

Dec. 30, 1969

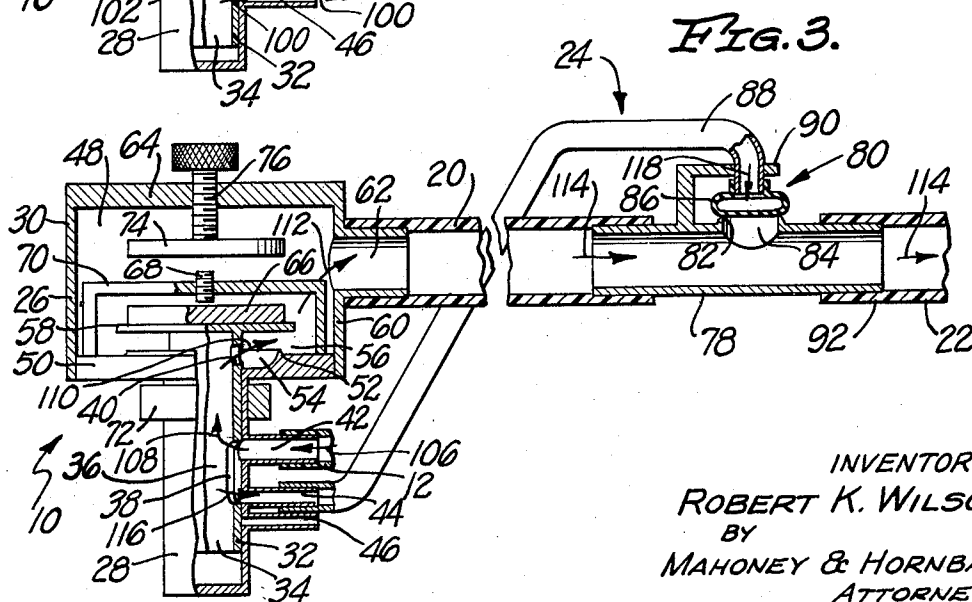
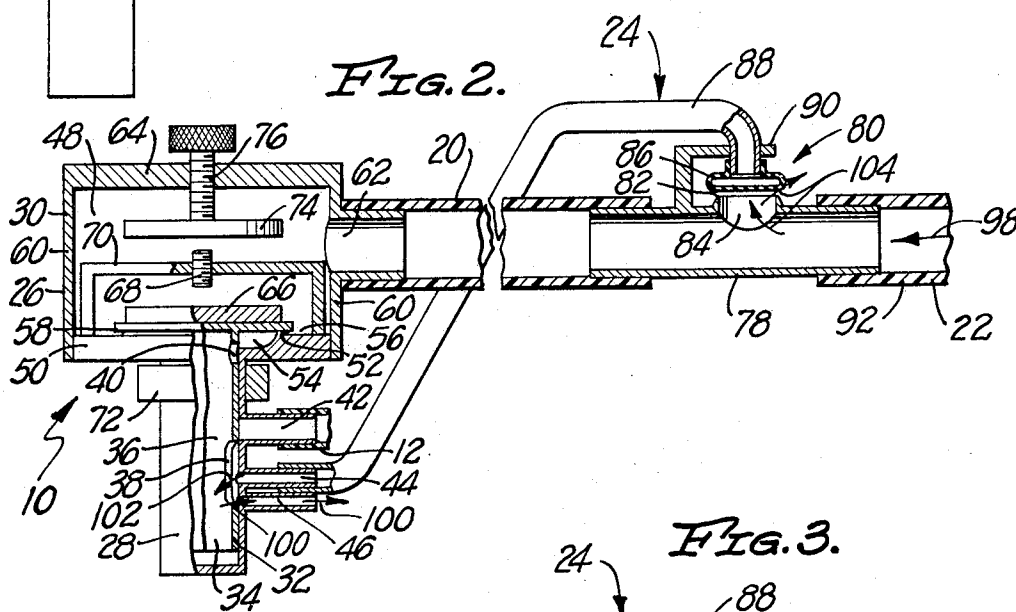
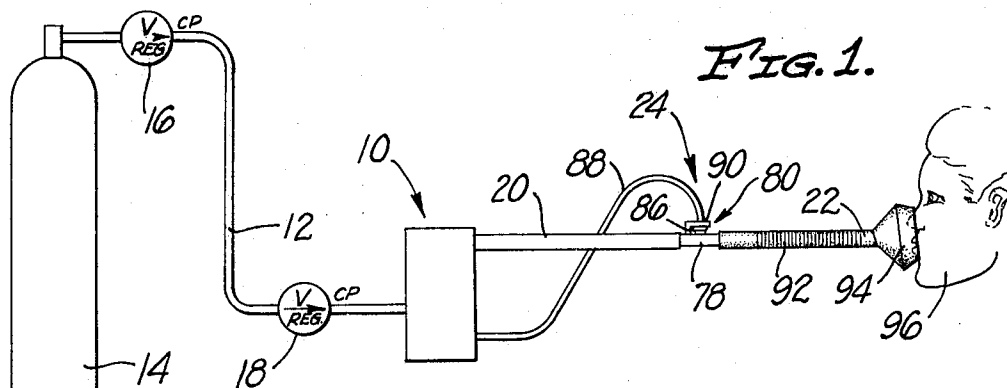
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3,486,502

POSITIVE PRESSURE FLOW CUT-OFF RESPIRATION SYSTEM

Filed Sept. 9, 1966

2 Sheets-Sheet 1



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POSITIVE PRESSURE FLOW CUT-OFF RESPIRATION SYSTEM

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2 Sheets-Sheet 2

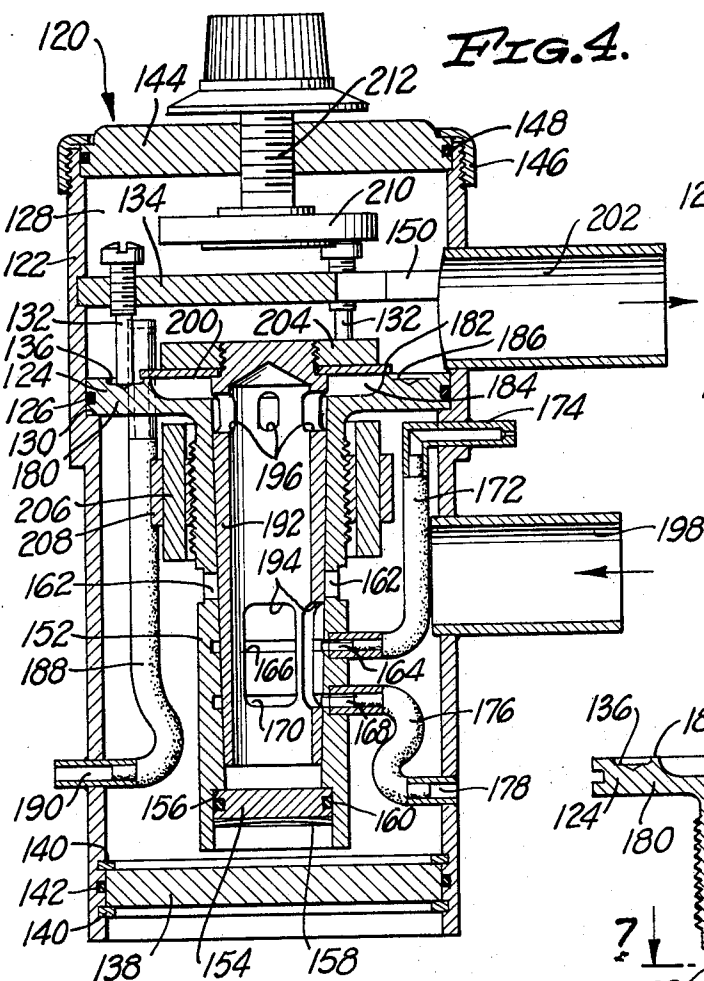


FIG. 5.

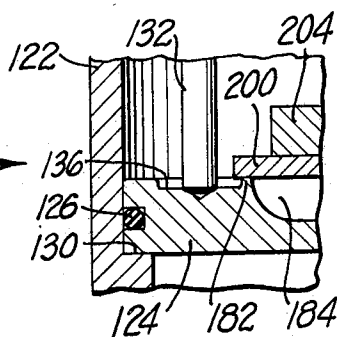


FIG. 6.

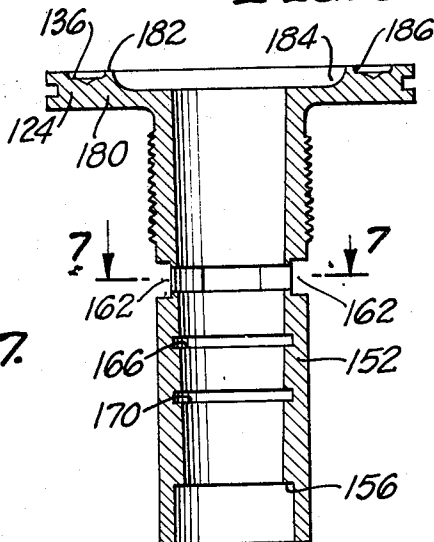
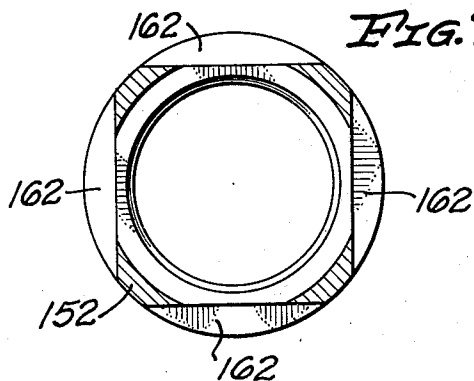


FIG. 7.



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POSITIVE PRESSURE FLOW CUT-OFF RESPIRATION SYSTEM

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14 Claims

ABSTRACT OF THE DISCLOSURE

A combined poppet and shuttle valve is vertically movable between a lower closed and upper open position controlling gas flow from an upstream supply to a downstream patient face mask. The valve is balanced closed through the combination of its own weight and magnet means normally subject to opening purely through a patient's attempted inspiration, and closing automatically upon cessation of the patient's inspiration. Upon initial movement to open position, the valve is maintained open only through gas flow therethrough while maintaining an expiration gas vent closed, and the valve permits opening of the expiration gas vent when closed.

This invention relates to a positive pressure flow cut-off respiration system for the administration of oxygen and similar adjuvant gases to a patient, and to a simplified valve particularly adapted for utilization in conjunction with said respiration system. More particularly, this invention relates to such a respiration system of improved simplified form and incorporating an improved valve having far greater demand initiation reaction sensitivity than has heretofore been possible in systems of this character.

Positive pressure respiration systems of varying types have been used in inhalation therapy for the administration of oxygen and other adjuvant gases in the treatment of patients having various pulmonary and coronary diseases, as well as for a multiplicity of other medical treatment purposes, and these positive pressure respiration systems are normally classifiable into two broad classifications, that is, positive pressure volume limited systems and positive pressure flow cut-off or flow limited systems. Positive pressure volume limited respiration systems are distinguishable by the fact that in the use thereof, a predetermined volume of gas is forced into the patient's lungs at predetermined intervals. In positive pressure flow cut-off respiration systems, the patient initiates the flow of gas by slight inspiration, after which, said patient is forced to inspire as much of a desired gas, such as oxygen, as his lungs will permit or accept, and the present invention involves this latter class of respiration system.

Prior positive pressure flow cut-off respiration systems have been characterized by their extremely high cost due to the necessarily precise nature of the valve incorporated therein, as well as the control means utilized for controlling these valves. Clearly, if the respiration system is of the positive pressure flow cut-off form initiated by slight inspiration attempts of the patient, it must be extremely sensitive to the patient's inspiration impulses. This has required the prior art devices to include complex electrical control circuits, as well as very precisely formed valves controlled for positive reaction to said patient's slight inspiration impulses.

It is, therefore, an object of my invention to provide a positive pressure flow cut-off respiration system which can be manufactured and sold at a much lower cost than conventional systems heretofore provided. The respiration system of the present invention does not include com-

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plex electrical control circuits characteristic of prior art devices due to the unique nature of the sensitive valve incorporated therein in the unique manner of incorporation of said valve into the system. Furthermore, the flow valve of the present invention, while functioning in an extremely precise and responsive manner, is nevertheless, because of its inherent design, much less complicated and may be manufactured to less precise tolerances than the prior art valves.

Another object of my invention is the provision of a positive pressure flow cut-off respiration system which is initially responsive to the negative pressure of vacuum created by slight attempted inspiration of the patient utilizing the system to begin the pressure flow of gas, such flow being cut off by the patient's lung capacity being reached, and which, thus, eliminates completely the need for auxiliary control devices or circuits. The unique construction of the flow valve of the system is such that the valve is highly sensitive to the slight vacuum created by the attempted inspiration of the patient for initiating the opening of the valve, after which the positive gas flow under pressure retains the valve open until the patient's lung capacity has been reached and then the valve automatically closes interrupting the flow of gas, while at the same time controlling the flow of the patient's expiration gases from the system.

An additional object of my invention is the provision of a valve for a positive pressure flow cut-off respiration system whose sensitivity can be adjusted within precise limits to permit the respiration system in which it is incorporated to be adjusted into compatibility with the needs and capabilities of the patient utilizing the system. The valve includes means therein for precisely balancing the movable valve member or members thereof highly sensitive to the slight vacuum created by the patient's attempted inspiration, thereafter the valve being retained opened by the positive pressure of gas flow to the patient and until the patient's inspiration capacity has been reached. The balancing means is so constructed and related to the valve member that precise adjustments may be made therein for adjusting such balance precisely compatible, in combination with gas flow pressure, to a particular inspiration condition.

Another object of my invention is the provision of a valve for a positive pressure flow cut-off respiration system which includes a primary control valve member which is responsive to a slight negative pressure or vacuum created in a pressure chamber through attempted inspiration by the patient, with magnet means associated with the valve member and with the housing for the valve member providing balancing and adjustability of such balancing as hereinbefore discussed. A magnet may be operatively connected with the valve member and repulsion and attraction magnets operatively connected with the valve housing, said repulsion and attraction magnets being adapted, respectively, to repel and attract said magnet on said valve member and both tending to urge said valve member toward an open position. Also, the repulsion and attraction magnets may be operatively connected to the housing so as to be adjustable relative to the magnet on the valve member, thereby permitting the balance of the valve member to be adjusted within the precise limits for meeting needs of the patient as set forth.

A further object of my invention is the provision, in a valve of the aforementioned character, of primary and secondary valve members, said primary member being operatively connected to said secondary member and said primary member being initially responsive to a slight vacuum created by the attempted inspiration of a patient impressed thereupon. By the provision of operatively connected primary and secondary valve members, it is not only possible to precisely control the positive pressure

flow of gases through the valve for forced inspiration by the patient, but it is also possible to precisely control the flow of expiration gases from the patient and from the system. The valve members immediately automatically move to open position under the positive pressure of and for the positive pressure flow of inspiration gases to the patient upon the reception of the slight inspiration impulse vacuum from the patient, and immediately automatically move to closed position upon the patient's lung capacity being reached, and at the same time, open ports controlling the direction of expiration gases from the patient and from the system for exhausting the same.

Other objects and advantages of the invention will be apparent from the following specification and the accompanying drawings which are for the purpose of illustration only, and in which:

FIG. 1 is a somewhat diagrammatic view showing an embodiment of the overall positive pressure flow cut-off respiration system according to the principles of the present invention;

FIG. 2 is an enlarged, fragmentary, side elevational view, with certain parts broken away and certain parts in vertical section, showing an embodiment of the control valve of the present invention in the system of FIG. 1 and operably connected with the inspiration gas tube and expiration gas control means thereof, said valve being in the closed position;

FIG. 3 is a view similar to FIG. 2, with the valve in the open position;

FIG. 4 is a vertical, sectional view of another embodiment of the control valve of the present invention and usable in the system of FIG. 1;

FIG. 5 is an enlarged, fragmentary, vertical, sectional view taken from FIG. 4;

FIG. 6 is a vertical, sectional view of the combination shuttle valve cylinder and poppet valve seat member removed from the valve of FIG. 4; and

FIG. 7 is an enlarged, horizontal, sectional view taken along the broken line 7—7 in FIG. 6.

As hereinbefore stated, the present invention relates primarily to a positive pressure flow cut-off respiration system and a highly sensitive control valve usable in conjunction with and forming a part of such system. Furthermore, the embodiments of the system and valves of the present invention illustrated and described herein are of the positive pressure flow cut-off type. It will be apparent, however, from a complete understanding of the system and valve of the present invention, that the broader principles thereof are equally applicable to respiration systems and valves of other types and by such statements, illustrations and descriptions, it is not intended to limit the principles of the present invention to positive pressure flow cut-off respiration systems and valves alone, except as required by the disclosures of the prior art.

Referring to the drawings, and particularly FIG. 1, the respiration system of the present invention includes a control valve generally indicated at 10 operably connected through a gas supply tube 12 to a pressure oxygen tank 14, said gas supply tube including a usual high pressure flow regulator 16 and low pressure flow regulator 18. Further, the control valve 10 is operably connected through an inspiration gas tube 20 to a face mask 22 and an expiration gas control means generally indicated at 24, the latter also being operably connected back through the demand valve, as will be hereinafter more clearly understood. All of the elements of the system are formed of usual and suitable materials apparent to those skilled in the art.

Referring particularly to FIG. 2, the control valve 10 includes a housing 26 forming a shuttle valve cylinder 28 and a poppet valve housing 30 so that the poppet valve housing is secured to an upper end of the shuttle valve cylinder. The shuttle valve cylinder 28 is preferably slightly tapered inwardly toward the lower end thereof for production tolerance and friction elimination pur-

poses and receives a vertically movable, closely fitting and similarly tapered, tubular valve member 32 having an open lower end 34, with the tubular construction forming a gas passage 36. Further, the shuttle valve member 32 is formed with a combined gas inlet and exhaust orifice 38 and a gas outlet orifice 40, both communicating through the shuttle valve member into the gas passage 36 and both specifically located relative to an inspiration gas inlet port 42, an expiration valve control port 44 and an exhaust port 46 and an exhaust port 46, all formed communicating through the shuttle valve cylinder 28, and the poppet valve housing 30, as will be clearly set forth in the following description.

The poppet valve housing 30 encloses a poppet valve chamber 48 and includes a bottom wall 50 upon which is formed an annular poppet valve seat 52 having a recessed inlet side 54 and an outlet side 56 opening into the chamber. A preferably flat, cylindrical poppet valve member 58 is secured overlying and closing the upper end of the shuttle valve member 32, with the poppet valve member also overlying the poppet valve seat 52 within the poppet valve chamber 48 movable toward and away from said seat upon upward and downward movement of the shuttle valve member. The poppet valve housing 30 also includes a side wall 60 having an inspiration gas outlet port 62 formed communicating therethrough into the poppet valve chamber 48, and a top wall 64 completing the enclosure of the chamber.

The gas inlet and exhaust orifice 38 is located in the shuttle valve member 32 and is of appropriate size so that when the shuttle valve member is in the lower or first position with the poppet valve member 58 in closed position sealing against the poppet valve seat 52, as shown in FIG. 2, the gas inlet and exhaust orifice is below the inspiration gas inlet port 42 causing the shuttle valve member to close and seal off the inspiration gas inlet port, while at the same time the gas inlet and exhaust orifice is positioned forming a communication from the expiration valve control port 44 into the gas passage 36 and a communication from the gas passage outwardly through the exhaust port 46. In the upper or second position of the shuttle valve member 32, as shown in FIG. 3, the poppet valve member 58 is in open position spaced above the poppet valve seat 52, while the gas inlet and exhaust orifice 38 has been moved upwardly and provides a communication from the inspiration gas inlet port 42 into the gas passage 36 and a communication from the gas passage outwardly into the expiration valve control port 44, with the exhaust port 46 being closed and sealed off by the shuttle valve member. The gas outlet orifice 40 of the shuttle valve member 32 may communicate with the inlet side 54 of the poppet valve seat 52 in both positions of the shuttle and poppet valve members 32 and 58, but must fully communicate with the inlet side of the poppet valve seat when the shuttle and poppet valve members are respectively in the second and open positions in order to insure a free positive pressure flow of inspiration gas from the shuttle valve gas passage 36 to the inspiration

A permanent magnet 66 is secured to and overlying the poppet valve member 58 so that the magnet 66, the shuttle valve member 32 and the poppet valve member 58 are movable upwardly and downwardly in unison, with the upward movement of the magnet and the valve members being limited by a selectively adjustable stop screw 68 threadably received through an inverted U-shaped supporting member 70 supported on the bottom wall 50 of the poppet valve housing 30 and providing gas communication therearound. A repelling magnet 72 is mounted surrounding the shuttle valve cylinder 28 spaced below the bottom wall 50 of the poppet valve housing 30, with the repelling magnet tending to repel the valve member magnet 66 and thereby tending to move the shuttle and poppet valve members 32 and 58 upwardly from the first and closed positions toward the second and open positions. Also, an attracting magnet 74 is suspended within

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the poppet valve chamber 48 spaced above the valve member magnet 66 and spaced downwardly from the top wall 64 of the poppet valve housing 30 by a positioning screw 76 threadably received through the top wall of the poppet valve housing so that the attracting magnet tends to attract the valve member magnet and therefore likewise tends to urge the shuttle and poppet valve members 32 and 58 from their first and closed positions toward their second and open positions, with the effect of the attracting magnet thereon being selectively adjustable through the positioning screw 76.

The relative positioning of the valve member magnet 66, the repelling magnet 72 and the attracting magnet 74 is such that the movement of the shuttle and poppet valve members 32 and 58 is balanced so that the valve members are sensitive to a minimum force tending to urge the valve members from the first and closed positions toward the second and open positions, critically important to certain of the principles of the present invention, as will appear hereinafter. In other words, the weights of the shuttle and poppet valve members 32 and 58, as well as that of the valve member magnet 66 and the various frictional forces involved, may be nearly overcome by the repelling and attracting magnetic forces so that the movement of the valve members is extremely sensitive to any given degree desired to a minor force tending to move the valve members upwardly and downwardly. Also, this sensitivity may be varied by selective adjustment of at least the attracting magnet 74.

The gas supply tube 12 is connected communicating through the inspiration gas inlet port 42, as shown, and the flow of inspiration gas into the control valve 10 from the gas supply tube is controlled by the particular positioning of the shuttle valve member 32, as will be hereinafter more fully described during the description of the operation of the system of the present invention. Furthermore, the inspiration gas tube 20 is connected communicating with the inspiration gas outlet port 62 of the control valve, as shown, for the reception of inspiration gas from the poppet valve chamber 48 and the transmission thereof to the face mask 22. The inspiration gas tube 20 may be formed of a resilient or flexible material, with the exception of an expiration gas valve section 78, which forms a communication for the inspiration gas from the inspiration gas tube to and through the face mask 22, but also at which is formed an expiration valve generally indicated at 80.

As best seen in FIGS. 2 and 3, the expiration valve 80 includes an annular valve seat 82 formed on the expiration valve section 78 surrounding an expiration gas port 84 communicating with the atmosphere from the expiration valve section when this expiration exhaust port is open. Further, the expiration valve 80 includes a resilient valve diaphragm 86 telescoped over and communicating with an expiration valve control tube 88, with the diaphragm closing off the end of the control tube. Overlying the valve diaphragm 86, the expiration valve control tube 88 is suspended on a support member 90 connected to the expiration valve section 78 to thereby position the valve diaphragm overlying and engaged with the valve seat 82 closing off the expiration exhaust port 84 when the diaphragm is in extended condition, as shown in FIG. 3, and spaced from the valve seat opening the expiration exhaust port to the atmosphere when the diaphragm is in retracted condition, as shown in FIG. 2, all for a purpose to be hereinafter explained.

The face mask 22 is generally of usual construction and may include a connection tube portion 92 positioned communicating with the expiration valve section 78, and a mask portion 94 which is positioned around the mouth and nose of a patient 96. An opposite end of the expiration valve control tube 88 spaced from the expiration valve 80 is connected communicating into the expiration valve control port 44 of the demand valve 10, and since the valve diaphragm 86 closes off the expiration valve

control tube at the expiration valve, the sole gas flow into and from the expiration valve control tube is through the expiration valve control port. Thus, the positioning of the valve diaphragm 86 in either extended or retracted condition for closing or opening the expiration valve 80 is controlled by the flow of inspiration gas either into or from the expiration valve control tube 88 through expiration valve control port 44 and as determined by the flow of inspiration gas within the gas passage 36 of the shuttle valve member 32, as will be pointed out below.

In operation of the positive pressure flow cut-off respiration system of the present invention and the control valve 10 thereof, assuming the gas to be administered to the patient 96 is oxygen and the high and low pressure flow regulators 16 and 18 have been properly adjusted for providing the desired positive pressure flow thereof as determined by the particular patient 96, the balance of the shuttle and poppet valve members 32 and 58 is adjusted through the adjustment of at least the attracting magnet 74, as hereinbefore described, so that this balance will be of proper sensitivity for the condition of the patient.

First, referring to FIG. 2, the respiration system of the present invention is in the expiration position. In movement into the expiration position of the system, the capacity of the patient's lungs will have been reached so that the positive pressure flow of oxygen from the tank 14 through the control valve 10 will have ceased and due to the balance of the shuttle and poppet valve members 32 and 58, the valve members will automatically move downwardly to the first and closed positions, as shown in FIG. 2.

Downward movement of the poppet valve member 58 will cause the poppet valve member to engage and seal at the poppet valve seat 52, and at the same time, downward movement of the shuttle valve member 32 will move the gas inlet and exhaust orifice 38 downwardly from the inspiration gas inlet port 42 to seal off the flow of gas from the tank 14. The repositioning of the gas inlet and exhaust orifice 38 will align the same still communicating with the expiration valve control port 44, but also communicating with the exhaust port 46 to thereby permit the exhaust of inspiration gas from the gas passage 36 as indicated by arrows 100, allowing the downward movement of the shuttle valve member, as well as permit the flow of inspiration gas from the expiration valve control tube 88 through the expiration valve control port 44 as indicated by arrow 102. The reversal of pressure of the inspiration gas within the expiration valve control tube 88 will permit the valve diaphragm 86 of expiration valve 80 to move into retracted condition away from the valve seat 82, as shown in FIG. 2, upon expiration by the patient 96 causing a flow of expiration gases from the face mask 22 in the direction of the arrow 98 and into the expiration valve section 78, thereby opening the expiration valve and permitting the exhaust of expiration gases through the expiration exhaust port 84 to the atmosphere, as indicated by arrows 104 shown in FIG. 2.

After expiration by the patient 96, attempted inspiration begins, which will cause at least a slight negative pressure or vacuum to be created by the patient at the face mask 22, thereby creating a slight negative pressure force at the inspiration gas outlet port 62 of the demand valve 10. Due to the delicate balance of the shuttle and poppet valve members 32 and 58 as caused by the magnets 66, 72 and 74, the shuttle and poppet valve members will begin to move upwardly to the second and open positions, as shown in FIG. 3, and immediately the positive pressure flow of oxygen from the tank 14 through the control valve 10 will move the valve members fully upwardly placing the respiration system in the inspiration position.

Upward movement of the shuttle valve member 32 to the second position will move the gas inlet and exhaust orifice 38 upwardly sealing off the exhaust port 46, still maintaining the expiration valve control port 44 open and

providing communication through the inspiration gas inlet port 42 into the gas passage 36. At the same time, upward movement of the poppet valve member 58 away from sealing against the poppet valve seat 52 will provide the communication from the gas passage 36 through the gas outlet orifice 40 into poppet valve chamber 48 and through inspiration gas outlet port 62.

Thus, inspiration gas from the oxygen tank 14 will force flow under positive pressure through gas supply tube 12 into the inspiration gas inlet port 42, as indicated by arrow 106 and shown in FIG. 3, into the gas passage 36, as indicated by arrow 108, over the poppet valve seat 52 into the poppet valve chamber 48, as indicated by arrow 110, and from the poppet valve chamber into the inspiration gas outlet port 62, as indicated by arrow 112. The inspiration gas flows from the inspiration gas outlet port 62 through the inspiration gas tube 20 to the face mask 22, as indicated by arrows 114 in FIG. 3, for inspiration by the patient 96. At the same time, the flow of inspiration gas into the gas passage 36 creates a flow of inspiration gas from the gas passage through the lower portion of the gas inlet and exhaust orifice 38 into the expiration valve control port 44, as indicated by arrow 116 in FIG. 3, which inspiration gas flow is received internally against the valve diaphragm 86 of the expiration valve 80, as indicated by arrow 118, forcing the valve diaphragm to extended condition to seal against the valve seat 82 and positively close off the expiration exhaust port 84 preventing the escape of inspiration oxygen through the expiration valve.

The shuttle and poppet valve members 32 and 58 will remain in the second and open positions retaining the respiration system in the inspiration position shown in FIG. 3 as long as a positive flow of oxygen therethrough continues as caused by said flow and a slight flow pressure drop through shuttle valve gas outlet orifice 40, the latter being predetermined by the particular size of said orifice. Upon the patient's lung capacity being reached, such flow will cease and the respiration system will immediately and automatically begin movement back to the expiration position, as hereinbefore described.

Thus, according to the principles of the present invention, due to the unique construction of the control valve 10, the respiration system does not require complex electrical control circuits characteristic of certain of the prior art devices. The control valve 10, due to the unique manner of incorporation into the system, as well as the unique construction thereof, will function in an extremely precise and responsive manner, although the valve is less complicated and may be manufactured to less precise tolerances than the prior art valves. The unique construction of the control valve 10 is such that the valve is highly sensitive to the slight negative pressure created by the attempted inspiration of the patient for beginning opening of the valve to supply the desired gas under positive pressure, in this case oxygen from the oxygen tank 14, and upon the patient's lung capacity having been reached the valve automatically closes, cutting off the supply of gas to the patient, while at the same time, controlling the flow of the patient's expiration gases for exhausting the same into the atmosphere.

The sensitivity of the control valve 10 is created by the balancing of the shuttle and poppet valve members 32 and 58, as obtained by the unique use of the magnets 66, 72 and 74, as described. Furthermore, the sensitivity and balance of the shuttle and poppet valve members 32 and 58 may be selectively adjusted for precise regulation of the system according to a particular patient using the same through adjustability of these magnets. Also, the control valve 10 not only operates precisely according to the inspiration and expiration cycles of the patient, but also efficiently controls the flow of the inspiration gases therethrough by virtue of the unique combining in this control valve of the shuttle and poppet valve members 32 and 58, the shuttle valve member controlling both the

flow of expiration gases from the the patient, as well as the flow of inspiration gases to the patient, while the poppet valve member working in co-operation with the shuttle valve member controls the flow of inspiration gases to the patient.

Referring to FIGS. 4 through 7, a second embodiment of the control valve of the present invention is shown generally indicated at 120 in a slightly more sophisticated construction, but operating generally in the same manner as the first embodiment control valve 10 hereinbefore described. As shown, the valve 120 includes a housing 122 enclosing a unitary valve cylinder and valve seat member 124 sealed against the housing by a sealing ring 126 and creating within the housing a poppet valve chamber 128 above the member. The valve cylinder and valve seat member 124 is retained assembled within the housing 122 against an annular shoulder 130 by retaining screws 132 threadably adjustable received through a retaining plate 134, with lower ends of the screws bearing downwardly against the valve cylinder and valve seat member within recesses 136.

The housing 122 is downwardly closed by a bottom wall 138 secured in place by retaining rings 140 and sealed by sealing ring 142. The upper end of the housing 122 is closed by top wall 144 secured to the housing by a threadably engaged retaining ring 146 and sealed by sealing ring 148. An opening 150 is formed through the retaining plate 134 for gas communication purposes, as will be hereinafter pointed out.

A shuttle valve cylinder portion 152 of the valve cylinder and valve seat member 124 may be internally tapered, as shown, for friction relief and to allow for production tolerances, and is downwardly closed by a cylinder bottom wall 154 retained in place against a shoulder 156 by a retaining plate 158 and sealed by a sealing ring 160. Furthermore, the shuttle valve cylinder portion 152 is formed with a series of circumferentially spaced inspiration gas inlet orifices 162, an expiration gas control port 164 connected to an annular distribution groove 166, and an exhaust port 168 connected to an annular distribution groove 170. The expiration gas control port 164 is outwardly connected through a connection tube 172 to an elbow 174 which projects through housing 122 for reception of and communication with an expiration valve control tube (not shown), and exhaust port 168 is outwardly connected through a connection tube 176 to a housing exhaust port 178 communicating with the atmosphere.

At the upper end thereof, the shuttle valve cylinder portion 152 is outwardly flanged to form a poppet valve seat portion 180 having a valve seat 182 with an inlet side 184 and an outlet side 186 communicating into the poppet valve chamber 128. A pressure gauge tube 188 may be secured with an upper end thereof extending upwardly through the poppet valve seat portion 180, and with a lower end thereof connected to a pressure port 190 extending through the housing 122 and connected to a pressure gauge (not shown) measuring both negative and positive pressure.

A shuttle valve member 192 may be tapered for vertically movable reception in the shuttle valve cylinder portion 152, being formed with a series of circumferentially spaced combined gas inlet and exhaust orifices 194 and a series of circumferentially spaced gas outlet orifices 196. As in the case of the first embodiment control valve 10, in the second embodiment control valve 120, the gas inlet and exhaust orifices 194 are located relative to the inspiration gas inlet orifices 162, the expiration gas control port 164 and the exhaust port 168 so that when the shuttle valve member 192 is in a lower or first position, the gas inlet and exhaust orifices communicate with both the expiration gas control port and exhaust port while sealing off the inspiration gas inlet orifices, and when the shuttle valve member is in an upper or second position, the gas inlet and exhaust orifices communicate with the inspiration gas inlet orifices and expiration gas control port while

sealing off the exhaust port. An inspiration gas inlet port 198 is secured through the housing 122 to provide communication through the housing to the inspiration gas inlet orifices 162, with the port being outwardly connected to a gas supply tube (not shown).

A poppet valve member 200 is secured to an upper end of the shuttle valve member 192 so as to be movable with the shuttle valve member between a closed position sealing against the valve seat 182 when the shuttle valve member is in first position and being in open position spaced upwardly from the valve seat when the shuttle valve member is in the second position. The gas outlet orifices 196 of the shuttle valve member 192 are again positioned in full communication with the inlet side 184 of the poppet valve seat 182, at least when the shuttle valve member is in the second position and the poppet valve member 200 is in the open position.

Thus, as in the case of the first embodiment control valve 10, with this second embodiment control valve 120, when the shuttle and poppet valve members 192 and 200 are respectively in the first and closed positions, the inspiration gas inlet orifices 162, and therefore the inspiration gas inlet port 198, are closed off by the shuttle valve member while the combination gas inlet and exhaust orifices 194 communicate from the expiration gas control port 164 into the shuttle valve member and from the shuttle valve member into the exhaust port 168 and outwardly through the housing exhaust port 178. When the shuttle and poppet valve members 192 and 200 are respectively in the second and open positions, the exhaust port 168 is sealed off by the shuttle valve member and the gas inlet and exhaust orifices 194 provide communication from the inspiration gas inlet port 198 through the inspiration gas inlet orifices 162 into the shuttle valve member and from the shuttle valve member outwardly through the expiration gas control port 164. In this same positioning of the shuttle and poppet valve members 192 and 200 in the second and open positions, the gas outlet orifices 196 of the shuttle valve member are positioned for full communication with the inlet side 184 over the valve seat 182 and through the outlet side 186 beneath the poppet valve member and into the poppet valve chamber 128. From poppet valve chamber 128, the inspiration gases flow by the retaining plate 134 through the opening 150 and into an inspiration gas outlet port 202 secured through the housing 122 and provided for operable connection with an inspiration gas tube (not shown).

A valve member magnet 204 is threadably secured to the shuttle valve member 192 overlying the poppet valve member 200 for movement with the valve members. A repelling magnet member 206 is retained in a holding ring 208 threadably adjustably surrounding a part of the shuttle valve cylinder portion 152, and an attracting magnet member 210 is suspended spaced upwardly from and overlying the valve member magnet 204 within the housing poppet valve chamber 128 by a positioning screw 212 threadably adjustably received through the housing top wall 144, as shown. Thus, through adjustment of the repelling and attracting magnet members 206 and 210 relative to the valve member magnet 204, the shuttle and poppet valve members 192 and 200 may be provided sensitive in any way desired degree to a minimum force, in this case the slight inspiration negative pressure of the patient attempting to inspire, tending to move the valve members from the first and closed positions to the second and open positions and then positively moving to such positions through positive gas flow therethrough, with the valve members automatically moving back to the first and closed positions upon the positive gas flow ceasing as a result of the patient's lung capacity having been reached.

In this second embodiment control valve 120, as previously pointed out, relative to the first embodiment control valve 10, the shuttle and poppet valve members 192 and 200 are maintained in the second and open positions

by positive gas flow therethrough once moved toward said positions, such gas flow creating a positive retainment force through the flow movement and a predetermined pressure drop through the shuttle valve gas outlet orifices 190. Precalculation of the sizes of orifices 196 will create the proper retainment force as determined by the other balancing and flow forces on the valve members 192 and 200.

The adjustment and operation of the second embodiment control valve 120 is, therefore, similar to that of the first embodiment control valve 10 previously described. Furthermore, the unique qualities and features thereof, as well as the advantageous use thereof in the positive pressure flow cut-off respiration system of the present invention, are virtually the same.

As used herein, the term face mask or mask portion is intended to be any usual form, whether of the type shown or merely a usual mouthpiece form. The only important feature thereof is that the patient is able to inspire and expire gases therethrough. Such terms, therefore, are intended to be broadly construed.

I claim:

1. In a flow sensitive respiration system for the administration of oxygen and similar adjuvant gases to a patient, the combination of: a poppet valve including a valve member movable between open and closed positions, a poppet valve seat having inlet and outlet sides, said poppet valve member engaging said valve seat in said closed position and being spaced therefrom in said open position; a face mask operably connected with said valve seat outlet side of said poppet valve; a shuttle valve including a valve cylinder, a shuttle valve member having a gas passage therethrough and being reciprocal in said cylinder movable between first and second positions, said poppet valve member being secured to and reciprocally movable with said shuttle valve member between said closed and open positions, inlet orifice means in said shuttle valve member opening into said gas passage closed in said shuttle valve member first position and open in said valve member second position, outlet orifice means in said shuttle valve member opening into said gas passage and open directly in communication with said valve seat inlet side of said poppet valve at least in said shuttle valve member second position, said poppet valve seat being adjacent said shuttle valve member and said shuttle valve outlet orifice means; said securing between said valve members connecting said valve members of said poppet and shuttle valves for absolute simultaneous movement to said closed and first positions and to said open and second positions, said valve members being immovable relative to each other; gas supply means operably connected communicating with said inlet orifice means of said shuttle valve for supplying upstream adjuvant gas under pressure to said inlet orifice means of said shuttle valve and through said shuttle and poppet valves downstream to said face mask when said valves are moved respectively to said second and open positions; said poppet valve member and poppet valve seat including means engaged therebetween when said poppet valve member is in said closed position for sealing between said poppet valve seat outlet and inlet sides, said means engaged permitting initial simultaneous movement of said poppet and shuttle valve members toward said open and second positions when in said closed and first positions by a minimum negative force downstream of said poppet valve seat outlet side caused by a flow of gas away from said poppet valve seat outlet side as a result of a patient's attempted inhalation at said face mask tending to draw said poppet valve member from said poppet valve seat; said shuttle valve inlet orifice means including means engaged when said shuttle valve member is in said first position for sealing between said upstream gas supply means and said shuttle valve gas passage and preventing any upstream gas pressure from moving said poppet and shuttle valve members from said

closed and first positions when fully in said positions; and said poppet and shuttle valve members normally being free of any forces capable of moving said valve members from said closed and first positions when fully in said positions other than said downstream minimum negative force, said poppet and shuttle valve members after said initial movement by said downstream minimum negative force being immediately forced to move fully to said open and second positions by the pressure flow of upstream gas therethrough and remaining in said open and second positions so long as said flow exists, said poppet and shuttle valve members simultaneously returning to said closed and first positions upon cessation of said gas pressure flow caused by a patient's lungs becoming full.

2. A respiration system as defined in claim 1 in which said poppet valve includes a valve housing secured to an end of said shuttle valve cylinder, said poppet valve member being secured to an end of said shuttle valve member reciprocally movable with said shuttle valve member between said closed and open positions, said poppet valve member being movable in said poppet valve housing, said poppet valve seat being located in said poppet valve housing between said housing and said shuttle valve cylinder and adjacent said shuttle valve outlet orifice means; and in which said face mask is operably connected with said poppet valve housing at said valve seat outlet side.

3. In a positive pressure flow cut-off respiration system for the positive pressure flow administration of oxygen and similar adjuvant gases to a patient, the combination of: a face mask; valve means operably connected to said mask for automatically opening and supplying upstream gas under positive pressure flow to said mask through the combination of an initial negative downstream flow force created on said valve means through attempted inspiration by said patient initially drawing said valve means toward opening and immediate subsequent positive pressure gas flow through said valve means permitted by said initial opening and forcing said valve means to fully open, said valve means automatically closing and interrupting said upstream gas supply to said mask upon cessation of said gas flow through said valve means permitting said closing upon the lung capacity of said patient having been reached, said valve means being constructed and arranged incapable of movement initially from fully closed toward opening from pressure of said upstream gas and always remaining fully closed regardless of said pressure, said valve means normally being free of any force capable of moving said valve means from fully closed when fully closed other than said negative downstream flow force by said patient, said valve means including magnet means for balancing said valve means normally closed when fully closed and sensitive to said initial inspiration negative downstream flow force by said patient and said subsequent positive pressure gas flow to permit said automatic opening of said valve means upon said attempted inspiration, said magnet means including repelling magnet means and attracting magnet means both actionable tending to urge said valve means from said closed toward said open positions and balancing said valve means in fully closed position subject to said initial inspiration negative downstream flow force; and gas supply means operably connected with said valve means for supplying said upstream gas under positive pressure flow.

4. A respiration system as defined in claim 3 in which adjustment means is operably connected to at least one of said repelling and attracting magnet means for selectively altering the action of said magnet means on said valve means to thereby selectively alter said balancing and sensitivity of said valve means to said initial inspiration negative downstream flow force and said subsequent upstream positive gas flow.

5. In a valve for use in conjunction with a flow sensitive respiration system, the combination of: a housing;

a poppet valve in said housing including a valve member movable between open and closed position, a poppet valve seat having inlet and outlet sides, said poppet valve member engaging said valve seat in said closed position and being spaced therefrom in said open position; a shuttle valve in a shuttle valve cylinder of said housing including a valve member secured to and movable exactly simultaneously with said poppet valve member, said poppet and shuttle valve members being immovable relative to each other, said shuttle valve member having a gas passage therethrough and being reciprocal in said cylinder moved to a first position when said poppet valve member is moved to said closed position and moved to a second position when said poppet valve member is moved to said open position, inlet orifice means in said shuttle valve member opening into said gas passage closed in said shuttle valve member first position and open in said shuttle valve member second position, outlet orifice means in said shuttle valve member opening into said gas passage and open directly in communication with said valve seat inlet side of said poppet valve at least in said shuttle valve member second position, said poppet valve seat being adjacent said shuttle valve member and cylinder and in communication with said outlet orifice means; an upstream pressure gas inlet port operably connected communicating with said inlet orifice means of said shuttle valve; a downstream gas outlet port operably connected communicating with said valve seat outlet side of said poppet valve; said poppet valve member and poppet valve seat including means engaged therebetween when said poppet valve member is in said closed position for sealing between said poppet valve seat outlet and inlet sides, said means engaged permitting initial simultaneous movement of said poppet and shuttle valve members toward said open and second positions when in said closed and first positions by a minimum negative force downstream of said poppet valve seat outlet side such as that as would be caused by a flow of gas away from said poppet valve seat outlet side at said downstream gas outlet port as a result of a patient's attempted inhalation, said minimum negative force tending to draw said poppet valve member from said poppet valve seat; said shuttle valve inlet orifice means including means engaged when said shuttle valve member is in said first position for sealing between said upstream pressure gas inlet port and said shuttle valve gas passage and preventing any upstream gas pressure from moving said poppet and shuttle valve members from said closed and first positions when fully in said positions; and said poppet and shuttle valve members normally being free of any forces capable of moving said valve members from said closed and first positions when fully in said positions other than as could be caused by said downstream minimum negative force, said poppet and shuttle valve members after said initial movement by said downstream minimum negative force being constructed and arranged for being immediately forced to move fully to said open and second positions by the pressure flow of upstream gas therethrough and remaining in said open and second positions so long as such a flow exists, said poppet and shuttle valve members simultaneously returning to said closed and first positions upon cessation of said gas pressure flow such as would be caused by the lungs of a patient being supplied said gas becoming full.

6. A valve as defined in claim 5 in which said housing includes a poppet valve housing secured to an end of said shuttle valve cylinder, said poppet valve member being movable in said poppet valve housing, said poppet valve seat being located in said poppet valve housing between said housing and said shuttle valve cylinder; and in which said downstream gas outlet port is operably connected communicating with said valve seat outlet of said poppet valve through said poppet valve housing.

7. In a valve for use in conjunction with a respiration system, the combination of: a housing having gas inlet and outlet ports; a valve member in said housing between said

inlet and outlet ports; and means operably connecting said valve member to said housing for movement between a closed position interrupting the flow of gas through said housing between said inlet and outlet ports and an open position permitting the flow of gas through said housing between said ports, said means including magnet means actionable between said valve member and housing for balancing said valve member sensitive to a minimum force tending to move said valve member from said closed to said open position and permitting movement by said force to said open position, said magnet means including repelling magnet means and attracting magnet means, both tending to urge said valve member from said closed toward said open position, adjustment means operably connected to at least one of said repelling and attracting magnet means for selectively varying the relationship between said one magnet means and said valve member to thereby vary said balancing and sensitivity of said valve member to said minimum force.

8. In a valve for use in conjunction with a positive pressure flow cut-off respiration system of the type for administration of oxygen and similar adjuvant gases to a patient, the combination of: a housing having gas inlet and outlet ports; a valve member in said housing between said inlet and outlet ports; means operably connecting said valve member to said housing for automatically moving to an open position from a closed position permitting a positive pressure flow of upstream gas through said housing between said inlet and outlet ports upon the combination of an initial negative downstream flow force created on said valve member from said outlet port through attempted inspiration by a patient being received at said outlet port initially drawing said valve member from closed toward open position immediately followed by said positive pressure upstream gas flow from said inlet port through said housing permitted by said initial valve member opening movement and forcing said valve member to fully open position, said valve member automatically moving to said closed position interrupting said flow of upstream gas through said housing between said ports upon cessation of said upstream gas flow through said housing permitting said closed position movement upon the lung capacity of said patient having been reached, said valve member being operably connected to said housing by said means so as to be incapable of movement initially from said fully closed position toward said open position from pressure of said upstream gas through said inlet port and always remaining fully in said closed position regardless of said upstream gas pressure, said valve member normally being free of any force capable of moving said valve member from said fully closed position when in said fully closed position other than said negative downstream flow force created by said patient attempted inspiration, said means including magnet means actionable between said valve member and housing for balancing said valve member when in said fully closed position sensitive to said negative downstream flow force by said patient and permitting movement of said valve member from said initially open to said fully open position by said positive pressure upstream gas flow, said magnet means including repelling magnet means and attracting magnet means both tending to urge said valve member from said closed toward said open position when in said fully closed position; and adjustment means operably connected to at least one of said repelling and attracting magnet means for selectively altering the relationship between said one magnet means and said valve member in said valve member fully closed position to thereby alter said balancing and sensitivity of said valve member in said fully closed position to said initial negative downstream flow force and said following positive pressure upstream gas flow.

9. In a flow sensitive respiration system for the administration of oxygen and similar adjuvant gases to a patient, the combination of: a poppet valve including a valve member movable between open and closed posi-

tions, a poppet valve seat having inlet and outlet sides, said poppet valve member engaging said valve seat in said closed position and being spaced therefrom in said open position; a face mask operably connected with said valve seat outlet side of said poppet valve; a shuttle valve including a shuttle valve member having a gas passage therethrough and being movable between first and second positions, inlet orifice means in said shuttle valve member opening into said gas passage closed in said shuttle valve member first position and open in said valve member second position, outlet orifice means in said shuttle valve member opening into said gas passage and open directly in communication with said valve seat inlet side of said poppet valve at least in said shuttle valve member second position; means securely connecting said valve members of said poppet and shuttle valves for absolute simultaneous movement to said closed and first positions and to said open and second positions, said valve members being immovable relative to each other; gas supply means operably connected communicating with said inlet orifice means of said shuttle valve for supplying upstream adjuvant gas under pressure to said inlet orifice means of said shuttle valve and through said shuttle and poppet valves downstream to said face mask when said valves are moved respectively to said second and open positions; said poppet valve member and poppet valve seat including means engaged therebetween when said poppet valve member is in said closed position for sealing between said poppet valve seat outlet and inlet sides, said means engaged permitting initial simultaneous movement of said poppet and shuttle valve members toward said open and second positions when in said closed and first positions by a minimum negative force downstream of said poppet valve seat outlet side caused by a flow of gas away from said poppet valve seat outlet side as a result of a patient's attempted inhalation at said face mask tending to draw said poppet valve member from said poppet valve seat; said shuttle valve inlet orifice means including means engaged when said shuttle valve member is in said first position for sealing between said upstream gas supply means and said shuttle valve gas passage and preventing any upstream gas pressure from moving said poppet and shuttle valve members from said closed and first positions when fully in said positions; said poppet and shuttle valve members normally being free of any forces capable of moving said valve members from said closed and first positions when fully in said positions other than said downstream minimum negative force, said poppet and shuttle valve members after said initial movement by said downstream minimum negative force being immediately forced to move fully to said open and second positions upon cessation of said gas pressure flow caused by a and remaining in said open and second positions so long as said flow exists, said poppet and shuttle valve members simultaneously returning to said closed and first positions upon cessation of said pressure flow caused by a patient's lungs becoming full; and magnet means operably connected to said poppet and shuttle valves and balancing said valve members in said closed and first positions sensitive to said minimum negative force tending to initially move said valve members from said closed and first positions to said open and second positions and permitting said movement by said force to said open and second positions, said magnet means including repelling magnet means and attracting means both tending to urge said valve members from said closed and first positions toward said open and second positions against weights of said valve members normally maintaining them in said closed and first positions.

10. A respiration system as defined in claim 9 in which adjustment means is operably connected to at least one of said repelling and attracting magnet means for selectively adjusting said one magnet means relative to said valve members and thereby alter said balance of said

valve members and said sensitivity to said minimum force.

11. In a valve for use in conjunction with a flow sensitive respiration system, the combination of: a housing; a poppet valve in said housing including a valve member movable between open and closed position, a poppet valve seat having inlet and outlet sides, said poppet valve member engaging said valve seat in said closed position and being spaced therefrom in said open position; a shuttle valve in said housing including a valve member secured to and movable exactly simultaneously with said poppet valve member, said poppet and shuttle valve members being immovable relative to each other, said shuttle valve member having a gas passage therethrough and being moved to a first position when said poppet valve member is moved to said closed position and being moved to a second position when said poppet valve member is moved to said open position, inlet orifice means in said shuttle valve member opening into said gas passage closed in said shuttle valve member first position and open in said shuttle valve member second position, outlet orifice means in said shuttle valve member opening into said gas passage and open directly in communication with said valve seat inlet side of said poppet valve at least in said shuttle valve member second position; an upstream pressure gas inlet port operably connected communicating with said inlet orifice means of said shuttle valve; a downstream gas outlet port operably connected communicating with said valve seat outlet side of said poppet valve; said poppet valve member and poppet valve seat including means engaged therebetween when said poppet valve member is in said closed position for sealing between said poppet valve seat outlet and inlet sides, said means engaged permitting initial simultaneous movement of said poppet and shuttle valve members toward said open and second positions when in said closed and first positions by a minimum negative force downstream of said poppet valve seat outlet side such as that as would be caused by a flow of gas away from said poppet valve seat outlet side at said downstream gas outlet port as a result of a patient's attempted inhalation, said minimum negative force tending to draw said poppet valve member from said poppet valve seat; said shuttle valve inlet orifice means including means engaged when said shuttle valve member is in said first position for sealing between said upstream pressure gas inlet port and said shuttle valve gas passage and preventing any upstream gas pressure from moving said poppet and shuttle valve members from said closed and first positions when fully in said positions; said poppet and shuttle valve members normally being free of any forces capable of moving said valve members from said closed and first positions when fully in said positions other than as could be caused by said downstream minimum negative force, said poppet and shuttle valve members after said initial movement by said downstream minimum negative force being constructed and arranged for being immediately forced to move fully to said open and second positions by the pressure flow of upstream gas therethrough and remaining in said open and second positions so long as such a flow exists, said poppet and shuttle valve members simultaneously returning to said closed and first positions upon cessation of said gas pressure flow such as would be caused by the lungs of a patient being supplied said gas becoming full; and magnet means operably connected to said poppet and shuttle valves for aiding in balancing said valve members in said closed and first positions sensitive to said minimum negative downstream force tending to

initially move said valve members from said fully closed and first positions to said open and second positions and permitting said movement by said force to said open and second positions, said magnet means including repelling magnet means and attracting magnet means both action-able tending to urge said valve members from said closed and first positions toward said open and second positions against weights of said valve members normally maintaining them in said closed and first positions.

12. A valve as defined in claim 11 in which adjustment means is operably connected to at least one of said repelling and attracting magnet means for selectively adjusting said one magnet means relative to said valve members and thereby alter said balancing of said valve members in said closed and first positions and said sensitivity to said initial minimum negative force.

13. A valve as defined in claim 11 in which said magnet means includes a magnet mounted on and movable with said valve members, said repelling magnet being mounted on said housing positioned repelling said valve member magnet and thereby tending to urge said valve members from said closed and first positions toward said open and second positions, said attracting magnet being mounted on said housing positioned attracting said valve member magnet and thereby tending to urge said valve members from said closed and first positions toward said open and second positions, said weights of said valve members opposing magnetic forces of said magnets maintaining said valve members initially in said fully closed and first positions sensitive to said minimum negative downstream force.

14. A valve as defined in claim 11 in which said magnet means includes a magnet mounted on and movable with said valve members, said repelling magnet being mounted on said housing positioned repelling said valve member magnet and thereby tending to urge said valve members from said closed and first positions toward said open and second positions, said attracting magnet being mounted on said housing positioned attracting said valve member magnet and thereby tending to urge said valve members from said closed and first positions toward said open and second positions, said weights of said valve members opposing magnetic forces of said magnets maintaining said valve members initially in said fully closed and first positions sensitive to said minimum negative downstream force; and in which adjustment means is operably connected between each of said repelling and attracting magnets and said housing for selectively adjusting the positions of said repelling and attracting magnets relative to said valve member magnet thereby altering said balancing of said valve members and said sensitivity thereof initially to said minimum negative downstream force.

References Cited

UNITED STATES PATENTS

2,287,840	6/1942	Stratton	137—538
2,881,757	4/1959	Haverland	128—145.8
3,039,481	6/1962	Schreiber et al.	251—65
3,114,365	12/1963	Franz	128—145.8
3,212,751	10/1965	Hassa	251—65
3,234,932	2/1966	Bird et al.	128—145.6
3,265,062	8/1966	Hesse	128—145.8

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