

[72]	Inventors	Clare E. Barkalow Comstock Park; Ilden R. Folkerth, Sparta, both of Mich.
[21]	Appl. No.	765,468
[22]	Filed	Oct. 7, 1968
[45]	Patented	Oct. 5, 1971
[73]	Assignee	Michigan Instruments, Inc. Grand Rapids, Mich.

3,114,365	12/1963	Franz	128/145.8
3,191,596	6/1965	Bird et al.	128/145.5
3,221,734	12/1965	Beasley	128/145.8
3,426,794	2/1969	Freytag	128/145.5
3,486,502	12/1969	Wilson	128/145.8

Primary Examiner—Charles F. Rosenbaum
Attorney—Price, Heneveld, Huizenga & Cooper

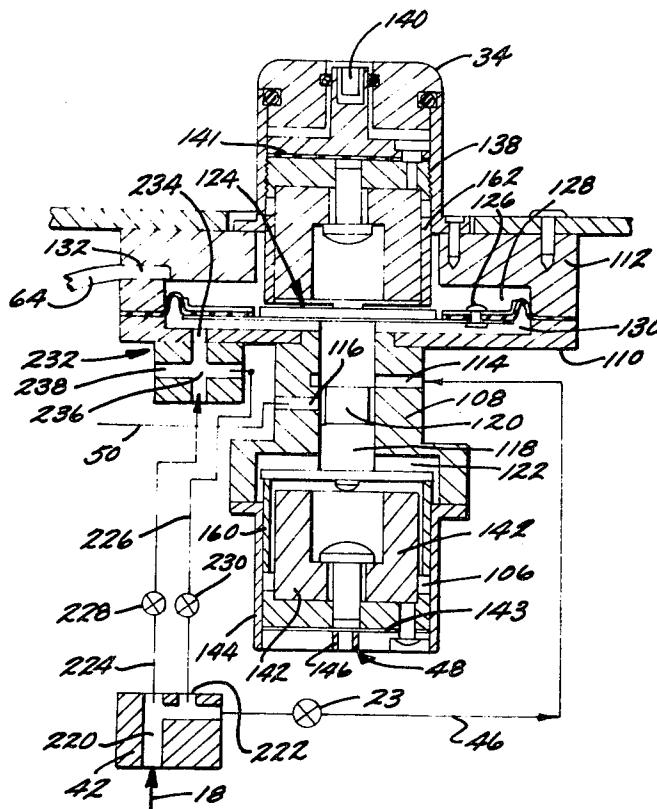
[54] INHALATION POSITIVE PRESSURE BREATHING APPARATUS
13 Claims, 10 Drawing Figs.

[52]	U.S. Cl.....	128/145.8
[51]	Int. Cl.....	A62b 7/00
[50]	Field of Search.....	128/145.5, 145.6, 145.7, 145.8

[56] **References Cited**
UNITED STATES PATENTS

3,068,856	12/1962	Bird et al.	128/145.5
3,071,131	1/1963	Johannisson et al.	128/145.5

ABSTRACT: This disclosure relates to an inhalation positive pressure breathing apparatus adapted to operate from a source of compressed oxygen-containing gas such as air or oxygen. A main control valve opens and closes with the pressure of the gas in a patient adapter such as a mask or mouthpiece, which adapter supplies oxygen-containing gas for use. A throttle valve is positioned in a supply line to the patient adapter to control the maximum flow rate of gas passing to the adapter and to control the acceleration of gas flow to the adapter. A spring-biased piston cylinder operates the throttle valve responsive to gas passing through the main control valve. An adjustable bleed valve in the piston cylinder enriches the air drawn by a venturi into the supply line to the patient adapter.



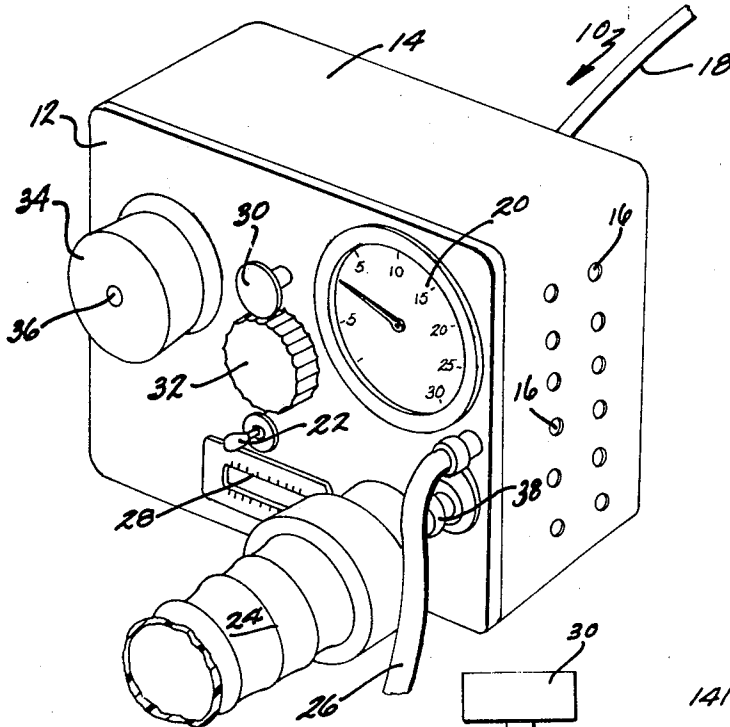


FIG. 1.

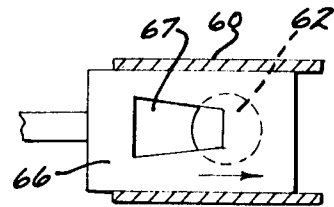


FIG. 5.

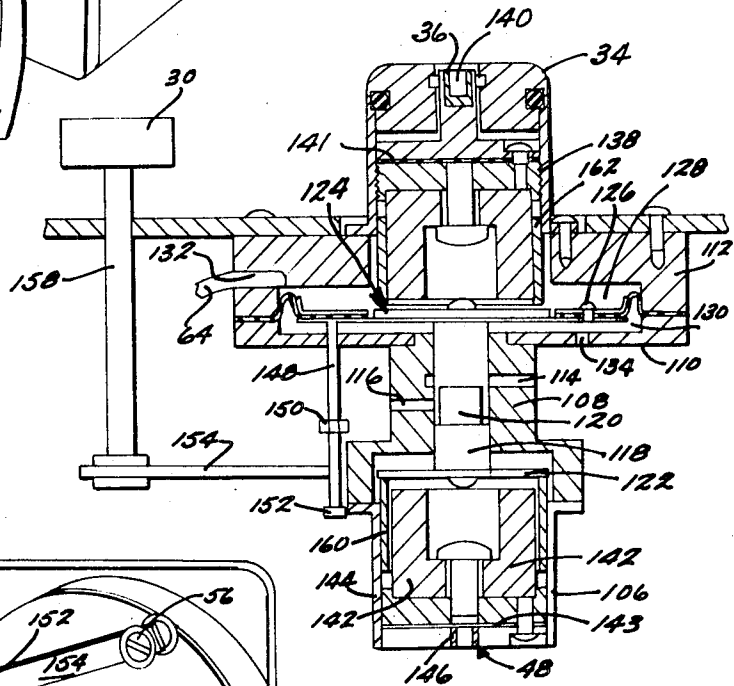


FIG. 6.

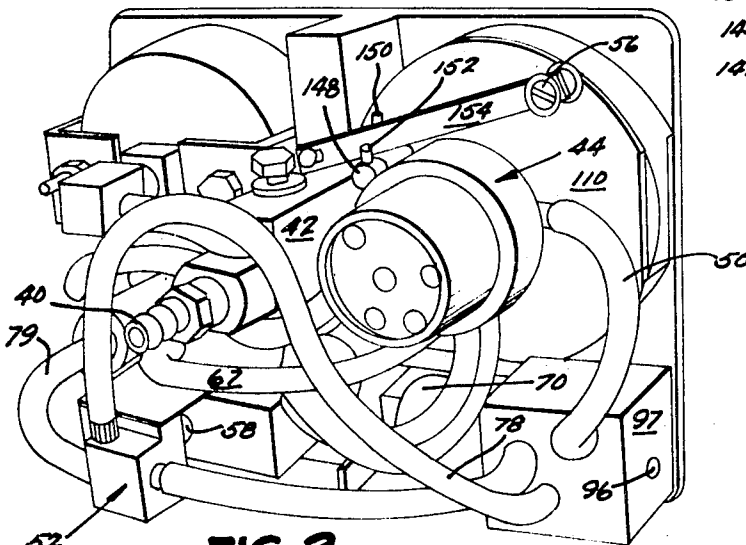


FIG. 2.

INVENTORS
CLARE E. BARKALOW
ILDEN R. FOLKERTH
BY *Price, Keneveld
Lutzinger & Cooper*

ATTORNEYS

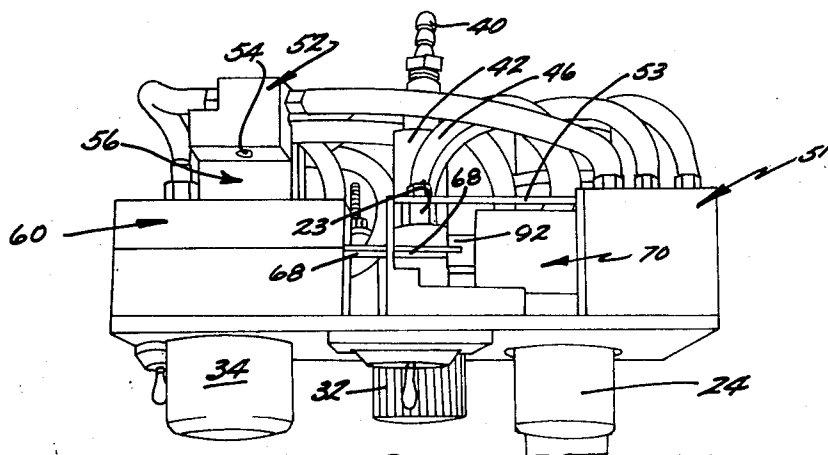


FIG. 3.

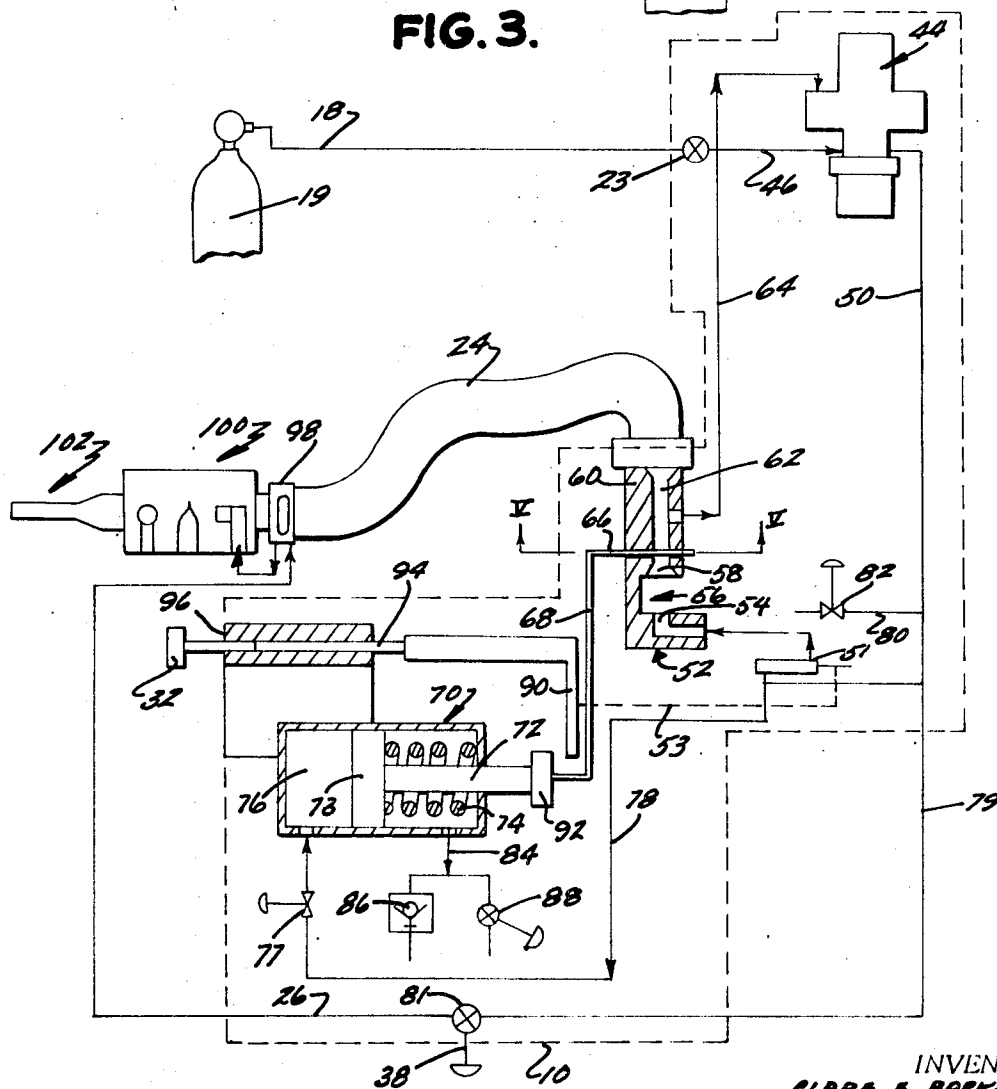


FIG. 4.

INVENTORS
CLARK E. BARNALOW
ILDEN R. FOLKERT
BY *Chas. H. Hensveld*
Huijenga & Cooper
ATTORNEYS

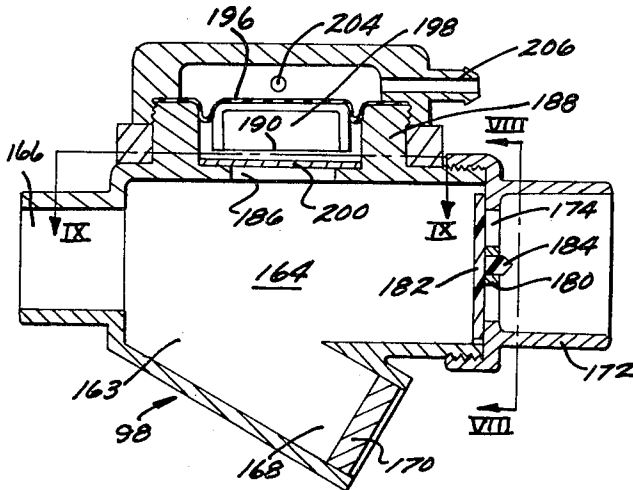


FIG. 7.

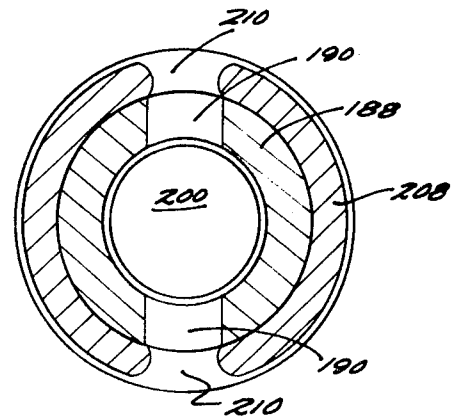


FIG. 9.

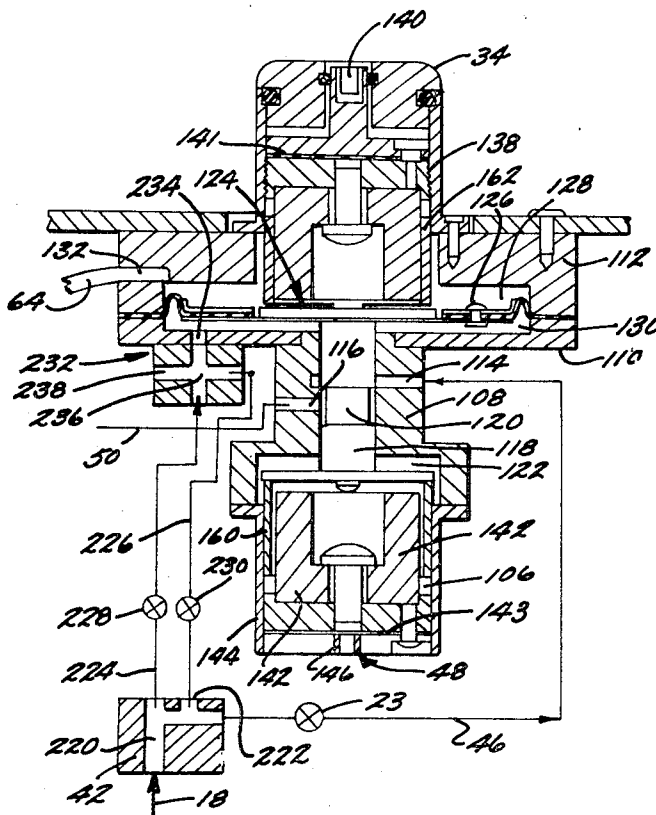


FIG. 10.

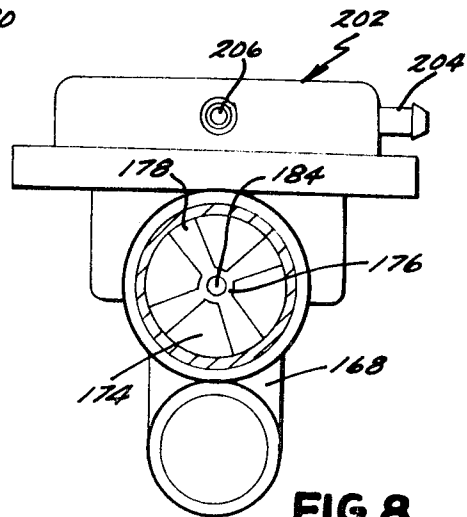


FIG. 8.

INVENTORS
CLARE E. BARKERLOW
ILDEN R. FOLKERTH
BY *Price, Henshaw
Klingenberg & Company*
ATTORNEYS

INHALATION POSITIVE PRESSURE BREATHING APPARATUS

This invention relates to an inhalation positive pressure breathing apparatus.

Many forms of respirators or inhalation positive pressure breathing apparatuses have been developed. More popular versions have a magnetic toggle valve which opens upon inhalation by a patient and which closes when a predetermined pressure is reached in an air supply hose to the face mask or mouthpiece. These apparatuses therefore instantaneously supply air or oxygen-enriched air at a predetermined pressure.

Resistance to air passage to the lungs tends to be highest at the initiation of ventilation. The air passage can be distorted by partial ventilation which reduces the resistance. After this distortion, increased flow rates can be realized with a minimum of air resistance.

It has been found that a gradual increase in the flow rate and inspirational pressure during inspiration decreases turbulence so that a more uniform diffusion of breathing gas into the pulmonary alveoli is promoted. A more efficient pulmonary gas exchange is then realized.

It is therefore desirable to gradually increase the pressure and flow rate of air entering the lungs. My improved device provides a controlled rate of acceleration of flow to the patient during the inspirational phase. Other advantageous features are contained in my improved device as will be hereinafter described.

By various aspects of this invention, one or more of the following, or other, objects can be obtained.

It is an object of this invention to provide an improved inhalation positive pressure breathing apparatus.

It is a further object of this invention to provide an improved inhalation positive pressure breathing apparatus wherein the flow rate to the patient builds up gradually during the inspirational phase.

It is yet another object of this invention to provide a respiratory breathing apparatus having a means to control the maximum flow rate of gas flowing to the patient.

It is a still further object of this invention to provide an inhalation positive pressure breathing apparatus in which oxygen-enriched gas is supplied to a patient wherein the amount of oxygen enrichment is adjustable.

It is another object of this invention to provide an improved inhalation positive pressure breathing apparatus wherein the acceleration of the flow of gases to the patient can be adjustably controlled.

Other aspects, objects, and the several advantages of this invention are apparent to one skilled in the art from a study of this disclosure, the drawings, and the appended claims.

Briefly, the invention provides an inhalation positive pressure breathing assembly having a pressure supply conduit means adapted to receive pressurized oxygen-containing gas from a source and deliver oxygen-containing gas to a patient adapter for use. A main valve is positioned in the supply conduit to permit passage of the pressurized oxygen-containing gas to the patient adapter, when open, and to close off the flow of the pressurized oxygen-containing gas when closed. A control means for the main valve means is associated with the patient adapter such that the main control valve is closed when a predetermined hyperambient pressure is reached in the patient adapter and such that the main valve means is opened upon a predetermined subambient pressure in the patient adapter. A throttle valve is positioned in the pressure supply conduit downstream from the main valve means. Means are provided to control the throttle valve such that the acceleration of flow of the oxygen-containing gas to the patient adapter is regulated as the main control valve opens. The throttle valve permits rapid deceleration of the flow of the oxygen-containing gas to the patient adapter as the main control valve closes.

The invention will now be described with reference to the accompanying drawings in which:

FIG. 1 is a perspective view of a device embodying the invention;

FIG. 2 is a rear perspective view of the device shown in FIG. 1 with the cover removed;

FIG. 3 is a top view of the device shown in FIGS. 1 and 2 with the cover removed;

FIG. 4 is a schematic illustration of the device shown in FIGS. 1, 2, and 3;

FIG. 5 is a sectional view taken along lines V—V of FIG. 4 illustrating the throttle valve;

FIG. 6 is a cross-sectional view of the main control valve;

FIG. 7 is a cross-sectional view of the nonbreathing valve schematically illustrated in FIG. 4;

FIG. 8 is a sectional view taken along lines VIII—VIII of FIG. 7;

FIG. 9 is a sectional view taken along lines IX—IX of FIG. 7; and

FIG. 10 is a schematic representation of a modified form of the invention illustrating a pneumatic override for the main valve.

Referring now to the drawings, and to FIGS. 1 through 5 in particular, a cabinet 10 has a front control panel 12 and a cover 14. Ventholes 16 are provided in the sides of the cover 14. An oxygen supply hose 18 is connected to a fitting 40 at the rear portion of the cabinet. A pressure gauge dial 20 indicates the inspirational and exhalation pressures reached in an air delivery conduit 24. An on-off switch 22 is provided for admitting and closing off pressurized oxygen to the device. A manual override button 30 is provided to manually operate the device. A nebulizer air supply hose 26 is provided for supplying pressurized oxygen to a nebulizer. The pressure to the nebulizer through the hose 26 is controlled by the adjustment knob 38. An adjusting knob 32 has a hexagonal wrench stem which is positioned in the front cabinet for making various adjustments as will be hereinafter described. A housing 34 for the main valve projects out from the front cabinet 12. An adjusting hole 36 has a hexagonal socket in the housing 34 to adjust the cutoff pressure. Knob 32 can be removed from the front of the cabinet and the hexagonal stem can be inserted in hole 35 for this adjusting function. A flow rate indicator gauge 28 gives a visual indication of the maximum flow rate of air passing through the air delivery conduit 24.

As seen in FIG. 2, the main control valve 44 has an inspirational actuating pressure adjusting hole 48. The adjusting knob 32 with the hexagonal stem can also be used to adjust the inspirational actuating pressure by inserting the stem into the hole 48 and turning the knob. To this end, a hole (not shown) can be provided in the back of cover 14 so that the cover need not be removed in order to adjust this pressure.

The pressurized oxygen in hose 18 passes through fitting 40 into the manifold 42. A hose 46 then carries the oxygen from the manifold 42 to the on-off valve 23, and then to one side of the main control valve 44. The on-off switch 22 controls the on-off valve 23. A conduit 50 carries the pressurized oxygen from the other side of the control valve 44 through an adjustable throttle valve 51 to venturi block 52 when the main control valve is open. The block has a nozzle opening 54 (FIG. 4) which permits the pressurized oxygen to pass through the venturi opening 56 into port 58 in block 60. A bore 62 (FIG. 4) provides a path of communication between the venturi opening 56 and the air delivery conduit 24. A hose 64 (FIG. 4) is provided for transmitting the pressure in the bore 62 to a diaphragm chamber in the main control valve 44. A hose 78 is provided to pass the gas within the venturi block 52 to a pressure chamber 76 in a piston cylinder 70. A hose 79 is provided to transmit the pressurized gas from the venturi block 52 through pressure regulator 81 which is controlled by knob 38 to nebulizer air supply hose 26.

A throttle valve 66 is provided in block 60 to control the flow of fluid through bore 62. As seen in FIG. 5, the throttle valve 66 comprises a slidable plate having a wedge shaped opening 67 which slides across the front of bore 62 to permit passage of gas through the wedge-shaped opening and through bore 62.

The throttle valve 66 is controlled by the piston cylinder 70 having a piston rod 72, a piston 73, and a connecting rod 68

between the valve and the piston rod 72. A spring 74 biases the piston 73 to the left as illustrated in FIG. 4. In this position the valve 66 will be closed.

A bleed conduit 80 has an adjustable bleed valve 82 and can provide a flow of O₂ into the interior of the cabinet 10 for O₂ enrichment.

An exhaust conduit 84 having a check valve 86 and an adjustable valve 88 permits exhaust and reentry of air into the chamber containing spring 74.

An adjustable stop 90 is threadably engaged by a threaded adjusting rod 94 for movement to the right and left as illustrated in FIG. 4. A collar 92 on the piston rod 72 contacts the adjustable stop as the piston 73 moves to the right of the cylinder illustrated in FIG. 4. The threaded adjusting rod 94 has a hexagonal socket at the outer end in hole 96. It can be turned to move the stop 90 by inserting the hexagonal wrench stem of knob 32 into the hole 96 to engage the hexagonal socket of rod 94.

The air delivery conduit 24 has on the outer end thereof a nonbreathing valve 98, a nebulizer 100 and a mouthpiece 102. The nonbreathing valve permits gas to flow from air delivery conduit 24 to nebulizer 100 when the pressure in conduit 24 is greater than that in the nebulizer 100. When the gas pressure in the nebulizer 100 is greater than that in conduit 24, such as during exhalation, the gas in the nebulizer 100 will be exhausted through valve 98 to the atmosphere without passing into conduit 24. A preferred nonbreathing valve is shown in FIGS. 7 through 9.

The nebulizer 100 is a standard item which is described in U.S. Pat. No. 3,068,856 and delivers 1- to 4-micron airborne particles of liquid during the inspiratory phase.

Reference is now made to FIG. 6 for a description of the main control valve 44. The main control valve is a bistable pneumatically operated magnetic toggle valve. The valve has an end housing 106, a central housing 108 and a housing 34 which has already been described. The diaphragm chamber is formed by plate 110 and plate 112. An inlet port 114 is provided in the central valve housing 108 and an outlet port 116 is provided at the other side of the central housing 108. A spool valve 118 having a reduced-diameter portion 120 is reciprocable within the central portion of the central housing. The spool valve is adapted to open and close communication between inlet port 114 and the outlet port 116. Attached at either end of the spool valve 118 are armature plates 122 and 124. A diaphragm 126 is fixed to armature plate 124. The diaphragm 126 forms a first chamber 128 and a second chamber 130 on either side thereof. A port 132 is provided in diaphragm chamber 128 and a port 134 is provided in the second chamber 130. A magnet 136 threadably engages at 138 valve housing 34. A hexagonal socket 140 is coupled to the magnet 136 through a connector 141.

A second magnet 142 threadably engages at 144 end housing 106. A wrench socket 146 is coupled to magnet 142 through connector 143. A cylindrical member 160 is fixed to the inner portion of end housing 106 and prevents the armature plate 122 from contacting the magnet 142. In the same manner, a cylindrical member 162 is fixed to the housing 34 to prevent the armature plate 124 from contacting the magnet 136.

A post 148 is fixed to diaphragm 126 and extends out through plate 110. Spaced stops 150 and 152 are provided on the outer portion of post 148.

A flexible strap 154 (seen also in FIG. 2) is fixed at one end thereof to plate 110 through screw 156. At the outer end, the flexible strap 154 extends between stops 150 and 152 and is fixed to override bar 158.

If desirable, an adjustable throttle valve 51 can also be placed in line 50. As illustrated in FIG. 4, the throttle valve 51 is ganged to the stop 90 and adjustable therewith. Thus, the main oxygen supply will be throttled in accordance with the maximum allowable flow through valve 66.

Referring now specifically to FIGS. 7, 8 and 9, there is shown the nonbreathing valve schematically illustrated in

FIG. 4. The nonbreathing valve 98 comprises a main housing 163, a cap 172 at one end thereof, and a cap 202 and valve assembly at the top portion thereof.

The main housing has an open, portion 166. A branch conduit 168 is provided at an angle to the main conduit 164 and is provided with a plug 170. If a main stream nebulizer such as disclosed in U.S. Pat. No. 3,068,856 is used, the exit portion 166 will be connected directly to the nebulizer. If a side stream nebulizer is employed, then the exit conduit 166 will be connected directly to the patient adapter. In this latter instance, a nebulizer will be connected to the branch conduit 168 and plug 170 will be removed.

The cap 172 is cylindrically shaped having a plurality of radial arms 178 forming a hub 176 at the central portion thereof. Openings 174 are formed between the arms 178. The hub 176 has a central opening 180. A nonbreathing check valve is positioned against the openings 174 to prevent rebreathing through the cap 172. Cap 172 will be connected directly to the air delivery conduit 24. The check valve comprises a flexible leaf valve disc 182 and a retainer lug 184 which is positioned in the central opening 180 to hold the leaf valve disc 182 against the opening. A small amount of air pressure in the air delivery conduit 24 will cause the leaf valve to open to permit the air to pass into the main conduit 164 and through the exit portion 166. If desirable, the leaf valve can be eliminated so long as the throttle valve 66 is present in the system upstream from the nonbreathing valve.

The main housing has an exhale opening 186 at a top portion thereof and a cylindrical boss 188 surrounding the opening. The boss 188 has a pair of exhale ports 190 at either side thereof as seen more clearly in FIG. 9. A flexible diaphragm 196 extends across the top of the cylindrical boss and is fixed to a holding cap 198. A floating check valve disc 200 is positioned within the annular boss 188 between the holding cap 198 and the top of the main housing 163 to cover the exhale opening 186.

The cap 202 has an inner recess chamber communicating with the top of the diaphragm 196 and threadably engages the boss 188. The cap 202 is provided with a port 204 which is connected to the nebulizer air supply hose 26 and a port 206 which is connected to line 27 which feeds air pressure to the nebulizer 100.

An adjustable exhale retard ring 208 surrounds the cylindrical boss 188 between the cap 202 and the top of the main housing 163 coextensive with the exhale ports 190. The retard ring 208 has a plurality of openings 210 which correspond to the exhale ports 190 in the cylindrical boss 188. The retard ring is adjustable from the position shown in FIG. 9 wherein there is no restriction of gas passing out of exhale ports 190 to a position in which the exhale ports 190 are substantially completely blocked to substantially completely restrict the flow of gas through the exhale ports 190.

The operation of the device will now be described specifically with reference to FIGS. 4, 5, and 6. Oxygen-containing gas, such as oxygen or air, is supplied from a suitable source such as a tank 19 or a compressor to the device. The oxygen-containing gas under pressure passes through a pressure regulator on the tank 19, through line 18, through on-off valve 23, through line 46 to the main control valve 44. If the valve is closed, as illustrated in FIG. 6, the gas will not pass any further into the device.

When a patient draws on the mouthpiece 102, the suction will be transferred through nebulizer 100, through nonbreathing valve 98, through air delivery conduit 24, through the outer portion of bore 58 to feedback conduit 64. This negative pressure will be transmitted to the first chamber 128. The negative pressure in this chamber will cause the diaphragm to move up against the force of the magnet 142 and in the same direction as the force of magnet 136. The armature plate 124 will snap against cylinder 162 due to the force of the magnet 136. At this point, the spool valve 118 will permit the oxygen-containing gas to pass through port 114, through the reduced-diameter portion 120 and out port 116.

The oxygen-containing gas will then pass through line 50, through throttle valve 51, to venturi block 52, out nozzle 54, through venturi opening 56 and into bore 58. However, due to the force of the spring 74 against piston 73, the valve 66 will close off bore 58. The oxygen-containing gas also passes through line 78 into pressure chamber 76. The pressure entering the pressure chamber 76 forces piston 73 against the force of spring 74. At this point, the movement of the piston and piston rod 73 to the right will cause a corresponding movement to the right of the valve 66, thereby opening the bore 62. As illustrated in FIG. 5, at first only a small portion of the bore is open permitting the passage of small quantities of gas through bore 62, through air delivery conduit 24, through nonbreathing valve 98, nebulizer 100 and into the mouthpiece 102. The rate at which the piston 73 moves to the right and the valve opens is dependent upon the rate of gas exhaustion from the right hand chamber of the piston cylinder 70. The gas escapes through exhaust conduit 84 and through adjustable valve 88. In this manner, the rate at which the valve opens is dependent upon the settings of valve 88. The valve 88 is adjustable so that the rate at which the valve opens is adjustable. The acceleration of flow of oxygen-containing gas is dependent, therefore, on the rate at which the valve 66 moves to the right to open the bore 58. The check valve 86 permits rapid return to the left of piston 73 when pressure is released from chamber 76. The maximum degree of openness of the valve 66 is limited by stop 90 which contacts collar 92 as the piston 73 is forced to the right. The position of stop 90 is adjustable through threaded adjusting rod 94. Thus, in this manner, the maximum flow rate to the mouthpiece 102 is controlled. Additionally, the primary supply of air is throttled by adjusting valve 51 as the threaded rod 94 is adjusted.

As is understood by one skilled in the art, the gas under pressure passing through nozzle 54 into bore 58 will result in an expansion of the compressed gas and a drawing in of the surrounding air into bore 58, through bore 62 and into air delivery conduit 24. Since the venturi is within the cabinet 10, the gas drawn into conduit 24 must come from within the cabinet. To this end, the holes 16 in the cover have been provided. The air passing into the cabinet through holes 16 can therefore be filtered to provide for cleaner air as desirable to the patient.

When pure oxygen is used as the pressurized gas, then the gas passing through the air supply conduit 24 will be approximately 33 percent oxygen. If it is desirable to increase this oxygen content, the bleed valve 82 is opened to permit the oxygen in line 50 to bleed through line 80 and into the interior of the cabinet. As the valve is opened farther, more and more oxygen passes into the cabinet. This condition results in less and less air (containing a lower percentage of oxygen) to be drawn in through holes 16. Thus, the content of the oxygen supply to the patient is easily adjustable.

When the patient's lungs are filled with gas, the pressure begins to build up in air supply conduit 24 and in feedback conduit 64. This pressure buildup forces the diaphragm down as seen in FIG. 6 against the force of magnet 136. When the pressure reaches a predetermined value, the valve 118 will snap down and be held by the force of magnet 142 against armature 122. In this manner, the flow of gas through the valve is closed off.

When the pressure in the line 50 ceases, there will no longer be pressurized gas pumping the venturi and the air will immediately cease flowing through the air supply conduit 24. The pressure in line 78 and in pressure cylinder 76 will then be immediately released whereupon the piston 73 will move to the left thereby closing the valve 66. Gas enters the right chamber of the piston cylinder 70 through check valve 86 and through exhaust conduit 84.

As an alternate method of controlling the rate at which the slidable plate valve 66 opens, a restricted orifice 77 can be provided in line 78. Valve 88 and check valve 86 can then be removed. With this restricted orifice 77 in place of the valve 88 and check valve 86, the pressurized gas will flow into the

pressure chamber 76 at a controlled rate when the main valve 44 is open. Therefore, the piston will be forced to the right to open the slidable plate valve 66 at a controlled rate.

When the valve 44 is compressed gas passes through line 79, through pressure regulator 81, line 26 to the nebulizer 100. When the valve 44 is closed, the compressed gas cannot flow through line 79, valve 81, line 26 to the nebulizer 100.

The operation of the nonbreathing valve will now be described. Prior to operation of the device, the valve is in the position shown in FIGS. 7, 8 and 9. As the patient begins to inhale, the check valve disc 200 is drawn downward to seal exhaust opening 186. This will permit the negative inspirational pressure to be transmitted through air delivery conduit 24, and via feedback conduit 64 to control valve 44, causing it to open.

When control valve 44 opens, the pressure developed in nebulizer supply hose 26 will force diaphragm 196 downwardly to cause the cap 198 to bear against the check valve disc 200 to maintain the exhale opening 186 closed.

During the exhalation phase, valve 66 closes, preventing retrograde flow through air delivery conduit 24, and the pressure in the nebulizer supply line 26 will be cut off so that diaphragm 196 returns to the position shown in FIG. 7. The pressure within the main conduit 164 forces the floating check valve disc 200 upwardly so that the air can flow through the exhale opening 186 and through the exhale port 190.

For patients suffering from emphysema, it is necessary to provide a back pressure at the exhale port. For this purpose, the adjustable exhale retard ring 208 has been provided. The ring is rotatable on the boss 188 so that the relationship between the openings 210 and the exhale ports 190 can be changed. For emphysema patients, the ring is rotated so that the size of the exhale ports is cut down to a desirable minimum. This decreased exhale port size will then have the effect of building up back pressure during the exhalation cycle. The exhale retard ring 208 is made slightly eccentric on the boss 188 so that there is a frictional fit between the ring 208 and the boss 188. In this manner, the ring 208 will remain in a fixed position once it is set relative to the boss 188.

The main valve 44 has a manual override which is operated by button 30 and override bar 158. Normally, the movement of the diaphragm causes the post 148 to move up and down as seen in FIG. 6 without having the stops 150 and 152 contact the flexible bar 154. However, when the button 30 is pulled, the flexible bar 154 will contact the stop 150 to force the diaphragm up, thereby opening the valve manually. Conversely, when the button 30 is pushed inwardly, the flexible bar 154 will contact stop 152 to push the diaphragm down, thereby moving valve 118 down to manually close the main valve.

The magnetic valve is adjustable by inserting a proper wrench in either one or both of the sockets 140 and 146. The turning of the socket 140 to cause the magnet 136 to move down, for example, would increase the ventilation pressure required to close the valve. Conversely, the movement of the magnet 136 upward would decrease the ventilation pressure required to close the valve.

The movement of the magnet 142 upward would increase the required inspirational pressure to open the valve whereas the movement of the magnet 142 downward would decrease the inspirational pressure required to open the valve.

An alternate override system for the main valve is schematically illustrated in FIG. 10. The main valve is identical to that shown in FIG. 6 except that port 134 in plate 110 has been replaced by exhaust port 234. Ports 220 and 222 are provided in the manifold 42 to communicate with the supply hose 18. A block 232 is fixed to plate 110 and is provided with an axial bore 236 and an interconnecting lateral bore 238. The axial bore 236 is directly aligned with exhaust conduit 234. A line 224, having an on-off valve 228, transmits pressure to axial bore 236 from port 220 when valve 228 is open. A line 226, having an on-off valve 230, transmits pressure to lateral bore 238 from line 226 when the valve 230 is open.

The operation of the pneumatic override is as follows: the magnetic toggle valve works as previously described when valves 228 and 230 are closed. The second chamber 130 communicates with the atmosphere through exhaust port 234 and lateral bore 238. If the main valve 44 is off, and it is desirable to turn it on manually, the valve 228 will be opened to cause pressurized gas to flow through axial bore 236, creating a pressure within the second chamber to force the diaphragm 126 and spool valve 118 upwardly. The inlet port 114 will thereby communicate with the outlet port 116 so that pressurized gas passes through the main valve 44. The main valve 44 can be manually closed by closing valve 228 and opening valve 230 to permit pressurized gas to pass through line 226 and through lateral bore 238. The flow of gas through lateral bore 238 creates a suction on the second chamber to pull diaphragm 126 and spool valve 118 downwardly, thereby closing the main valve 44.

Reasonable variation and modification are possible within the scope of the foregoing disclosure, the drawings, and the appended claims without departing from the spirit of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows.

1. In a positive pressure breathing apparatus comprising:
 - a pressure supply conduit means adapted to receive pressurized oxygen-containing gas from a source and deliver oxygen containing gas to a patient adapter for use;
 - a main valve means in said supply conduit means to permit passage of said pressurized oxygen-containing gas to said patient adapter when open, and to shut off the flow of said pressurized oxygen-containing gas when closed;
 - control means for said main valve means and associated with said patient adapter such that said main control valve is closed when a predetermined hyperambient pressure is reached in said patient adapter, and to open said valve means when a predetermined subambient pressure is present in said patient adapter;
 - the improvement which comprises:
 - throttle valve means in said pressure supply conduit means downstream from said main valve, said throttle valve means comprising a movable member in said pressure supply conduit means, said member having a shaped opening means movable from a first position wherein flow through said conduit means is blocked to alternative positions wherein a complete range of flow rates through said conduit means to said patient is permitted dependent upon the shape of said opening means;
 - throttle valve control means for regulating the acceleration of the flow of said oxygen-containing gas to said patient adapter as said main control valve means opens, said means operatively linked to said member for movement thereof and in communication with said pressure supply conduit means upstream from said throttle valve means, said throttle valve control means adjustable so that when said main valve means is open, the acceleration of flow through said throttle valve means builds up at a preselected and controlled rate.
2. The inhalation positive pressure breathing apparatus of claim 1 wherein said throttle valve control means has means to permit rapid deceleration of the flow of said oxygen-containing gas to said patient adapter as said main control valve closes, said deceleration being more rapid than and independent of said acceleration.
3. The positive pressure breathing apparatus of claim 1 wherein said throttle valve control means comprises a fluid pressure cylinder means having a piston operably connected to said movable member so as to actuate movement of said member between said first and alternative positions as said cylinder is filled with fluid, said cylinder in communication at one end with said pressure supply conduit means which supplies the pressure thereto when said main control valve means is open, said cylinder having an exhaust being adjustable to control the rate of movement of said piston between said one

to said other end; and means biasing said piston to a position so as to cause said movable member to be in said first position.

4. The positive pressure breathing apparatus according to claim 1 wherein said movable member is slidable in a direction perpendicular to the direction of flow of said gas through said conduit means and includes means defining an opening having a varying cross section so that as said opening is aligned in said conduit means to permit flow therethrough, the flow rate is shaped.

5. The inhalation positive pressure breathing apparatus according to claim 3 wherein said throttle valve control means further includes an adjustable control valve to control the rate at which fluid pressure enters said one end of said cylinder and, in turn, controls the rate at which said piston opens said throttle valve.

6. The inhalation positive pressure breathing apparatus according to claim 1 wherein adjustable stop means operably associated with said throttle valve control means adjustably limits the maximum movement of said member from said first position to said alternative positions to limit the volume of said oxygen-containing gas flowing to said patient adapter.

7. In a positive pressure breathing apparatus comprising:

- a pressure supply conduit means adapted to receive pressurized oxygen-containing gas from a source and deliver oxygen-containing gas to a patient adapter for use;
- a main valve means in said supply conduit means to permit passage of said pressurized oxygen-containing gas to said patient adapter when open, and to shut off the flow of said pressurized oxygen-containing gas when closed;
- control means for said main valve means and associated with said patient adapter such that said main control valve is closed when a predetermined hyperambient pressure is reached in said patient adapter, and to open said valve means when a predetermined subambient pressure is present in said patient adapter;

 the improvement which comprises:

throttle valve means in said pressure supply conduit means downstream from said main valve, said throttle valve means comprising a slidable plate in said supply conduit means, said slidable plate so shaped and positioned as to block the flow of gas through said conduit means when in a first position, to permit extensive flow of gas through said conduit means in a second position, and to permit intermediate flow rates of gas through said conduit means when said plate is between said first and second positions;

control means for said throttle valve to regulate the acceleration of the flow of said oxygen-containing gas to said patient adapter as said main control valve means opens so that the flow rate of said oxygen-containing gas to said patient adapter builds up at a controlled rate, said control means for said throttle valve comprising a fluid pressure cylinder means having a piston operably connected to said plate so as to actuate movement of said plate between said first and second positions as said cylinder is filled with fluid, and means biasing said piston to a position so as to cause said plate to be in said first position, said cylinder having at one end a fluid pressure supply line which supplies the fluid pressure thereto when said main control means is open, said cylinder having at the other end thereof an exhaust conduit with an adjustable control valve in said conduit to control the rate of movement of said piston between said first and said other end of said cylinder; and

a fluid supply conduit in communication with said other end of said cylinder and check valve means within said conduit to permit rapid flow of fluid pressure into said other end of said cylinder but to prevent the flow of fluid pressure from said other end of said cylinder through said check valve means.

8. In a positive pressure breathing apparatus comprising:

- a pressure supply conduit means adapted to receive pressurized oxygen-containing gas from a source and deliver oxygen containing gas to a patient adapter for use;

a main valve means in said supply conduit means to permit passage of said pressurized oxygen-containing gas to said patient adapter when open, and to shut off the flow of said pressurized oxygen-containing gas when closed;

control means for said main valve means and associated with said patient adapter such that said main control valve is closed when a predetermined hyperambient pressure is reached in said patient adapter, and to open said valve means when a predetermined subambient pressure is present in said patient adapter;

the improvement which comprises:

throttle valve means in said pressure supply conduit means downstream from said main valve, said throttle valve means being adjustable to limit the volume of said oxygen-containing gas flowing to said patient adapter;

control means for said throttle valve to regulate the acceleration of the flow of said oxygen-containing gas to said patient adapter as said main control valve means opens so that the flow rate of said oxygen-containing gas to said patient adapter builds up at a controlled rate;

a venturi pump in said pressure supply conduit means between said throttle valve means and said main valve means;

a second throttle valve means in said pressure supply conduit means between said main valve means and said venturi pump, said second throttle valve being adjustable to limit the flow of gas passing between said main valve means and said venturi pump; and

means operably associated with said first-mentioned throttle valve means and said second throttle valve means to adjust said second throttle valve means to limit the flow of oxygen-containing gas passing to said venturi pump in accordance with the maximum allowable flow of oxygen-containing gas permitted by said first-mentioned throttle valve means.

9. In a positive pressure breathing apparatus comprising:

a pressure supply conduit means adapted to receive pressurized oxygen-containing gas from a source and deliver oxygen-containing gas to a patient adapter for use;

a main valve means in said supply conduit means to permit passage of said pressurized oxygen-containing gas to said patient adapter when open, and to shut off the flow of said pressurized oxygen-containing gas when closed;

control means for said main valve means and associated with said patient adapter such that said main control valve is closed when a predetermined hyperambient pressure is reached in said patient adapter, and to open said valve means when a predetermined subambient pressure is present in said patient adapter;

the improvement which comprises:

throttle valve means in said pressure supply conduit means downstream from said main valve;

control means for said throttle valve to regulate the acceleration of the flow of said oxygen-containing gas to said patient adapter as said main control valve means opens so that the flow rate of said oxygen-containing gas to said patient adapter builds up at a controlled rate;

a cabinet for housing at least said throttle valve means and said control means, said cabinet having controlled apertures for permitting entry of air into said housing;

a venturi in said supply conduit means between said main valve means and said throttle valve means, said venturi means positioned within said cabinet so as to draw gas within said cabinet into said supply conduit means;

said control means for said throttle means comprising a pressure-operated piston cylinder having a pressure chamber, a bleed port in said pressure chamber opening into said cabinet, a pressure supply line for said fluid pressure cylinder leading from said pressure supply conduit means between said main valve means and said venturi to said pressure cylinder to actuate said throttle valve as said main valve means opens, whereby air supplied to said patient adapter can be enriched by said oxygen-containing gas bleeding from said piston cylinder into said cabinet.

10. An inhalation positive pressure breathing apparatus according to claim 9 wherein the opening in said bleed port is adjustable to vary the amount of oxygen enrichment of said gas passing into said patient adapter.

11. In a respiratory apparatus having a pressure supply conduit means adapted to receive pressurized oxygen-containing gas from a source and deliver oxygen-containing gas to a patient adapter for use, a main control valve in said conduit adapter to permit passage of said pressurized gas therethrough when open and to prevent the passage of said pressurized oxygen-containing gas when closed, said valve being a diaphragm-controlled magnetic toggle valve, a manual override means for said valve, the improvement in said last means comprising:

a stem fixed to said diaphragm and extending exteriorly of said valve;

a handle engageable with said stem only during manual operation of said valve;

said stem having spaced stop members and said handle is attached to a resiliently biased bar, said bar being positioned between said stop members so as to control said stop members when actuated by said handle and so as to avoid contacting said stop members when said valve is pneumatically operated.

12. In a respiratory apparatus having a pressure supply conduit means adapted to receive pressurized oxygen-containing gas from a source and deliver oxygen-containing gas to a patient adapter for use;

a main control valve in said conduit adapter to permit passage of said pressurized gas therethrough when open and to prevent the passage of said pressurized oxygen-containing gas when closed; said valve being a diaphragm-controlled magnetic toggle valve; a manually operable override means for said valve, the improvement in said last means comprising:

pneumatic means communicating with said main control valve to pressurize and depressurize a chamber in said main control valve to actuate said diaphragm for movement to close and open said main control valve, said pneumatic means comprising:

a block having an axial bore leading directly into said chamber;

first pressurized gas supply means communicating with said axial bore so as to pressurize said chamber when fluid pressure is supplied to said axial bore;

means to control the flow of pressurized gas from said first pressurized gas supply means to said axial bore;

a lateral bore through said block intersecting and transverse to said lateral bore;

a second pressurized gas supply means communicating with said lateral bore so as to cause pressurized gas to pass across said axial bore, thereby creating a suction within said chamber; and

means to control the flow of pressurized gas from said second pressurized gas supply to said lateral bore.

13. In a respiratory apparatus having a pressure supply conduit means adapted to receive pressurized oxygen-containing gas from a source and deliver oxygen-containing gas to a patient adapter for use;

a main control valve in said conduit means, said valve controlling the flow of said gas to said patient adapter so that when said valve is open, gas is permitted to flow to said adapter and when said valve is closed, flow to said adapter is prevented; said valve being a diaphragm-controlled magnetic toggle valve; a manually operable override means for said main control valve, the improvement in said last means comprising:

pneumatic means communicating with said main control valve to pressurize and depressurize a chamber in said main control valve to actuate said diaphragm for movement to close and open said main control valve, said pneumatic means comprising:

a block having an axial bore leading directly into said chamber; first pressurized gas supply means commu-

11

communicating with said axial bore so as to pressurize said chamber when fluid pressure is supplied to said axial bore;
means to control the flow of pressurized gas from said first pressurized gas supply means to said axial bore; 5
a lateral bore through said block intersecting and traverse to said axial bore;

12

a second pressurized gas supply means communicating with said lateral bore so as to cause pressurized gas to pass across said axial bore, thereby creating a suction within said chamber; and
means to control the flow of pressurized gas from said second pressurized gas supply to said lateral bore.

10

15

20

25

30

35

40

45

50

55

60

65

70

75

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,610,237 Dated October 5, 1971

Inventor(s) Clare E. Barkalow et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 4;
Delete "open," and insert --- main conduit 164
with an exit ---;

Column 6, line 4;
After "is" insert --- open,---.

Signed and sealed this 25th day of April 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents