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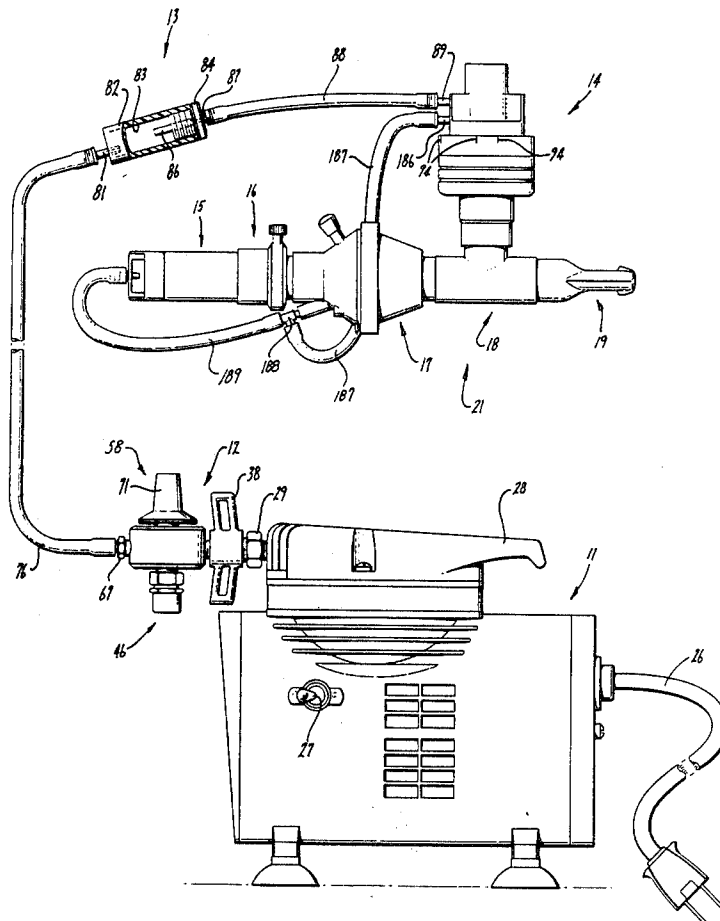
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[54] **RESPIRATORY APPARATUS**
18 Claims, 6 Drawing Figs.

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[51] Int. Cl. **A62b 7/00**
[50] Field of Search. **128/145.5,**
145.6, 145.7, 145.8, 142, 142.2, 142.3, 140;
137/63 R, 494; 251/65

ABSTRACT: Respiratory apparatus having a patient adapter in the form of a mouthpiece and a servocontrol valve assembly and exhaust valve assembly mounted on the mouthpiece and carried by the mouthpiece for controlling the inhalation phase and the exhalation phase of the respiratory apparatus.



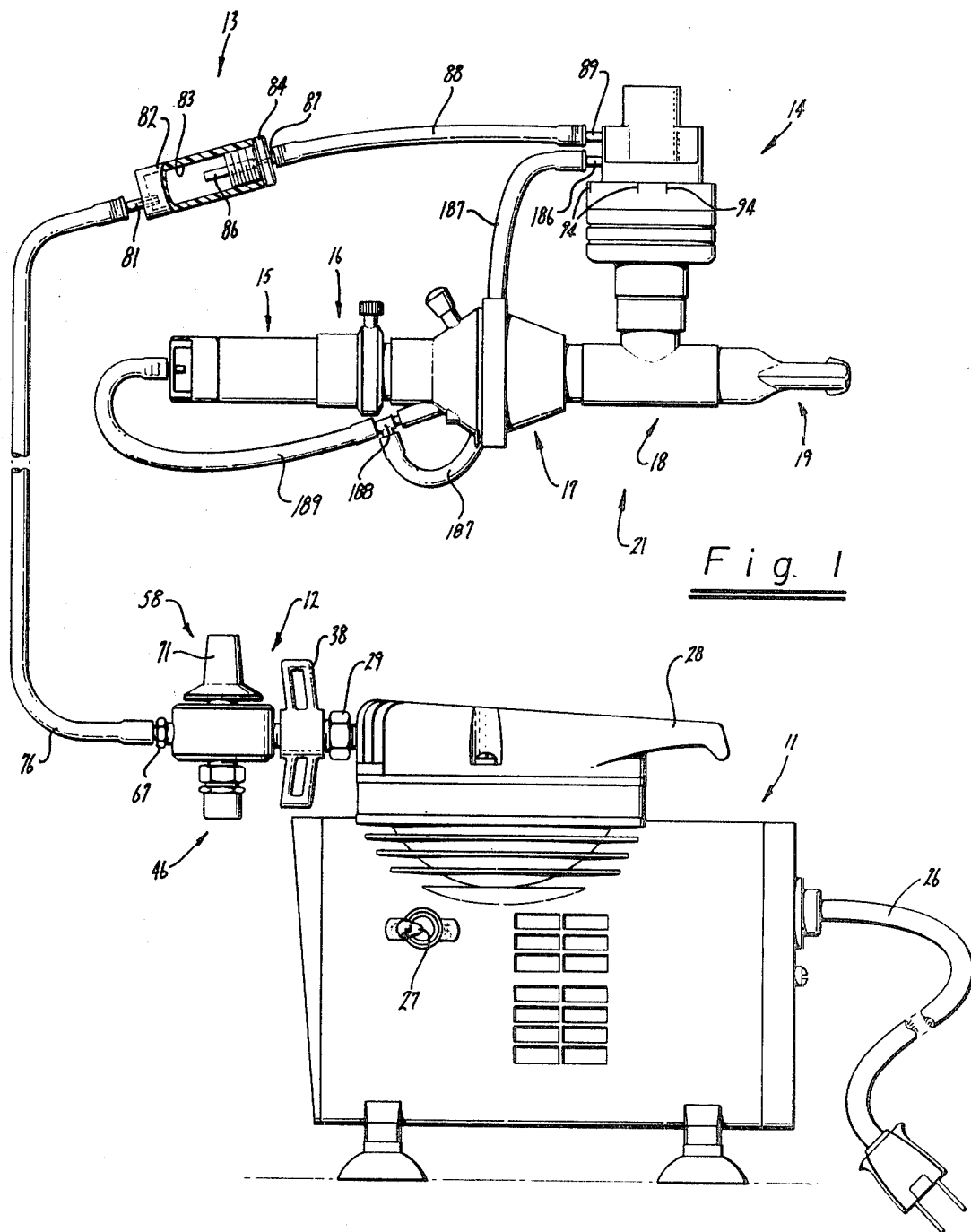


Fig. 1

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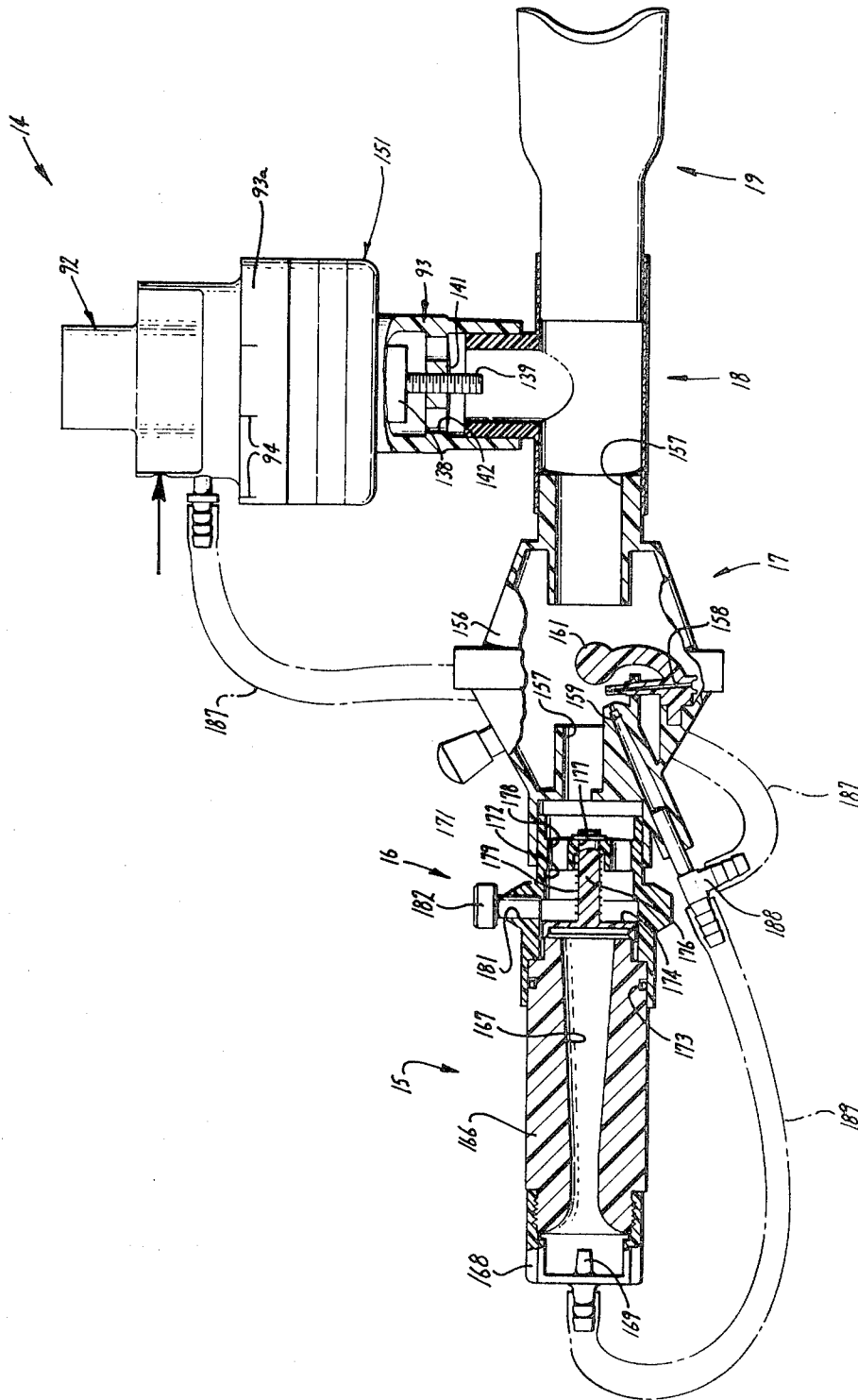


Fig. 2

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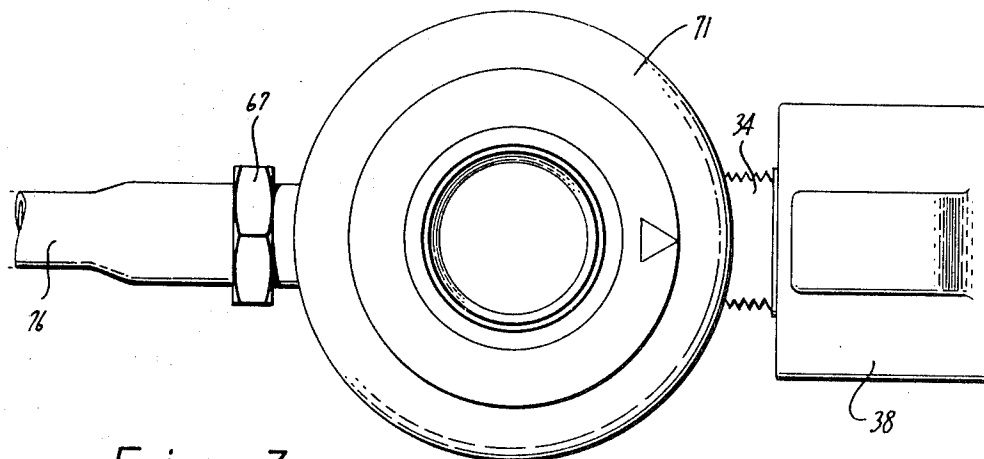


Fig. 3

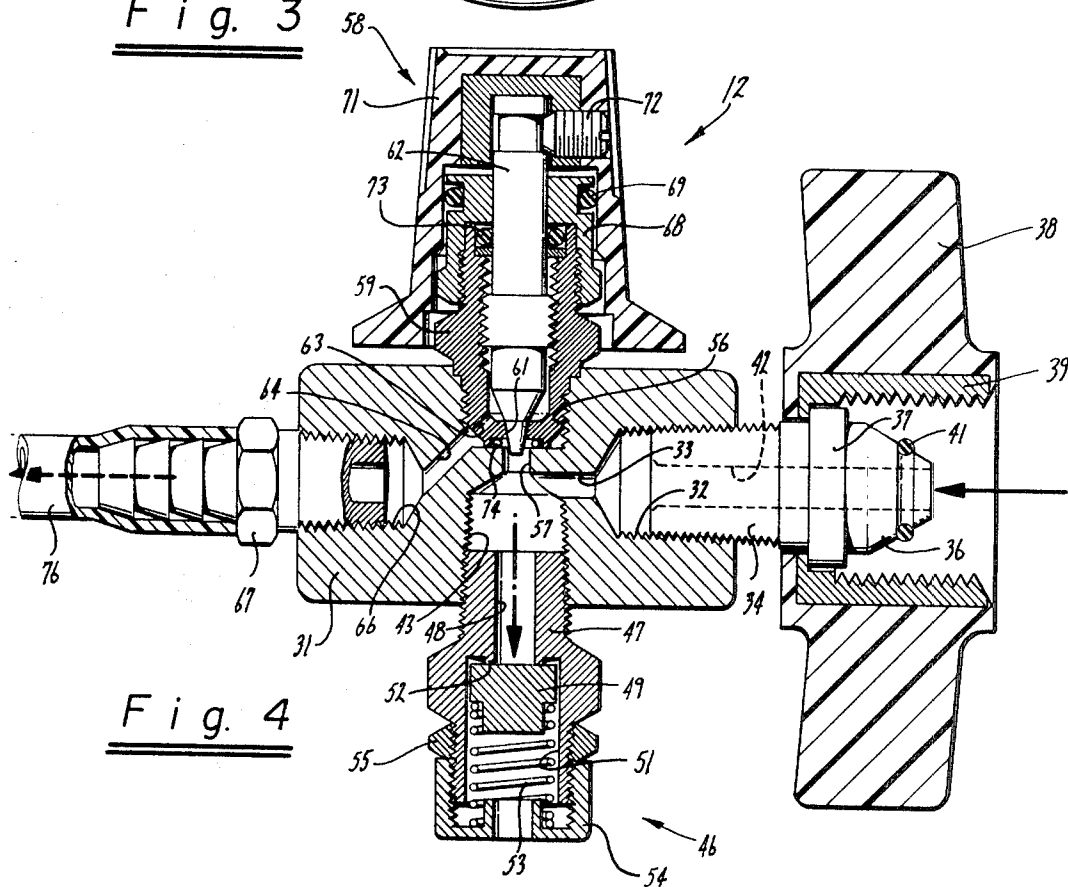


Fig. 4

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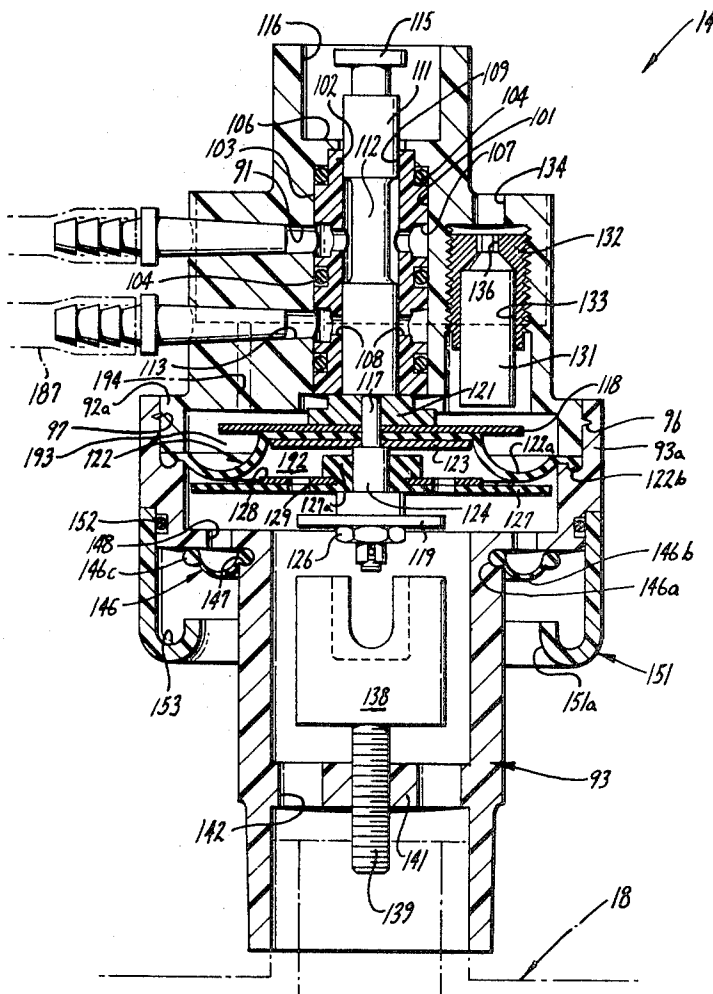


Fig. 5

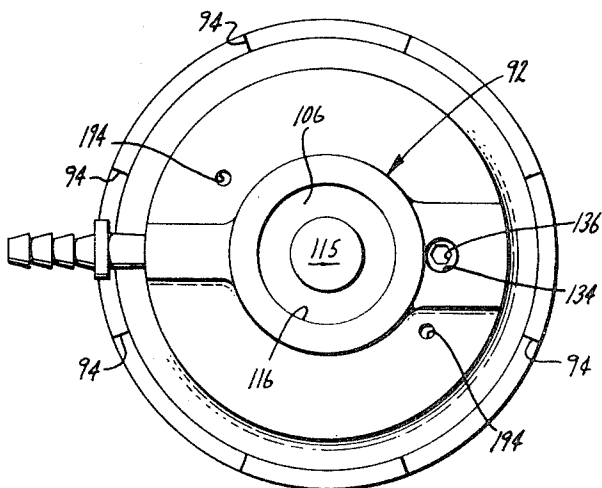


Fig. 6

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RESPIRATORY APPARATUS

BACKGROUND OF THE INVENTION

Respiratory apparatus has heretofore been developed. However, such apparatus has not been particularly adapted for home use. In addition, even in hospitals there has not been available a lightweight, portable, ethical, respiratory apparatus. There is, therefore, a need for a new and improved respiratory apparatus.

SUMMARY OF THE INVENTION AND OBJECTS

The respiratory apparatus has an inhalation phase and an exhalation phase in its operative cycle. It consists of a servocontrol assembly having an inlet adapted to be connected to a source of gas under pressure which interrupts the flow of relatively high pressure gas from the source. The control assembly is provided with an outlet adapted to be connected to the airway of the patient. Typically, the outlet supplies a venturi assembly and a micronebulizer to provide the inspiratory gas to the patient within physiological limits. A control valve is provided in the servocontrol assembly and is movable between open and closed positions to control the flow of gas from the inlet to the outlet. Means is also provided for operating the control valve so that it is in the open position in the inhalation phase and in the closed position during the exhalation phase. A diaphragm connected to the control valve is disposed in the servocontrol assembly and forms first and second chambers therein. The first chamber is open to the atmosphere. The servocontrol assembly has a passage therein establishing communication of the second chamber with the airway of the patient and an opening therein for establishing communication of the second chamber with the atmosphere. Valve means is provided which closes the opening during the inhalation phase and opens the opening during the exhalation phase.

In general, it is an object of the present invention to provide a respiratory apparatus which is particularly adapted for home use.

Another object of the invention is to provide a respiratory apparatus of the above character which is relatively light in weight and which is portable.

Another object of the invention is to provide a respiratory apparatus of the above character in which the sensitivity and patient effort to initiate inspiration as well as peak inspiratory pressure can be readily adjusted.

Another object of the invention is to provide a respiratory apparatus of the above character which can be formed of non-corrosive and long lasting parts and which can be readily disassembled and cleaned.

Another object of the invention is to provide a respiratory apparatus of the above character in which the control valve assembly is carried by the mouthpiece.

Another object of the invention is to provide a respiratory apparatus of the above character which does not require the use of a separate exhalation valve assembly.

Another object of the invention is to provide a respiratory apparatus of the above character that has very few controls and, therefore, particularly lends itself for home use.

Another object of the invention is to provide a respiratory apparatus of the above character which can be utilized while the patient exercises.

Additional objects and features of the invention will appear from the following description in which the preferred embodiment is set forth in detail in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevational view of respiratory apparatus incorporating the present invention.

FIG. 2 is an enlarged detail view of the mouthpiece, the control valve and exhalation assembly, the nebulizer, the venturi assembly and the gate valve assembly which form a part of the respiratory apparatus shown in FIG. 1.

FIG. 3 is a top plan view of the flow rate and relief valve assembly shown in FIG. 1.

FIG. 4 is a cross-sectional view of the control valve assembly shown in FIG. 3.

FIG. 5 is a cross-sectional view of the control and exhaust valve assembly.

FIG. 6 is a top plan view of the control and exhaust valve assembly shown in FIG. 5.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown particularly in FIG. 1, the respiratory apparatus incorporating the present invention consists of a compressor 11, a flow rate and relief valve assembly 12, a water filter 13, a control and exhaust valve assembly 14, a venturi assembly 15, a gate valve assembly 16, a micronebulizer 17, a tee 18 and a mouthpiece 19. The control and exhaust valve assembly 14, the venturi assembly 15, the gate valve assembly 16, the micronebulizer 17, the tee 18 and the mouthpiece 19 can be considered in combination as a breathing head assembly 21.

The compressor 11 is of a conventional type and preferably is a diaphragm-type compressor which is provided with an outlet cord 26 which is adapted to be connected to a conventional source of current such as 110 volts, 60 cycle AC. The compressor is provided with an on-off switch 27 and has a carrying handle 28. The compressor is provided with an output fitting 29 through which air which has been compressed by the compressor is delivered under pressure. The flow rate and relief valve assembly 12 is mounted upon the fitting 29.

The assembly 12 consists of a body 31. The body 31 is provided with a large threaded passage 32 which is in communication with a passage 33. A nipple 34 is threaded into the passage 32. A nose 36 is threaded onto the nipple 34 and carries a collar 37. A wingnut 38 is mounted on the nose 36 and engages the collar. It is provided with a threaded insert 39 which is adapted to be threaded onto the fitting 29 carried by the compressor 11. An O-ring 41 is provided on the nose 36 to establish good sealing contact with an interior surface of the fitting 29. A passage 42 is provided in the nipple 34 and the nose 36 which is in communication with the passage 33.

The body 31 is also provided with a threaded bore 43 which extends in the body generally at right angles to the bore 32 and opens into the passage 33 in the body. A relief valve assembly 46 is threaded into the bore 43 and consists of a nipple 47 which is threaded into the body and which has a passage 48 extending therethrough which is in communication with the passage 33. A valve member 49 is slidably disposed within a bore 51 provided in the nipple and is adapted to engage a raised annular shoulder 52 formed in the nipple. A spring 53 is disposed within the bore 51 and has one end engaging the valve member 52 and yieldably urges the valve member towards a closed position with respect to the shoulder seat 52. The other end of the spring is engaged by a cap 54 which is threaded onto the nipple 47 and is locked in position by lock nut 55 also threaded onto the nipple 47. The cap is positioned so a compressive force is applied by the spring 53 sufficient to prevent opening of the valve member 49 below a predetermined pressure as, for example 40 p.s.i.

The body 31 is provided with an additional threaded bore 56 which is generally in alignment with the threaded bore 43 and which is in communication with a hole 57 which is in communication with the bore 33. A control valve assembly 58 is threaded into the threaded bore 56.

The control valve assembly 58 consists of an adapter 59 which is threaded into the bore 56 and which is provided with a valve seat 61 which is adapted to be engaged by a valve member in the form of a valve stem 62 threaded into the adapter 59. The flow of gas through the hole 57 into the adapter 59 is controlled by means of the adjustable aperture formed by seat 61 and valve stem 62. The gas, after it enters the adapter 59, passes through an opening 63 in the adapter which is in communication with a passage 64 in the body 31. The passage 64 is in communication with a threaded bore 66 also provided in the body 31. A nipple 67 is threaded into the

bore. A sleeve 68 is threaded onto the adapter 59 and carries an O-ring 69. A knob 71 encloses the threaded sleeve 68 and the adapter 59 and is secured to the valve stem by a setscrew 72. Additional O-rings 73 and 74 are provided for establishing seals between the associated parts.

From the foregoing, it can be seen that the flow of gas through the nipple 67 can be readily controlled by operation of the control valve assembly 58 and that overpressures within the passage 33 can be relieved by the relief valve assembly 46.

A long, relatively lightweight length of tubing 76 has one end connected to the fitting 67. The tubing 76 can have a suitable length, such as 15 feet or more, to enable the patient to use a neck brace to hold the breathing assembly 21 in position while he takes physical exercises. The tubing is connected to a fitting 81 which forms a part of the water filter 13. The water filter 13 consists of a cylindrical body 82 which has a fitting 81 mounted thereon. The body 82 is provided with a recess 83 which has a cap 84 threaded therein. A cartridge 86 of a suitable type, such as a filter which is conventionally used in a tobacco pipe, is mounted in the cap 84. A fitting 87 is provided on the cap 84 and is in communication with the fitting 81 through the filter 86. The filter serves to remove any droplets of water from the air which enters the water filter 13. The air is then supplied to the fitting 87 to a tube 88 which has a fitting 89 mounted in the other end thereof. The fitting 89 fits in a tapered bore 91 provided in the control and exhaust valve assembly 14.

The control and exhaust valve assembly 14 consists of first and second or upper and lower body sections 92 and 93. The body sections 92 and 93 are formed of suitable material such as plastic. The first or upper body section is provided with a male skirt portion 92a which is adapted to seat within a female skirt portion 93a of the second body section 93. As can be seen, the skirt portion 93a is provided with slits 94 to facilitate insertion of the male skirt portion into the female skirt portion. In addition, the male skirt portion 92a is provided with an annular ridge 96 which is adapted to seat within an annular recess 97 provided in the female skirt portion 93a so that the two body sections can be snapped together and are held in place by the engagement of the ridge 96 with the groove 97 as shown particularly in FIG. 2.

The upper body section 92 is provided with a bore 101 which receives a spool 102 formed of a suitable material such as ceramic. The spool 102 is provided with three spaced lands 103 which carry O-rings 104 that establish sealing engagement between the lands and the sidewall forming the bore 101. One extremity of the spool is seated against an annular shoulder 106 provided in the body section 92. The spool 102 is provided with a pair of spaced annular recesses 107 which are disposed between the O-rings 104 and a plurality of spaced, radially extending holes 108 which open into the recesses 107 and which also open into a central bore 109 in the spool 102.

A spindle 111, formed of a suitable material such as ceramic, is slidably mounted in the bore 109. The spindle 111 is formed with an elongate annular recess 112. As hereinafter explained, the spindle 111 is adapted to be moved between two positions, one of which prevents the flow of fluid from one annular recess 107 to the other annular recess 107, and the other of which permits such fluid flow. As can be seen from FIG. 2, the tapered bore 91 is in registration with the upper annular recess 107 shown in FIG. 5, whereas the lower annular recess 107 is in communication with a tapered bore 113.

A flanged cap 115 is mounted on the upper end of the spindle 111 in a recess 116 in the body 92 and is secured thereto by a screw 117 which extends through the cap 116 and through the spindle 111. First and second armature plates 118 and 119 are mounted upon the screw 117. As shown in FIG. 5, a flanged spacer 121, formed of a suitable material such as plastic, is disposed between the lower extremity of the spindle 111 and the upper side of the armature plate 118. The inner margin of a control or master diaphragm 122 is clamped against the armature plate 118 by a circular plate 123. Plate 123 is held in place by a bearing spacer 124 which is threaded

onto the screw 117. The second armature plate 119 is held in position against the bearing spacer 124 by a nut 126 threaded onto the screw 117. The master or control diaphragm 122 is formed of a very flexible material and is provided with an annular dish-shaped portion 122a and an outer beaded portion 122b which is clamped between the lower extremity of the first body section 92 and the second body section 93.

A rotor 127 in the form of a flexible circulator disc is slidably and rotatably mounted upon the bearing spacer 124 for movement axially of the postnut. The rotor is formed of a suitable material such as "Silastic" and is provided with a central hub portion 127a. A rigid reinforcing plate 128 is bonded to the upper side of the rotor 127. A pair of spaced holes 129 extend through the plate 128 and the rotor 127.

A sensitivity magnet 131, which is adapted to attract the armature plate 118, is mounted in a magnet holder 132 threaded into a threaded bore 133 provided in the first body section 92. A hole 134 is provided in the body section 92 to permit access to a recess 136 in the magnet holder to permit adjustment of the magnet holder axially of the bore 133 with respect to the armature plate 118.

A pressure magnet 138 is disposed in the second body section 93 in the vicinity of the second armature plate 119 and is mounted upon a threaded shaft 139 which extends through and is threaded into a radially extending wall 141 provided within the second body section 93. The wall is provided with a plurality of circular spaced holes 142 which extend through the wall. The shaft 139 is provided with a slot (not shown) for receiving a screwdriver so that the position of the magnet 138 can be adjusted with respect to the armature plate 119. The magnet 138 is coated with a suitable plastic material so that it is impervious to moisture.

An exhalation valve diaphragm 146 is carried by the second body section 93 and is provided with an inner beaded portion 146a that is disposed within an annular recess 147 provided in the second body section 93. The diaphragm 146 is also provided with an intermediate annular curved portion 146b and an outer beaded portion 146c. As shown in FIG. 2, the outer beaded portion is adapted to engage the lower exterior surface of the second body section 93 so that spaced oval slots 148 provided in the second body section are covered.

A drip-preventing skirt 151 is mounted on the second body section 93 and is frictionally and removably retained thereon by an O-ring 152. As can be seen, the skirt 151 is provided with inwardly and upwardly turned portion 151a which forms a trough 153 for collecting moisture as hereinafter described.

The second body section 93 of the control and exhaust valve assembly 14 is mounted upon the tee 18 as shown. The mouthpiece 19 is mounted on one end of the tee 18, whereas the micronebulizer 17 is mounted on the other end of the tee. The micronebulizer 17 is of a type generally described in U.S. Pat. No. 3,172,406. As described therein, it generally consists of a hollow body 156 which is adapted to carry the liquid which is to be utilized in the micronebulizer. The body is provided with a main flow passage 157 which is adapted to receive liquid from the nebulizer which has been aspirated through a passage 158 by means of a nozzle 159. The liquid impinges upon a ball 161 which breaks it up into small particles to facilitate entraining of the liquid particles in the main airstream passing through the flow passage 157.

The venturi assembly 16 which delivers the main airstream to the micronebulizer 17 consists of a body 166 which has a venturilike passage 167 extending therethrough. A cap 168 is threaded onto the inlet end of the body 166 and carries a nozzle 169 which is adapted to supply a jet of air through the venturilike passage 167.

The outlet end of the venturi assembly is mounted in the gate valve assembly 16. The gate valve assembly 16 consists of a body 171 which has a main passage 172 extending therethrough and which is adapted to communicate with the venturilike passage 167. An O-ring 173 is provided for establishing sealing engagement between the outlet end of the venturi assembly 15 and the inlet end of the gate valve as-

sembly 16. The gate valve 174 is slidably mounted in the passage 172 and carries a stem 176. The stem 176 is slidably mounted in a bore 177 provided in a riblike structure 178 formed as a part of the body 171 and extending across the passage 172. A relatively light spring 179 is mounted on the stem 176 and yieldably urges the gate valve 174 into a position in which it closes the outlet from the venturilike passage 167. A hole 181 is provided in the body 171 which can be used for a number of purposes as, for example, a manometer can be connected to this hole to measure pressure within the passage 172. The hole 181 is normally closed by a plug 182.

A fitting 186 is mounted in the tapered hole 113 in the upper body section 92 and is connected by a tube 187 to a tee 188. One end of the tee 188 is mounted in the nozzle 159 of the micronebulizer 17 and the other end of the tee is connected by a tube 189 to the nozzle 169 of the venturi assembly 15.

The main or master diaphragm 122 divides the cavity formed by the first and second body sections 92 and 93 into a pressure chamber 192 below the diaphragm and an ambient chamber 193 which is open to the atmosphere through holes 194 provided in the body section 92.

Operation and use of the respiratory apparatus may now be briefly described as follows. Let it be assumed that the apparatus is to be used in the home by a patient requiring treatment for a destructive lung disease, such as asthma, emphysema, bronchitis and the like. The apparatus is placed in operation by plugging the cord 26 into an appropriate outlet in the home and turning the switch 27 of the compressor to an "on" position. The knob 71 of the flow rate and relief valve assembly 12 is then adjusted for the proper rate of flow of compressed air. This air is delivered through the water filter 13 which removes any water droplets in the air under pressure. The air under pressure is then delivered to the tapered hole 91 of the control and exhaust valve assembly 14 of the breathing head assembly 21. In the breathing head assembly 21 shown in the drawings, a mouthpiece is provided which is adapted to be inserted in the mouth of the patient. It should be appreciated that, if desired, any other type of patient adapter can be utilized as, for example, a mask or a tracheotomy fitting. With any of these patient adapters, the breathing head assembly 21 is connected into the physiological airway of the patient.

Let it be assumed that the compressed air is continuously being delivered to the control and exhaust valve assembly 14 and that the servocontrol portion thereof is in the "off" position, i.e., the spindle 111 is in the position shown in FIG. 5 of the drawings. At this time, the exhaust valve portion thereof is active, i.e., the exhaust valve diaphragm 146 is free to open. The sensitivity magnet 131 is normally positioned so that it attracts the armature plate 118 and holds the servo portion of the control and exhaust valve assembly 14 in the "off" position. However, it should be appreciated that the assembly can be adjusted so that the sensitivity is either negative or positive. It is positive in the static position shown in FIG. 5 when the by the magnet 31 on the armature plate 118 is greater than the attraction of the magnet 138 on the armature plate 119. Thus, it can be considered that the sensitivity is positive when the magnet 131 exerts a force on the armature plate 118 which is greater than the force that the magnet 138 exerts on the armature plate 119 and, conversely, it is negative when the force exerted by the sensitivity magnet 131 on the armature 118 is less than that exerted by the magnet 138 on the armature plate 119.

Let it be assumed that the exhalation phase has just been completed and that the exhalation diaphragm 146 has moved to the position shown in FIG. 5 and has closed off the pressure chamber 192 below the master control diaphragm 122 from the atmosphere. As the patient commences inhalation, the pressure within the airway is reduced slightly below ambient so that the pressure within the chamber 192 is reduced below atmospheric pressure. The chamber 193 on the other side of the diaphragm 122 is exposed to the atmosphere through the holes 194 in the first body section 92. This causes a dif-

ferential pressure to be placed across the diaphragm 122 which gradually increases until the pressure is sufficient to overcome the attraction of the sensitivity magnet 131 for the armature plate 118. As soon as this magnetic force is overcome, the spindle 111 which, in effect, acts as a shuttle valve rapidly shifts to the open position. It should be pointed out that it is the gate valve 174 under the pressure of spring 179 which separates chamber 192 from the atmosphere which permits the formation of a slightly negative pressure within the pressure chamber 192 to permit initiation of the inspiratory phase of the respiratory apparatus. In addition, the exhalation or exhaust diaphragm 146 has its outer beaded portion 146c in close proximity to the lower exterior surface of the body section 93. This beaded portion 146c is drawn into place against the body section 93 to make a good seal and close off the slots 148 in body section 93. In other words, both the gate valve 174 and the exhaust diaphragm separate the main central passageway of the breathing assembly 21 from the atmosphere.

Thus, it can be seen that for the patient to initiate the inspiratory phase of the respiratory apparatus, it is merely necessary for the patient to draw in a little air as if he were breathing and this will switch the respiratory apparatus to the "on" position. As soon as this occurs, the compressed air in the passage 91 is delivered through the annular recess 112 through the holes 108 in the spool 102 into the recesses 107 and out through the bore 113 to the tube 187 where it is delivered to the micronebulizer 17 and also to the nozzle 169 of the venturi assembly 15.

The spindle 111 is rapidly shifted to the open position under the force of the magnet 138 which attracts the armature plate 119. As the armature plate 119 and the spindle 111 carried thereby move downwardly as viewed in FIG. 5, the rotor 127 also moves downwardly either by force of gravity upon the same and/or by the plate 123 engaging the hub portion 127a and pushing the rotor towards the inner surface of the body section 123 to occlude the slots 148 in the body section 93. In view of the fact that the rotor 127 is slidably mounted on the bearing spacer 124, slight relative movement may occur between the rotor 127 and the armature plate 119 so that it is possible for the rotor 127 to engage the inner surface of the body section 93 and occlude the slots 148 prior to the time that the plate 123 comes into engagement with the hub portion 127a. When the rotor 127 has come to a stop and the plate 123 is in engagement with the central hub portion 127a, the rotor 127 will be held in place by the magnetic forces of the magnet 138 applied to the armature plate 119, which forces are transmitted to the screw 117 and to the plate 123. Thus, it can be seen that the rotor 127 can come to a stop before the armature plate 119. However, it is possible that both the rotor 127 and the armature plate 119 can come to a stop substantially simultaneously.

As pointed out previously, as soon as the servocontrol portion of the control and exhaust valve assembly 14 moves to the open or inspiratory position, as described above, compressed air is delivered therefrom which is divided to supply the micronebulizer 17 and the venturi assembly 15. The venturi assembly 15 acts as a pneumatic clutch and serves to direct a jet of air through the venturi passage 167 which entrains additional air from the atmosphere to cause opening of the gate valve 174 and to deliver a substantial volume of air under pressure through the main passage 157 of the micronebulizer 17. As explained previously, the micronebulizer serves to deliver very small particles of the liquid being utilized in the nebulizer into the main airstream so that the air is delivered in a laminar flow to the mouthpiece 19 and thence to the airway of the patient.

The respiratory apparatus will continue to deliver air under pressure to the airway of the patient until a predetermined peak inspiratory pressure is reached as, for example, a pressure equal to 15 cm. of water. This peak inspiratory pressure is determined by adjustment of the position of the magnet 138 and reaches chamber 192 through the openings 129 in the

rotor 127. This pressure helps to hold the rotor 127 against the inner surface of the body section 93 to seal the exhaust openings 148. As soon as the pressure in the pressure chamber 192 exerted on the main diaphragm 122 is sufficient to overcome the magnetic attraction of the armature plate 119 to the magnet 138, the spindle 111 moves upwardly as viewed in FIG. 5 and prevents further delivery of gases under pressure to the bore 113. Movement towards the "off" position is enhanced by the attraction afforded by the sensitivity magnet 131 on the armature plate 118. Movement towards the "off" position is facilitated because the spindle 111 carrying the armature plate 119 can move a light distance towards the "off" position without moving the rotor because, as pointed out previously, the rotor is slidably mounted upon the spacer bearing 124. It is only after some movement of the spindle 111 has occurred that the rotor 127 is picked up and carried with the spindle to open the slots 148 and to permit emission of the expiratory gases through the slots 148 and to open the exhalation valve diaphragm 146 to permit the exhalation gases to escape to the atmosphere. Thus the spindle 111 and the parts associated therewith are permitted to pick up momentum to overcome the inertia of the rotor 127 at rest to insure reliable and positive opening of the exhaust slots 148. The annular skirt 151 serves to collect any condensate or any other materials exhaled by the patient so they will not drip on the patient. Thus, the skirt prevents staining and the collection of exhalation material on the patient's clothing. Periodically, the skirt 151 can be removed and cleaned. The exhaled gases cannot be delivered through the venturi assembly 15 because of the gate valve 174. It can be seen from the foregoing description that it is only necessary that the annular exhalation diaphragm 146 occlude the openings 148 and maintain sealed condition during inspiration.

As soon as the exhalation phase is completed, the exhalation diaphragm 146 will move into sealing engagement to close the slots 148 permitting a subambient pressure to be established in the chamber 192 and to cause the spindle 111 to be shifted to the open position in the manner hereinbefore described and to thereafter cause the same sequence of operations.

It should be appreciated that in place of the armature plates 118 and 119, magnets can be substituted to increase the magnetic attractions between the parts and to also make it possible to increase the sensitivity.

The relief valve assembly 46 serves to emit to the atmosphere any overpressure which is developed by the compressor 11 during the expiratory phase of the respiratory apparatus. Since the breathing assembly 21 is relatively light, it can be readily seen that it can be carried by the patient by use of a neck brace so the arms of the patient can be free to do exercises. Thus, it can be seen that the patient can undertake physical exercises at the time that he is taking therapy from the respiratory apparatus.

The fact that the control and exhaust valve assembly 14 forms a part of the breathing head assembly is also important in that it permits adjustment of the peak inspiratory pressure merely by shifting the angular position of the control and exhaust valve assembly 14. Thus, with the breathing head assembly in the 12 o'clock position as shown in FIG. 1, it can be seen that one peak inspiratory pressure can be obtained. In this position, the force of gravity is acting upon the armature plates 118 and 119 to pull them downwardly toward the magnet 138. Added to this, of course, is the weight of the spindle 111 and the other associated moving parts.

It also can be seen that when the control and exhaust valve assembly is shifted to the 3 o'clock position, the weight of the ceramic spindle 111 and the diaphragms 118 and 119 and the moving parts associated therewith would have no effect upon the peak inspiratory pressure and, therefore, the peak inspiratory pressure produced by the apparatus would be increased.

If the breathing head assembly is moved so that the control and exhaust valve assembly 14 is in the 6 o'clock position, the force exerted by gravity will be exactly in the opposite

direction than the armature plates 118 and 119 so that the effect of gravity is aiding the sensitivity magnet and to decrease the peak inspiratory pressure applied to the patient. Thus, it can be seen that merely by rotating the control and exhaust valve assembly 14 about an axis which is parallel to the main airway of the breathing head assembly, various inspiratory pressures can be obtained without the necessity of adjusting the position of the magnet 138. Further adjustments of the inspiratory peak pressure can be readily obtained by adjusting the position of the magnet 138 as hereinbefore described.

By way of example, it has been found that it is possible to obtain a peak inspiratory pressure differential equivalent to 4 cm. of water by rotation of the control and exhaust valve assembly 14 in the manner hereinbefore described.

It should be pointed out that the flanged cap 115 can be utilized as a knob which can be grasped manually for moving the spindle 111 between open and closed positions for resuscitation of an unconscious patient.

The respiratory apparatus will perform satisfactorily in hyperbaric chambers at several atmospheres of pressure above ambient and equally well in rarefied atmospheres such as may be found in unpressurized aircraft cabins at high altitude without the requirement of making compensatory adjustments in the sensitivity and pressure controls.

It can be seen from the foregoing that the respiratory apparatus is very versatile. It can be utilized as an automatic respiratory or it can be operated manually. The peak inspiratory pressure can be adjusted merely by rotating the breathing head assembly in angular increments up to 180°. Laminar flow of gases to the airway of the patient is obtained by utilizing the in-line arrangement of the venturi assembly 15, the gate valve assembly 16, the micronebulizer 17, the tee 18 and the mouthpiece 19. The apparatus is also such that it can be operated as a therapy unit remote from the air or oxygen source being utilized to permit patient exercise programs without difficulty. The peak inspiratory pressure and sensitivity controls are relatively tamperproof.

It can be seen from the foregoing that there has been provided a lightweight, portable, ethical, respiratory apparatus which can be readily utilized in the home and which also can be utilized in hospitals and clinics. Its construction is such that it requires very little adjustment for its proper operation. The respiratory apparatus is such that it can be readily disassembled and sterilized and then assembled by relatively unskilled personnel.

We claim:

1. In a respiratory apparatus of the type having an inhalation phase and an exhalation phase in its operative cycle, and adapted to be connected to a source of gas under pressure, a control and exhaust valve assembly comprising a body, said body having an inlet adapted to be connected to the source of gas under pressure and an outlet adapted to be connected to the airway of the patient, a control valve movable between open and closed positions to control the flow of gas from the inlet to the outlet, a diaphragm mounted within the body and connected to the control valve for moving the control valve between said open and closed positions, said diaphragm providing a first chamber in the body of one side of the diaphragm which is open to the atmosphere and a second chamber in the body which is in communication with said outlet, magnetic means for adjusting the forces required for moving the control valve between open and closed positions, an exhaust valve carried by the body for venting the second chamber to the atmosphere, and a patient adapter carrying said control and exhaust valve assembly and having an airway therein in communication with the outlet, said patient adapter and said control valve and exhaust assembly being of a size so that they can be held by the hand of a patient.

2. Respiratory apparatus as in claim 1 wherein said body is formed with holes for exposing said second chamber to the atmosphere together with an exhaust diaphragm mounted outside the second chamber closing said holes in said body.

3. Respiratory apparatus as in claim 2 together with a valve member carried by said control valve and being disposed in said second chamber and being moved to a position to cover the holes in the body when the control valve is moved to the position during the inspiratory phase.

4. Respiratory apparatus as in claim 1 together with an annular skirt mounted on said body and extending from the second chamber to define an exhaust port, said skirt having an inwardly and upwardly turning portion at its distal end defining a trough to receive exhalation products carried through the exhaust port from the patient.

5. Respiratory apparatus as in claim 1 wherein said magnetic means mounted on one side of the diaphragm comprises a first magnet mounted in the body and a first armature plate carried by the control valve and wherein the magnetic means on the other side of the diaphragm comprises a second magnet mounted in the body and a second armature plate.

6. Respiratory apparatus as in claim 1 together with means for supplying gas under pressure from the control and exhaust valve assembly to the venturi assembly.

7. Respiratory apparatus as in claim 1 wherein said body is formed in two body sections and wherein the outer annular margin of said diaphragm is secured between the two body sections.

8. In a respiratory apparatus of a type having an inhalation phase and an exhalation phase in its operative cycle, a body, said body having an inlet adapted to be connected to a source of gas under pressure and an outlet adapted to be connected to the airway of the patient, a control valve movable between open and closed positions to control the flow of gas from the inlet to the outlet, a diaphragm mounted within the body and connected to the control valve for moving the control valve between said open and closed positions, said diaphragm providing a first chamber in the body on one side of the diaphragm which is open to the atmosphere and a second chamber in the body which is adapted to be placed in communication with the airway of the patient, adjustable magnetic means for attracting said control valve to an open position and additional adjustable magnetic means for attracting said control valve to a closed position, said body being formed with holes for exposing said second chamber to the atmosphere together with an exhaust diaphragm mounted outside the second chamber closing said holes in said body, a valve member carried by said control valve and being disposed in said second chamber and being moved to a position to cover the holes in the body when the control valve is moved to the position during the inspiratory phase, said last named valve member being slidably and rotatably mounted on said control valve to permit movement of the control valve member in an axial direction after the valve member closes said holes.

9. In a respiratory apparatus, an air compressor, a flow rate control valve for adjusting the rate of flow of compressed air from the compressor, a control and exhaust valve assembly connected to the flow rate valve, said control and exhaust valve assembly comprising a body having an inlet for receiving the compressed gases and an outlet for delivering the compressed gases, a control valve movable between open and closed positions to control the flow of compressed gases from the inlet to the outlet, a diaphragm connected to the control valve and disposed in the body to provide first and second chambers on opposite sides of the diaphragm, the first chamber being exposed to the atmosphere and the second chamber adapted to be exposed to the airway of the patient, a patient adapter adapted to be connected to the patient and having a flow passage, means mounting said control valve and exhaust valve assembly so that it is carried by the patient adapter, a venturi assembly having a flow passage therein in communication with the flow passage in the patient adapter, means for delivering a jet of air from the control valve and ex-

haust valve assembly to the venturi assembly, and an exhaust valve carried by the body for venting the second chamber to the atmosphere, the said body being formed with openings for venting the second chamber to the atmosphere, said exhaust valve comprising a flexible diaphragm carried by the body exterior of the second chamber, and a flexible rotor disposed in the second chamber and carried by the control valve for closing the openings which are adapted to vent the second chamber to the atmosphere.

10. Apparatus as in claim 9 wherein said rotor is slidably mounted on said control valve to permit movement of the control valve independent of movement of the rotor.

11. In a respiratory apparatus, an air compressor, a flow rate control valve for adjusting the rate of flow of compressed air from the compressor, a control and exhaust valve assembly connected to the flow rate valve, said control and exhaust valve assembly comprising a body having an inlet for receiving the compressed gases and an outlet for delivering the compressed gases, a control valve movable between open and closed positions to control the flow of compressed gases from the inlet to the outlet, a diaphragm connected to the control valve and disposed in the body to provide first and second chambers on opposite sides of the diaphragm, the first chamber being exposed to the atmosphere and the second chamber being exposed to the airway of the patient, magnet means for controlling the forces required to move said control valve between open and closed positions, a patient adapter adapted to be connected to the patient and having a flow passage, means mounting said control valve and exhaust valve assembly so that it is carried by the patient adapter, a venturi assembly having a flow passage therein in communication with the flow passage in the patient adapter, a nebulizer connected between the venturi assembly and the patient adapter, means for delivering a jet of air from the control valve and exhaust valve assembly to the venturi assembly, and an exhaust valve carried by the body for venting the second chamber to the atmosphere.

12. Apparatus as in claim 11 wherein said body is formed with openings for venting the second chamber to the atmosphere and wherein said exhaust valve comprises a flexible diaphragm carried by the body exterior of the second chamber.

13. Apparatus as in claim 11 together with a yieldable gate valve closing off said flow passage in said venturi assembly from the airway of the patient.

14. A respiratory apparatus as in claim 11 wherein said control and exhaust valve assembly and said venturi assembly are formed as a unitary breathing head assembly.

15. A respiratory apparatus as in claim 14 wherein said means mounting the control valve and exhaust valve assembly with the patient adapter includes means to selectively shift the angular position of the control valve in a vertical plane with respect to the flow axis of the patient adapter flow passage to vary the inspiratory pressure supplied to the patient.

16. A respiratory apparatus as in claim 11 wherein said control and exhaust valve assembly has a flow passage therethrough and wherein said flow passage in said venturi assembly is in communication and in line with the flow passage in the control and exhaust valve assembly.

17. A respiratory apparatus as in claim 16, wherein said nebulizer has a passage therethrough and wherein said nebulizer is mounted so that its passage therethrough is in alignment with the passage in the venturi assembly and the passage in the control and exhaust valve assembly.

18. A respiratory apparatus as in claim 11 where said control valve movable between open and closed positions includes means permitting manual grasping of the control valve to shift it between open and closed positions.