird 5900 pediatric ventilator.

1-2. MAJOR COMPONENTS

a. **Oxygen Blender**. The oxygen blender (figure 1-2) precisely controls oxygen concentrations delivered to the Babybird ventilator. It requires reliable sources of air and oxygen to function properly. Control of source-gas pressure is important as the blender delivers gas mixtures at about 2psi below the lowest source-gas pressure. The ventilator requires a minimum of 45psi source pressure to operate. Minor differences in incoming pressures are compensated for within the blender. Both air and oxygen pressures are precisely balanced by dual pressure regulators and controlled by a calibrated proportioning valve. Use the control knob to set the exact oxygen and air mixtures for required concentrations of oxygen. If one of the gas supplies fail, the blender allows the other gas to continue to flow to the patient and sounds an alarm to warn of the failure. The alarm system consists of two diaphragm operated poppet valves, one of which opens and allows gas pressure to overcome spring tension on the valve and direct one of the gases to the audible alarm. When the ventilator is first activated, the alarm sounds until both air and oxygen pressures are equalized in the blender.

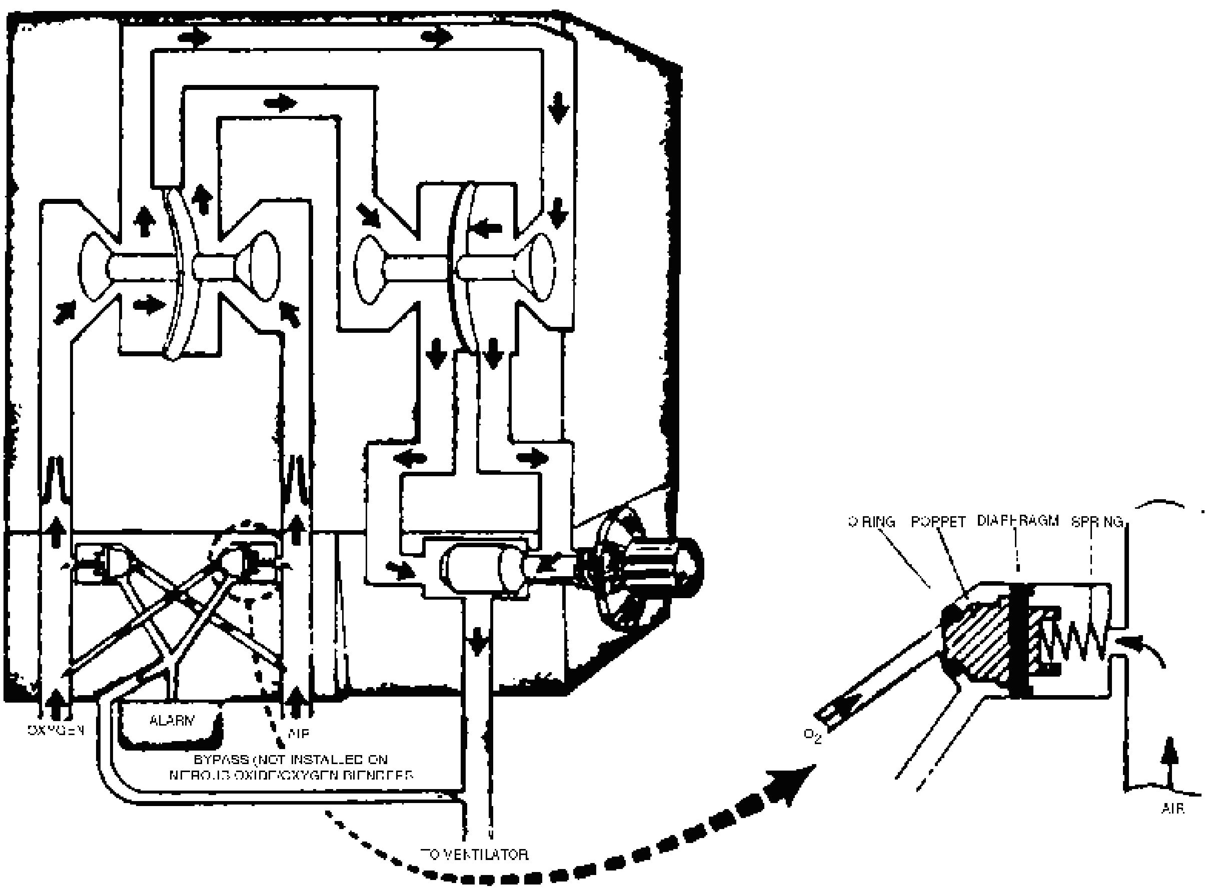


Figure 1-2. Oxygen blender and alarm.

b. **Delivery Circuit**. The selected mixture of air and oxygen is delivered to the ventilator's inlet manifold through a wing nut mounted atop the unit.

(1) Inlet manifold. The inlet manifold, shown at A in figure 1-3, contains a five micron sintered bronze filter and has six outlet ports which direct gas mixtures to the functional components of the ventilator. The pressure gauge indicates source-gas pressure to the ventilator from one outlet of the inlet manifold. The green wedge on the dial indicates the mandatory pressure range of 45 to 55psi.

(2) Flow-control regulator. A second outlet from the inlet manifold is connected to the flow-control regulator shown in figure 1-3 "B." One outlet from the regulator is connected to a gauge calibrated in liters-per-minute (lpm) flow. The other regulator outlet delivers the gas mixture to a tee fitting.

NOTE: Do not attempt to service the flow-control regulator. It is set at the factory and is not to be disassembled.

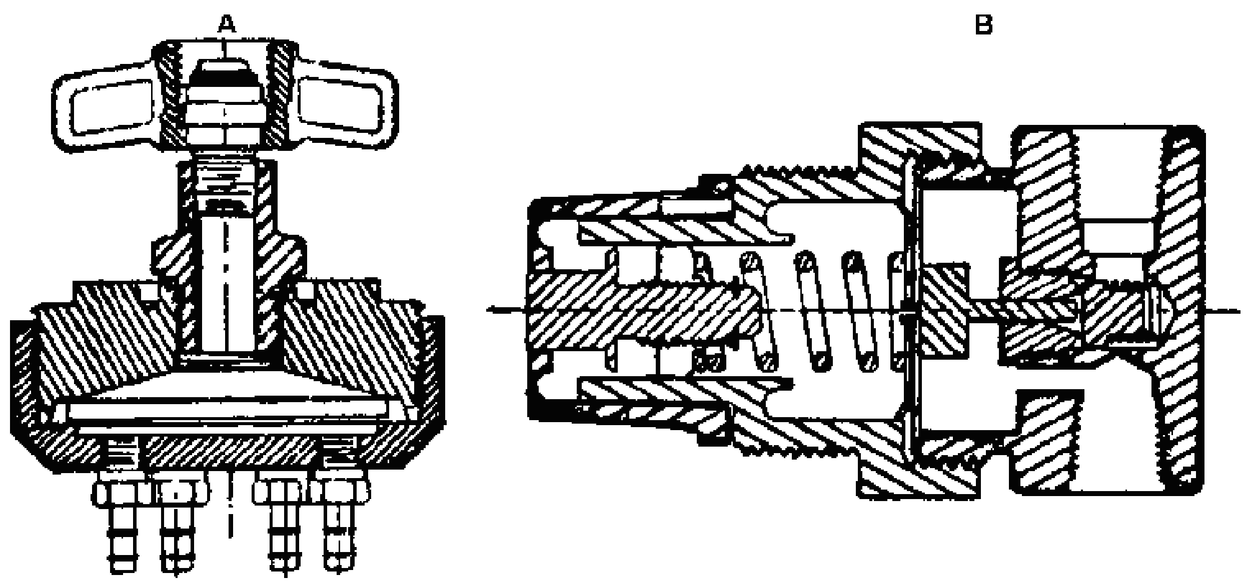


Figure 1-3. Inlet manifold (A) and flow-control regulator (B).

(3) Flow-bypass valve. One outlet from the tee fitting is connected to the flow-bypass valve shown in figure 1-4 and is used in conjunction with the nebulizer control. Its function is to bypass gas flow around the nebulization control to the auxiliary jet socket. It also serves as a pressure governor to maintain calibrated flow to the breathing circuit. It consists of an adjustable orifice, a plunger, and a spring.

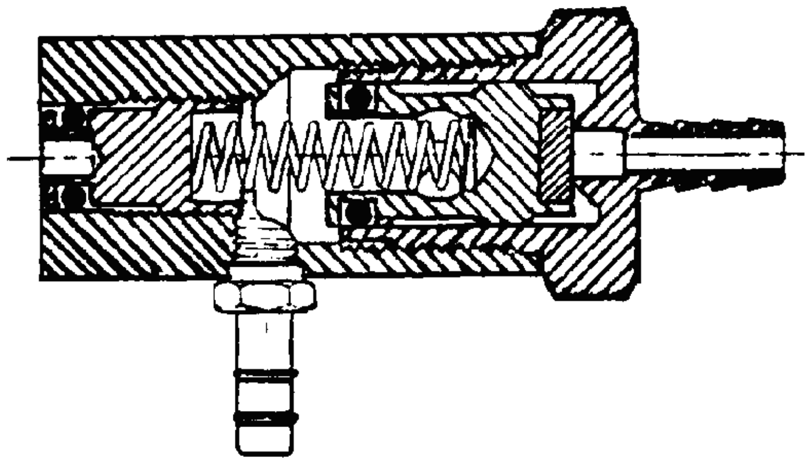


Figure 1-4. Flow-bypass valve.

(a) Another outlet from the tee fitting is connected to an adjustable needle valve used to control maximum and minimum flow to the nebulizer/humidifier jet. With the nebulizer control turned to MAX (valve closed), the jet orifice is subjected to the full flow provided by the regulator. The nebulizer jet cannot accommodate full flow, so the bypass valve opens against spring tension and directs the excess flow to the auxiliary flow socket.

CAUTION: The auxiliary flow power line must never be restricted. DO NOT USE THIS GAS FLOW SOURCE TO POWER THE NEBULIZER JETS. The entire calibrated flow system is balanced to the micro-nebulizer only.

(b) A third outlet from the inlet manifold delivers source gas to the mode selector, a two-piston rotary control valve which selects the mode of operation in which the ventilator is to be used. One position is labeled CONTROLLED IMV and the other is SPONTANEOUS BREATHING.

(4) Mark 2 servo. The Mark 2 servo (figure 1-5) functions only in the controlled intermittent mandatory ventilation phase and has two controls. One control sets inspiratory time, the other sets expiratory time. The servo consists of a central valve assembly called a "plunger." It operates between two diaphragms separating the plunger from two timing chambers. When gas pressure is first supplied to the Mark 2 servo inlet, the right-hand disc (valve number 1) is closed and no gas flows from the outlet. Gas will flow through the expiratory time control valve into chamber A, causing pressure to build up since valve number 2 is closed. When pressure in chamber A is strong enough to overcome the force of spring tension on valve number 1, the valve opens and gas flows through the outlet. Gas also flows into timing chamber B, causing pressure against the diaphragm to increase. Valve number 3 is closed by pressure from valve number 1. When valve number 2 closes, pressure again builds up in chamber A through the expiratory time control valve.

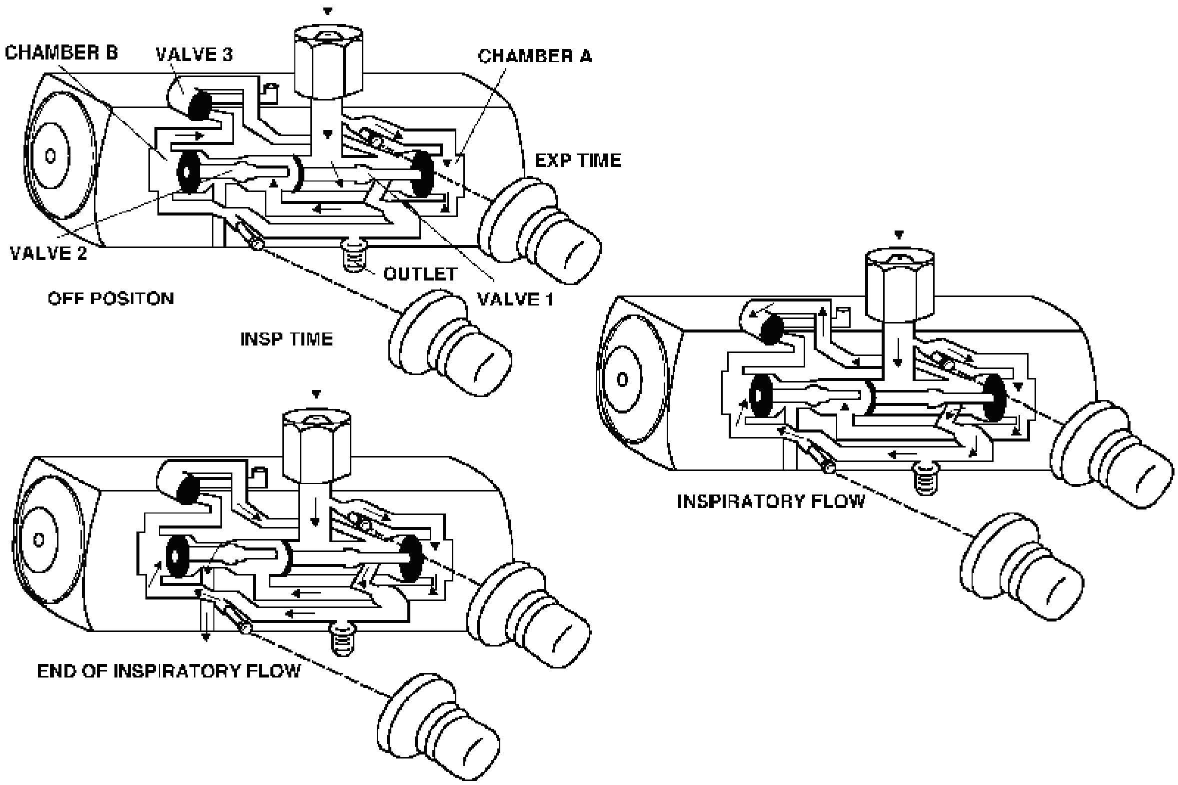


Figure 1-5. Mark 2 servo.

(a) When pressure in chamber B overcomes spring tension, valve number 2 opens, venting chamber A. The tension of the spring closes valve number 1 and terminates gas flow from the outlet, ending the inspiratory phase. As this occurs, valve number 3 opens due to the loss of gas pressure from valve number 1 to its diaphragm, and allows chamber B to vent to the atmosphere, which causes valve number 2 to close.

(b) Adjustment of the expiratory time control determines the length of time required to fill chamber A, or the expiratory time. Adjustment of the inspiratory time control sets the length of time required to fill chamber B, or the inspiratory time. To summarize the function of the Mark 2 servo, it is on in inhalation of CIMV and it is off in exhalation of CIMV.

(5) Inspiratory-interrupter switch. A fourth outlet from the inlet manifold delivers source gas to the inlet of the inspiratory-interrupter switch (A in figure 1-6), which consists of a spring-loaded plunger and diaphragm within a closed housing. During the expiratory phase of controlled ventilation and during spontaneous breathing, the interrupter switch performs two functions when source gas flow through: the first is to load the diaphragms of the compound-lockout cartridge and the second is to power the jet of the expiratory venturi located in the breathing circuit.

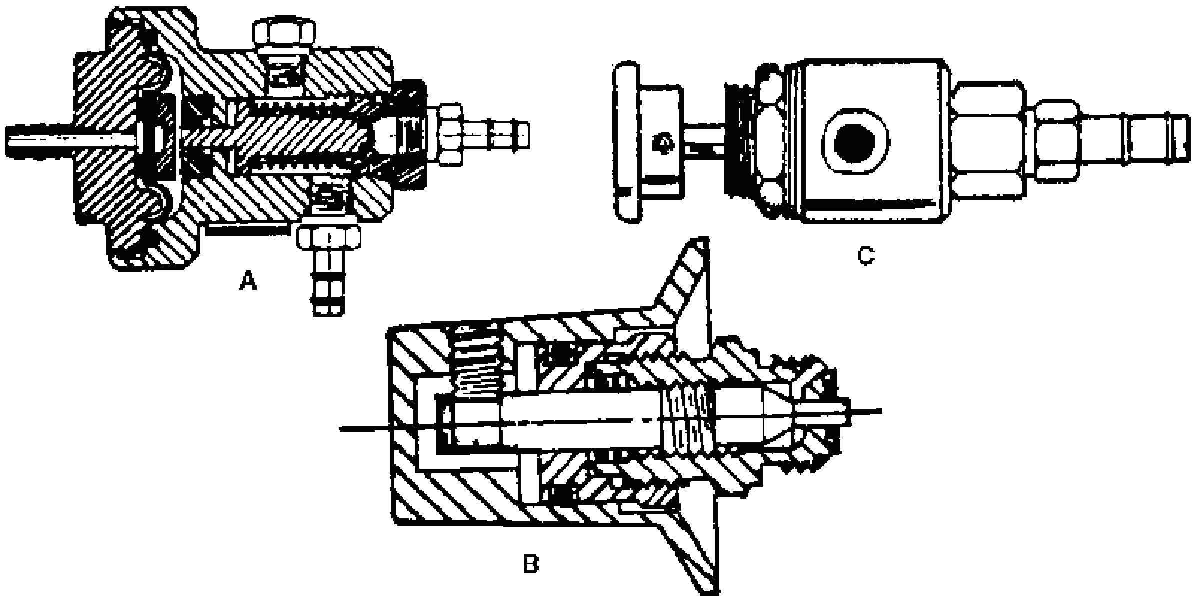


Figure 1-6. Inspiratory-interrupter switch(A), inspiratory time-limit control (B), and reset button (C).

(6) Inspiratory time-limit control. Gas flows from the inspiratory-interrupter switch through the duckbill-check valve to the inspiratory time-limit control (B in figure 1-6), an unrestricted needle valve. The needle valve provides a means of interrupting the inspiratory phase after the preset inspiratory- time interval has elapsed. This allows the compound-lockout cartridge to drain. Flow through the needle valve from the inspiratory-interrupter switch is constant during spontaneous breathing and occurs during the expiratory phase of IMV. Gas also flows from the inspiratory-interrupter switch to the expiratory flow gradient control, which controls the expiratory venturi in the shuttle valve to assist in exhalation. During the spontaneous breathing mode, the expiratory flow gradient control can be used to precisely control pressure within the breathing circuit. This is done by using the expiratory venturi passively, to overcome mechanical resistance caused by gas flow through the breathing circuit.

(7) Reset button. Gas pressure trapped by the venturi jet side of the compound-lockout cartridge and held behind the inspiratory-interrupter switch diaphragm (holding it closed) can be dumped to atmosphere by pressing the reset button (C in figure 1-6). This allows the compound-lockout cartridge to refill after lockout occurs.

(8) Compound-lockout cartridge. The compound-lockout cartridge (A in figure 1-7) consists of a double diaphragm, a spring-loaded poppet valve with four gas connections, and an adjustable screw on one end for calibration of the lockout function. The flow through the lockout cartridge also goes to a lockout alarm. A tee connection is installed in the inlet power line of the Mark 2 servo, which delivers source-gas pressure from the mode selector valve to the inlet side of the inspiratory-lockout cartridge. Flow out of the cartridge is directed to a tee fitting and to the pneumatic alarm. Its function is to terminate inspiration when the inspiratory time limit is exceeded and sound an alarm.

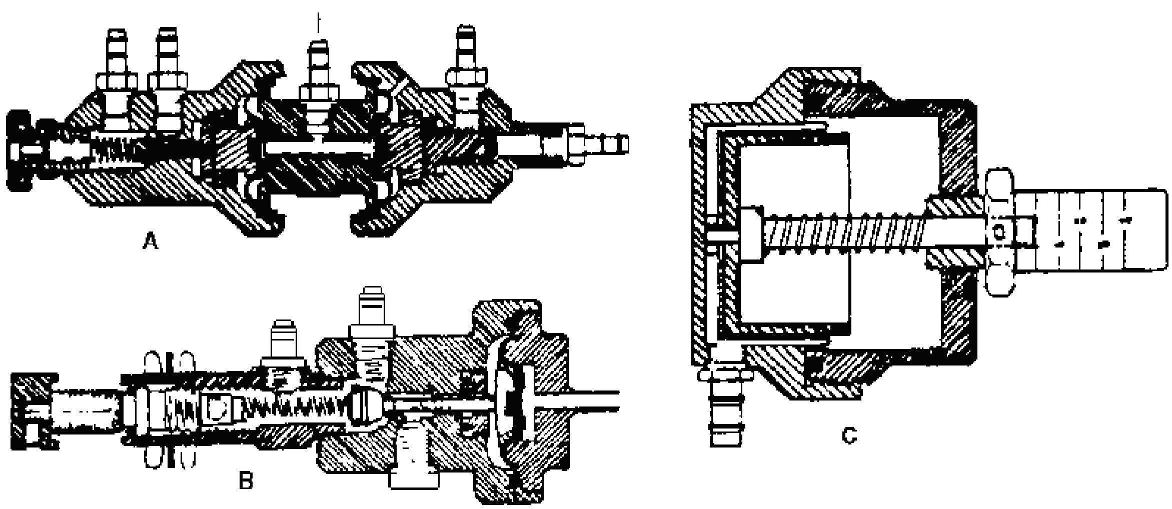


Figure 1-7. Compound-lockout cartridge (A), low pressure alarm (B), and self-test device (C).

(9) Low pressure alarm. The fifth and sixth outlets from the inlet manifold deliver source gas to a pneumatically-operated, low pressure alarm cartridge (B in figure 1-7). It functions on the spring balanced diaphragm principle. When source pressure against the diaphragm drops below the value required to keep the valve closed against the tension of the opening spring (below 43psi), the valve opens, allowing direct flow to the alarm. There are two flow paths to the low pressure alarm. One operates the diaphragm, the other operates the pneumatic alarm.

(a) Peak inspiratory pressures are controlled by adjusting venturi output pressures directed to a diaphragm in the outflow valve. Venturi output pressure is controlled by the inspiratory relief pressure control, an unrestricted needle valve with a bleeder port which controls the gas mixture pressure delivered to the venturi.

(b) Considered part of the spoiler assembly, the inspiratory relief pressure control, maintains a single operational pressure at the inspiratory interrupter cartridge diaphragm to ensure stable operation during controlled IMV.

(10) Self-test device. The self-test device (C in figure 1-7) is a spring-loaded rolling diaphragm in a housing. The spring holds the diaphragm collapsed. On the ambient side of the diaphragm is an indexed shaft which slides within a calibrated transparent tube. The area to the rear of the diaphragm and reset spring is such that a mechanical approximation of an infant lung is created. A functional volume display from 0 to 40cc is incised in the tube to demonstrate tidal volume of gas mixtures delivered to the patient. The self-testing device is used to demonstrate the controlled IMV mode of operation, or to provide a functional checkout of the ventilator. Individual operator proficiency can be raised by practicing with this device.

c. **Breathing Circuit.** The breathing circuit (figure 1-8) is powered by five power source sockets, indexed A through E. Each socket is carefully labeled to prevent improper hookup.

(1) Tee connections. There are two important tee connections. The master tee (item 3, figure 1-8) mates with the pin-indexed quick-disconnect adapter in only one position. The nebulizer mounting tee (item 1, figure 1-8) serves two purposes. The inside therapy bifurcation (two routes) provides for attachment of the Bird micronebulizer to the rear port.

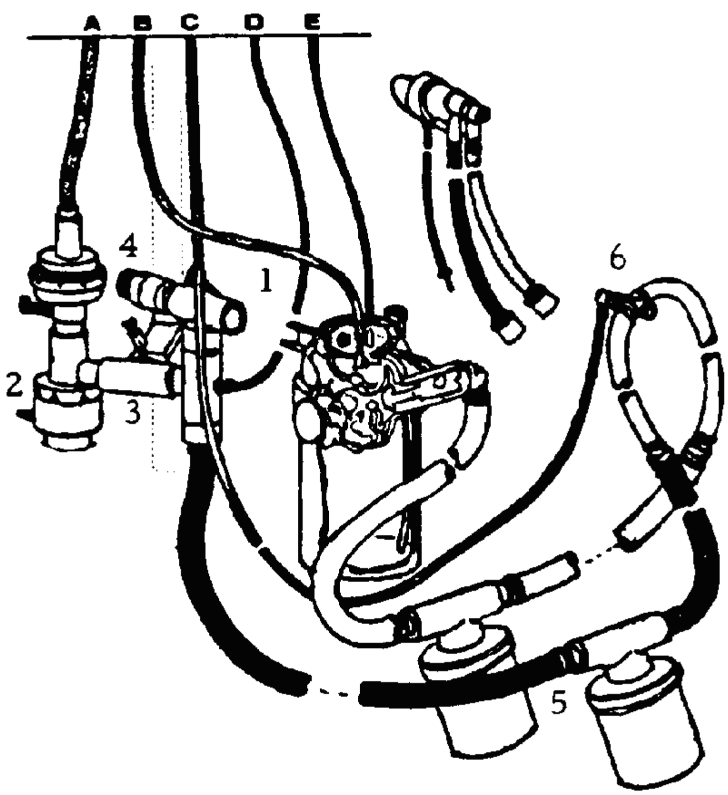


Figure 1-8. Breathing circuit.

(2) Inspiratory tube. The inspiratory breathing tube connects to the front port. The bottom port connects to a large green tube from the water trap. To prevent possible misalignment of components, the master tee, shuttle valve (item 2, figure 1-8), and nebulizer mounting tee are permanently fused together. Inspiratory gases are conducted from the nebulizer mounting tee to a Bird water trap (item 5, figure 1-8) to collect condensate and reduce mechanical resistance in the inspiratory side of the breathing circuit. From the water trap, a smaller green tube transports the gas to the airway "Y" junction (item 6, figure 1-8).

(3) Expiratory breathing circuit. The expiratory side of the breathing circuit begins at the "Y" junction with a small red tube extending to the expiratory water trap, which is connected by larger red tubing to the expiratory shuttle valve. Exhaled gases leave the shuttle valve through the expiratory venturi, flow through the master tee, over the top of the airBird valve diaphragm to the outflow valve and vent to atmosphere. Pressurized lines provide pneumatic control over the dynamic breathing circuit. The first of these, a large green tube of the quick-disconnect type, is attached at socket A and provides inspiratory gases to the top of the outflow valve diaphragm.

(4) Proximal airway pressure gauge. From socket B, a line extends to the nebulizer jet, providing constant flow of medication to the nebulizer. A line from the mechanical airway junction extends through socket C to feed airway pressure to the proximal airway pressure (PAP) gauge, which measures actual physiological airway pressure.

(5) Gas flow lines. Pressurized gas is directed from socket D to the expiratory venturi jet in the shuttle valve. Respiratory gases are delivered to an accessory port in the top of the 500cc nebulizer/humidifier from the auxiliary flow socket E. Inflow gases are delivered into the inspiratory side of the breathing circuit through the ports of the nebulizer from two outlet power sources, but both flows are totalled at the flowrate gauge in liters per minute. Take care to avoid confusing the nebulizer jet and auxiliary flow connections on the top of the nebulizer.

NOTE: The tall socket is the nebulizer jet socket.

(6) Outflow valve. The outflow valve (figure 1-9) helps regulate pressure in the breathing circuit. Exhaled gases enter the outflow valve through an unrestricted orifice controlled by a red lever which may be moved through a 180-degree arc, having a stop on either side.

(a) The expiratory resistance from the orifice is controlled by a molded elastomer seat on the bottom of the diaphragm. The diaphragm assembly is held together by a stainless steel screw through the top of the valve seat. A vented piston attached to the diaphragm acts as an anti-chatter device. It also provides a seat for alignment between the orifice and the hard plastic seat. The outflow valve allows the operator to select a constant positive pressure within the breathing circuit. Constant positive pressures from 0 to 20mmHg can be developed.

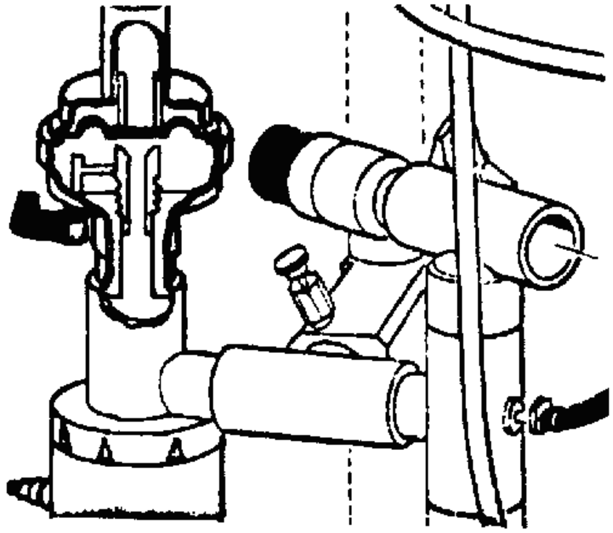


Figure 1-9. Outflow valve.

(b) The outflow valve provides peak inspiratory pressure limiting during controlled IMV. When inspiratory venturi output pressure is directed to top of the outflow valve diaphragm, a secondary closing force is developed: the venturi opposes the flow of expelled cases from the patient circuit, so increased pressure against the outflow valve diaphragm will increase the pressure of the expelled gases. Peak inspiratory pressure limiting is adjusted by the inspiratory pressure relief control, normally between 10 and 60mmHg. The airBird and shuttle valve provide for backup manually-controlled ventilation.

(7) Overpressure governor. The overpressure governor shown in figure 1-10 prevents the development of breathing circuit pressures in excess of 30cmH_2O. Overpressures are vented to the atmosphere through the governor. A mechanical alarm is built into the governor. The alarm is a pneumatically-operated split reed which is allowed to float off its seat as overpressures are vented to the atmosphere when the flow setting on the reed is exceeded. As the reed vibrates, a tone sounds.

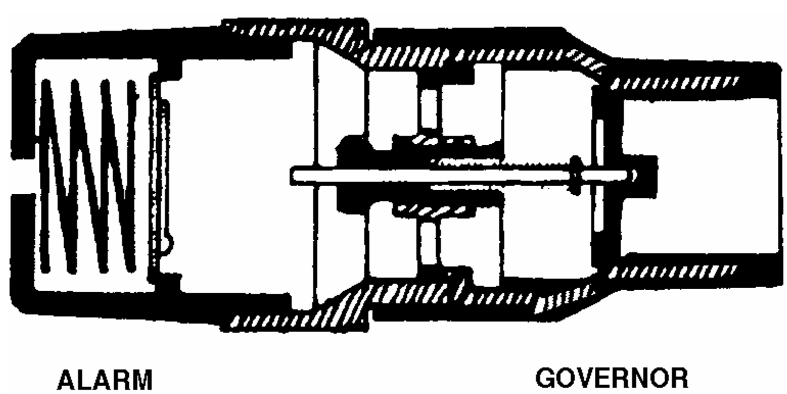


Figure 1-10. Overpressure governor.

(8) Expiratory venturi. The expiratory venturi part of the shuttle valve assembly shown in figure 1-11 is designed to lower pressures above the exhalation valve within the shuttle valve assembly. The amount of pressure drop is proportional to the velocity of flow from the expiratory venturi jet, which is controlled by the expiratory flow gradient control knob. The expiratory venturi functions actively only during the expiratory phase of controlled IMV.

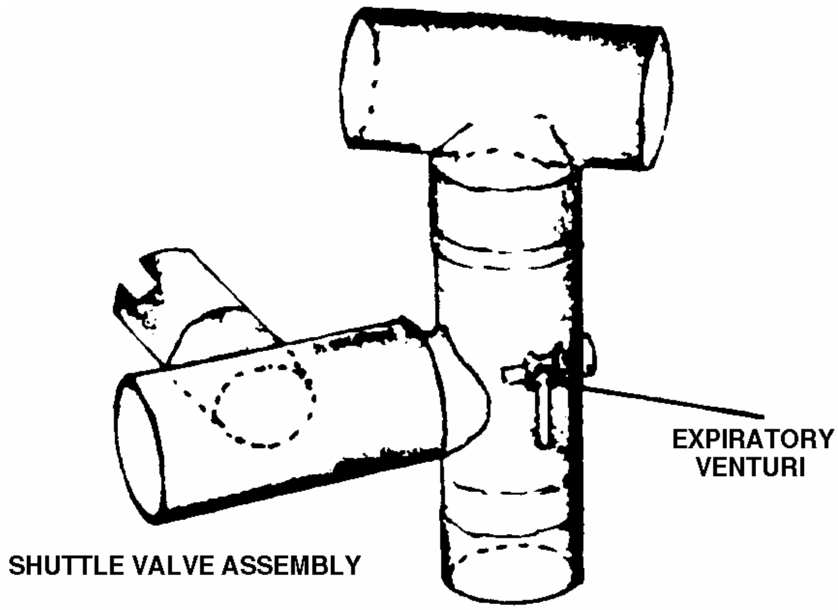


Figure 1-11. Expiratory venturi.

Section II. THEORY OF OPERATION

1-3. OPERATING MODES

Spontaneous breathing is the breathing rate the patient sets. A continuous flow of gas is sent through the circuit. Continuous positive airway pressure (spontaneous breathing) exists within the breathing circuit at all times. This mode is used when the patient is capable of normal or nearly normal respiration. In spontaneous breathing, both inspiratory and expiratory phases can be mechanically assisted to increase the tidal volume during inspiration and enhance the expiratory flow of gases from the lungs during expiration.

a. Controlled IMV superimposes controlled ventilation upon the patient's breathing pattern. The patient breathes at his own rate and tidal volume, but at predetermined intervals receives a breath from the ventilator.

b. The operational procedures printed on the side of the Babybird cabinet serve as a minimum guide or checkout list. It is not a complete maintenance checkout procedure, nor is it a complete operating procedure.

1-4. SPONTANEOUS BREATHING MODE

In spontaneous breathing, unit operation is controlled entirely by the patient's inhalation and exhalation efforts. Gases flow from the oxygen blender, are filtered in the inlet manifold, and delivered to the functional components of the unit.

a. During the inspiratory phase of the spontaneous breathing mode (figure 1-12) a constant flow of gas is provided from the inlet manifold to the pressure gauge and to the flow regulator. The flow gauge indicates the flow of gases in lpm before delivery to the patient airway. As gas leaves the flow regulator, it flows in two paths: one is directed to the nebulization control and the other to the by-pass valve.

b. As gas flows into the 500cc nebulizer, any liquids within are nebulized. Gas flows from the nebulizer to the top flapper of the shuttle valve and to the overpressure governor. Gas also flows through the bifurcation fitting, through the large green hose and the water trap to the patient-airway connection. Overpressure-governor reed valves are set at 30cmH_2O. Pressures in the inspiratory lines will build up to the preset level. If there is an obstruction of outflow gases, the overpressure governor will open at 30cmH_2O and relieve this pressure to the atmosphere.

c. At the mechanical airway connection, some of the gas flows into the red expiratory line along with the patient's exhaled gases. Expiratory gases are directed through the water trap and the expiratory valve in the shuttle-valve assembly. Exhaled gases leave the shuttle valve through the master tee and flow over the top surface of the airBird non-rebreathing-valve diaphragm through the outflow valve to the atmosphere. The outflow valve pressure is indicated on the proximal airway gauge.

d. During the expiratory phase (figure 1-13), gas flows through the inspiratory-interrupter cartridge and the expiratory flow-gradient control to the venturi in the shuttle valve assembly.

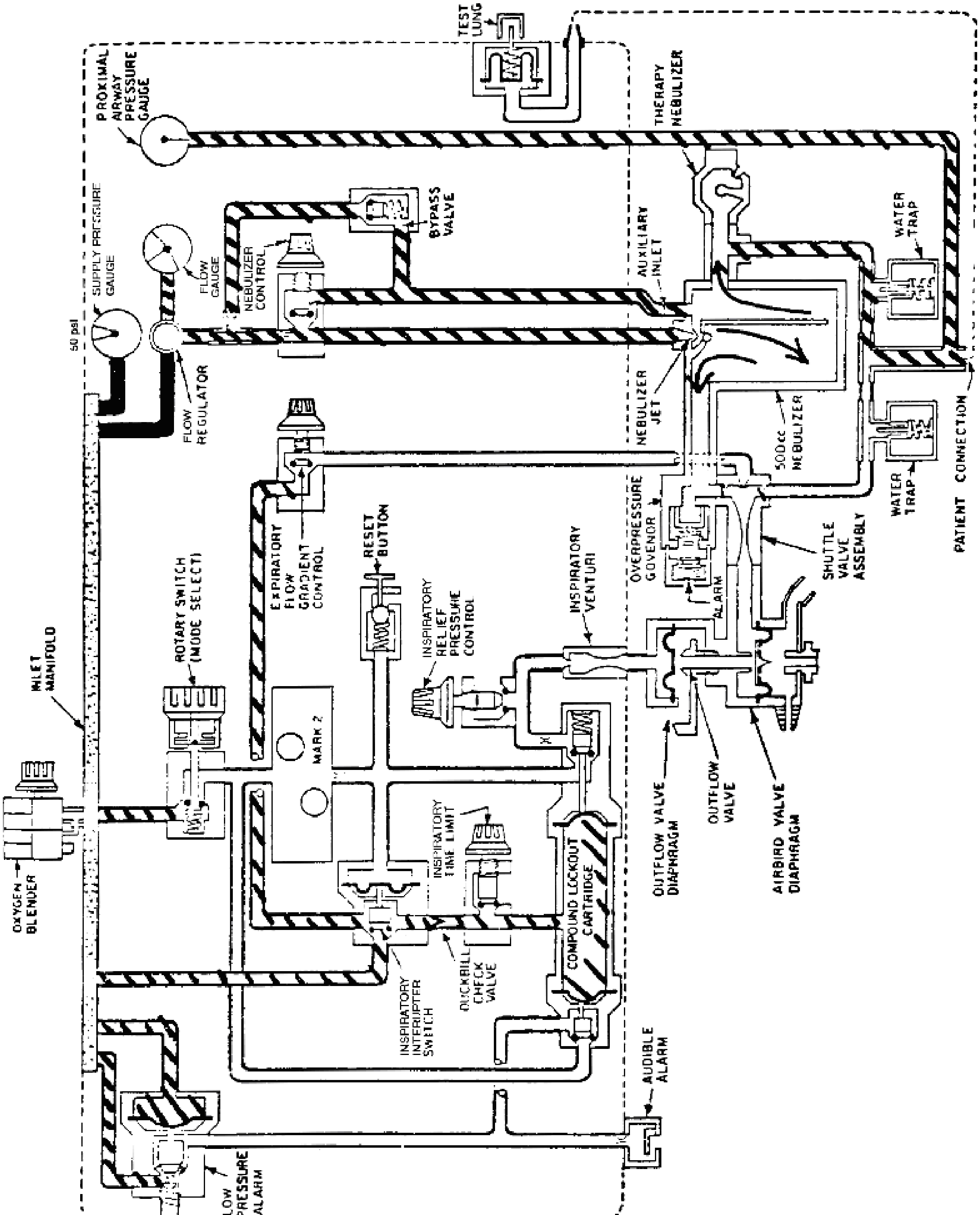


Figure 1-12. Inhalation phase of the spontaneous mode.

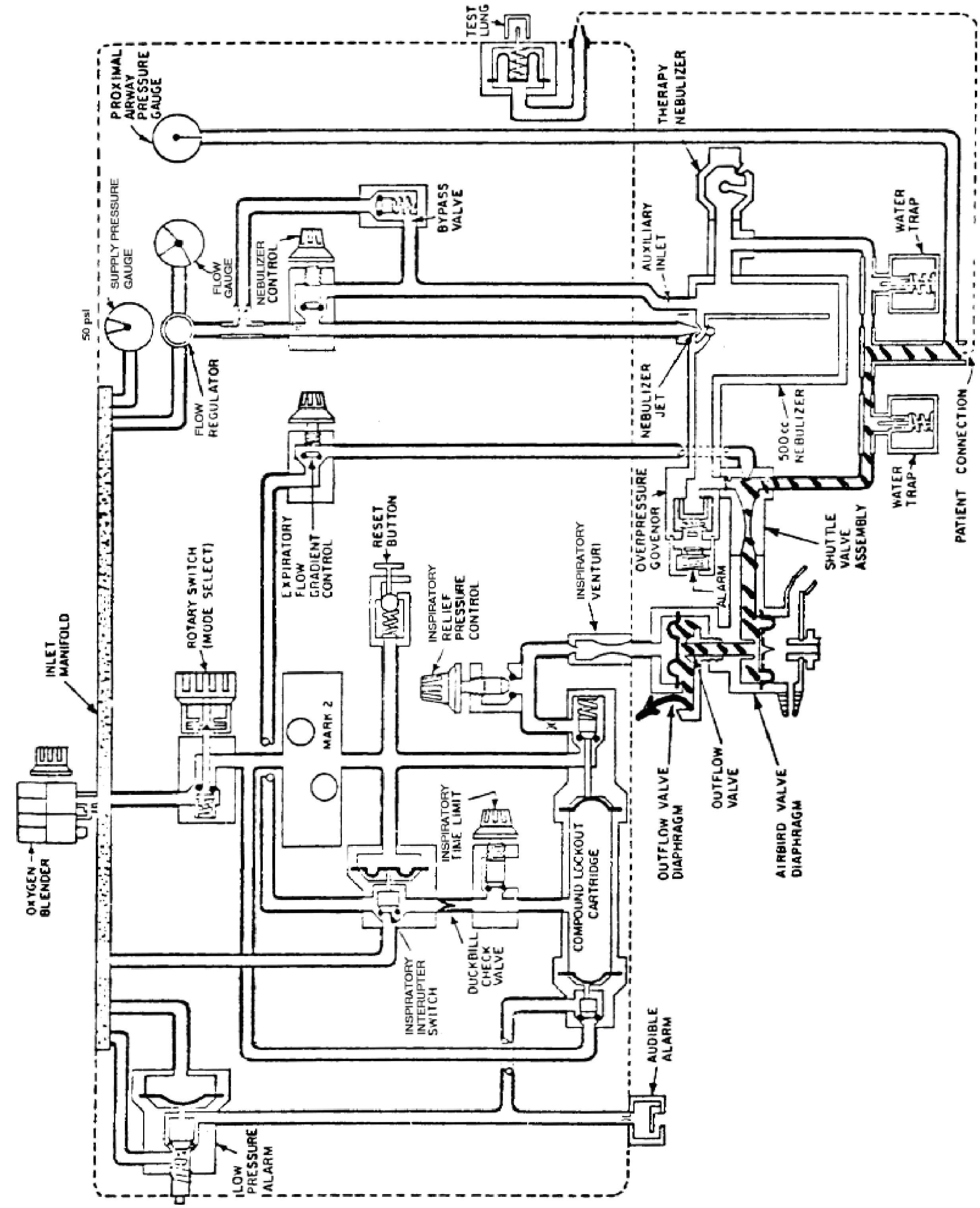


Figure 1-13. Expiratory path in any mode of operation.

1-5. CONTROLLED INTERMITTENT MANDATORY VENTILATION MODE

When controlled IMV is selected, gas flows from the inlet manifold to the Mark-2 servo, low pressure alarm, nebulizer, inspiratory-interrupter cartridge, and compound-lockout cartridge. With the servo off, gas flow is stopped inside. As the servo cycles to the inspiratory phase, gas flows from the outlet.

a. During the inspiratory phase (figure 1-14), the approximately 15- to 18-psi gas flow applies pressure against the diaphragm in the inspiratory-interrupter switch, closing it and interrupting the flow of gas to the compound-lockout cartridge through the duckbill-check valve. This pressure is also applied to the inspiratory-venturi switch, which is open due to the gas trapped between the diaphragms of the compound-lockout cartridge, and to the reset button, holding it closed. From the venturi switch, gas flows through the inspiratory relief pressure control through the spoiler assembly to the top of the outflow-valve diaphragm. As the diaphragm is pressurized, peak inspiratory pressure limiting is maintained by the outflow valve.

b. The trapped gas between the diaphragms of the compound-lockout cartridge escapes to the atmosphere through the inspiratory time-limit control outlet port and pneumatic bleed down begins. If the inspiratory time limit set on the Mark 2 exceeds the inspiratory bleed-down time, the inspiratory phase is terminated and an audible alarm sounds.

c. Inspiratory lockout occurs when the trapped gas has bled off completely. As the diaphragms relax, the inspiratory-venturi switch closes and no more gas is supplied to the outflow-valve diaphragm.

d. When the diaphragms of the compound-lockout cartridge are depressurized, the following two events occur simultaneously.

(1) Gas flow to the inspiratory venturi and the spoiler assembly is interrupted, ending the inspiratory phase.

(2) The inspiratory time-limit alarm is activated by the flow through the lockout-alarm switch of the compound-lockout cartridge, notifying the operator that the ventilator has automatically switched over to spontaneous breathing.

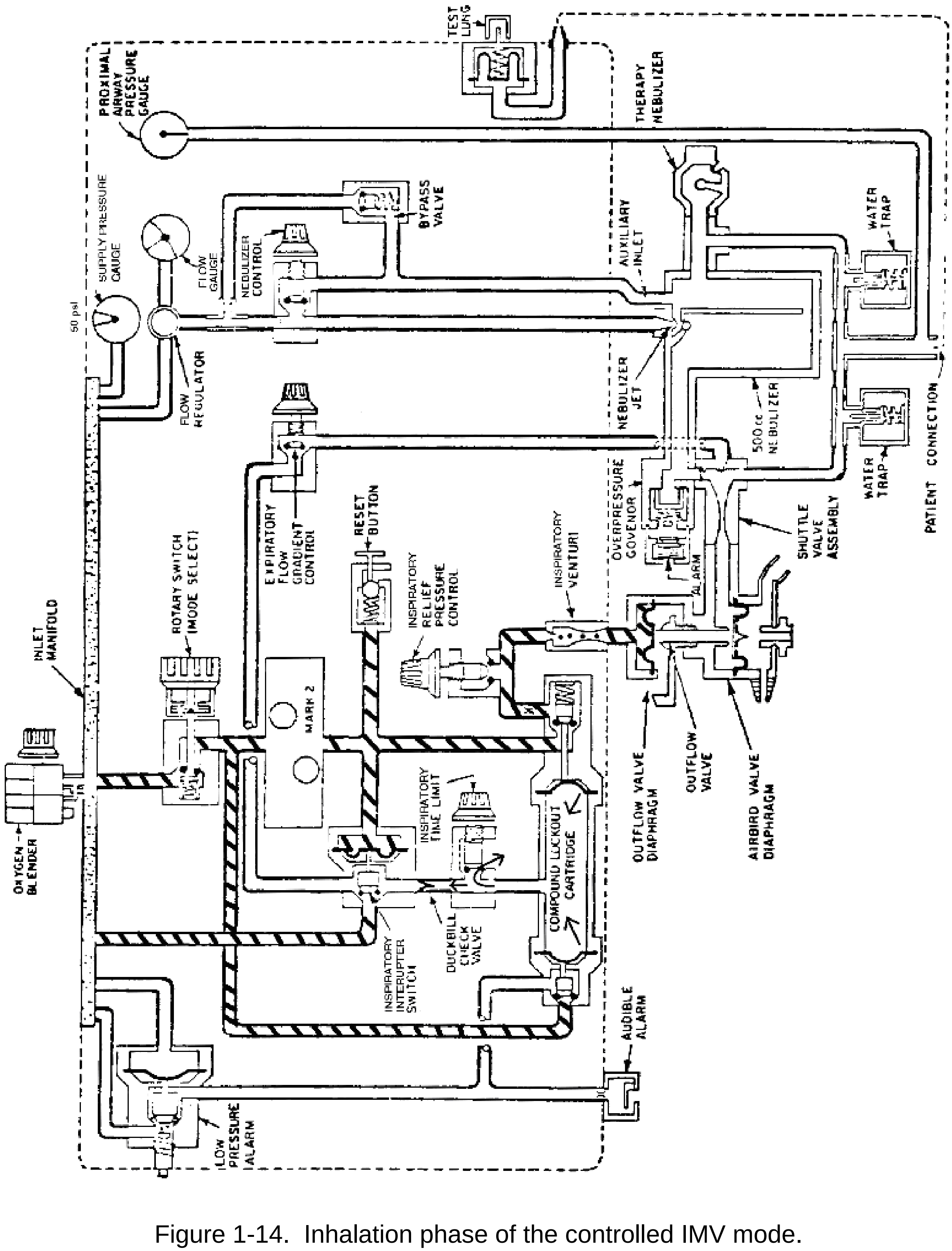


Figure 1-14. Inhalation phase of the controlled IMV mode.

(3) The Mark-2 servo is held in the inspiratory phase but locked out of access to the breathing circuit. The controlled function can be reestablished ONLY by pressing the reset pushbutton, which dumps the gas trapped between the Mark-2 servo and the inspiratory-venturi switch to atmosphere. If a second lockout occurs after the next inspiratory cycle, the controlled-inspiratory time may have exceeded the preset time limit, inspiratory time may be longer than expiratory time, or component failure may have occurred in the Mark 2, holding the unit in inspiration. Malfunction or omission in assembly of the small duckbill-check valve between the outlet of the inspiratory-interrupter switch and the inspiratory time-limit valve would also cause premature lockout.

e. During the expiratory phase (figure 1-15), source gas flows through the inspiratory-interrupter switch to power the jet of the expiratory venturi in the shuttle valve and through the inspiratory time-limit control to load the space between the diaphragms of the compound-lockout cartridge.

f. Exhaled gases flow through the bottom diaphragm of the shuttle valve to meet pressure from the expiratory venturi jet, then flow to the bottom of the outflow-valve diaphragm and out to the atmosphere.

g. The Mark-2 servo is in the expiratory phase and no opposing pressure is felt on the outflow-valve diaphragm. The expiratory venturi allows exhaled gases to flow to the atmosphere.

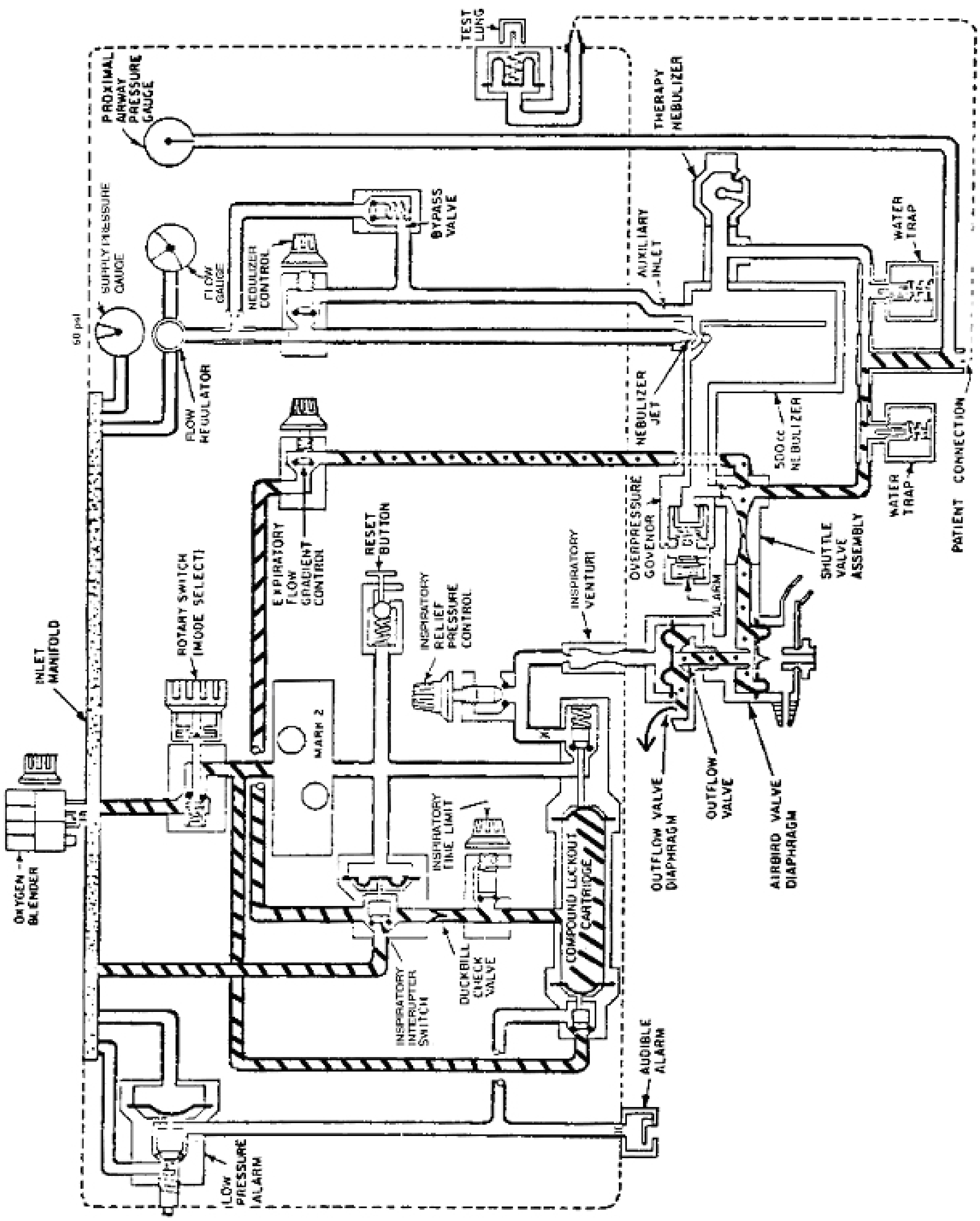


Figure 1-15. Exhalation phase with negative pressure in the controlled IMV mode.

Section III. PREVENTIVE MAINTENANCE CHECKS AND SERVICES

1-6. GENERAL

There are many phases of operation in the Babybird ventilator. To help ensure the ventilator is operational when needed, perform PMCS as required and make any necessary repairs.

1-7. PERFORM PREVENTIVE MAINTENANCE CHECKS AND SERVICES

a. **Inspect the Case**.

(1) Check for broken, loose, or missing control knobs.

(2) Check for broken glass and gauges.

(3) Check for rusted and chipped surfaces.

b. **Inspect the Air/Oxygen Regulator**. Look for cracks, loose fittings, and air leaks.

c. **Inspect the Tubing and Hoses**. Inspect for dry rot, deterioration, crimps, and leaking or damaged connector fittings.

d. **Inspect the Blender**.

(1) Test the operation of the alarm according to the manufacturer's literature.

(2) Check the oxygen and air regulators to ensure proper adjustment to output pressure of 50 psi plus or minus five psi.

e. **Inspect the Outflow Valve and the Patient Circuit**.

(1) Check for cracks.

(2) Check for leaks.

(3) Check for discoloration.

f. **Perform a Function Check**.

(1) In the spontaneous-breathing mode, ensure there is a minimum of 20cm$H_2$0 deflection when the red handle of the outflow valve is moved through its entire range. Check for negative pressure by opening the expiratory-flow gradient control.

(2) Test the operation of the control module. Ensure you have 20cm$H_2$0 deflection when the red handle on the outflow valve is moved through its entire range.

(3) Perform controlled IMV mode checks.

(a) Turn the rotary mode selector switch to CONTROLLED IMV.

(b) Turn the inspiratory relief pressure control to the fully clockwise position.

(c) Turn the inspiratory time control to the fully clockwise position.

(d) Turn the expiratory time-limit control to the midpoint of travel.

(e) Observe the PAP gauge. Inspiration should last 1.5 to 2.5 seconds. The PAP gauge should reach at least 60cm$H_2$0. Expiration should last 1 to 2 seconds. The PAP gauge should fall to the level established by the red arm on the outflow valve.

(f) Turn the expiratory-flow gradient counterclockwise. Negative pressure should be apparent in expiration. Disconnect the red expiratory-flow line from the negative venturi. Verify expiratory flow is present only during expiration.

(g) Turn the inspiratory time limit counterclockwise to initiate the alarm. After the alarm sounds, rotate the inspiratory time limit clockwise, and then push the reset button to shut off the alarm.

g. **Correct Minor Deficiencies After Reassembly**. After thoroughly cleaning and reassembling all components, carefully inspect all pressure lines. Replace any which have been damaged during reassembly. After the Babybird has been reassembled, it must be recalibrated. Refer to Lesson 2, paragraph 2-2.

Continue with Exercises

EXERCISES, LESSON 1

INSTRUCTIONS: Answer the following questions by marking the lettered response that best answers the question or best completes the incomplete sentence.

After you have answered all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the lesson material referenced after the solution.

1. The low pressure alarm is one of the safety features of the Babybird pediatric ventilator. What activates the alarm?

   a. An internal operating pressure lower than 53psi.

   b. An internal operating pressure lower than 43psi.

   c. Failure of the expiratory venturi during the inspiratory phase of controlled ventilation.

   d. A source-gas flow of less than 6 1/2 lpm.

2. The oxygen blender precisely controls concentrations of air and oxygen supplied to the patient. What happens when the supply of one of the gases is cut off?

   a. The diaphragm operated poppet valves both close.

   b. An alarm sounds and the supply of both gases is halted.

   c. The needle on the flowmeter falls below the green wedge.

   d. The blender continues to supply the remaining gas to the patient.

3. Which of the following statements concerning the auxiliary-flow power line is correct?

   a. In the controlled intermittent mandatory ventilation phase, the auxiliary flow power line is restricted.

   b. Never use the auxiliary flow power line to power the nebulizer jets.

   c. The auxiliary flow power line supplies gas to the nebulizer jets.

   d. The auxiliary flow line delivers source gas to the mode selector.

4. Gas pressure has built up behind the inspiratory interrupter switch diaphragm. How do you vent the gas to the atmosphere?

   a. Disassemble the inspiratory-interrupter switch.

   b. Push the reset button.

   c. Unscrew the expiratory venturi tube.

   d. Depress the spring-loaded poppet valve on the compound- lockout cartridge.

5. How do you distinguish between the expiratory and inspiratory sides of the breathing circuit?

   a. The inspiratory side has green tubing; the expiratory side has red tubing.

   b. Components on the inspiratory side are metal; components on the expiratory side of the circuit are glass.

   c. Pressures on the expiratory side are positive; inspiratory pressures are negative.

   d. The expiratory side of the circuit is indistinguishable from the inspiratory side of the circuit.

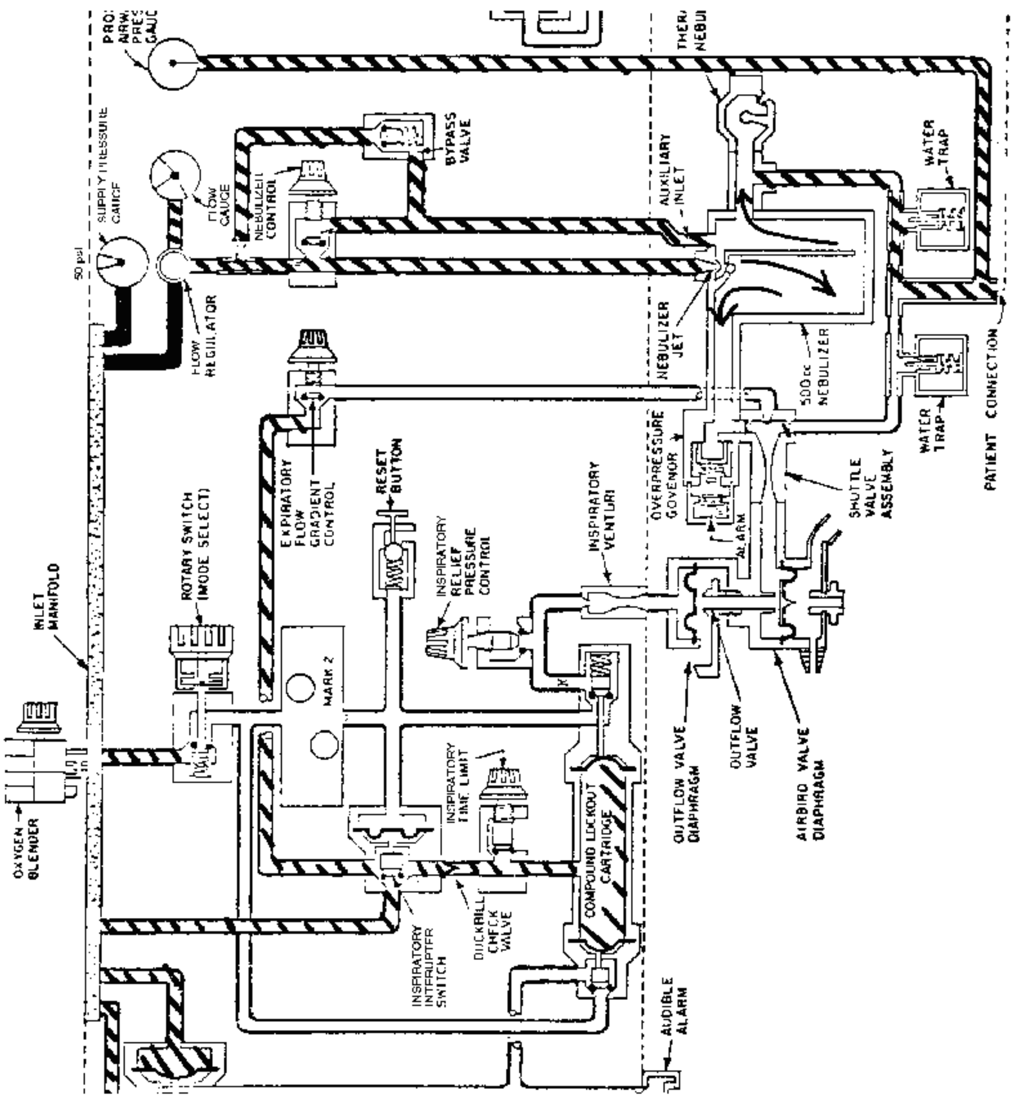
6. Refer to the figure below. What is the patient doing and in which mode of operation?

   a. The patient is inhaling in the spontaneous mode.

   b. The patient is exhaling in the spontaneous mode.

   c. The patient is inhaling in the controlled mode.

   d. The patient is exhaling in the controlled mode.



SITUATION: You are performing function checks during PMCS. You have checked the Babybird ventilator's performance in the spontaneous breathing mode and are checking the ventilator's operation in the controlled IMV mode. Use this situation to answer questions 7 through 9.

7. In what position should the inspiratory-time control be?

    a. Fully clockwise.

    b. Fully counterclockwise.

    c. To the mid-point clockwise of its travel.

    d. To the mid-point counterclockwise of its travel.

8. You are observing the PAP gauge. How long does inspiration last?

    a. 0.5 to 1 second.

    b. 1 to 2 seconds.

    c. 1.5 to 2.5 seconds.

    d. 2 to 3 seconds.

9. You are observing the PAP gauge. During expiration, the gauge should read:

    a. 60cmH_2O.

    b. 20cmH_2O.

    c. -8cmH_2O.

    d. The level established by the red handle on the outflow valve.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 1

1. b (para 1-1c)

2. d (para 1-2a)

3. b (para 1-2b(3)(a)) CAUTION)

4. b (para 1-2b(7))

5. a (para 1-2c(2)&(3))

6. a (para 1-4a)

7. a (para 1-7f(3)(c))

8. c (para 1-7f(3)(e))

9. d (para 1-7f(3)(e))

End of Lesson 1

LESSON ASSIGNMENT

LESSON 2	Locating and Replacing Defective Components.
TEXT ASSIGNMENT	Paragraphs 2-1 through 2-4.
TASKS TAUGHT	Isolate Malfunctions to Component Level in the Portable Ventilator. Remove and Replace or Repair Defective Components of the Portable Ventilator.
LESSON OBJECTIVES	2-1. Identify procedures to calibrate the ventilator. 2-2. Identify troubleshooting procedures.
SUGGESTION	Work the lesson exercises at the end of this lesson before beginning the examination. These exercises will help you accomplish the lesson objectives.

LESSON 2

LOCATING AND REPLACING DEFECTIVE COMPONENTS

Section I. CALIBRATION PROCEDURES

2-1. PERFORM AN OPERATIONAL CHECKOUT

Performing an operational checkout can reveal malfunctions which require calibration or repair. There are no absolutely correct checkout procedures for the Babybird 5900 Pediatric Ventilator. The ventilator case has instructions similar to the following procedures printed on its side. They serve as a useful starting point for calibrating the ventilator.

a. **Initial Setup**.

(1) Verify the incoming pressure gauge reads between 45 and 55psi.

(2) Adjust the flow-control regulator until you obtain a flow-gauge reading of 15 liters per minute (lpm).

(3) Turn the nebulization control fully clockwise.

(4) Turn the inspiratory time-limit control fully clockwise.

(5) Turn the expiratory-flow gradient fully clockwise.

(6) Turn the mode selector rotary switch to spontaneous breathing.

b. **Spontaneous Breathing**.

(1) Turn the red arm on the outflow valve fully counterclockwise. The proximal airway pressure (PAP) gauge should show at least a 20cm deflection.

(2) Turn the red arm on the outflow valve fully clockwise. The PAP gauge should now show some positive pressure.

(3) Turn the expiratory-flow gradient counterclockwise. The PAP gauge should now indicate more negative pressure.

<u>NOTE</u>: If any symptom appears in the spontaneous breathing operations mode, such as low pressure on the PAP gauge, that same symptom will also appear in the controlled intermittent mandatory breathing mode. Complete the entire checkout procedure, but return to the spontaneous breathing mode for troubleshooting symptoms common to both modes of operation.

c. **Controlled Intermittent Mandatory Ventilation.**

(1) Turn the rotary selector switch to CONTROLLED IMV.

(2) Turn the inspiratory relief pressure control to the fully clockwise position.

(3) Turn the inspiratory time control to the fully clockwise position.

(4) Turn the expiratory time control to the midpoint of its travel.

(5) Observe the PAP gauge. Inspiration should last 1.5 to 2.5 seconds. The PAP gauge should read at least 60cmH_2O. Expiration should last 1 to 2 seconds. The PAP gauge should fall to the level established by the red arm on the outflow valve.

(6) Turn the expiratory-flow gradient counterclockwise. Negative pressure should be apparent in expiration. Disconnect the red expiratory-flow line from the negative (expiratory) venturi. Verify expiratory flow is present only during expiration.

(7) Turn the inspiratory-time-limit control counterclockwise until the alarm sounds. After the alarm sounds, rotate the inspiratory time-limit control clockwise and then push the reset button. Pushing the reset button should shut off the alarm.

2-2. CALIBRATE THE VENTILATOR

Now that you have learned how to perform the operational checkout of the system, use the following procedures to calibrate the Babybird portable ventilator. Complete the steps in the sequence presented in this lesson to obtain the calibration parameters required. If the required parameters cannot be met, refer to the troubleshooting procedures at the end of each system.

a. **Equipment and Tools Required**. You will need special items to calibrate the Babybird ventilator. These special items may be obtained from Bird Corporation under the following part numbers.

(1) P/N 042--Lubewick.

(2) P/N 370--Mounting bracket.

(3) P/N 4418--Flow test device.

(4) P/N 4454--Inspiratory lockout test gauge.

(5) P/N 5907--Babybird breathing assembly.

(6) P/N 6754--Calibration regulator.

(7) P/N 6758--Nebulization power line test gauge.

(8) Additional tools required for this calibration procedure include the following.

(a) 5/16-inch open end wrench.

(b) Slot-head screwdriver (small, thin blade).

(c) 3/32-inch Allen wrench.

(d) Phillips-head screwdriver.

(e) Stop watch.

(9) Before attempting to service or calibrate the Babybird ventilator, you should be familiar with the design and operation of the unit as explained earlier in this lesson.

b. **Prepare the Ventilator for Calibration**.

(1) Turn off the source gas and install the calibration regulator (P/N 6754) between the gas source and the inlet assembly located atop the ventilator.

(2) It will be necessary to attach the Babybird ventilator and breathing assembly to a power source in such a manner that the combination back and side cover can be removed and still retain access to the front control panel. This may be accomplished by either of the following.

(a) Install a mounting bracket (P/N 370) on top of the Babybird stand and attach the ventilator so the controls are facing the pole.

(b) Use a 5/32-inch Allen wrench to remove the post assembly (P/N 4293) from the bottom of the ventilator so the Babybird may be attached to the pedestal stand (P/N 050) in a reverse fashion. The bracket assembly (P/N 4262) supporting the breathing circuit can then be secured to the vertical portion of the pedestal (figure 2-1).

(3) Use the Phillips-head screwdriver to remove the 12 screws securing the combination back and side panels. There are six screws securing the back and three on each side panel.

(4) Remove the back and side panels, but position the unit so the Babybird circuit may be connected to the mechanical test lung.

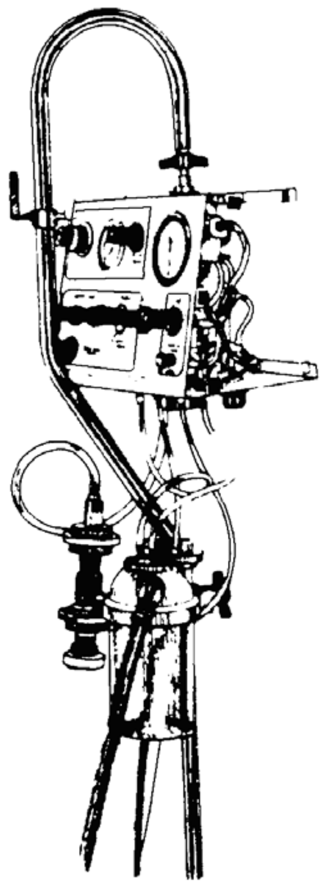


Figure 2-1. Ventilator mounted for calibration with back and side panel removed.

(5) Connect the Babybird breathing assembly circuit (P/N 5907) to the ventilator (do not include the 5cc medication nebulizer and its bifurcation during the calibration procedure). Check for tightness of all connections and secure the patient connector to the mechanical test lung located on the side panel.

(6) Use the 3/32-inch Allen wrench to remove the following control knobs.

(a) Nebulization.

(b) Inspiratory time.

(c) Expiratory time.

(d) Inspiratory-relief pressure.

(e) Expiratory-flow rate.

(f) Inspiratory time limit.

(7) Adjust the mode selector control to spontaneous breathing on and rotate the following controls fully clockwise.

(a) Nebulization.

(b) Expiratory flow.

(c) Inspiratory time limit.

(d) Red handle of the outflow valve (proximal airway pressure (PAP control).

(8) Rotate the following controls fully counterclockwise.

(a) Flow.

(b) Inspiratory time.

(c) Expiratory time.

(d) Inspiratory relief pressure.

(9) Turn the source gas on, pull the red locking ring forward, and rotate the calibration regulator clockwise for a pressure of 50psig (pounds-per-square-inch-gravity) (static). Lock the regulator by pushing the red ring back.

(10) Observe the pressure gauge on top of the ventilator for an operating pressure of 45 to 55psig as indicated by the green wedge. If the pressure is within the green wedge (45-55psig), proceed to paragraph c below. However, if the indicated pressure is outside the wedge, refer to Table 2-1 for procedures on troubleshooting the source pressure gauge.

c. **Calibrate the Ventilator**.

(1) Airway manometer.

(a) Using slot-head screwdriver, remove the black bezel ring around the face of the manometer.

(b) Use the same screwdriver to rotate the adjusting screw at the 12 o'clock or 3 o'clock position, left or right as needed, to center the needle at zero.

(c) Tap the gauge (to shock the needle). Check to ensure the gauge still registers zero.

Problem	Potential Cause	Corrective Action
Operating pressure is outside of green wedge (45-55psig).	Calibration regulator not adjusted to correct pressure.	1. Adjust to a static 50psig.
	Malfunction in calibration regulator.	2. Remove regulator from system and rotate base of regulator COUNTER-CLOCKWISE to expose diaphragm. Replace if cut or torn. OR
	OR	3. Adjust inlet pressure with another regulator to determine if source pressure gauge or gauge or calibration regulator is at fault.
	Leak between inlet assembly and pressure gauge. OR	4. Ensure tube is secured from inlet assembly to pressure gauge. Apply liquid leak detector to both ends of tube. Correct any connection which bubbles.
	Malfunction in source pressure gauge.	5. Replace with new gauge (P/N 501).

Table 2-1. Source pressure gauge troubleshooting.

NOTE: On earlier models, the adjusting screw is located on the back of the manometer at the 12 o'clock position. To simplify calibration of the pressure manometer, it is recommended it be updated with P/N 4407R.

(d) Reinstall the bezel and recheck for zero. Table 2-2 explains troubleshooting procedures for the airway manometer.

Problem	Potential Cause	Corrective Action
Airway manometer will not calibrate to zero.	Gas flow delivery to breathing circuit manometer is measuring resistance of flow through tubing. OR	1. Reduce flow to ventilator to zero. Recalibrate.
	Internal malfunction of the manometer.	2. Replace the manometer with P/N 4407R. Ensure a .013D orifice (P/N 4016D) is placed in the tubing attached to the back of the manometer.
Manometer will not register pressure change with ventilator active.	External tube discon-nected. OR	3. Ensure airway pressure tube is attached to patient con-nection and outlet under ventilator marked "Airway Pressure Monitor."
	Internal tube discon-nected. OR	4. Ensure tube is secured from manometer to airway-pressure monitor outlet inside base of ventilator.
	Internal malfunction of the manometer.	5. See action #2 above.

Table 2-2. Airway manometer troubleshooting.

NOTE: Check the calibration of the flow test device (P/N 4418) for zero. The calibration screw is either located at the 12 o'clock position on the back of the gauge (0-40cm$H_2$0) or at the 12 or 3 o'clock position on the front of the 0-120cmH_2O gauge.

(2) Flow system.

(a) Disconnect the green patient-breathing tube from the outlet of the 500cc in-line nebulizer.

(b) Install the flow test device (P/N 4418) to the nebulizer outlet with the orifice pointing away from the nebulizer.

(c) The flow is determined indirectly as a proportional function of measured backpressure (orifice).

(d) Rotate the flow control clockwise for 10 lpm. Pressure on the flow test device should be 8cmH_2O. A range of acceptable flow parameters is shown in the chart below. If the pressure registered on the flow test device is not within the specified range, refer to paragraph (e) below for flow adjustments. Flow is measured as backpressure (cmH_2O) on the flow test device (P/N 4418). Refer to Table 2-3.

Actual Flow + 2 LPM	Recommended	Minimum Acceptable	Maximum
10 lpm	8cmH_2O	6 1/2cmH_2O	12 1/2cmH_2O
15 lpm	17cmH_2O	14cmH_2O	21 1/2cmH_2O
20 lpm	29cmH_2O	24 1/2cmH_2O	34cmH_2O

Table 2-3. Flow test device pressures.

(e) Corrections of flows are made by using the 3/32-inch Allen wrench to rotate the adjusting screw on the end of the bypass valve (refer to figure 2-2, point A). A clockwise rotation of this screw will decrease the backpressure (lower gauge reading). A counterclockwise rotation will increase backpressure (higher gauge reading). You may have to set a minimum or maximum flow at one setting to achieve an acceptable range at another setting.

(f) If the flow from the Babybird ventilator falls within the acceptable ranges at 10, 15, and 20 lpm, disconnect the flow test device and reconnect the green patient-breathing tube to the 500cc nebulizer.

(g) If the flow/backpressure parameters cannot be satisfactorily adjusted, follow the procedures in Table 2-4 to troubleshoot the flow system.

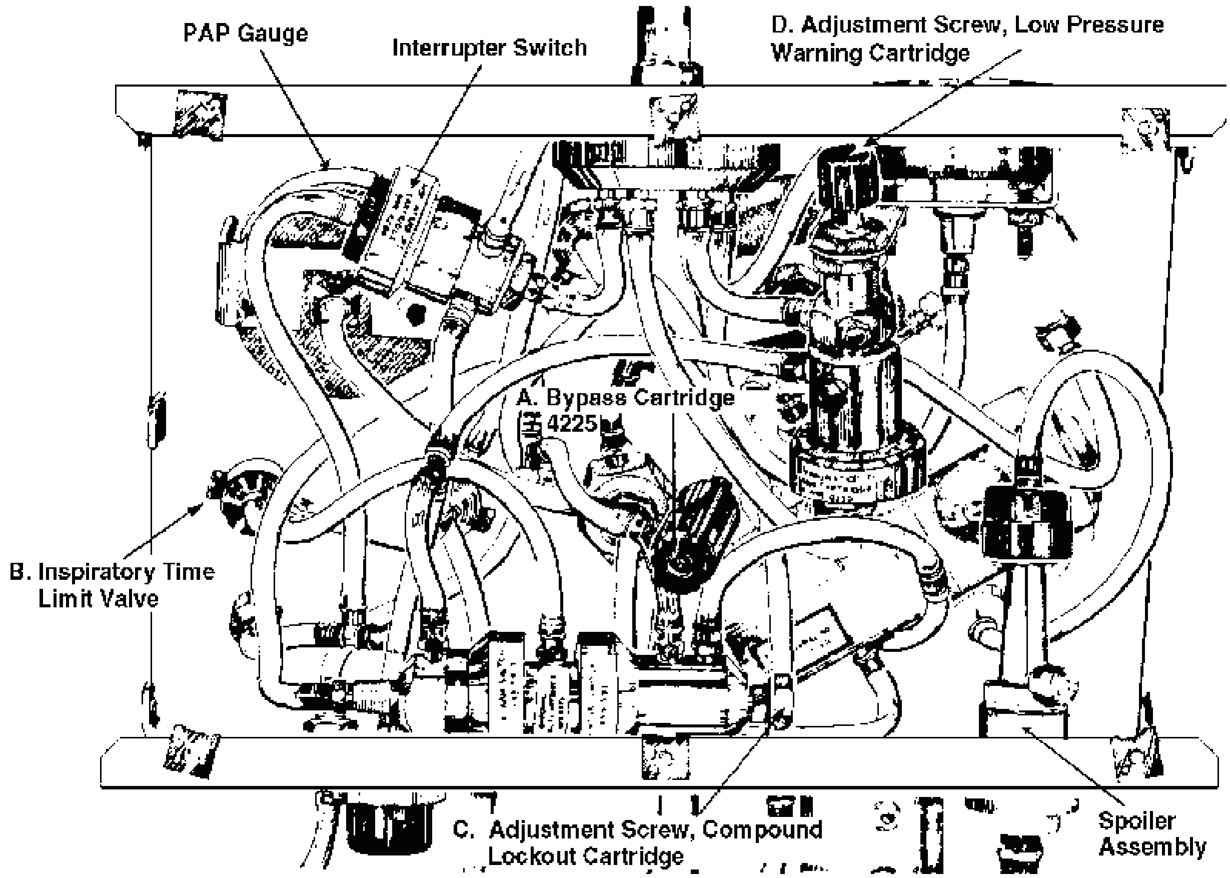


Figure 2-2. Ventilator interior.

(3) Nebulization system.

(a) Disconnect the green nebulizer jet line from the outlet in the bottom of the ventilator. Install a nebulizer power line test gauge (P/N 6758, 0-60psig gauge with green tubing) into this outlet and close this system by securing the nebulizer jet line to the female adapter of the test gauge.

(b) Check for a single-cam stop secured on the nebulization valve at the 6 o'clock position (figure 2-3).

Problem	Potential Cause	Corrective Action
Cannot achieve the recommended flow or backpressure parameters.	Source pressure not adjusted for 50psig. OR	1. Adjust calibration regulator for a static 50psig.
	Leak in the flow tubing system. OR	2. Adjust flow for 15 lpm and apply a liquid leak detector to both ends of tubes color-coded "clear." Correct any bubbling connections.
	Green and white tubing connected into 500cc nebulizer is reversed. OR	3. Ensure green tubing is connected from nebulizer jet outlet to the tallest connection of the nebulizer crown and the white auxiliary tubing is connected to the auxiliary-flow outlet and into one of the smaller connections on the crown (additional small connections on the crown should be plugged)

Table 2-4. Flow system troubleshooting (continued).

Problem	Potential Cause	Corrective Action
	Calibration gauge not calibrated to zero. OR	4. Calibrate as outlined in step (b).
	Malfunction in the bypass valve. OR	5. Remove the bypass valve so you can take it apart. Use a 1/2 inch and 5/8 inch wrench to open the valve. Remove valve seat (P/N 2867) and check condition of rubber disk (P/N 2877) and O-ring (P/N 2838). Replace if cut, flat or worn. Replace spring (P/N 2839) if corroded. Rotate adjuster screw (P/N 4227) fully clock-wise to remove. Replace O-ring (P/N 274) if worn, cut, or flat. OR
		6. Replace bypass valve (P/N 4225).
	Worn O-ring (P/N 114) on end of nebulizer valve.	7. Use 1/2 inch open-end wrench to remove valve. Replace O-ring if cut, flat, or worn.

Table 2-4. Flow system troubleshooting (concluded).

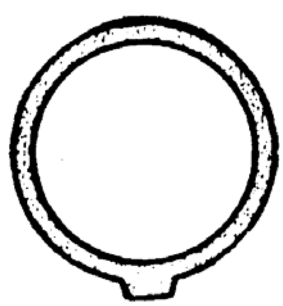


Figure 2-3. Cam stop.

(c) Adjust the flow for 10 lpm and rotate the nebulization-control stem fully clockwise (maximum). Pressure on the test gauge should be 12 to 16psig.

(d) With the nebulization stem turned fully clockwise, apply Lubewick (P/N 042) to the 0-ring on the outside of the valve-retention cap and secure the control knob with the index clockwise against the 6 o'clock cam stop (figure 2-4).

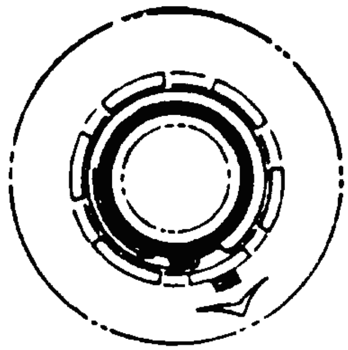


Figure 2-4. Nebulizer control knob.

(e) Rotate the control knob fully counterclockwise (minimum) and observe the test gauge for a pressure range of 2 to 6psig.

(f) If the pressures observed are not within the acceptable range, proceed to the troubleshooting procedures in Table 2-5.

(g) If the nebulization control parameters are acceptable at both the minimum and maximum settings, remove the test gauge and reconnect the nebulizer jet line into the Babybird (push and twist).

(4) <u>Expiratory-flow gradient</u>.

(a) Ensure the mode selector is still adjusted for spontaneous breathing and the outflow valve is open (fully clockwise).

(b) Adjust the flow to 10 lpm. The airway manometer should register between 2 to 4cmH_20. This is caused by the resistance of the breathing circuit to the flow.

(c) Rotate the expiratory-flow valve stem fully counterclockwise. The sub-ambient pressure observed on the manometer should register at least -10cmH_20.

<u>1</u> To limit the maximum sub-ambient pressure to -10cmH_20 (not mandatory), use a 1/2-inch open-end wrench to remove the retention cap on the valve stem.

Problem	Potential Cause	Corrective Action
Cannot achieve at least 12psi with nebulizer stem fully clockwise at 10 lpm. OR	Source pressure less than 50psig (static)/flow set for less than 10 lpm. OR	1. Adjust source pressure and flow to recommended parameters.
Cannot achieve at least 2psig with nebulizer stem fully counterclock-wise (CCW).	Flow system not calibrated correctly. OR	2. Check calibration of flow system.
	Leak in the flow/ nebulization tubing system. OR	3. Adjust flow for 15 lpm and apply a liquid leak detector to both ends of tubes color-coded "clear." Correct any connections where bubbles appear.
	Gas escaping around O-ring(P/N 114) on end of nebulization valve. OR	4. Use 1/2 inch open-end wrench to remove valve. Check condition of small O-ring on end of valve. Replace if cut, flat, or worn.
	Faulty nebulization valve (P/N 5995)	5. Replace with new valve.
Nebulization pressure greater than 16psig with valve stem full clockwise. OR Greater than 6psig with valve stem fully CCW.	Source pressure greater than 50psig (static)/ flow set higher than 10 lpm. OR	6. See corrective action #1 above.
	Flow system is not calibrated correctly. OR	7. Check calibration of flow system.
	Faulty nebulization valve (P/N 5995).	8. Replace with new valve.

Table 2-5. Nebulization system troubleshooting.

2 Install a washer (P/N 4021) and a single cam stop (P/N 4020) between the 5 to 7 o'clock position (trial and error). Secure the parts in place with the wrench.

(d) Rotate the valve stem fully clockwise. Pressure on the manometer should return to +2 to +4cmH_20.

(e) Apply Lubewick to the O-ring on the outside of the retention cap and secure the control knob with its index at the OFF position.

NOTE: The control knob for the expiratory-flow gradient, shown in figure 2-5, is the only Babybird knob with the increase arrow directed counterclockwise.

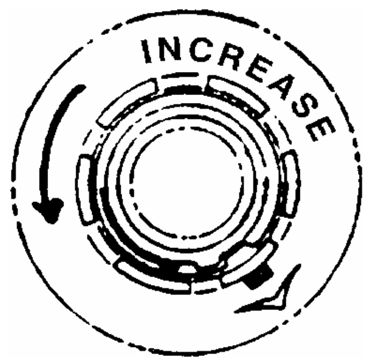


Figure 2-5. Expiratory flow gradient control knob.

(f) Table 2-6 gives the problems, possible causes, and remedial procedures used in troubleshooting the expiratory flow gradient system.

(5) Outflow valve continuous positive airway pressure control (CPAP).

(a) Adjust the flow for 15 liters per minute.

(b) Rotate the valve's red control lever fully counterclockwise and observe the airway manometer for a CPAP of at least 20cmH_20.

(c) A flutter of the outflow-valve diaphragm may occur as reflected by the manometer. To eliminate the flutter, remove the outflow valve diaphragm and lightly lubricate the extension attached to the diaphragm. Use Bird special lubricant (P/N 631) or Lubewick (P/N 042).

(d) Rotate the red control lever back to a fully clockwise position.

Problem	Potential Cause	Corrective Action
Cannot achieve at least -10cmH_2O on manometer with expiratory flow valve full CCW.	Leak in the breathing circuit. OR	1. Secure all connections.
	Gas escaping around O-ring (P/N 114) in expiratory valve. OR	2. Use 1/2 inch open-end wrench to remove valve. Check condition of small O-ring on end of valve. Replace if cut, flat, or worn.
	Leak in expiratory-flow tubing. OR	3. Adjust flow for 15 lpm and apply liquid to both ends of tubes color coded "yellow." Correct any connections that bubble.
	Faulty expiratory flow gradient valve. OR	4. Use 1/2 inch open-end wrench to remove valve. Replace with new valve (P/N 1198).
	Malfunction in inspiratory-cartridge (P/N 4286).	5. Remove cartridge from system so you can take it apart. Remove the back of cartridge and check the condition of diaphragm, O-rings, and spring. Replace any worn parts. OR
		6. Replace inspiratory-interrupter cartridge (P/N 4286).
Cannot stop expiratory flow with valve closed (full clockwise).	Gas escaping around O-ring on expiratory valve. OR	7. See action #2 above.
	Faulty expiratory flow valve.	8. See action #4 above.

Table 2-6. Expiratory flow gradient troubleshooting (concluded).

(e) If necessary, troubleshoot the outflow valve using the procedures outlined in Table 2-7 below.

Problem	Potential Cause	Corrective Action
Cannot achieve 20cmH_2O of CPAP at a flow rate of 15 lpm.	Leak in the breathing circuit. OR	1. Check and secure all connections and ensure the patient connector is attached to the mechanical test lung for a closed system.
	Faulty outflow valve (P/N 5940)	2. Replace the diaphragm with a new diaphragm (P/N 5630).

Table 2-7. Outflow valve troubleshooting.

(6) Pressure relief valve.

(a) Ensure the flow is adjusted to 10 lpm.

(b) Remove the red patient-exhalation tubing attached to the bottom of the shuttle-valve assembly.

(c) Seal or otherwise block the end of the disconnected tubing and observe the manometer for a pressure rise and plateau of 30cmH_2O. An audible alarm should be heard at this pressure.

(d) If a distinct audible alarm is not heard (at 30cmH_2O), remove the reed alarm from the back of the relief valve (to get at the adjusting nut) and use a 1/4-inch nut driver to adjust the device to the correct relief pressure. A clockwise rotation of the adjusting nut increases the relief pressure.

(e) Replace the reed alarm and recheck the pressure. Back pressure of the reed alarm may increase pop-off pressure; adjust accordingly. Ensure the audible alarm is heard during a 30cmH_2O pressure plateau.

(f) Reconnect the exhalation tube to the shuttle valve.

(g) Use the procedures outlined in Table 2-8 to troubleshoot the pressure relief valve.

Problem	Potential Cause	Corrective Action
Cannot achieve 30cmH_2O peak pressure.	Pressure relief valve adjusted to a lower peak pressure. OR	1. Adjust for a higher relief pressure as in steps (6)(a) through (f) above.
	Leak in the breathing circuit. OR	2. Check and secure all connections except the expiratory tubing as outlined in step (6)(b) above.
	Faulty pressure-relief valve (P/N 4230C).	3. Replace the valve.
Audible alarm does not sound during pop-off.	Faulty reed alarm (P/N 4465).	4. Replace the reed alarm if adjustment step (6)(d) will not compensate.

Table 2-8. Pressure relief valve troubleshooting.

(7) Mark-2 timing system.

(a) Rotate the mode selector switch to CONTROLLED IMV ON. The Babybird ventilator should commence rapid cycling.

(b) Use a stop watch to determine the cycling frequency. The Mark 2 must be capable of cycling at least 100 cycles per minute.

(c) If the cycling frequency of the Mark 2 is less than 100 cycles per minute, refer to step (d), troubleshooting, before continuing with calibration of the inspiratory relief pressure valve.

(d) Use the procedures outlined in Table 2-9 to troubleshoot the Mark-2 timing system.

(8) Inspiratory relief pressure valve.

(a) Check for a single cam stop secured at the 3 o'clock position (figure 2-6) on the inspiratory relief pressure control valve.

Problem	Potential Cause	Corrective Action
Babybird ventilator will not cycle at least 100/min.	Expiratory and inspiratory valves not fully open. OR	1. Rotate both valve stems fully counterclockwise.
	Faulty expiratory time valve (P/N 1360A). OR	2. Use 1/2 inch open-end wrench to remove valve. Replace with new valve.
	Leak in tubing leading to or away from the Mark 2. OR	3. Apply liquid leak detector to both ends of tubing color coded green. Correct any bubbling connections.
	Internal malfunction of the Mark 2.	4. Remove Mark 2 from the Babybird ventilator and follow the disassembly and reassembly instruction as outlined in form L707, Mark 2 Ventilator Service and Repair Instructions.

Table 2-9. Mark-2 timing system troubleshooting.

(b) Rotate the inspiratory time and expiratory time valve stems approximately two turns clockwise.

(c) Check to ensure the mode selector is adjusted to CONTROLLED IMV ON and a flow of 10 lpm is indicated.

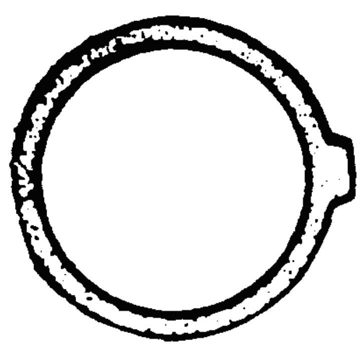


Figure 2-6. Cam stop.

(d) Adjust the inspiratory time stem for a 3 second (plus or minus 0.1 second) inspiratory pause.

(e) Rotate the inspiratory relief pressure stem clockwise to obtain a peak inspiratory pressure of 80-82cmH_20 (60mmHg).

(f) Apply Lubewick to the O-ring on the outside of the retention clip and secure the control knob with the index clockwise to the 3 o'clock cam stop as shown in figure 2-7.

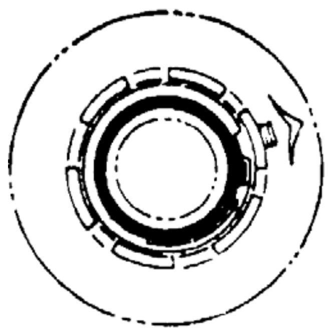


Figure 2-7. Control knob position.

(g) Confirm a peak inspiratory pressure of 80 to 82cmH_20 and then rotate the control knob fully counterclockwise. Peak cycling pressure on the manometer should fall between 8 to 14cmH_2O.

(h) Use the procedures detailed in Table 2-10 to troubleshoot the inspiratory-relief pressure (spoiler assembly).

(9) Inspiratory lockout (compound-lockout cartridge).

(a) Turn the source gas off and use a 5/16-inch wrench to remove the 9-o'clock plug from the side of the inspiratory time-limit valve (refer to figure 2-2, point B).

(b) Connect the inspiratory lockout test gauge (P/N 4454, 0 to 60psig gauge with red tubing) into the same outlet port.

(c) Rotate the inspiratory time-limit stem (located above the reset button) approximately 1/2 turn counterclockwise and then turn the source gas on. The following should occur.

1 The Babybird ventilator cycles once, followed by an inspiratory lockout (ventilator automatically switches to a continuous-flow system) which activates an audible alarm.

Problem	Potential Cause	Corrective Action
Cannot achieve 80-82cmH_2O peak inspiratory pressure. OR Minimum cycling pressure less than 8cmH_2O.	Leak in the breathing circuit. OR	1. Check and secure all connections and ensure the patient connector is attached to the mechanical test lung for a closed system.
	Outflow-valve diaphragm not seating properly or diaphragm ruptured. OR	2. Ensure diaphragm is positioned correctly and is not ruptured. Replace the diaphragm, if needed, with P/N 5630.
	Leak in the inspiratory relief pressure tubing system. OR	3. Apply a liquid leak detector to both ends of tubing connections color coded blue. Tighten or correct any connection which bubbles.
	Gas escaping around O-ring on inspiratory relief pressure valve. OR	4. Use 1/2 inch open-end wrench to remove valve. Check condition of small O-ring on end of valve. Replace if worn, flat, or cut.
	Faulty inspiratory relief pressure valve (P/N 344B).	5. Replace with new valve.
	Inspiratory time set for less than 1 second.	6. Adjust inspiratory time as discussed earlier in step (4) above.
Minimum cycling pressure is greater than 14cmH_2O.	Faulty inspiratory relief pressure valve.	7. Replace with a new valve (P/N 344B).

Table 2-10. Inspiratory relief pressure troubleshooting.

2 If an inspiratory lockout is not activated, rotate the inspiratory time-limit stem further counterclockwise.

(d) Watch the test gauge, push the reset button, and observe the following.

1 The test gauge registers a pressure of approximately 45psig.

2 The ventilator then cycles once, enters into a lockout again, followed by an audible alarm.

3 Inspiratory lockout occurred between 12 to 14psig on test gauge.

4 The alarm was activated between 8 and 10psig.

(e) To adjust the lockout pressure, use a 3/32 inch Allen wrench to rotate the adjustment screw located in the end of the compound-lockout cartridge (refer to figure 2-2, point C). A clockwise rotation increases the pressure at which a lockout occurs.

(f) If lockout occurs between 12 to 14psig, followed by an audible alarm, turn off the source gas to remove the test gauge so the plug may be reinstalled into the valve. However, if the above parameters are not met, troubleshoot the assembly before continuing.

(g) Use the procedures outlined in Table 2-11 to troubleshoot the inspiratory lockout (compound-lockout cartridge).

(10) Inspiratory time limit.

(a) Rotate the mode selector to SPONTANEOUS BREATHING ON. Ensure the inspiratory time-limit stem is fully clockwise and adjust the expiratory flow gradient control knob to obtain a zero reading on the manometer.

(b) Use a 1/2-inch open-end wrench to remove only the retention cap on the inspiratory time-limit valve. Install a cam-stop washer (P/N 4021) followed by a single cam stop (P/N 4020). Finger tighten the retention cap onto the valve body.

(c) Rotate the Mark 2 inspiratory-time stem fully clockwise, then counterclockwise 1/4 to 1/2 turn.

(d) Turn the source gas on and rotate the mode selector to CONTROLLED IMV ON. Check for flow set at 10 lpm. Push the reset button and ensure inspiratory time is 7 seconds or more.

Problem	Potential Cause	Corrective Action
Cannot adjust compound-lockout cartridge for inspiratory lockout at 12 to 14psig.	Leak in the inspiratory tubing system. OR	1. Apply a liquid leak detector to both ends of tube connected to the compound-lockout cartridge and correct any connection which bubbles.
	Internal malfunction of compound-lockout cartridge (P/N 5913).	2. Remove cartridge from the ventilator and disassemble it. Replace worn component parts. OR 3. Install a new compound-lockout cartridge.
Audible alarm not activated after an inspiratory lockout.	Alarm assembly not secured to bottom of ventilator. OR	4. Ensure the alarm is firmly attached to the ventilator bottom.
	Faulty reed (P/N 1866) in alarm. OR	5. Replace reed. OR 6. Replace with new alarm (P/N 5127).
	Malfunction in compound-lockout cartridge.	7. See actions 1 through 3 above.

Table 2-11. Inspiratory lockout troubleshooting.

(e) Slowly rotate the inspiratory time-limit stem counterclockwise until an inspiratory lockout occurs at 3 seconds (plus or minus 0.2 second). Begin your timing at the start of an inspiratory cycle and stop timing when the unit locks out, <u>not</u> at the sound of the alarm.

(f) Confirm a 3 second lockout (plus or minus 0.2 second) and then mark the end of the inspiratory time-limit stem at 12 o'clock with a pencil.

(g) Push the reset button and rotate the inspiratory time-limit stem clockwise for a 5.5- to 6.5-second lockout time.

(h) Push the reset button. Rotate the mode selector to SPONTANEOUS BREATHING ON and position the single cam stop at the same position as the pencil mark on the stem. Secure in place by tightening the retention cap with the 1/2-inch open-end wrench.

(i) Rotate the pencil mark on the stem back to 12 o'clock, turn the mode selector to CONTROLLED IMV, and confirm an inspiratory-lockout time of 3 seconds (plus or minus 0.2 second).

(j) Apply Lubewick to the O-ring on the outside of the retention cap and secure the control knob with the index at the 12 o'clock position as shown in figure 2-8. Recheck for a 3 second lockout time.

(k) Rotate the knob clockwise against the cam stop to confirm a 5 to 7 second lockout time.

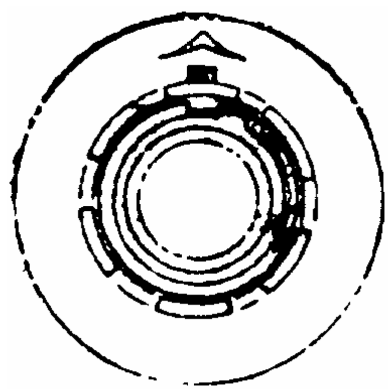


Figure 2-8. Control knob set at 3 seconds.

(l) Push the reset button and rotate the mode selector to SPONTANEOUS BREATHING ON. If the inspiratory time- limit parameters are met, rotate the expiratory flow gradient control fully clockwise (off) and proceed to the next step, calibrating inspiratory time. If they are not met, you will have to troubleshoot the inspiratory time-limit system.

(m) Use the procedures outlined in Table 2-12 to troubleshoot the inspiratory time-limit system.

Problem	Potential Cause	Corrective Action
Cannot achieve a 3-second inspiratory lockout at 12-o'clock knob position. OR A maximum inspiratory lockout of 5-7 seconds.	Leak in the inspiratory lockout tubing system. OR	1. Apply a liquid leak detector to both ends of tubes connected to the compound-lockout cartridge and both ends of tubes color coded yellow. Correct any bubbling connections.
	Gas escaping around a worn O-ring on time-limit valve. OR	2. Use 1/2 inch open-end wrench to remove valve. Check condition of small O-ring on end of valve. Replace if cut, flat, or worn.
	Faulty time-limit valve (P/N 344B) OR	3. Replace with a new valve.
	Internal malfunction of compound-lockout cartridge.	4. Troubleshoot the compound-lockout cartridge.

Table 2-12. Inspiratory time-limit troubleshooting.

(11) Inspiratory time (Mark 2).

(a) Rotate the mode selector to CONTROLLED IMV ON and adjust the Mark 2 inspiratory time for 2.5 seconds (plus or minus 0.2 second).

(b) Apply Lubewick to the O-ring on the outside of the retention cap and install the control knob so the flange stop screw is clockwise (above) the 3-o'clock stop on the face plate.

(c) Confirm a 2.5 second (plus or minus 0.2 second) inspiratory time and then rotate the control knob counterclockwise to ensure the stop screw in the knob flange is backed out far enough to allow rotation past the face-plate stop.

(d) A fully counterclockwise position should achieve an inspiratory time of less than 0.5 second.

(e) Rotate the inspiratory time-limit control knob fully clockwise.

(f) Troubleshoot the Mark 2 inspiratory time system as detailed in Table 2-13.

Problem	Potential Cause	Corrective Action
Cannot achieve a 2.5-second inspiratory lockout.	Premature lockout. OR	1. Ensure the inspiratory time-limit control knob is fully clockwise.
	Gas escaping around small O-ring (P/N 114) in inspiratory time-limit valve. OR	2. Use a 1/2 inch open-end wrench to remove valve. Check condition of small O-ring on end of valve. Replace if cut, flat, or worn.
	Faulty inspiratory time valve (P/N 1360A) OR	3. Replace with a new valve.
	Malfunction in Mark 2.	4. Refer to the Mark 2 Timing System troubleshooting procedures.

Table 2-13. Inspiratory time (Mark 2) troubleshooting.

(12) Expiratory time (Mark 2).

(a) Rotate the expiratory-time stem clockwise for an 8 to 10 second expiratory time. Begin timing from the end of an inspiratory cycle to the beginning of the next cycle.

(b) Apply Lubewick to the O-ring on the outside of the retention cap and install the control knob with the flange-stop screw clockwise (below) to the 9-o'clock stop on face plate.

(c) A full counterclockwise rotation should produce an expiratory time of less than 0.5 (1/2) second.

(d) Rotate the expiratory-time stem fully clockwise against the stop and then rotate the mode selector to SPONTANEOUS BREATHING ON.

(e) Use the procedures outlined in Table 2-14 below to troubleshoot the Mark 2 expiratory time system.

Problem	Potential Cause	Corrective Action
Cannot achieve an 8 to 10 sec. expiratory time.	Gas escaping around small O-ring (P/N 114) on expiratory valve. OR	1. Use 1/2 inch open-end wrench to remove valve. Check condition of small O-ring on end of valve. Replace if cut, flat, or worn.
	Faulty expiratory time valve. OR	2. Replace with new valve (P/N 1360A).
	Malfunction in the Mark 2.	3. Refer to para (7)(d) troubleshooting the Mark 2 timing system.

Table 2-14. Expiratory time (Mark 2) troubleshooting.

(13) Low pressure alarm system.

(a) Decrease source pressure on the calibration regulator from 50psig to a pressure at which the low pressure alarm sounds. The alarm should sound when the pressure reaches 43psig and drops from the green pressure wedge on the gauge atop the ventilator.

(b) To adjust the pressure at which the alarm is activated, locate the adjustment knob on the low pressure alarm cartridge (refer to figure 2-2, point D).

(c) A clockwise rotation will increase the alarm pressure. A counterclockwise turn will decrease the pressure. Adjust the knob so the alarm sounds at 43psig.

(d) If the low pressure alarm adjusts for 43psig, proceed to the next step (e) below. However, if the low pressure alarm system is not functioning, go on to step (f) below, troubleshooting the low pressure, alarm system.

(e) Adjust calibration regulator back to 50psig. This completes calibration of the Babybird ventilator. However, before reassembling the back and side plate, we recommend one last check of all parameters by performing the following calibration test in paragraph d.

(f) Use the procedures detailed in Table 2-15 to troubleshoot the low pressure alarm system.

Problem	Potential Cause	Corrective Action
Low pressure alarm is activated at a pressure other than 43psig.	Leak in low pressure alarm tubing system. OR	1. Apply a liquid leak detector to both ends of tubing connections color coded red. Correct any bubbling connections.
	Internal malfunction of low pressure alarm cartridge (P/N 4250D).	2. Remove cartridge from ventilator so it can be taken apart. Replace any worn component parts. OR Install a new low pressure alarm cartridge.
Audible alarm not activated when a low-pressure situation occurs.	Alarm assembly not secured to bottom of ventilator. OR	3. Ensure the alarm is securely attached to the ventilator.
	Faulty reed (P/N 1866) in alarm.	4. Replace reed. OR 5. Replace with new alarm (P/N 5127).

Table 2-15. Low pressure alarm system troubleshooting.

d. **Calibration Test**. If the following parameters are not met, refer back to paragraph 2-2 to obtain correct values. Ensure a static 50psig driving pressure to the ventilator.

(1) Source pressure gauge.

(a) Rotate the mode selector to SPONTANEOUS BREATHING ON and adjust the flow to zero.

(b) Check for an operating pressure of 45 to 55psig as indicated by the green wedge.

(2) Airway manometer. Tap the gauge (to shock the needle). Check the needle to ensure it is indicating zero.

(3) Flow system.

(a) Disconnect the green patient-breathing tube from the 500cc in-line nebulizer.

(b) Install a flow test device (P/N 4418) to the nebulizer outlet with the orifice pointing away from the nebulizer.

(c) Adjust the nebulization control to maximum and refer to Table 2-2 for the flow parameters.

(d) Remove the flow test device and reconnect the tubing to the nebulizer.

(4) Nebulization system.

(a) Disconnect the green nebulizer jet line from the outlet in the bottom of the ventilator. Install the male adapter of a 0 to 60psig nebulization gauge (P/N 6758) into the nebulizer jet outlet and connect the female adapter of the gauge to the nebulizer jet line.

(b) Set the flow for 10 lpm. The maximum setting on the nebulizer control should indicate 12 to 16psig. The minimum setting should drop gauge pressure to between 2 to 6psig.

(c) Disconnect the test gauge and reconnect the nebulizer jet line into the base of the ventilator.

(5) Expiratory-flow gradient.

(a) Ensure the outflow valve is fully OPEN (clockwise). The airway manometer should register between 2 to 4cmH_2O.

(b) Rotate the expiratory flow control knob fully counterclockwise. The sub-ambient pressure observed on the manometer should register at least -10cmH_20.

(c) Rotate the expiratory-flow knob fully clockwise to OFF.

(6) Outflow valve (CPAP control).

(a) Adjust the flow for 15 lpm. Rotate the red control lever fully counterclockwise and observe the manometer for a CPAP of at least 20cmH_20.

(b) Rotate the red control lever back to a minimum setting (fully clockwise).

(7) Pressure relief valve.

(a) Adjust the flow from 10 lpm and remove the red patient-exhalation tubing attached to the bottom of the shuttle valve.

(b) Block the end of the disconnected tubing and observe the manometer for a pressure rise and plateau at 65mmHg (88cm$H_2$0). You should be hearing the audible alarm at this pressure.

(c) Reconnect the red tubing into the shuttle valve.

(8) Mark 2 timing system, inspiratory time and expiratory time.

(a) Rotate mode selector to CONTROLLED IMV ON.

(b) Rotate both the inspiratory and expiratory time-control knobs fully counterclockwise. The Babybird ventilator should cycle at least 100 cycles per minute.

(c) Rotate both the inspiratory and expiratory time-control knobs clockwise against the face plate stops. Check for a 2.5 second (plus or minus 0.2 second) inspiratory time and an 8 to 10 second expiratory time.

(9) Inspiratory relief pressure.

(a) Rotate the inspiratory relief pressure-control knob fully clockwise.

(b) Confirm a peak inspiratory pressure of 80 to 82cmH_2O and then rotate this control knob fully counterclockwise for a peak cycling pressure of 8 to 14cm$H_2$0.

(c) Adjust the inspiratory relief pressure control knob to the 12-o'clock position.

(10) Inspiratory time limit.

(a) Rotate the expiratory-flow-gradient control clockwise until the manometer needle registers zero.

(b) Back out (but do not remove) the stop screw on the inspiratory time knob flange and then rotate this knob fully clockwise.

(c) Set the inspiratory time-limit control knob to 3 seconds (12 o'clock).

(d) An inspiratory lockout should occur at 3 seconds (plus or minus 0.2 second), followed by the alarm.

(e) Rotate the inspiratory time-limit control knob clockwise against its stop and check for an inspirator lockout between 5 to 7 seconds thereafter.

(f) Push the reset button and adjust the inspiratory time control for 2.5 seconds. Recheck the position of the stop screw.

(g) Rotate the mode selector to SPONTANEOUS BREATHING ON and rotate the expiratory flow gradient control to OFF.

(11) Low pressure alarm system.

(a) Decrease the source pressure on the calibration regulator from 50psi to a pressure at which the low pressure alarm sounds.

(b) Confirm 43psig is indicated on the gauge as the pressure drops from the green wedge of the system-pressure gauge.

e. **Reassembly**. Turn the source gas off.

(1) Ensure all test devices have been removed from the ventilator.

(2) Install the combination back and side plate and secure with the 12 screws.

(3) Disconnect the ventilator from the calibration stand and attach it to the Babybird stand for clinical usage. Calibration of the Babybird ventilator is now complete.

Section II. TROUBLESHOOTING AND REMOVAL AND REPLACEMENT PROCEDURES

2-3. TROUBLESHOOTING THE VENTILATOR.

Use the procedures in Tables 2-16 through 2-19 to troubleshoot in the modes of operation indicated in the table.

Problem	Potential Cause	Corrective Action
Blender alarm sounds.	Pressure differential between source gases exceeds 20psi.	Adjust both source-gas pressures to approximately 50psi, but not below 48psi.
	Water condensate in air supply.	Protect air source from water condensate (install drier, etc.). Disassemble, clean, assemble, and calibrate blender to restore function.
	Source-gas hose blocked, kinked.	Obvious.

Table 2-16. Troubleshooting at start up in either mode (continued).

Problem	Potential Cause	Corrective Action
Babybird audible alarm sounds.	One or both source-gas pressures are too low (below psi).	Increase source gas or gases pressure to 50 to 55psi.
	Inlet gas connections are not tight.	Ensure connections are leak-free and tight.
	Large leak in source-gas distribution system (after oxygen blender).	Check for leaks and eliminate them.
	Inlet filter blocked.	Clean or replace filter.
	Lockout function is activated.	Press reset button.
	O-ring on low-pressure alarm is damaged.	Replace O-ring.
	Leak in charging circuit of compound-lockout cartridge OR duckbill valve has failed.	Check for leak and eliminate OR replace check valve.
	Mark 2 servo has failed in the inspiratory phase.	Check Mark 2, find the cause of failure, and repair.

Table 2-16. Troubleshooting at start up in either mode (continued).

Problem	Potential Cause	Corrective Action
	Large leak in source pressure monitoring circuit.	Eliminate leak.
	Inspiratory time and/or expiratory time controls have been forced open past internal stops.	Disassemble and examine valve; repair or replace as necessary.

Table 2-16. Troubleshooting at start up in either mode (concluded).

Problem	Potential Cause	Corrective Action
Increasing flow does not cause flow gauge to change from zero.	Source gas not turned on. OR Pressure-balance spring omitted from regulator assembly. OR Regulator valve is leaking; flow vents to atmosphere.	Turn source gas on. Install spring and check regulator function. Replace diaphragm and check regulator function.
Increasing flow control does not cause flow gauge to increase in proportion; may be unable to rise above 20 - 25 lpm.	Gauge is faulty. OR Leak in nebulization control. OR Leak in bypass valve.	Repair or replace gauge. Check nebulization control circuit for leaks and eliminate them. Check bypass valve condition and calibrate.

Table 2-17. Troubleshooting in either mode of operation (continued).

Problem	Potential Cause	Corrective Action
Decreasing flow control does not cause flow gauge to decrease; may read 25 lpm or more.	Regulator seat damaged allowing a large leak.	Replace seat and check regulator.
	Airway pressure monitor tube blocked or disconnected.	Connect or clear blockage.
	Proximal airway pressure gauge is malfunctioning.	Repair or replace gauge.
	With mechanical lung connected: rolling diaphragm is ruptured.	Replace diaphragm.
Nebulizer not delivering adequate nebulization regardless of control setting.	Nebulizer jet is blocked.	Clean the jet.
	Pendant missing from 500cc nebulizer. OR Capillary missing from therapy nebulizer.	Replace missing component and check nebulizer function.
	Nebulizer empty.	Replace contents.
With all controls set for minimum CPAP, up to 4mmHg remains in breathing circuit when outflow valve is set to minimum.	Resistance to flow within the breathing circuit.	Adjust expiratory flow gradient control.

Table 2-17. Troubleshooting in either mode of operation (continued).

Problem	Potential Cause	Corrective Action
As CPAP lever on outflow valve is increased, no increase in CPAP occurs.	Outflow valve diaphragm was omitted in assembly.	Install diaphragm.
	Outflow valve body parts not snapped together tightly.	Press parts firmly together until secure.
	AirBird nonre-breathing valve diaphragm omitted during assembly.	Install diaphragm.
	Inflow not enough for desired CPAP.	Increase flow control.
	Nebulizer/water trap not tightly connected.	Check components, tighten connections to eliminate leaks.
	Nebulizer inlet socket not covered with red cap.	Place cap on unused open sockets on either nebulizer.
	Water trap drain valve left open.	Close drain valve.
Maximum peak inspiratory pressure is 18mmHg regardless of control settings.	O-ring seal missing in either nebulizer.	Replace O-ring.
	Reservoir not tight on 500cc nebulizer.	Tighten.
	Red cap missing from auxiliary port in nebulizer crown.	Install red cap.

Table 2-17. Troubleshooting in either mode of operation (concluded).

Problem	Potential Cause	Corrective Action
Unit operates in CIMV mode.	O-ring in mode-select valve is damaged allowing a large leak.	Replace O-ring.

Table 2-18. Troubleshooting in the spontaneous breathing mode.

Problem	Potential Cause	Corrective Action
Unit will not operate in the controlled mode.	Inspiratory venturi jet is blocked.	Clean the jet.
	Lockout-alarm delay-adjustment valve is out of calibration.	Recalibrate the valve.
Decreasing inspiratory time control does not activate lockout.	Inspiratory-interrupter cartridge has failed.	Repair or replace as necessary.
Inspiratory pressure limit increases to about 25mmHg without any control change.	Diaphragm OR O-ring in inspiratory-interrupter cartridge is defective.	Replace O-ring OR diaphragm.

Table 2-19. Troubleshooting in the controlled IMV mode.

2-4. REMOVE AND REPLACE MAJOR COMPONENTS

Once you isolate the defective component causing the malfunction, you remove and replace that component. The following paragraphs describe how to remove and replace major components.

a. **Remove and Replace the Low Pressure Alarm Assembly**. Refer to figure 2-2. Follow these procedures to remove and replace the low pressure alarm assembly.

(1) Disconnect the unit from the source gas.

(2) Attach the Babybird to a pedestal.

(3) With a screwdriver, remove the screws that hold the case together.

(4) Slide the front panel forward.

(5) Locate the alarm assembly in the center of the unit.

(6) With a crescent wrench, loosen and remove the nut holding the alarm assembly to the flow gauge bracket.

(7) Carefully pull the alarm assembly out of the bracket.

(8) Remove one hose at a time and place the new alarm assembly in its proper place. Attach all three hoses.

(9) Reassemble in the reverse order.

b. **Remove and Replace the Rotary Switch (Part Number 4285) Rotary Valve Assembly (Controlled INTERMITTENT MANDATORY VENTILATION/Spontaneous Breathing).** Refer to figure 2-9. Follow these procedures to remove and replace the rotary switch.

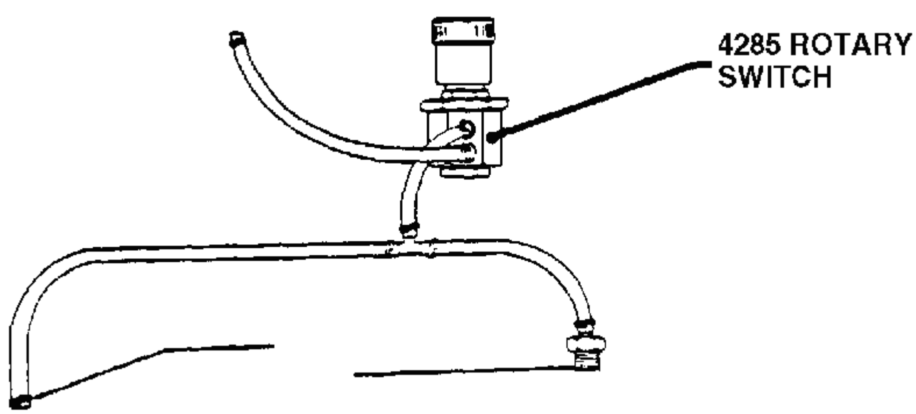


Figure 2-9. Rotary valve assembly and rotary switch.

(1) Disconnect the unit from the source gas.

(2) Use a screwdriver and remove the screws that hold the case together.

(3) Separate the front panel from the rear case.

(4) Locate the on/off switch.

(5) With a hex wrench, loosen the set screw in the on/off knob and pull the knob off.

(6) With a crescent wrench, loosen the nut securing the rotary valve assembly to the front panel.

(7) From the inside of the front panel, pull the rotary valve out of the hole.

(8) Replace the green tubing on the proper two outlets.

(9) Remove and replace the on/off switch.

(10) Reassemble in the reverse order.

c. **Remove and Replace the PAP Gauge (Part Number 9407R)**. Refer to figure 2-2 and follow these procedures to remove and replace the PAP gauge.

(1) Disconnect the unit from the source gas.

(2) Use a screwdriver and remove the screws that hold the case together.

(3) Separate the front panel from the rear case.

(4) Locate the PAP gauge.

(5) With a 7/16 inch nut driver or socket wrench, remove the two nuts on the PAP gauge bracket.

(6) Slide the gauge out of its position in the front panel.

(7) Replace the tube.

(8) Remove and replace the PAP gauge.

(9) Reassemble in the reverse order.

d. **Remove and Replace the Compound-Lockout Cartridge (Part Number 5913)**. Refer to figure 2-2 and follow these procedures to remove and replace the compound-lockout cartridge.

(1) Disconnect the unit from the source gas.

(2) Use a screwdriver and remove the screws that hold the case together.

(3) Slide the front panel forward.

(4) Locate the cartridge on the bottom side of the front panel assembly.

(5) With a crescent wrench, remove the two nuts which secure the cartridge to the case. These nuts are located outside the front panel.

(6) With a crescent wrench, remove the lock nut on the end of the cartridge.

(7) Gently (do not pull the hoses loose) pull the cartridge up.

(8) Replace the five hoses one at a time to avoid mixing up the correct positions.

(9) Remove and replace the cartridge.

(10) Reassemble in the reverse order.

e. **Remove and Replace the Bypass Valve**. Refer to figure 2-10 and follow these procedures to remove and replace the bypass valve.

(1) Turn off the source gas.

(2) With a screwdriver, remove the screws that hold the case together.

(3) Separate the case.

(4) Locate the bypass valve inside the unit, directly behind the nebulizer valve.

(5) Carefully remove the bypass valve and replace both hoses.

(6) Reassemble in the reverse order.

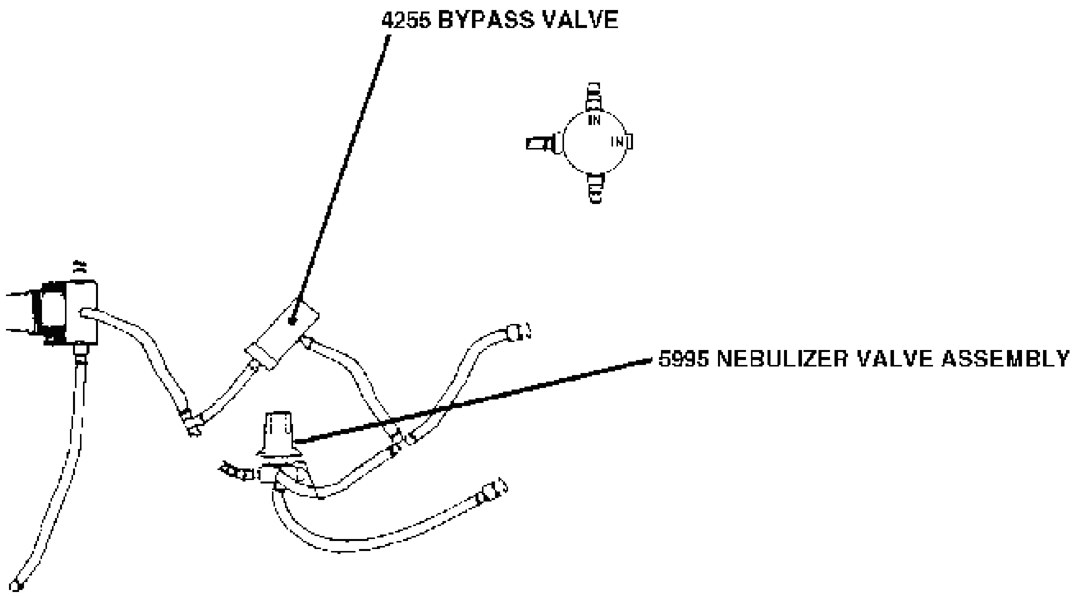


Figure 2-10. Flow regulator assembly.

f. **Remove and Replace the Nebulizer Valve**. Refer to figure 2-10 and follow these procedures to remove the nebulizer valve.

(1) Turn off the source gas.

(2) With a screwdriver, remove the screws that hold the case together.

(3) Separate the case.

(4) With an Allen wrench, remove the hex nut which holds the nebulizer knob on the valve shaft. Pull the knob off from the front of the unit.

(5) With a crescent wrench, remove the nut which holds the valve body to the front case.

(6) Carefully remove the nebulizer valve from inside the case.

(7) Replace the hoses on the new valve.

(8) Reassemble in the reverse order.

Continue with Exercises

EXERCISES, LESSON 2

INSTRUCTIONS: Answer the following questions by marking the lettered response that best answers the question or best completes the incomplete sentence.

After you have answered all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the lesson material referenced after the solution.

1. You are preparing the Babybird for calibration. Which of the following should you do?

   a. Disconnect the breathing assembly circuit from the ventilator.

   b. Connect the Babybird circuit to a mechanical lung.

   c. Rotate the expiratory flow control counterclockwise.

   d. Rotate the inspiratory time control clockwise.

2. You are preparing the Babybird for calibration. You turn on the source gas and pull the red locking ring forward. You then rotate the calibration regulator clockwise for a pressure of:

   a. 50psig.

   b. 55psig.

   c. 60psig.

   d. 65psig.

SITUATION: You are calibrating a Babybird pediatric ventilator. Use this situation to answer questions 3 through 5.

3. You are calibrating the flow system and have not been able to obtain acceptable flow rates from the ventilator. You have determined the problem is not the calibration regulator, leaks in the tubing, misconnections of the green and white tubing, nor the calibration gauge. What should you examine next?

   a. Calibration regulator.

   b. Expiratory flow gradient valve.

   c. The bypass valve.

   d. The outflow valve.

4. You are calibrating the expiratory-flow gradient with the selector switch in spontaneous breathing and the outflow valve fully open. You adjust the flow to 10 lpm. What should the test manometer read?

   a. Minus 10cmH_2O.

   b. Plus 2 to 4cmH_2O.

   c. The 5 to 7 o'clock position.

   d. Twelve to 15psig.

5. To calibrate the inspiratory-relief pressure, you check for a single CAM stop at which of the following positions?

   a. 3 o'clock.

   b. 6 o'clock.

   c. 9 o'clock.

   d. 12 o'clock.

SITUATION: You have started the Babybird portable ventilator in the spontaneous breathing mode of operation and the audible alarm (not the oxygen blender alarm) sounds. Use this situation to answer questions 6 and 7.

6. What is a potential cause for this problem?

   a. Water condensate in the air supply.

   b. The lockout function is deactivated.

   c. The duckbill-check valve has failed.

   d. Source-gas pressures are too high.

7. What remedial action should you take?

   a. Adjust source-gas pressure to 40 to 55psi.

   b. Protect air source from water condensate.

   c. Clean the nebulizer jet.

   d. Replace the duckbill-check valve.

8. Where is the low pressure alarm assembly located in the unit?

   a. Right side.

   b. Front.

   c. Back.

   d. Center.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES: LESSON 2

1. b (para 2-2b(4))

2. a (para 2-2b(9))

3. c (para 2-2c(2)(g))

4. b (para 2-2c(4)(b))

5. a (para 2-2c(8)(a))

6. c (Table 2-16)

7. d (Table 2-16)

8. d (para 2-4a(5))

End of Lesson 2