

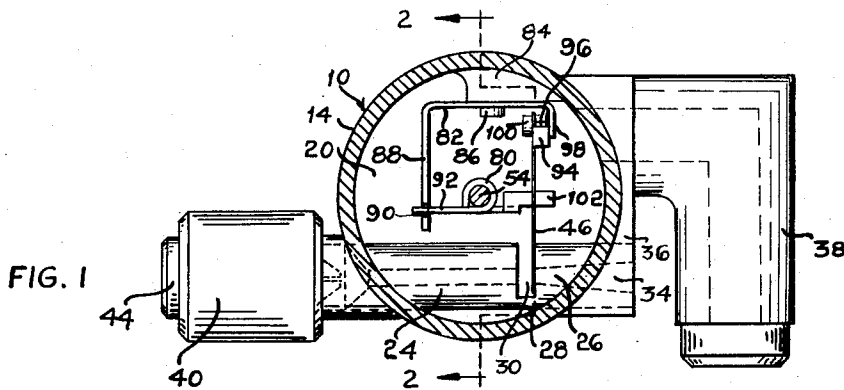
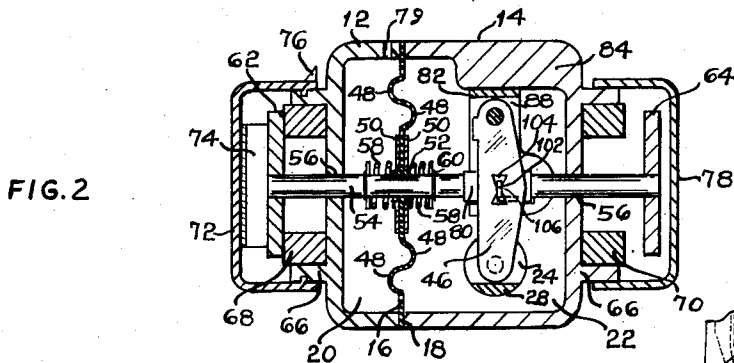
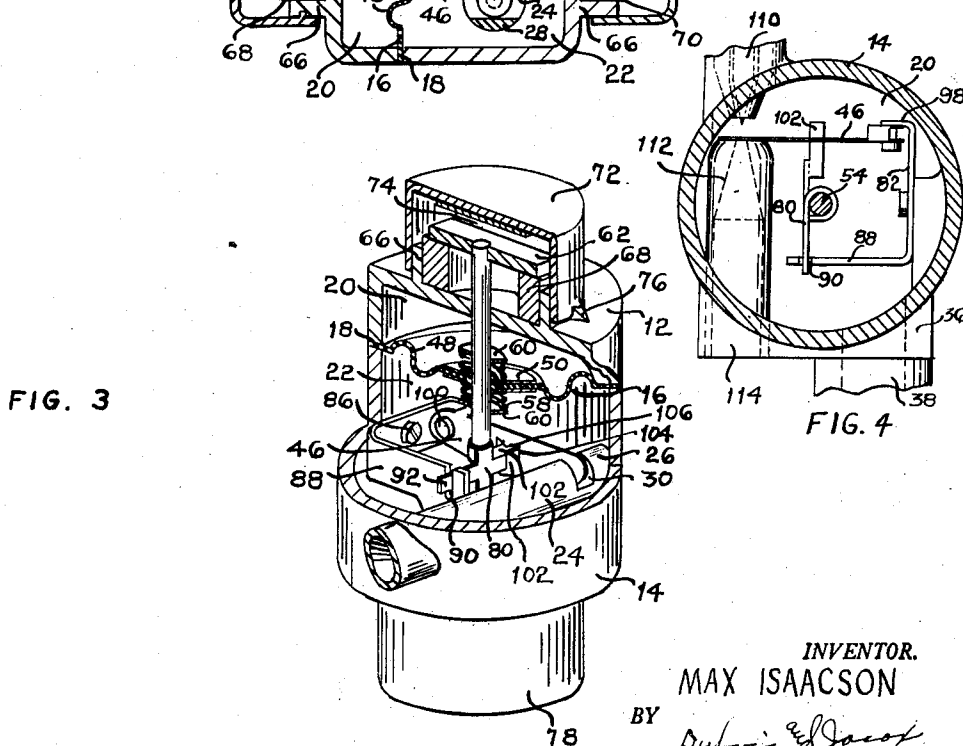
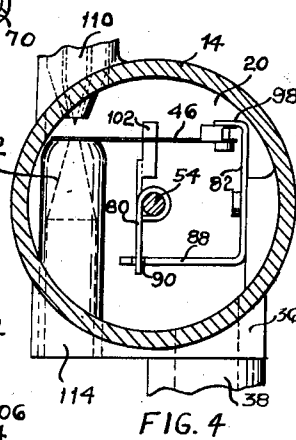
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RESUSCITATOR VALVE ASSEMBLY

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RESUSCITATOR VALVE ASSEMBLY

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This invention relates to a pressure control apparatus for resuscitators and the like, and more particularly to an improved valve assembly therefor, although not necessarily so limited.

The pressure control apparatus of this invention is designed for use in resuscitators operating from a source of gas under pressure, the control apparatus including an aspirator assembly or venturi tube for producing gas pressures less than the pressure of the ambient atmosphere, that is, negative pressures. The resuscitator breathing cycle, comprising successive intervals of positive and negative pressure produced in the control apparatus, is regulated by intermittently opening and closing the aspirator assembly with a valve mechanism. In the operation of this valve mechanism, the efficiency of the valve action regarding absence of leakage and the energy required for operation is of critical importance.

An object of this invention is to provide a valve assembly constructed from light weight parts for use in resuscitators, which assembly can be actuated with a minimum of effort by a reciprocating member moving through a relatively short stroke.

Another object of this invention is to provide a valve assembly employing a self-sealing flexible reed member as a slide valve, so as to provide positive valving action.

Still another object of this invention is to provide a valve assembly for alternately opening and closing an aspirator tube, which valve is located so as not to obstruct the flow of gas in the tube when the aspirator tube is open.

Other objects and advantages reside in the construction of parts, the combination thereof and the mode of operation, as will become more apparent from the following description.

In the drawings,

Figure 1 is a top plan view of the pressure control apparatus of this invention, with parts broken away.

Figure 2 is a sectional view taken substantially along the line 2—2 of Figure 1.

Figure 3 is a perspective view of the pressure control apparatus, with parts broken away.

Figure 4 is a top plan view of a modification of this invention, with parts broken away.

The resuscitator to which this invention applies utilizes a source of gas under pressure as a means of forcing a patient to inhale and an aspirator through which the gas under pressure flows as a means of withdrawing the gas from the lungs of the patient for exhalation. In the construction of such a resuscitator, it is common practice to connect the source of gas to the aspirator, providing a connection between an opening in the aspirator and the patient's lungs, and to provide a butterfly valve or the like in the aspirator, downstream from the opening, for opening and closing the downstream portion of the aspirator assembly. When the valve is in the closed position, the aspirator is inoperative and gas under pressure flows out of the aspirator opening to the patient's lungs. When the valve is in the open position,

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the aspirator is operative and gas is withdrawn from the patient's lungs through the aspirator opening.

The present invention resides in a novel valve and aspirator construction and arrangement whereby the fluid flow through the aspirator is unobstructed when the resuscitator is operating to produce a negative pressure and whereby the fluid flow into the aspirator is utilized as an aid in seating a valve which substantially completely shuts off the fluid flow through the downstream portion of the aspirator when the resuscitator is operating to produce a positive pressure.

Referring to the drawings in greater detail, a cylindrical housing 10 houses the pressure control apparatus of this invention. The housing 10 is formed from two mating cup-shaped members 12 and 14 separated by a flexible, radially disposed circular membrane or diaphragm 16. The marginal portion 18 of the diaphragm 16 provides a sealing gasket between the two members 12 and 14 which are held in compressive engagement therewith by suitable clasps (not shown).

The housing 10 is thus divided into two chambers 20 and 22, the latter being maintained air-tight and the former being open to the ambient atmosphere, as will be described subsequently.

An aspirator assembly, comprising two axially aligned conduit members 24 and 26, traverses the housing member 14 in the chamber 22. The conduit members 24 and 26 are held in fixed spaced relationship by a thin segmental wall portion 28 to provide an opening or spill port 30 therebetween.

The conduit member 26, representing the downstream portion of the aspirator assembly, connects to the ambient atmosphere through the wall of the housing member 14 and through a block 36 integral with the housing member 14.

The conduit member 24, representing the upstream portion of the aspirator assembly, connects to a jet injection device 40 through the wall of the housing member 14. The jet injection device is provided with an adapter 44 for connection to a source of gas under pressure, as, for example, a cylinder of compressed oxygen or air. Preferably, the jet injection device is equipped with means (not shown) for adjusting the flow of gas through the jet and with means (not shown) for diluting the gas stream with air when this is desired.

In the operation of the aspirator assembly, gas is injected in a jet stream into the upstream conduit member 24 by the jet injection device 40. As shown in the drawings, a thin flexible reed-like valve member 46 closes the conduit member 26. The gas, traveling through the conduit member 24, impinges upon the valve member 46 and is deflected into the chamber 22. The chamber 22 connects through a coupling member 38 supported by the block 36, and through a face mask or breathing tube (not shown) to the lungs of a patient. The chamber 22, coupling member 38, face mask or the like, and the patient's lungs represent a closed volume which is filled by the gas delivered by the conduit member 24.

By a mechanism to be described subsequently, the valve member 46 is pivoted to open the conduit member 26 when the gas pressure in the closed volume reaches a critical maximum value. The gas stream, traveling through the conduit 24, then no longer deflected by the valve member 46, crosses the spill port 30 to enter the conduit member 26 which has a tapered channel 34 passing therethrough.

The flow of gas from the smaller conduit member 24 into the tapered channel 34 creates a low pressure zone at the mouth of the conduit member 26. As a result, gas is evacuated from the chamber 22 through the conduit 26. This reduces the pressure in the closed volume including the chamber 22. When the gas pressure drops

sufficiently below that of the ambient atmosphere, the valve member 46 is reseated on the conduit member 26, to reinitiate an inhalation cycle.

In this manner, the aspirator assembly is employed to provide a cyclic rising and falling pressure in the closed volume including the chamber 22. The mechanism for actuating the valve member 46 operates as follows.

The rising and falling pressure in the chamber 22 tends to move the diaphragm 16 axially in the housing 10, so as to increase or decrease the volume of the chamber 22. The axial motion of the diaphragm is promoted by providing a pair of oppositely directed annular arches 48 adjacent the cylindrical wall of the housing 10, which enable the central portion of the diaphragm to move axially without stretching. The central portion of the diaphragm is further prevented from bowing or stretching by providing a thin disc 50 of metal or plastic, or the like, on either side thereof. The discs may be secured to the diaphragm by an elastomeric grommet 52, as shown, or by any other suitable means.

A rod 54 extends axially through the housing 10 and the grommet 52, the rod 54 passing through apertures 56 provided therefor in the end walls of the housing. The grommet 52 compressively engages the rod 54 to provide an air-tight seal between the rod and the diaphragm. Oppositely directed coil springs 58, secured to the rod 54 by washers 60, compressively abut the discs 50 on either side of the diaphragm to yieldingly secure the diaphragm 16 to the rod 54. The rod 54 is thus urged to move axially by the diaphragm 16 when the pressure in the chamber 22 rises or falls.

Secured non-rotatably to opposite ends of the rod 54 are bars of ferro-magnetic material, such as iron, forming armatures 62 and 64 extending normal to the axis of the rod. The two armatures 62 and 64 are disposed in parallel relationship. Annular flanges 66 projecting axially from each end of the housing 10 provide cylindrical cavities, one at each end of the housing 10, into which are press-fitted ring magnets, there being one ring magnet 68 at one end of the housing 10 adjacent the armature 62, and another ring magnet 70 at the opposite end of the housing 10 adjacent the armature 64. The two ring magnets 68 and 70 are so oriented that the magnetic field in one is parallel to the magnetic field in the other.

The length of the rod 54 is such that when the armature 62 is in contact with the adjacent magnet 68 at one end of the rod, the armature 64 and the magnet 70 at the opposite end of the rod are spaced apart. When a force is exerted upon the rod 54, so as to move the armature 62 axially away from the magnet 68, as may be exerted by the diaphragm 16 when the pressure in the chamber 22 rises, movement of the armature 62 away from the magnet 68 is opposed by the magnetic field therebetween until the armatures 62 and 64 are equally spaced from their respective magnets 68 and 70 a neutral point. With continued axial movement of the rod 54, the attractive force between the magnet 70 and the armature 64 becomes dominant and the rod 54 is accelerated by the magnetic field until the armature 64 contacts the magnet 70. Thus, as the pressure in the chamber 22 rises or falls, movement of the diaphragm 16 is at first opposed or restrained by the magnets, then subsequently accelerated by the magnets.

In the operation of this restraining mechanism, a finite pressure must be developed in the chamber 22 before the armature 62 can be separated from the magnet 68. As this critical pressure is approached, the opposing springs 58 are displaced slightly by the diaphragm 16. At the instant the armature 62 separates from the magnet 68 under the influence of rising pressure in the chamber 22, the energy stored in the springs 58 is released, this energy being sufficient to throw the rod 54, carrying the armatures 62 and 64, past the neutral point, so that the armature 64, attracted by the magnet 70, moves into contact therewith.

The combined forces of the magnets 68 and 70 and the springs 58 are sufficient to throw the rod 54 from one extreme axial position in the housing 10 to an opposite extreme position in the housing 10 after the pressure in the chamber 22 has reached a critical minimum value. Similarly, if the pressure in the chamber drops sufficiently below the pressure of the ambient atmosphere, the rod 54 is thrown to the reverse extreme position by the combined action of the springs 58 and the magnets 68 and 70. There is no stable position of the rod 54 intermediate the extreme axial positions thereof.

Clearly, the maximum and minimum pressures required to actuate the rod 54 are determined by the strength of magnetic attraction between the armatures and the magnets. When the armatures are aligned in parallel relation with the north and south poles of the ring magnets, the magnetic attraction is at a maximum and, when the armatures are disposed normal to the poles of the ring magnets, the attraction is at a minimum. By rotating the armatures 62 and 64 relative to the magnets 68 and 70, the critical gas pressures required to actuate the rod 54 may be varied.

Rotation of the armatures is provided for in the following: A cap 72 is rotatably secured to the annular flange 66 integral with the member 12. A flange 74, depending from the cap 72, engages the side of the armature 62, so that both the armature 62 and the armature 64 may be rotated by rotating the cap 72. The flange 74 in no way restricts the axial motion of the armature 62. Preferably, the cap 72 and flange 74 are fabricated from a paramagnetic material, such as aluminum, so as not to interfere appreciably with the magnetic interaction between the armature 62 and the magnet 68.

A pointer 76, located external to the cap 72, indicates the relative position of the armature. A scale (not shown) may be placed on the housing 10 to facilitate positioning of the armatures. A similar cap 78 is press-fitted, or otherwise secured, to the flange 66 at the opposite end of the housing 10, to provide an air-tight closure for isolating the chamber 22 from the ambient atmosphere. A hole 79 is placed in the wall of the housing member 12, so as to provide a direct connection between the chamber 20 and the ambient atmosphere.

The reciprocating snap action of the rod 54 is employed to actuate the valve member 46 situated in the chamber 22 as follows. Rotatably secured to the rod 54 is an actuator member 80, which moves axially therewith. Rotation of the actuator member 80 is restricted by a substantially L-shaped bracket having one leg 82 secured to a projection 84 integral with the housing member 14 by means of a screw 86. The other leg 88 of the bracket has an axially extending slot 90 therein, into which an arm 92 of the actuator member 80 projects. The slot 90 permits axial movement of the actuator member, but restricts rotary movement of the actuator member.

At one end of the valve member 46 an integral flange portion is arched or folded over to provide a substantially U-shaped portion 94, the legs of which are apertured to accommodate a pin 96. The pin 96, journaled to the U-shaped portion 94, is secured to a flange 98 projecting normally from the leg 82 of the L-shaped bracket member. The valve member 46 is thus pivotally secured to the L-shaped bracket member. The legs of the U-shaped portion 94 are freely or slightly yieldingly disposed between the flange 98 on one side and an enlarged portion 100 of the pin 96 on the other side, so that the valve member 46 is self-aligning upon the pin 96 and relatively freely pivoted for opening and closing the downstream portion or inlet opening of the conduit 26.

The actuator member 80 is provided with an arm 102 for engaging the valve member 46, the arm 102 projecting into an aperture 104 provided therefor in the valve member 46. Substantially triangular tongue portions 106, integral with the valve member 46, project oppo-

sitely into the aperture 104 to provide knife edges for engagement with the actuator arm 102.

As the rod 54 and actuator member 80 undergo reciprocal motion, the actuator arm 102 engaging the valve member 46 causes the valve member to pivot about the pin 96. The unsupported end of the valve member 46 projects into the spill port 30 of the aspirator assembly, to seat upon the end of the conduit member 26 which is finished to provide a flat valve seat.

The reciprocating snap action of the rod 54, created by rising and falling pressure in the chamber 22, causes the actuator arm 102 to pivot the valve member 46 between extreme pivotal positions, the valve member 46 acting as a slide valve opening and closing the conduit member 26. The arrangement and size of parts is such that as the rod 54 reciprocates between extreme positions, the valve member 46 fully opens or fully closes the conduit member 26.

The rate of intermittent cycling is determined by the rate of flow of gas from the injection device into the aspirator assembly in proportion to the closed volume of the chamber 22, lungs, et cetera. Clearly, any leaks in the closed volume will prolong the inhalation cycle. It is thus particularly important that the valve member 46 be firmly seated upon the conduit member 26 during the inhalation cycle, to provide a leak-proof closure. The valve member 46, due to its flexible reed-like construction, is particularly effective for this purpose, the valve being self-sealing under the influence of the impinging air stream.

It is preferable that a resuscitator apparatus have the capacity for operating at low pressure amplitudes, so as to provide a very gentle breathing action when this is desired. As was indicated previously, the pressure amplitude required for actuating the rod 54 is determined by the restraining forces exerted by the magnets 68 and 70. This restraining force is augmented somewhat by friction and inertia in the valve assembly. The valve assembly of this invention is designed to operate with a minimum of friction between parts and with a minimum of inertia, the design lending itself particularly to the use of light weight elements. In this construction, the weight of the actuator member 80 and the valve member 46 may be made negligible in comparison to the restraining forces exerted by the magnets 68 and 70. The valve member 46 may be, for example, a thin piece of metal or plastic, or the like. The valve member 46 illustrated herein is made of stainless steel, the member being a few thousandths of an inch in thickness.

The valve assembly is also particularly well suited to a short stroke of the rod 54 which is necessary for proper functioning of the magnet restraining assembly. The length of the stroke required of the rod is approximately one-half that required of the unsupported end of the valve member 46.

Figure 4 illustrates a modification of the preferred embodiment described in Figures 1-3. It will be noted in connection with the preferred embodiment, that the jet injection device 40 and aspirator assembly operate in combination to provide a pair of jets in tandem, there being one gas jet in the jet injection device and a second gas jet at the downstream end of the conduit 24. The first jet may be employed for air dilution of the gas by creating an aspirator effect in the jet injection device or for any other desired purpose. The second jet is used as described for evacuating the patient's lungs in forced exhalation in connection with the resuscitator operation.

In Figure 4, a modified resuscitator embodying only a single jet is shown. In this modification, the aspirator assembly traversing the housing member 14 includes a modified jet injection device 110 and a single conduit member 112 traversing the chamber 20 in axial alignment with the jet injection device. The conduit member 112 has a tapered channel portion 114 therein communicating with ambient atmosphere.

The end of the conduit member 112 adjacent the jet injection device 110 is machined to provide a valve seat for accommodating a pivotally mounted slide valve member. The valve member and mechanism for operating the valve member so as to open and close the conduit member 112 is substantially the same as that of the preferred embodiment with minor changes in the construction and arrangement of parts.

The leg 88 and the flange 98 of the L-shaped bracket member of the preferred embodiment are interchanged in the modification of Figure 4 so as to relocate the valve member 46. As in the preferred embodiment, the valve member 46 is pivotally secured to the flange 98 of the L-shaped bracket member. The actuator member 80 is pivoted 180° on the rod 54 so that, as in the preferred embodiment, the actuator member 80 moves slidably in the slot 90 of the leg 88 of the L-shaped bracket member. The arm 102 of the actuator member 80 engages the valve member 46 as in the preferred embodiment.

The mechanism for operating the valve member 46 so as to open and close the conduit member 46 is otherwise the same as that of the preferred embodiment. Again, the incoming gas stream from the jet injection device is utilized as an aid in firmly seating the valve member 46 upon the end of the conduit member 112.

Although the preferred embodiment and a modification of the device have been described, it will be understood that within the purview of this invention various changes may be made in the form, details, proportion and arrangement of parts, the combination thereof and mode of operation, which generally stated consist in a device capable of carrying out the objects set forth, as disclosed and defined in the appended claims.

Having thus described my invention, I claim:

1. A cycling valve apparatus for breathing equipment having a fluid receiving chamber enclosed by a pressure sensitive means; an outlet delivery conduit member connecting said chamber for periodically delivering fluid therefrom; an aspirator assembly associated with said chamber for periodically evacuating fluid from said chamber, said aspirator assembly comprising an aspirator conduit provided with an internal restriction for creating a jet stream of fluid to aid said evacuation, said aspirator conduit being discontinuous and comprising a first part into which fluid under pressure flows having an outlet opening in communication with said chamber and a spacedly opposed second part having an inlet opening in communication with said chamber, the peripheral area of the inlet opening of the second part of said aspirator conduit constituting a valve seat; a pivotally mounted thin flat flexible valve member spacedly mounted from the outlet opening of said first aspirator part and arranged to seat upon the entire area constituting said valve seat; the outlet opening of the first part of said aspirator conduit being arranged to direct a stream of fluid towards the inlet opening of the second part; a valve operating means connected to said valve member and including said pressure sensitive means and adapted to alternately cause said valve to completely open and completely seal the inlet opening of the second part of said aspirator conduit in response to predetermined pressures in said chamber; whereby when said valve member is seated to seal the inlet opening of the second part, a substantial inflow of fluid into said chamber around said valve member is permitted but substantially no flow is permitted through the second part for all operating pressures.

2. A cycling valve apparatus for breathing equipment having a fluid receiving chamber enclosed by a pressure sensitive means; an outlet delivery conduit member connecting said chamber for periodically delivering fluid therefrom; an aspirator assembly associated with said chamber for periodically evacuating fluid from said chamber, said aspirator assembly comprising an aspirator conduit provided with an internal restriction for creating

a jet stream of fluid to aid said evacuation, said aspirator conduit being discontinuous and comprising a first part into which fluid under pressure flows having an outlet opening in communication with said chamber and a spacedly opposed second part having an inlet opening in communication with said chamber, the peripheral area of the inlet opening of the second part of said aspirator conduit constituting a valve seat; a pivotally mounted thin flat flexible valve member spacedly mounted from the outlet opening of said first aspirator part and arranged to seat upon the entire area constituting said valve seat; the outlet opening of the first part of said aspirator conduit being arranged to direct a jet stream of fluid into the inlet opening of the second part when the valve member is removed from said inlet opening; a snap acting valve operating means connected to said valve member and including said pressure sensitive means and adapted to alternately cause said valve to completely open and completely seal the inlet opening of the second part of said aspirator conduit in response to predetermined pressures in said chamber; said parts of said aspirator conduit being so arranged that when said valve member is seated, the outlet opening of said first part is spaced from the valve member by such a distance that a primary and substantial inflow of fluid into said chamber around said valve member is permitted which impinges a flowing pressure stream upon said valve member to further insure its seating and whereby substantially no flow is permitted through the second part for all operating pressures.

3. A pressure control apparatus for use in resuscitators and the like, comprising a housing defining a fluid receiving chamber, a pressure sensitive diaphragm enclosing one wall of said chamber, an aspirator assembly associated with said housing into which a gas under pressure flows, said assembly including an aspirator conduit comprising a first part connecting with said chamber for delivering gas thereto and a spaced apart second part adjacent said first part and substantially coaxial therewith providing a gas outlet from said chamber connecting to the ambient atmosphere, a valve member slidably seated upon the end of said second part opposed to and spaced from the outlet of the first conduit part, means connected to the pressure sensitive diaphragm for periodically withdrawing said valve member into said chamber so as to open said second part of said conduit, and means for retaining said valve member in seated position when the pressure within the fluid receiving chamber is within predetermined limits, whereby when said valve member is seated to seal the second part, a substantial inflow of fluid into said chamber around said valve member is permitted but substantially no flow is permitted through the second part for all operating pressures.

4. A pressure control apparatus for use in resuscitators and the like, comprising a housing defining a gas receiving chamber, a pressure sensitive diaphragm enclosing one wall of said chamber, an aspirator assembly associated with said housing into which a gas under pressure flows, said assembly including an aspirator conduit provided with an internal restriction for creating a jet stream of fluid to aid the evacuation of said chamber periodically, said aspirator conduit being discontinuous and comprising a first part into which fluid under pressure flows having an outlet opening in communication with said chamber and a spacedly opposed second part having an inlet opening in communication with said chamber, the peripheral area of the inlet opening of the second part of said aspirator conduit constituting a valve seat; a pivotally mounted flexible valve member slidably seated upon said valve seat contacting the entire area constituting said valve seat; the outlet opening of the first part of said aspirator conduit being arranged to direct a jet stream of fluid into the inlet opening of the second part when the valve member is removed from said inlet opening; a snap acting valve operating means

interconnecting said diaphragm and said valve member and adapted to alternately cause said valve to completely open and completely seal the inlet opening of the second part of said aspirator conduit in response to predetermined pressures in said chamber; whereby when said valve member is seated, the outlet opening of said first part is spaced from the valve member by such a distance that a primary and substantial inflow of fluid into said chamber around said valve member is permitted which impinges a flowing pressure stream upon said valve member to further insure its seating and whereby substantially no flow is permitted through the second part for all operating pressures.

5. The pressure control apparatus of claim 4 wherein said valve operating means includes a rod reciprocally mounted in said housing connected to the pressure sensitive diaphragm, means connected to the rod for periodically pivoting said valve member into said chamber so as to open said inlet opening of the second part, and means biasing the movement of the rod so as to restrain the rod when the pressure within the gas receiving chamber is within predetermined limits.

6. A pressure control apparatus for use in resuscitators and the like, comprising a housing defining a gas receiving chamber, an aspirator assembly associated with said housing into which a gas under pressure flows, said assembly including a first conduit member connecting with said chamber for delivering gas thereto and a second conduit member adjacent said first conduit member and coaxial therewith providing a gas outlet from said chamber connecting to the ambient atmosphere, a pivotally mounted flexible valve member slidably seated upon the end of said second conduit member opposed to and spaced from the outlet of the first conduit member, a pressure sensitive diaphragm disposed in one wall of said chamber, a rod reciprocally mounted in said housing connected to the pressure sensitive diaphragm, means connected to the rod for periodically pivoting said valve member into said chamber so as to open said second conduit member, and means biasing the movement of the rod so as to restrain the rod when the pressure within the gas receiving chamber is within predetermined limits.

7. A pressure control apparatus for use in resuscitators and the like, comprising a housing defining a gas receiving chamber, an aspirator assembly associated with said housing into which a gas under pressure flows, said aspirator assembly including a first conduit member connecting with said chamber for delivering gas thereto and a second conduit member adjacent said first conduit member and coaxial therewith providing a gas outlet from said chamber connecting to the ambient atmosphere, a pivotally mounted flexible valve member slidably seated upon the end of said second conduit member adjacent the first conduit member for opening and closing said second conduit member, a pressure sensitive diaphragm disposed in one wall of said chamber, a rod reciprocally mounted in said housing yieldingly connected to the pressure sensitive diaphragm, actuator means connected to the rod for actuating said valve member to open and close said second conduit member, said valve member having an aperture therein and oppositely directed tongue members integral therewith projecting into said aperture so as to provide knife edges for engagement with said actuator means, and adjustable biasing means restraining the movement of said rod when the pressure within said gas receiving chamber is within predetermined limits.

8. A pressure control apparatus for use in resuscitators and the like, comprising a housing defining a gas receiving chamber, an aspirator assembly associated with said housing into which a gas under pressure flows, said aspirator assembly including a jet device connecting with said chamber for delivering gas thereto and a conduit member coaxial with said jet device providing a gas outlet from said chamber connecting to the ambient atmosphere, a pivotally mounted flexible valve member slid-

ably seated upon the end of said conduit member adjacent the jet device for opening and closing said conduit member, a pressure sensitive diaphragm disposed in one wall of said chamber, a rod reciprocally mounted in said housing yieldingly connected to the pressure sensitive diaphragm, actuator means connected to the rod for actuating said valve member to open and close said conduit member, said valve member having an aperture therein and oppositely directed tongue members integral therewith projecting into said aperture so as to provide knife edges for engagement with said actuator means, and adjustable biasing means restraining the movement of said rod when the pressure within said gas receiving chamber is within predetermined limits.

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