Sept. 16, 1969 F. M. BIRD ET AL 3,467,092

ANESTHESIA APPARATUS AND RESUSCITATOR

Filed Dec. 14, 1966 2 Sheets-Sheet 1

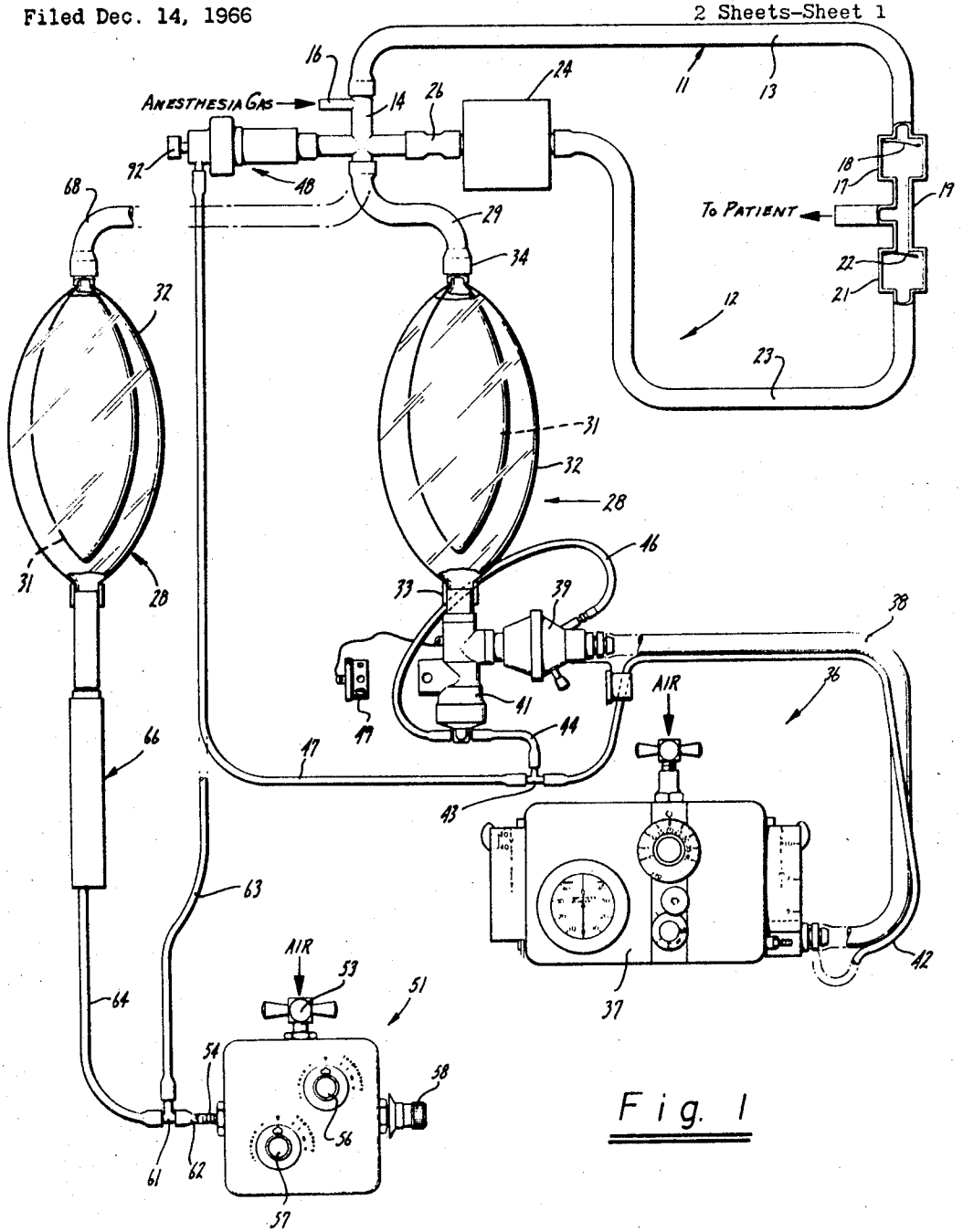

Fig. 1

Fig. 1A

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ANESTHESIA APPARATUS AND RESUSCITATOR

Filed Dec. 14, 1966 2 Sheets-Sheet 2

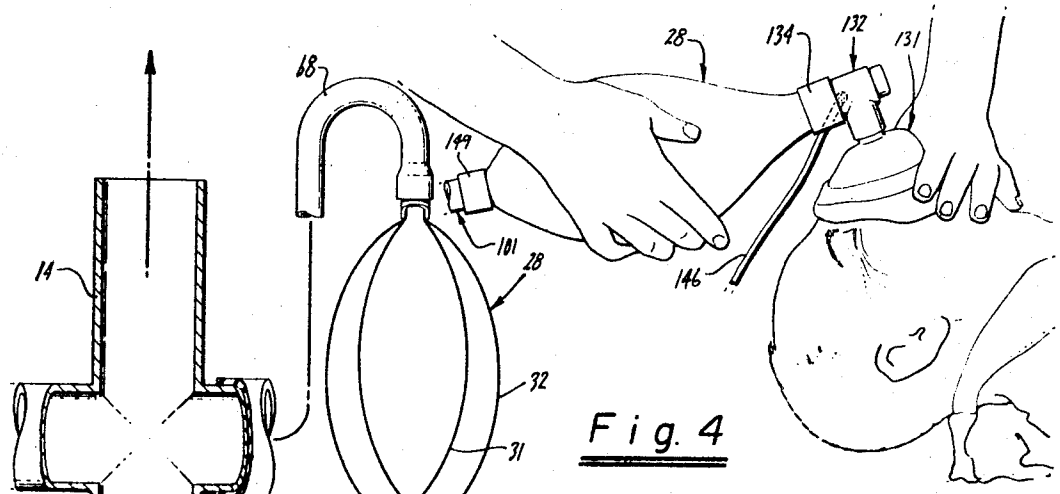

Fig. 4

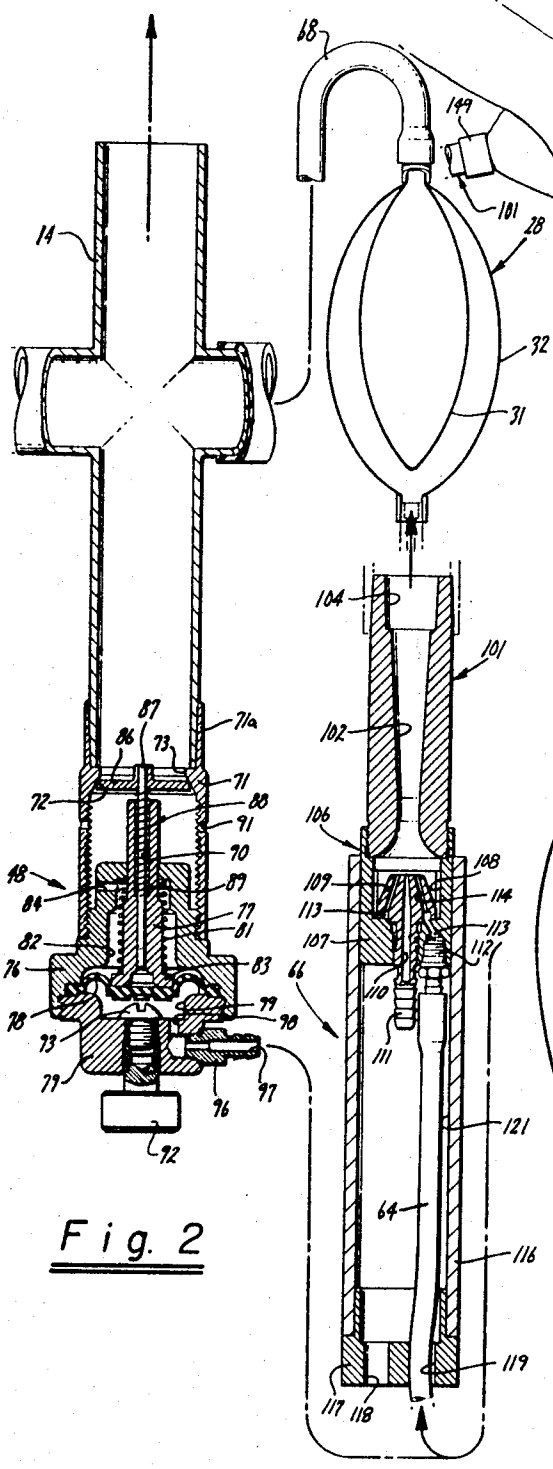

Fig. 2

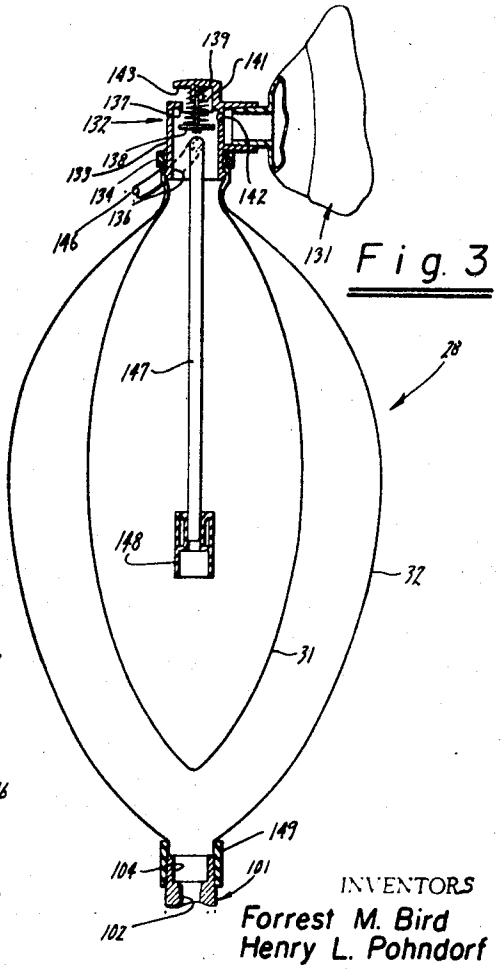

Fig. 3

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ANESTHESIA APPARATUS AND RESUSCITATOR

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U.S. Cl. 128—145.6 15 Claims

ABSTRACT OF THE DISCLOSURE

Anesthesia apparatus and resuscitator having a pneumatic bag assembly which includes an inner bag and an outer bag with the inner bag being in communication with a patient adapter and the outer bag being in communication with means for applying a pressure differential between the inner and outer bags to compress the inner bag.

This invention relates to an anesthesia apparatus and resuscitator and more particularly to an anesthesia apparatus resuscitator which is pressure limited.

Although anesthesia apparatus and resuscitators have heretofore been provided, such anesthesia apparatus and resuscitators have serious limitations. The operating rooms in many hospitals in the United States and throughout the world were designed many years ago and are very small. Since that time, there is a need for a large quantity of equipment for use in the operating room. Of necessity, the equipment which is to be utilized in the operating room should be as miniaturized and compact as is economically feasible. In addition, it has been found that anesthesia apparatus heretofore provided has been relatively expensive and has been relatively complicated so that it requires skilled personnel to operate the same. Resuscitators heretofore provided have not been particularly simple and practical. There is, therefore, a need for a new and improved anesthesia apparatus and resuscitator.

In general, it is an object of the present invention to provide an anesthesia apparatus and resuscitator which is relatively compact and inexpensive.

Another object of the invention is to provide apparatus of the above character which is pressure limited or, in other words, the patient is protected from overpressurization.

Another object of the invention is to provide apparatus of the above character which has a minimum of controls and which can be operated by relatively unskilled personnel.

Another object of the invention is to provide apparatus of the above character which can be utilized either in connection with anesthesia apparatus or the resuscitator.

Another object of the invention is to provide apparatus of the above character in which a single control valve controls both the flow rate and the peak inspiratory pressure.

Another object of the invention is to provide apparatus of the above character which utilizes a particularly unique pneumatic bag assembly.

Additional objects and features of the invention will appear from the following description in which the preferred embodiments are set forth in detail in conjunction with the accompanying drawings.

Referring to the drawings:

FIGURE 1 is a schematic illustration of anesthesia apparatus incorporating the present invention utilizing either a conventional ventilator for operating the anesthesia apparatus.

FIGURE 1A is a schematic illustration showing use of the anesthesia apparatus of FIGURE 1 with a different type of ventilator than shown in FIGURE 1.

FIGURE 2 is a schematic representation showing cross-sectional views of the gas balance valve assembly, the jet assembly, and the pneumatic bag utilized in the assembly shown in FIGURE 1.

FIGURE 3 is a schematic illustration partly in cross-section of apparatus incorporating the present invention for use as a resuscitator.

FIGURE 4 is a side elevational view showing the resuscitator in FIGURE 3 in use.

In general, the anesthesia apparatus consists of a supply of anesthesia gas. Piping is provided which forms a closed loop anesthesia breathing circuit. Means is provided for connecting the anesthesia gas into the piping. Valve means is disposed in the piping and permits the gas to flow in only one direction of the piping. A patient adaptor is connected into the piping for receiving the gas and for delivering it to the patient. A pneumatic bag is connected into the piping with the interior of the bag being in communication with the gas in the piping. Means is provided for periodically compressing the bag to expel the gases contained therein into the piping and to cause the gas to circulate through said piping. Gas valve balance means is connected into the piping to prevent overpressures. The pneumatic bag and certain other parts of the apparatus can be utilized as a resuscitator.

More particularly, the anesthesia apparatus shown in FIGURE 1 consists of piping **11** which forms a closed loop or anesthesia breathing circle. The piping **11** consists of one section **13** which is connected to one arm of a four-armed fitting **14**. The anesthesia gas to be delivered to the patient is supplied to an inlet **16** provided on the fitting **14** so that the anesthesia gas is delivered to the piping **11** to the patient through a directional valve **17**. The valve **17** includes a valve member **18** movable between open and closed positions and is movable to permit the anesthesia gas to be delivered to the patient's airway by fitting **19** during the inspiratory phase. During the expiratory phase, the exhaled gases pass through a directional valve **21** which includes a valve member **22** movable between open and closed positions and which is movable to permit the exhaled gases to flow in a clockwise direction as viewed in FIGURE 1 into another section **23** of the piping **11**. The valves **17** and **21** serve to prevent return of expired gases by preventing counter-clockwise flow of the gases in the piping **11**. The section **23** of the piping **11** is connected to an absorber **24** of a conventional type. The absorber is connected by a section **26** of the piping **11** to one of the arms of the fitting **14** to thereby provide a closed circuit through which the gases can pass.

A pneumatic bag assembly **28** is connected by piping **29** to another leg of the fitting **14** as shown particularly in FIGURE 1. The pneumatic bag assembly **28** consists of an inner flexible, distensible, collapsible bag **31** and a substantially non-extensible, clear plastic outer bag **32**. As can be seen in FIGURE 1, the bags **31** and **32** are generally ovoid in shape with the inner bag being substantially smaller than the outer bag. the outer bag is provided with fittings **33** and **34** in which the ends of the outer bag are disposed. One end of the inner bag **31** also opens into the end fitting **34**. The end fitting **34** is connected to the fitting **14** by the piping **29** hereinbefore described.

Mechanically operated means is provided for periodically causing relative movement of fluid with respect to the space provided between the inner bag **31** and the outer bag **32**. Such means can consist of a ventilating assembly **36** for supplying fluid under pressure to this space. The ventilating assembly **36** can be of any suitable type such as pressure limited or a volume limited ventilator. A pressure limited respirator is disclosed in U.S. Letters Patent 3,068,856. Such a ventilating assembly can consist of a respirator **37** which, as described in Patent No.

3,068,856, comprises main control valve means movable between open and closed positions to control the flow of gas through the respirator to the outlet. The control valve means is open during the inhalation phase of the respirator and is in a closed position during the exhalation phase of the respirator. The respirator **37** is supplied with air as indicated and this air under the control of the main control valve means in the respirator is supplied to the large tube **38** which is connected to a nebulizer **39** of the type described in U.S. Letters Patent 3,172,406. The nebulizer **39** is connected to an exhalation valve assembly **41**. A small tube **42** is also connected to the respirator **37** and is supplied with gas under positive pressure when the main control valve in the respirator **37** is open. The tube **42** is connected to a T **43** and gas from the line **42** is supplied to a conduit **44** which is connected to the exhalation valve assembly **41** and serves to hold the exhalation valve assembly **41** in a closed position during the time that the main control valve in the respirator **37** is open. Positive pressure is also supplied by the tube **46** to the nebulizer **39**. The gas under pressure is also supplied to another conduit **47** which is connected to a gas balance valve assembly **48** mounted upon the fitting **14**. The exhalation valve assembly **41** includes a retarder cap **49** of a type also described in Patent No. 3,234,932.

Alternatively, in place of the respirator **37**, the nebulizer **39** and the exhalation valve **41**, a ventilator **51** of the type described in copending application Ser. No. 601,770, filed Dec. 14, 1966, as shown in FIGURE 1A can be utilized. As described in that copending application, this ventilator is also operated by air under pressure applied to an inlet fitting **53** and periodically supplies air under pressure to an outlet fitting **54**. The ventilator **51** is provided with three separate control knobs **56**, **57** and **58**. The control knob **56** controls the inspiratory time. The control knob **57** controls the expiratory time, and the control knob **58** controls the rate of flow and downstream pressure.

The outlet fitting **54** is connected to a T **61** by a tube **62**. One leg of the T **61** is connected to a tube **63** which is adapted to be connected to the anesthesia gas valve in the same manner that the tube **47** is connected thereto. the other leg of the T is connected to a tube **64** which is connected to a venturi assembly **66**. The venturi assembly is connected to one end of a pneumatic bag assembly **28** identical to the pneumatic bag **28** previously described. The other end of the pneumatic bag **28** is connected to a tube **68** which is adapted to be connected to the fitting **14** in the same manner as tube **29** is connected thereto.

The gas balance valve **48** is shown in detail in FIGURE 2 and consists of a valve body **71** which is provided with an annular inclined seat **72** and an outlet passage **73**. The valve body is also provided with an extension **71***a* which is adapted to fit over one leg of the fitting **14** as shown particularly in FIGURE 2. A diaphragm housing **76** is threaded into the valve body **71**. A plunger **77** is slidably mounted in the housing **76** and has the inner central portion of a diaphragm **78** resting against it. The outer annular margin of the diaphragm **78** is secured between the diaphragm housing **76** and a cap **79** threaded into the diaphragm housing **76**. Means is provided for yieldably urging the plunger **77** and the inner portion of the diaphragm carried thereby in a direction towards the cap **79** and consists of a helical spring **81** which is concentric with the plunger and is disposed in a well **82** provided in the diaphragm housing **76**. One end of the spring engages the housing **76**, whereas the other end of the spring engages a flange **83** provided on the plunger **77**. The well **82** within the housing **76** opens into the valve body **71** through a passage **84**.

Valve member **86** is disposed within the valve body and is movable between open and closed positions with respect to the valve seat **72**. The valve member **86** is carried by a valve stem **87** which is slidably disposed within the plunger **77**. Means is provided for yieldably urging the valve member **86** in a direction towards a valve seat with respect to the plunger **77** and consists of a spring **88** which is mounted on the stem **87** and in a well **89** provided in the plunger **77**. One end of the spring engages a shoulder **89** in well **90**, whereas the other end of the spring engages the valve member **86**. The interior of the valve body is open to the atmosphere through vents **91** provided in the valve body.

A thumb screw **92** is threaded into the cap **79** and carries a screw **93** which is threaded therein which is adapted to engage the diaphragm **78** and the plunger **77** for a purpose hereinafter described. An inlet fitting **96** is threaded into the cap **79** and has a passage **97** therein which is in communication with a passage **98** provided in the cap and into the space **99** provided between the diaphragm **78** and the cap **79**.

The venturi assembly **66** consists of a venturi tube **101** which is provided with a venturi-like passage **102** therein. As shown particularly in FIGURE 2, the tube is provided with an annular recess **104** which is adapted to receive standard 15 mm. intubation and tracheostomy attachments and an outer diameter is designed to fit standard face masks and the pneumatic bag assembly **28**. The venturi tube **101** is threaded into a jet cap assembly **106**. It consists of a body **107** which is provided with a cylindrical recess **108** which is in axial alignment with the venturi passage **102** in the venturi tube **101**. A jet nozzle **109** is threaded into the body and is provided with a central passage **110** therein terminating in a nozzle **111**. The passage **110** is in axial alignment with the passage **102** in the tube **101**. An inlet fitting **112** is threaded into the body **107** and communicates with an annular passage **113** provided in the nozzle **109**. A plurality of additional passages **114** are provided in the nozzle **109** and encircle the central passage **110** and provide high range flow jets as an alternate to the low range flow of the main jet from the passage **110** for causing entrainment flow through the venturi passage **102**.

A cylindrical muffler **116** is mounted on the jet cap assembly **106** and is provided with an end cap **117** which is provided with a pair of holes **118** and **119** that open to the atmosphere and which are also of sufficient size to permit tubes to enter therethrough to be connected to the nozzle **109** and to the fitting **112** or central passage **110**. As shown in FIGURE 2, the tube **64** enters the hole **119** and is connected to the auxiliary high range converging jets **114** of nozzle **109**. The body **107** of the cap assembly **106** is provided with flats (not shown) which provide passages (not shown) which open into the space **121** provided in the muffler **116**. Thus, the venturi passage **102** is open to the atmosphere through the body **107** through the space **112** through the holes **118** and **119** provided in the cap **117**.

Operation of the apparatus shown in FIGURES 1 and 2 may now be briefly described as follows. Let it be assumed that the anesthesia apparatus which is shown in FIGURE 1 is connected to the patient and is connected to a supply of anesthesia gas and that the respirator **37**, the nebulizer **39** and the exhalation valve **41** are being utilized for operating the pneumatic bag. The respirator **37** is placed in operation in a conventional manner as described in Patent No. 3,068,856 so that it is passing through an inspiratory phase and an exhalation phase periodically and in sequence. During the inspiratory phase, air is supplied through the large tube **38** under a positive pressure and at the same time air is also supplied through the smaller tube **42** under a positive pressure. This positive pressure in the tube **42** is supplied to the exhalation valve assembly **41** which maintains the exhalation valve assembly in a closed position. A positive pressure is also supplied through the tube **46** to the nebulizer **39**. However, in this application, the nebulizer **39** will not be filled with fluid. The positive pressure is also introduced into the common line or conduit **47** to the gas balance valve **48** and supplies gas under pressure to the space **99** to apply a pressure on the diaphragm **78** to urge the plunger **77** against the force of the spring **81** upwards as viewed in FIGURE 2 which applies a force to the spring **88**

which, in turn, urges the valve seat **86** into sealing engagement with the valve seat **72** of the valve body **71** to retain the valve seat in a closed position. When the valve is in this position, anesthesia gases which are being introduced into the fitting **14** from the supply of anesthesia gases cannot escape from the loop or circle **12** to the atmosphere. This valve is held closed during inspiration as the upper end of plunger **77** presses against valve member **86**.

The air under positive pressure which is supplied through the large tube **38** passes through the nebulizer **39** into the exhalation valve assembly **41** and into the outer bag **32** of the pneumatic bag assembly **28**. This outer bag **32** is expanded to its limits and pressure is exerted on the outer surfaces of the inner bag to cause the inner bag to be compressed and to cause the gases contained therein to be forced into the large tube **29** and into the fitting **14** where they pass into the loop or circle **12** in a clockwise direction. These gases are then forced through the directional valve **17** into the patient adaptor **19** and into the airway of the patient. Because of the uniform pressure which is applied to the inner bag, a substantially laminar flow of gases under Pascal's law is supplied to the patient.

After completion of the inspiratory phase as determined by the respirator **37**, the gases under positive pressure are removed from the large tube **38** and from the small tube **42**. As soon as this occurs, the pressure is removed from the exhalation valve assembly **41** and the exhalation valve is permitted to open and the air which is contained within the outer bag **32** exhausts to the atmosphere through the exhalation valve as described in Patent No. 3,068,856.

As soon as the expiratory phase commences, the patient begins to exhale and the exhaled gases close the valve member **18** of the directional valve **17** to prevent counterclockwise flow of the exhaled gases and opens the valve member **22** of the directional valve **21** to permit the exhaled gases to pass into the tube section **23** and to pass through the soda/lime absorber **24** which removes the carbon dioxide. These gases then pass into the fitting **14** where they can refill the inner reservoir bag **31** and be recirculated through the piping **11**. Anesthesia gases are being introduced at a continuous rate during the inspiratory and expiratory phases into the fitting **14**. However, the gas balance valve **48** serves to balance the anesthesia gases on a breath-to-breath basis to prevent overfilling of the anesthesia circuit regardless of the inflow of the anesthesia gases.

As pointed out previously, during the inspiratory phase, the valve **48** is pneumatically closed and held in a closed position so that the anesthesia gases cannot escape from the circuit. During the initiation of the expiratory phase, the gas under positive pressure is removed and is permitted to bleed off through the line **46** through the nebulizer **39**. This removal of the positive pressure from the space **99** within the gas valve permits the spring **81** to urge the plunger **77** down as viewed in FIGURE 2 and to thereby remove plunger **77** from physical contact with valve member **86**. By ways of example, the force is reduced so that the valve member **86** will open against the small spring **88** and release gas from the closed circuit whenever the pressures within the system are above a pressure which is equivalent to 5 cm. of water. The lighter spring **88** returns the valve **86** to a closed position as soon as the pressure within the system is reduced to below this predetermined pressure. The excess gases which are released by the valve member **86** are vented to the atmosphere through the ports **91** provided in the valve body **71**.

Also, during the expiratory phase, the inner bag **31** again becomes filled with the pressurized anesthesia gases contained within the piping **11** because the pressure previously applied by the gases within the outer bag **32** has been removed.

When the expiratory or exhalation phase has been completed, the controller **37** again initiates the inspiratory phase which supplies gases under positive pressure to the large tube **38** and the small tube **42** to again initiate the inspiratory phase and to supply additional anesthesia gases to the airway of the patient.

If it is desired to operate the apparatus manually rather than automatically by use of the respirator **37**, the thumb screw **92** is rotated so that it engages the diaphragm **78** and moves the plunger **77** upwards (FIGURE 2) to maintain the valve member **86** in a closed position. The anesthetist may then use conventional procedures and apply manual force to the inner bag **31** with his hands by squeezing transparent bag **32** and control the supply of the anesthetic gases to the patient by visually observing the patient and supplying the gases to the patient by periodically pressurizing the inner bag **31**. The patient may respire spontaneously in and out of the inner bag **31** without impairment of any kind. For this reason, the use of the bag assembly **28** does not interfere with the conventional anesthesia practice if the anesthetist wishes to utilize the same.

It should be pointed out that even during mechanical operation of the apparatus by use of the respirator **37**, the anesthetist may squeeze either the inner bag **31** or the outer bag **32** with his hand or may superimpose pressure manually on the volume of air or gas separating the bags **31** and **32** to compress the inner bag **31**. The outer bag **32** is less distensible than the inner bag **31** but is almost equally collapsible and thereby enables the anesthetist to increase pressures without major distention of the outer bag. The outer bag **32**, which is preferably transparent so that the anesthetist can visually observe the action of the inner bag **31**, makes it possible for the anesthetist to have direct immediate manual control over the patient ventilation during any phase of operation of the respirator **37** or when the patient is apneic or is breathing spontaneously.

In general, it can be stated that the double wall pneumatic bag assembly **28** can be utilized in any existing anesthesia apparatus or gas machine or pulmonary ventilator. The inner bag **31**, can in addition to being able to be compressed by a positive pressure by gases supplied to the space between the inner bag **31** and the outer bag **32**, also be compressed by a negative pressure. This can be accomplished by withdrawing gases from within the outer bag **32** to cause the atmospheric pressures to apply pressure to collapse the outer bag **32** about the inner bag **31** and to apply pressure to the inner bag **31** to expel the gases therefrom in the same manner as if gases under positive pressures were supplied to the outer bag **32**. As can be appreciated, this latter action could not be obtained by the use of a rigid outer canister which does not collapse.

Operation of the anesthesia apparatus with the ventilator **51** and the venturi assembly **56** may now be briefly described as follows. As pointed out in copending application Ser. No. 601,770, filed Dec. 14, 1966, the ventilator **51** is set by adjusting the controls **56**, **57** and **58**. A controlled respiratory rate is established for starting mechanical ventilation. Inspiratory/expiratory time ratios can be easily established by simple adjustment to the respective control knobs. Maximum inspiratory pressure can be easily regulated to meet the existing pulmonary resistances by adjustment of the knob **58**. During the inspiratory phase, air under positive pressure is supplied to the T **61** which supplies air under pressure to the conduit or line **63** to the gas balance valve **48** to close the same in a manner hereinbefore described. Gas under positive pressure is also supplied to the tube **64** which is connected to the jet nozzle **109** which introduces a jet of air through the venturi passage **102**. In a manner well known to those skilled in the art, this jet of air causes aspiration of additional atmospheric gases into the venturi tube **102** to supply gas under positive pressure into the space in the outer bag **32**. This causes the outer bag to be extended to its maximum limits and to thereafter ap-

ply a pressure to the inner bag **31** to compress the same to cause the anesthesia gases contained therein to be expelled into the breathing circuit **12** and to be supplied to the airways of the patient in a manner hereinbefore described in conjunction with the operation of the respirator **37**. Low and high range pressure limits may be established by connecting tube **64** to passages **110** and **113** through their respective nipple fittings **111** and **112**. The venturi assembly **66** serves as a pressure limiting device because only a certain predetermined safe pressure can be developed by the jet or jets of air passing through the venturi **102** and this, in turn, limits the volume together with inspiratory time to a predetermined volume which can be delivered to the patient during the inspiratory phase. Any excess gas which may be contained in the bag **31** above a predetermined pressure will be exhausted to the atmosphere through a safety relief valve (not shown) found on any anesthesia gas machine. The patient may breathe spontaneously without interference from the bag **28** because the space between the inner bag **31** and the outer bag **32** is vented to the atmosphere through the venturi assembly **66**, and this vent acts as a safety or relief valve in respect to the mechanical ventilator circuit.

In the event there is a high pulmonary resistance by the patient, this can be overcome by using the auxiliary dual jets by connecting the tube **64** to the fitting **112**. This causes additional jets of air to be directed into the venturi passage **102** to increase the clutching pressure which can be developed by the venturi assembly **66** which should be more than enough to overcome any high pulmonary resistance which may be encountered.

During manual operation, the gas balance valve **48** must be locked in a closed position because if this were not done anesthesia gas would be purged from the system during the inspiratory phase when pressures exceeded 5 cm. of water. In place of the gas balance valve **48**, a conventional anesthesia bleed valve would be used. The bag **28** can be readily removed at any time and steriilzed in a conventional manner.

As the outer bag **32** is taking shape, it creates a clutching action at the start of the inspiratory phase which thereafter is complemented by the clutching action of the venturi jet assembly. At the initiation of the inspiratory phase, the venturi clutch effect is at its minimum and gradually increases and therefore complements the clutching action which is provided by the outer bag. The venturi clutch effect provided by the outer bag **32** can be enhanced by making the outer bag **32** more elastic.

When a venturi assembly is used, the venturi assembly acts as a permanent relief valve and minimizes expiratory resistance. In place of the single venturi system herein described, a double venturi system, that is having two opposing venturis or one positive and one negative venturi, may be utilized to ventilate the space provided between the two bags **31** and **32** and at the peak of inspiration, the volume could be evacuated to cause initial rapid expiration. Alternatively, a mechanical weight could be placed on the tail of the bag assembly **28** hanging in a vertical direction to introduce a lateral force arm on the inner bag to establish expiratory resistance. Similarly, a mechanical retard could be placed on the openings of the venturi assembly to the atmosphere to also establish expiratory resistance. This could take the form of a cap such as cap **49** provided on the exhalation valve assembly mounted on the end of the tube **116**.

Alternatively, a piston-type pump could be utilized for filling the space provided between the bags **31** and **32**. Upon the return stroke of the piston, the gas would be withdrawn from the space between the bags **31** and **32** to initiate a rapid exhalation phase. It may be desirable to provide a reverse relief valve which allows a predetermined maximum such as 2 cm. of water differential or less between the ambient and the pressure within the space between the bags **31** and **32**.

After the completion of the inspiratory phase, the ventilator **51** no longer supplies air under positive pressure to the T **61** and vents the positive pressure to the atmosphere as described in copending application Ser. No. 601, 770, filed on Dec. 14, 1966. This initiates the expiratory phase and permits the space between the inner bag **31** and the outer bag **32** to be emptied to the atmosphere through the venturi jet assembly **66**. This permits the patient to exhale into the inner bag **31** in the manner hereinbefore described in connection with the respirator **37**. After the expiratory phase is completed, the inspiratory phase is again initiated by supplying of air under positive pressure to the T **61** and the same sequence of operation as hereinbefore described is repeated.

The ventilator **51** in conjunction with the venturi assembly **66** can be utilized as a simple resusitator merely by connecting the open end of the venturi tube **101** to a suitable patient adaptor such as a conventional face mask mouthpiece or an in-dwelling airway catheter. Upon operation of the ventilator in the manner hereinbefore described, resuscitation can be applied to the patient. Air is supplied by the ventilator through the tube **64** to the venturi assembly **66** and passes through the nozzle **109** through the venturi passage **102** into the patient adaptor and into the airway of the patient. Air is supplied to the airway of the patient through the venturi passage **102** until a pre-established clutching pressure is reached or until termination of the expiratory phase by the ventilator **51**. Tidal volume is established against existing pulmonary resistances of the patient by either reaching the clutching pressure of the venturi or by the mechanical termination of the inspiratory phase. The patient exhales passively through the venturi tube **101** which is open to the atmosphere during the expiratory phase. Spontaneous respiration by the patient can be acommodated through the open venturi tube **101**.

It can be seen that this apparatus is very simple and is one which prevents any possible airway obstruction from mechanical valve failure because there are no valves which can fail. The apparatus, therefore, provides a very simplified means of controlling respiration during temporary respiratory embarrassment.

The ventilator **51** in conjunction with the venturi assembly **62** can also be used with a pnuematic bag assembly **28** of the type hereinbefore described with the bag **28** being connected to the patient adapter such as a face mask **131** shown in FIGURE 3 of the drawings. In this embodiment of the invention, the inner bag **31** would be in the form of a self-filling compression bulb and is attached to a valve assembly **132** connected to the face mask **131**. The valve assembly **132** consists of body **133** which is secured to the bags **31** and **32** by a ring **134**. The body is formed with a flow passage **136** encircled by a seat **137** and which can be closed by a valve member **138** engaging the seat. The valve member **138** is carried by a plunger **139** slidably mounted on the body **133**. Spring means in the form of a spring **141** yieldably urges the valve member **138** to an open position. A hole **142** in the body **133** establishes communication with the mask **131** and an opening **143** opens to the atmosphere. Means is provided for enriching the air in the inner bag **31** with oxygen and consists of a tube **146** connected to a source of oxygen. The tube **146** is connected to a soft plastic tube **147** mounted on the valve assembly **132**. A collapsible end fitting **148** is mounted on the end of tube **147** and prevents escape of oxygen through the tube **147** when the inner bag **31** contains pressure. For semi-automatic operation, the bag assembly **28** is connected to the venturi assembly **66** by the ring **149**.

With the apparatus shown in FIGURE 3 either manual or automatic ventilation or resuscitation can be conducted for the patient. The compression bulb or inner bag **31** can be manually compressed by hand or can be automatically compressed by pressurization of the space between the bags **31** and **32** by the passage of air into the space from the ventilator **51** during the inspiratory phase. This causes the air contained in the inner bag **31** to be forced

toward the valve member **138** and to snap the valve member **138** into a closed position. The air then passes into the mask **131** and into the airway of the patient. Upon initiation of the expiratory phase by the ventilator **51**, the space between the bags **31** and **32** is evacuated and the bulb **31** is permitted to fill automatically from the atmosphere as the valve member **138** of the valve assembly **132** opens. The valve member **138** remains open to ambient at the end of the expiratory phase. Upon initiation of the inspiratory phase, the same cycle is repeated. Thus, it can be seen that this repetitious cyclic controlled ventilating process of the patient is under the control of the ventilator **51** but may be overridden at any time by manual compression of the bag **28**.

From the foregoing, it can be seen that there has been provided novel apparatus which is particularly adapted for use in connection with anesthesia and for resuscitation. The apparatus is relatively simple and inexpensive and can be operated by relatively unskilled personnel.

We claim:

1. In apparatus of the character described, a patient adapter, a pneumatic bag assembly connected to the patient adapter, the bag assembly comprising an inner bag having an opening in communication with the patient adapter and an outer bag surrounding the inner bag and having an opening sealed to and about the inner bag to provide a space between the inner and the outer bag, said outer bag having an additional opening in communication with the space between the inner bag and the outer bag, and means connected to the outer bag and in communication with the additional opening for causing a pressure differential between the inner and outer bags to thereby cause the inner bag to be compressed and the fluid within the inner bag to be expelled into the patient adapter.

2. Apparatus as in claim **1** wherein said means connected to the additional opening includes means for cyclic application of a fluid under pressure to said space.

3. Apparatus as in claim **1** wherein said means connected to the additional opening includes means for cyclic application of a vacuum to said space.

4. Apparatus as in claim **1** wherein said outer bag is formed of a substantially transparent, relatively non-extensible material.

5. Apparatus as in claim **2** wherein the means for cyclic application of fluid under pressure to said space consists of a ventilator having a controlled inspiratory time and a controlled expiratory time.

6. Apparatus as in claim **2** wherein the means for cyclic application of fluid includes means for time cycling and means for limiting the pressure of the fluid.

7. Apparatus as in claim **2** together with a venturi assembly connected between the means for cyclic application of fluid under pressure and the additional opening of the bag assembly, said venturi assembly comprising a venturi passage, a nozzle positioned to direct a jet stream through the venturi passage and means connecting the fluid supply to the nozzle, one end of said venturi passage opening into the space between said inner and said outer bags and the other end of the venturi passage opening to the atmosphere.

8. In an apparatus for administering anesthesia, piping forming a closed loop anesthesia breathing circuit, a supply of anesthesia gas, means connecting said supply of anesthesia gas to said piping to feed a controlled amount of anesthesia gas into said piping, valve means disposed in the piping permitting the gas to flow in only one direction in the piping, a patient adapter connected into the piping and adapted to be connected to the airway of the patient for supplying gas from the piping and delivering it to the airway of the patient, a bag assembly connected into the piping, said bag assembly comprising an inner collapsible substantially non-porous bag having a single opening therein in communication with the piping and an outer substantially non-extensible, non-porous, collapsible bag surrounding the inner bag and having two openings therein with one of the openings sealed to the inner bag to form a space between the inner bag and the outer bag and means connected to the outer bag and in communication with the other openings of the outer bag for causing relative movement of fluid with respect to the space provided between the inner bag and the outer bag to cause compression of the inner bag and to thereby cause the gases contained therein to be expelled into the piping.

9. Apparatus as in claim **8** wherein said means for causing relative movement of fluid in said space provided between the inner bag and the outer bag consists of mechanical means for supplying a fluid under pressure to said space together with means actuated at a predetermined pressure for venting said piping to a predetermined expiratory pressure above atmospheric pressure.

10. Apparatus as in claim **9** wherein said means for supplying a fluid under positive pressure to said space between said inner bag and said outer bag has a controlled cyclic action in which there is an inspiratory phase and an expiratory phase, and wherein said means for supplying a fluid under positive pressure includes means effective during the inspiratory phase for preventing said means for venting said piping from venting to the atmosphere during the inspiratory phase.

11. Apparatus as in claim **9** together with a venturi assembly connected between said means for supplying fluid under pressure to said space between the inner and outer bags, said venturi assembly comprising a venturi passage, a nozzle aligned with said passage and for supplying a jet of air into said passage to supply air under positive pressure to the space between said inner and outer bags, one end of said venturi passage being open to the atmosphere and the other end opening into said space, the pressure of the fluid supplied to the space between the inner and outer bags being controlled solely by the clutching action of the venturi assembly.

12. Apparatus as in claim **8** wherein said outer bag is substantially transparent and non-extensible and wherein said inner bag is relatively opaque.

13. Apparatus as in claim **8** wherein said means for venting said piping comprises a valve body having a passage in communication with said piping, valve means mounted in said valve body movable between open and closed positions with respect to said passage, a housing mounted in said body, a plunger slidably mounted in said housing, a diaphragm having its inner portion positioned to apply a force to said plunger, a cap mounted on said housing and retaining the outer annular margin of said diaphragm in engagement with the housing and forming a space between the diaphragm and the cap, yieldable means retaining said valve means in a closed position and wherein said means for supplying fluid under positive pressure to said means for venting said piping is in communication with the space provided between the diaphragm and the cap for retaining the valve means in a closed position during application of fluid under positive pressure to said last named space, and adjustable means carried by the cap movable into engagement with the valve means for preventing movement of said valve means from the closed position.

14. In apparatus for administering anesthesia, piping forming a closed loop anesthesia breathing circuit, a supply of anesthesia gas, means connecting said supply of anesthesia gas to said piping to feed a controlled amount of the anesthesia gas into said piping, a patient adapter connected into the piping and adapted to be connected to the airway of the patient for supplying gas from the piping and delivering it to the airway of the patient, an outer container, an inner collapsible, substantially non-porous bag disposed within said container and forming a space between the outer container and the inner container, said container and said bag having a common opening sealed with respect to each other and connected into said piping, said container having an additional open-

ing in communication with the space between the bag and the container, mechanical means having an inspiratory phase and an expiratory phase connected to the container and in communication with the other opening of the container for causing relative movement of fluid with respect to said space to cause compression of the inner bag and to cause gases contained therein to be expelled into the piping, and gas balance means connected to said piping for providing breath-to-breath balancing of the gases in said piping, said gas balance valve including means for preventing gases from escaping from the piping during the inspiratory phase, means for automatically exhausting excess exhaled gases and excess anesthesia gases introduced during the respiratory pattern, and means for maintaining a predetermined positive pressure in the circuit during the expiratory phase.

15. Apparatus as in claim **14** wherein said gas balance valve includes valve means movable between open and closed positions, said valve means in a closed position serving to prevent the escape of gases from the piping through the gas balance value and in an open position

permitting the escape of gases from the piping through the gas balance valve, and wherein said means for preventing the escape of gases through the gas balance valve during the inspiratory phase includes means connected to the mechanically operated means for supplying a fluid under pressure to the gas balance valve to retain the valve means of the gas balance valve in a closed position during the inspiratory phase of the mechanically operated means.

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