

Jan. 10, 1933.

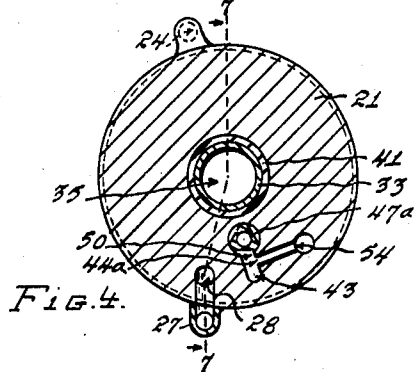
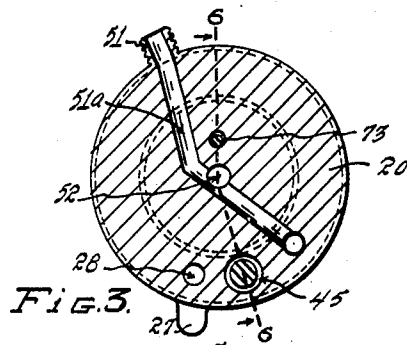
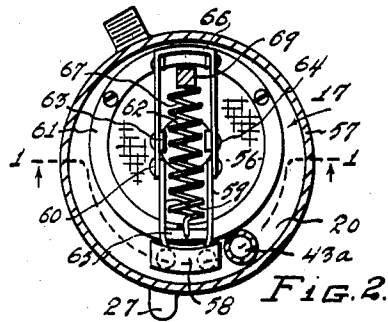
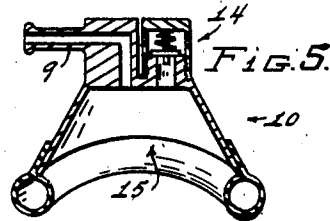
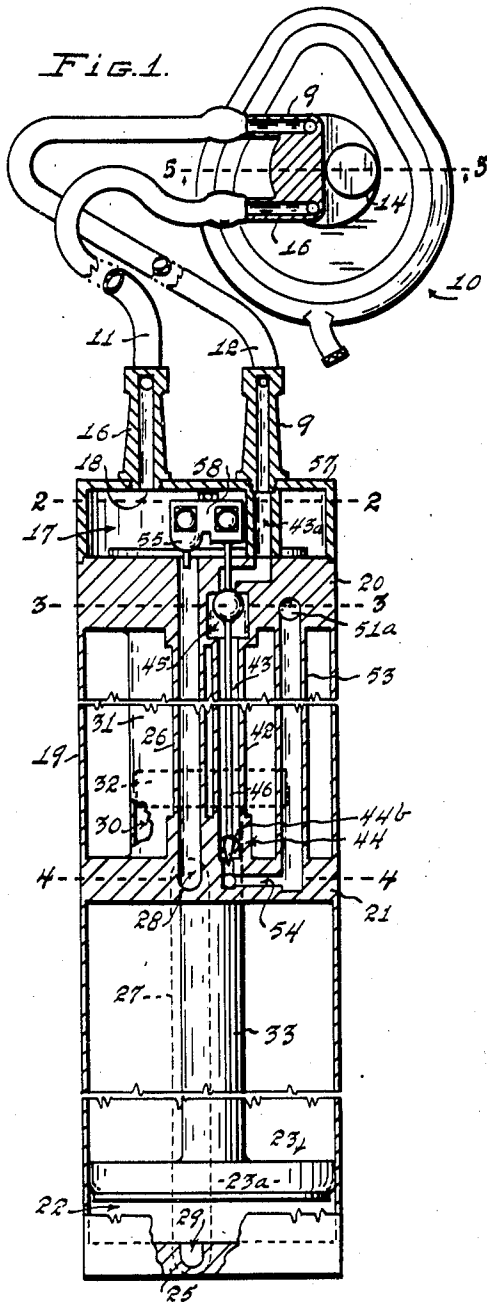
M. H. GOODNER

1,893,670

RESUSCITATOR AND THE LIKE

Filed Oct. 20, 1928

2 Sheets-Sheet 1



Morse H. Goodner
INVENTOR.

Jan. 10, 1932.

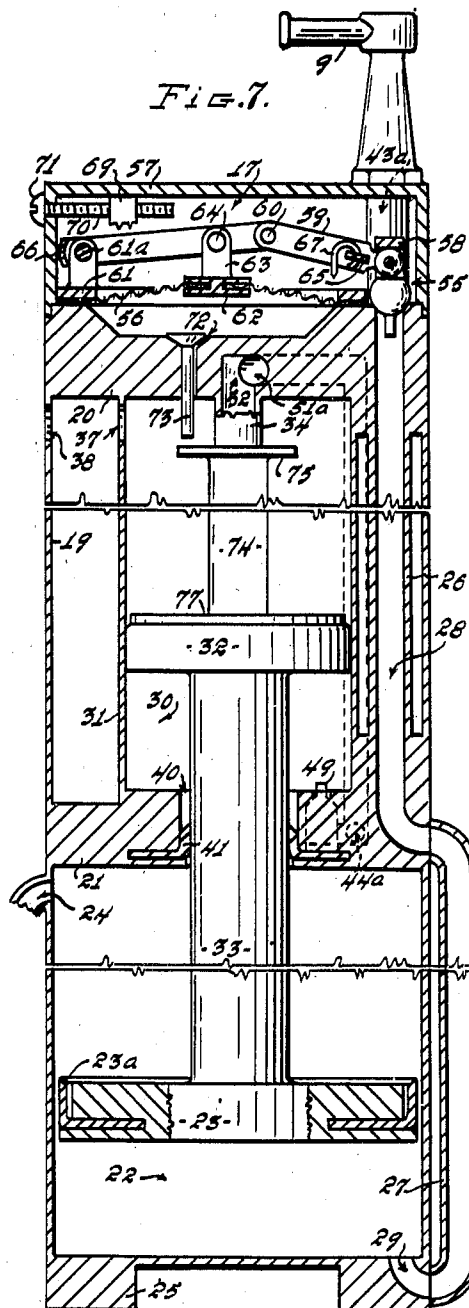
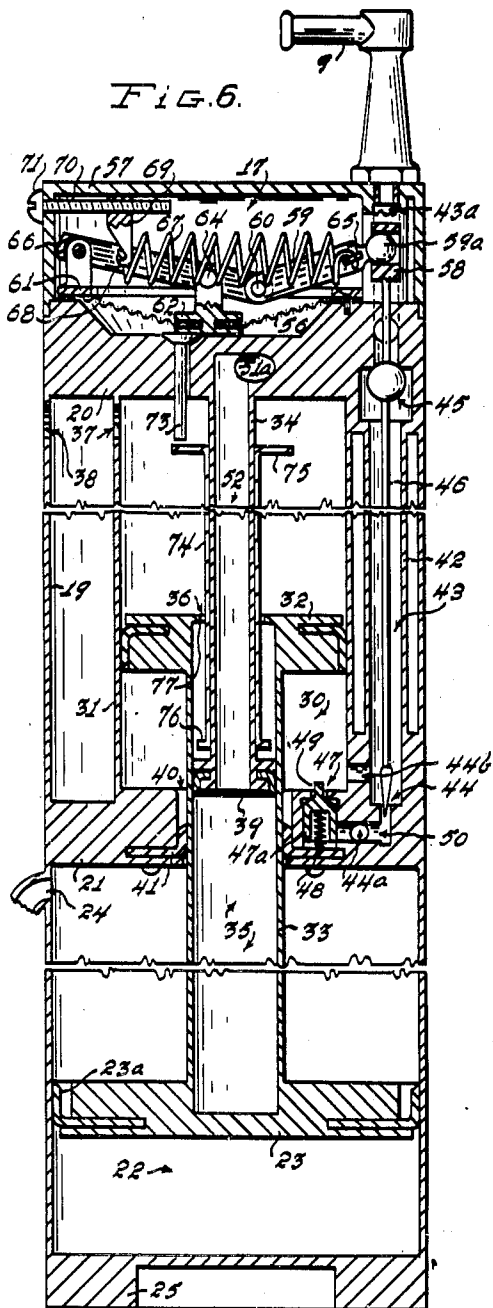
M. H. GOODNER

1,893,670

RESUSCITATOR AND THE LIKE

Filed Oct. 20, 1928

2 Sheets-Sheet 2



Monroe H. Goodner
INVENTOR.

UNITED STATES PATENT OFFICE

MONROE H. GOODNER, OF GLENDALE, CALIFORNIA, ASSIGNOR TO C. N. ERICKSON, OF GLENDALE, CALIFORNIA

RESUSCITATOR AND THE LIKE

Application filed October 20, 1928. Serial No. 313,973.

The invention relates to apparatus for alternately delivering and exhausting gases at controlled pressures with regard to cavities of fixed or variable volume and while the invention is applicable to many arts and practices it is well suited to resuscitation apparatus, lung pumps and the like.

Without imposing any limitations or restrictions on the scope of my invention, it will be described particularly hereinafter in its relation to the art of aiding the respiratory functions in partial asphyxiation and the like. Those skilled in the exhaustive art of pneumatics and allied arts will be enabled by the ensuing description to apply the invention to various other purposes and apparatus.

In the case of aiding a patient requiring resuscitation, an accepted and scientific procedure is to force oxygen bearing gases into the lungs and then subsequently evacuate the lungs in periodic pulsations so that "breathing" and respiration is induced by the mechanical and chemical action of the gases. The action of, and the results sought and attained by mechanical apparatus of this class are well known and need be discussed only briefly herein.

Of course each patient has an individual lung capacity and that may change with conditions. Pulmometry is more or less uncertain and speculative and obviously any apparatus which attempts to force predetermined volumes of gas to the lungs is unscientific and dangerous by reason of its undue or insufficient pressures.

Among other objects the present invention seeks to provide for automatically delivering to the patient enough gas at each induced respiration to inflate the lungs to a reasonable pressure, and to subsequently exhaust this gas and its compounds to an extent that will normally collapse the lungs without creating an undue suction pressure. While some of the prior apparatus attempts to do this, such apparatus may create that result only by the use of safety valves and similar devices which result in great waste of the gas.

It is therefore another object of the invention to provide apparatus of the class de-

scribed and capable of carrying out the above object without waste of gas, while operating solely and automatically by the potential energy of a stored volume of compressed gas.

Among other objects of the invention are the provision of structural and functional advantages which will be apparent to those skilled in the art after study of the accompanying drawings and the ensuing description.

I have illustrated, by the accompanying drawings, one practical embodiment of my invention in the form of a resuscitator.

In the said drawings:

Figure 1 is a view partly in elevation and partly in section of the resuscitator.

Figure 2 is a view in section on line 2—2.

Figure 3 is a view in section on line 3—3.

Figure 4 is a view in section on line 4—4.

Figure 5 is a view in section on line 5—5.

Figure 6 is a view in vertical section of the resuscitator, showing the disposition of parts during what is known as the suction or expiratory stroke.

Figure 7 is a view similar to that of Figure 6 and showing the disposition of parts during the inspiratory stroke.

Referring particularly to the drawings and to the numerals appearing thereon and indicating respective parts; the gas metering and handling apparatus is indicated at 1 and is connected to a common respiratory mask 10 by a suction hose and a pressure hose 11 and 12 respectively. The mask may be of any suitable or well known construction and while the resuscitator which I am about to describe is in no way dependent upon a safety valve for its normal operation, it is desirable to provide the safety valve 14 in the mask as shown so that should stoppage of the hose or like accidents occur, the interior space 15 of the mask will never be subject to abnormal pressure. The resuscitator and the mask are each fitted with corresponding suction nipples 16, connected by the suction hose 11, and corresponding pressure nipples connected by the pressure hose 12.

The resuscitator is provided with a diaphragm chamber 17 with which the suction nipple and hose are directly communicating

as at 18 so that the interior space 15 of the mask and the chamber 17 of the resuscitator are at all times intercommunicating and subject to equalized pressure.

The resuscitator proper includes in its structure an exterior annular wall or shell 19 fitted at the top with a top closure or head 20 and an intermediate horizontal dividing wall 21. That portion of the shell 19, below the wall 21 provides that which is herein-after known as the suction or expiratory cylinder or space indicated at 22. The suction cylinder is fitted with a cup type of piston 23 embodying the collapsible cup 23^a, capable of collapsing as shown in Fig. 7 so that gas may pass upwardly around it during downward travel of the piston; the cup in this case acting as a non-return valve. Adjacent the upper part, the cylinder 22 is provided with an exhaust outlet 24 opening to the atmosphere. Cylinder 22 is closed at the bottom by wall 25.

A valve controlled passage 28, provided by the intercommunicating tubes 26 and 27 respectively, provides communication between the diaphragm chamber and the suction cylinder. Tube 26 is disposed between the head and the wall 21 and connects them, while tube 27 connects wall 21 and the bottom wall 25. The bottom wall is provided with a suction opening 29 whereby passage 28 leads into suction cylinder 22.

Between the head and the wall 21 there is provided a pressure cylinder 30, axially located above the suction cylinder and separated therefrom by the wall 21; the pressure cylinder being smaller in diameter and provided with an internal shell 31 within the outer shell and connecting the head and the wall 21.

The aforesaid shells, tubes, and wall respectively are shown in the drawings as integral and in constructing the device according to the drawings said shells, tubes and walls respectively may be separately formed parts secured to one another by press fits, soldering, welding, or the like, so that they are substantially integral as shown.

The pressure cylinder is provided with a pressure inspiratory piston 32, which is connected directly to the suction piston by a tube 33 so that both pistons travel together; the pressure piston accomplishing its inspiratory stroke during downward movement of the piston assembly, and the suction piston accomplishing its expiratory stroke during upward movement of the assembly; the actual working stroke of the one piston being the return stroke of the other.

A tube 34 depends from the head down into the tube 33 and is there fitted with a cup 39 whereby it is in gas tight telescopic relation with tube 33; the space 35 enclosed by the interiors of said tubes being herein-after known as the actuating cylinder. The upper part of the actuating cylinder 35 and

the upper part of the pressure cylinder 30, at points entirely above the uppermost travel of the corresponding pistons, are each open to the atmosphere as at 36, 37 and 38 respectively so that the effective pressure in any of the aforesaid cylinders is the difference between atmosphere and the pressure existing in the corresponding cylinder below the corresponding piston or other moving gas-tight connection such as the cup 39.

The tube 33 passes through a central aperture 40 in wall 21; the wall providing a cup 41 fitting in gas tight relation around tube 33 while permitting of movement thereof. The pressure cylinder is at all times, during operation, subject to a pressure in excess of atmosphere and the cup 41 prevents escape of gas from the pressure cylinder to the atmosphere by way of the exhaust opening.

Between the wall 21 and the head another tube 42 is provided which provides a pressure passage 43 in which are respectively disposed an inlet valve 44 for the pressure cylinder, and an outlet valve 45 for the said pressure cylinder. These valves are carried by a common rod 46 so when one valve is seated the other is unseated; the inlet valve opening by upward movement of the rod and the outlet valve opening by downward movement of the rod. The passage 43 is isolated from the suction passage of the apparatus and from the diaphragm chamber, but is in communication with the pressure nipple by way of a continuing passage 43^a.

The intermediate wall 21 is provided with an inlet opening 44^a leading to the valve 44 and from the valve 44 another opening 44^b leads to the pressure cylinder.

An auxiliary inlet valve 47 is also provided for the pressure cylinder, this valve being also carried by the intermediate wall and comprising a movable valve member 47^a, of triangular cross section, held seated by a spring 48 and provided with a projection 49 extending into the pressure cylinder so that the lowermost position of the pressure piston will bring it in contact with the projection, to unseat the valve. The passage 50 provides communication from the inlet opening to both the main inlet valve and the auxiliary inlet valve.

To admit compressed gas from an outside source, such as a tank or bottle, to the apparatus an outside fitting such as 51 is provided and communicates with a horizontal passage 51^a drilled through the head and intersecting the bore 52 of the depending tube. Thus the actuating chamber is at all times subject to the pressure of gas admitted through the fitting 51. The passage 51^a continues from bore 52 and intersects the bore of a fourth tube 53. Tube 53 connects the head and the wall 21 and leads to a passage 54 in the wall 21; the passage 54

leading then to the inlet opening. The tendency of the pressure of gas being admitted to the device is to at all times force the piston assembly downward to the bottom of its stroke.

The suction or expiratory cylinder and the communicating passage are controlled by an inlet valve 55 which controls the time of intake of the suction or expiratory cylinder. This valve 55 is disposed between the diaphragm chamber and the suction chamber and is arranged to be closed on the downward stroke of the piston assembly.

The inlet valves for the suction and pressure cylinder respectively are all controlled by the diaphragm 56 situated in the diaphragm chamber; said chamber being provided above the head by a cap or inverted cup 57. To both the valve 45 and the valve 55 a yoke such as 58 is provided. For both yokes, valve operating mechanism is provided including a pair of parallel toggles 59. The toggles each have an intermediate pivot such as 60 and each are connected pivotally at one end to the head by a ring 61; the ring acting also to hold the diaphragm in place. A button 62 is fixed to the center of the diaphragm and includes a stud 63 which is pivotally connected to the toggles as 64. The levers are connected by transverse ties, one at each end, as at 65 and 66 respectively. A tension spring 67 is disposed between the toggles and is connected at one end to the tie 65. The other end of the spring is connected as at 68 to a fixed or adjustable member, in this case a hook 69. Said hook is threaded to an elongated screw 70 which passes out through the wall of the cap and terminates in a head 71 which prevents its being drawn by the spring into the diaphragm space. By turning this screw the hook is moved in the desired direction longitudinally of the spring to change the tension thereof and to predetermine the pressure required to operate the diaphragm and toggles.

As explained heretofore, the diaphragm chamber, and therefore the upper surface of the diaphragm, is subject at all times to the pressure in the suction hose and the pressure in the mask, or to any other cavity to which the suction hose may be connected. The under surface of the diaphragm, through an aperture 72, is subject to atmospheric pressure.

The operation of valve mechanism of the type illustrated is quite well understood and it is sufficient to say that when a pressure below the diaphragm is sufficient to urge it upwardly from the position shown in Fig. 6 the toggle pivot point 60 moves upwardly until the toggles are straight and horizontal; continued upward movement of the pivot results in the spring acting to again draw the ends of the toggles toward each other and resulting in forcible depression of the free ends thereof. These free ends each ride in the

corresponding yoke and in being depressed move the valves 45 and 55 downwardly.

The operation of certain parts and mechanisms of the apparatus having been explained, I will now proceed to describe the operation of the apparatus as a whole.

When the mask is held over the face of a patient to cover the mouth and nostrils, the lungs of the patient become a changeable cavity in direct communication with the apparatus through the pressure and suction hoses respectively, while the suction hose provides direct pressure equalizing communication between the lungs and the diaphragm cavity at all times.

The desired gas, such as pure oxygen, with a slight addition of carbon dioxide, is fed to the apparatus as from a common tank or bottle (not shown) commonly employed for this purpose. By means of a common pressure regulator or the like, (not shown) pressure in the inlet passages such as 51a is predetermined, although it is a feature of this apparatus that regardless of pressure in the inlet passages, the pressure to which the patient's lungs are subject is the same and is predetermined by the tension of the spring and the diaphragm. The higher the pressure of incoming gas at the small inlet valve 44, the faster the device will function, but such is the only effect which initial pressure has on the operation, and in fact the pressure, and therefore the rate, at which gas passes through the inlet valve is altered solely for the purpose of changing the frequency of pulsations of the piston assembly.

Gas, passing the inlet valve 44, enters the pressure chamber and forces the pistons upwardly as shown in Fig. 6. At such time the free ends of the toggles are uppermost so that the suction chamber's inlet valve is open while the inlet valve 44 for the pressure chamber is also open. Of course at the same time that gas is entering the pressure chamber it has free access to the actuating chamber 35 but from whence it cannot escape. The differential area between the pressure chamber and the actuating chamber is such, however, that the pistons arise when the pressure chamber is fed with gas.

Now, while the gas is entering the pressure chamber it is prevented from reaching the mask and lungs by reason of the outlet valve 45 being closed (see Fig. 6). At the same time, while the pistons are rising, the suction cylinder is increasing in volume and is in communication with the diaphragm chamber and the actuating chamber is such, respectively, by way of the passage 28 and the suction hose 11. The stroke of the pistons is such that the capacity of the suction chamber, is preferably in excess of two quarts so that the suction cylinder and its piston may evacuate the average pair of lungs and also draw a slight vacuum on the lungs

and the inter-communicating system of the apparatus.

I have found, for example, that best results seem to be obtained when the patient's lungs are first inflated to a pressure about and not exceeding four ounces per square inch, and are then evacuated by a suction pressure of about and not greater than four ounces per square inch.

When the upward movement of the suction piston has evacuated the patient's lungs to the extent that a four ounce suction pressure is created in the diaphragm chamber, then atmospheric pressure below the diaphragm, acting against the urge of the spring raises the diaphragm and the toggle pivot and causes the toggles to buckle into the position in which they are shown in Fig. 7. Now the position of the valves becomes reversed. The suction inlet valve becomes closed as shown and the inlet valve 44 of the pressure cylinder becomes closed as well while the outlet valve 45 for the pressure cylinder is now open.

Now the gas in the pressure chamber is released to the lungs and being at a pressure slightly in excess of atmosphere some of it passes quite rapidly to the lungs until pressures in the lungs and the system equalizes. Such takes place before the pressure piston begins its descent and at such time the pressure cylinder is full of new gas which must be delivered to the patient's lungs at the required rate so that their inflation is normal and properly timed.

When the outlet valve from the pressure cylinder is opened and the pressure in the pressure cylinder drops, the initial pressure in the actuating cylinder is now enough to force the pistons downwardly. Thus the new gas in the pressure chamber is positively displaced to the mask and lungs at a slow and predetermined rate through the valve 45, the passage 43 and the pressure hose 12. By this displacement the lungs are inflated to desired pressure and such pressure can register in the diaphragm chamber only after it has registered in the mask, since the only connection now remaining between the diaphragm chamber and the pressure chamber is via the pressure hose to the mask and from the mask via the suction hose.

Actually, in the case of full capacity lungs and low initial pressure in the pressure chamber, when the outlet valve first opens, the pressure chamber will not contain enough gas to fill the lungs to the required pressure and it is not essential that it shall. Therefore before lung pressure is built up sufficient to effect the valve operating mechanism, the pressure piston may descend until it strikes the auxiliary inlet valve and opens the auxiliary valve 47. Since at this time the inlet valve is closed and the outlet valve is open, the act of opening the auxiliary valve will

supply additional gas to the lungs by direct flow until the required lung pressure is reached. While the auxiliary valve is functioning the piston is of course stationary, the pressure in the actuating cylinder being sufficient to hold it down. When desired lung pressure is reached and the valve mechanism is again operated the up stroke of the pistons, previously described, begins again and one cycle is completed and another started.

The suction chamber, as explained, should be sufficient to evacuate the lungs while it is not essential that the pressure chamber be of equal capacity; the pressure chamber's principal function being to provide a small initial supply of gas and to return the pistons to uppermost position. When lungs of small capacity are encountered the suction piston may only travel upwardly a slight distance before it reverses; the entire apparatus being entirely automatic in adjusting itself to varying lung capacity and insuring the rhythmic inflation and deflation of the lungs without exceeding normal expiratory and inspiratory pressures respectively.

Even while a patient is being treated his lung capacity may change, in effect at least, such as by his attempting to breathe contrary to the rhythm of the apparatus. If, for instance, a recovering patient began to exhale into the mask while the piston was traveling down, the maximum pressure would be built up in the mask, the diaphragm would be affected and the piston would immediately reverse and travel with the patient's natural breathing attempts, rather than against it.

Such sudden reversals of the piston and other infrequent conditions may arise such as temporary leaks, and obstructions in the hose, or breathing passages of the patient, which result in the suction piston not having opportunity to begin its upward stroke from lowermost position, or not being able to pull the desired vacuum. In such case, traveling upwardly as shown in Fig. 6, it may reach the top of the suction cylinder before it has pulled a sufficient vacuum to operate the valve mechanism.

To provide against the pistons becoming stalled under such conditions, and to insure the return of the suction piston to the bottom of its stroke before a new stroke begins, I have provided certain safety mechanism. Such mechanism in this embodiment includes a push rod 73, a sleeve 74 with flanges 75 and 76 respectively, and an internal flange 77 on the piston.

The push rod 73 hangs in the aperture 72 and depends into the upper part of the pressure cylinder. The sleeve 74 is a frictional fit around the depending tube 34 so that while it can be moved axially of the tube it tends to remain in any position to which it is moved. This sleeve is provided at each end with the flange 75 and 76 respectively and the upper

flange 75 is disposed immediately below the lower end of the push rod. The lower flange 76 is disposed at all times within the tube 33 and below the flange 77. The latter is a loose fit around the sleeve but is arranged to strike the flange 76 when the piston moves to lowermost position.

If, in the operation of the apparatus, either by sudden reversal or by starting from an intermediate position, the suction piston is incapable of pulling the required vacuum to operate the diaphragm, the piston will continue upward until the flange is raised by the pressure piston and strikes the push rod and carries it high enough to operate the diaphragm mechanically. The sleeve, by reason of its frictional fit on the depending tube 34, will hold the diaphragm up until the pistons have moved to the very bottom of their stroke, by which time the internal flange 77 of the piston will have struck the lower flange of the sleeve and will have lowered the sleeve to normal position. When the pistons reach lowermost position the auxiliary valve will be opened and gas may flow to the mask and connected cavities until the pressure is built up as required and becomes again operative on the diaphragm through the suction hose. Thus the diaphragm will be depressed and the suction piston will begin its suction stroke under correct conditions.

While the sleeve 74 is acting to uphold the diaphragm and the vacuum piston is descending to begin a new stroke from lowermost position, the pressure piston may be delivering too much gas to the lungs. In such case the safety valve in the mask releases the excess gas, and it is only under such emergency conditions that any waste of gas takes place.

Summarizing the operation and advantages of the invention, it will be apparent that gas first enters the pressure cylinder and in so doing drives the suction piston on its expiratory stroke; this expiratory stroke creating a pressure less than atmospheric in the lungs and diaphragm chamber. Then the diaphragm is effected to open and close valves accordingly so that the gas in the pressure chamber is delivered to the mask and lungs by the act of the pistons returning to original position; this return being the inspiratory stroke of the pressure piston. If this strokes does not deliver the required amount of gas the auxiliary valve is opened by descent of the pressure piston and additional gas flows to the mask until it builds up a back pressure through the suction hose sufficient to again move the diaphragm, whereupon the next expiratory stroke begins.

When the suction piston starts from the very bottom and where the amount of gas sent to the mask is less than the volume of the suction cylinder, and where the other conditions remain constant, as they usually

do, the apparatus will function indefinitely without the safety features and the safety valve coming into play. However, to make the apparatus fool-proof and automatic even under adverse conditions, the advantages of the safety features will be appreciated.

After resuscitation is effected the apparatus may be used solely to supply gas to the mask, using same as a respirator only. This may be accomplished in many ways, and a simple method is to merely disconnect the suction hose so that the diaphragm cannot be depressed. Then the pressure piston, when it reaches the lower position will unseat the auxiliary valve and remain in that position indefinitely supplying gas through the pressure hose.

While I have shown and described a specific embodiment of my invention I do not limit myself thereto and I may alter the construction and arrangement of parts or eliminate certain parts and combinations thereof, or otherwise variously alter the apparatus within the scope of the appended claims, without departing from the spirit of my invention.

Having described my invention that which I claim as new and patentable is:—

1. In apparatus of the class described, a mask, an inspiratory cylinder connected with said mask, an expiratory cylinder connected with said mask; each cylinder including a reciprocating piston each having an operating stroke and a retrograde stroke respectively, means controlled by the pressure in said mask for alternately operating said pistons, means for conveying gas under pressure to said inspiratory cylinder, and an auxiliary valve operable at the end of the maximum operating stroke of the piston of said inspiratory cylinder to connect said means for conveying gas with said mask.

2. In apparatus of the class described, a mask, an inspiratory cylinder connected with said mask, an expiratory cylinder connected with said mask; each cylinder including a reciprocating piston each having an operating stroke and a retrograde stroke respectively, means controlled by the pressure in said mask for alternately operating said pistons, a member connecting said pistons, a primary inlet valve for said inspiratory cylinder, an outlet valve for said inspiratory cylinder; said pressure controlled means operable by a predetermined inspiratory pressure in said mask to close said outlet valve and to open said inlet valve.

3. In apparatus of the class described, a mask, an inspiratory cylinder connected with said mask, an expiratory cylinder connected with said mask; each cylinder including a reciprocating piston each having an operating stroke and a retrograde stroke respectively, means controlled by pressure in said mask for alternately operating said pistons, means for

conveying gas under pressure to said inspiratory cylinder, an auxiliary valve operable at the end of the maximum operating stroke of the piston of the said inspiratory cylinder to connect said means for conveying gas with said mask, a member connecting said pistons, a primary inlet valve for said inspiratory cylinder, an outlet valve for said inspiratory cylinder; said pressure controlled means operable by a predetermined inspiratory pressure in said mask to close said outlet valve and open said inlet valve; whereby pressure of gas in said means for conveying gas will urge the piston of said inspiratory cylinder on its retrograde stroke while moving the piston of said expiratory cylinder on its operating stroke.

4. In apparatus of the class described, a mask, an inspiratory cylinder connected with said mask, an expiratory cylinder connected with said mask, pistons, one in each cylinder, means controlled by the pressure in said mask for alternately operating said pistons, and other means operable at the end of the maximum operating stroke of said expiratory piston for setting said inspiratory piston in operation; said other means when having so operated acting to render said pressure controlled means inoperative until the inspiratory piston shall have completed its maximum stroke; said pistons being connected to each other to operate alternately, and a safety valve in said mask operable at a predetermined inspiratory pressure.

5. In apparatus of the class described, a mask, an inspiratory cylinder and piston respectively connected to force gas into said mask, an expiratory cylinder and piston respectively connected to withdraw gas from said mask, said pistons each having an operating stroke and a retrograde stroke respectively and connected to reciprocate together so that their operating strokes alternate, means for conveying gas under pressure to said inspiratory cylinder, an inlet valve operable to admit such gas to move said inspiratory piston on its retrograde stroke while moving said expiratory piston on its expiratory operative stroke, an outlet valve for said inspiratory cylinder leading to said mask and operable alternately with said inlet valve, a suction valve for said expiratory cylinder between same and said mask and arranged to open when said outlet valve is closed and said inlet valve is open, means operable by pressure in said mask to open said inlet valve and said suction valve while closing said outlet valves; said means also operable by reduced pressure in said mask to close said suction valve and said inlet valve while opening said outlet valve.

6. The apparatus as in claim 5 and further including an auxiliary inlet valve for said inspiratory cylinder disposed to be opened

when the inspiratory piston completes its maximum operating stroke.

7. The apparatus as in claim 5 and further including means operable at the end of the maximum stroke of said expiratory piston upon said pressure controlled means to render same inoperative on said valves until said expiratory piston shall have completed its maximum retrograde stroke.

8. The apparatus as in claim 5 and further including means operable at the end of the maximum stroke of said expiratory piston upon said pressure controlled means to render same inoperative on said valve until said expiratory piston shall have completed its maximum retrograde stroke, and a safety valve to relieve excess pressure in said mask while said inspiratory piston is being moved on its operative stroke by reason of said expiratory piston being so moved on its maximum retrograde stroke.

9. In apparatus of the class described, an inspiratory cylinder, a piston reciprocal in said cylinder, an inlet valve to said cylinder to admit gas behind said piston to force same outwardly, an expiratory cylinder aligned with said inspiratory cylinder, an expiratory piston in said cylinder connected with said inspiratory piston to operate when said inspiratory piston is moving outwardly, an outlet valve for said inspiratory cylinder, a mask connected with said cylinders and gas supply means connected for constantly urging said first piston inwardly.

10. In apparatus of the class described, a gas receiving mask, means for periodically exhausting said mask and including a cylinder, a closure at one end of said cylinder and a reciprocating suction piston in said cylinder, said piston moving to proximity to said closure wall on its retrograde stroke and moving away from said closure wall on its suction stroke, means for reversing said piston from retrograde stroke to suction stroke when a predetermined pressure is created in said mask by the gas received, and means operable after such reversal to move said piston to proximity to said closure wall before the next suction stroke is begun, an inspiratory cylinder and piston connected to force gas into said mask; said inspiratory piston connected to said first named piston.

11. In apparatus of the class described, an expiratory cylinder of at least normal lung capacity, an inspiratory cylinder of lesser capacity than said expiratory cylinder; pistons one in each cylinder and connected to each other for alternate operation, means for so operating said pistons, means for admitting gas to said inspiratory cylinder to be displaced therefrom, and auxiliary means operable between alternate operation of said pistons to supply additional gas to said inspiratory cylinder.

12. In apparatus of the class described, an

expiratory cylinder, an inspiratory cylinder of lesser volume than said expiratory cylinder and aligned therewith axially, a closure wall between said cylinders, a reciprocal piston in each cylinder, a tube connecting said pistons open at the end where it connects with said inspiratory piston and closed adjacent the other end to provide an actuating cylinder internally of said tube, a head above said inspiratory cylinder, a tube depending from said head and telescoping with said connecting tube thru the open end thereof; said head formed with a gas inlet passage leading from points exterior to said depending tube and said actuating cylinder, a gas supply tube leading from said passage to said closure wall, an auxiliary inlet valve in said closure wall opening from said gas supply tube to said inspiratory cylinder and disposed to be contacted and opened by the piston of said inspiratory cylinder temporarily while such piston is near the end of its inspiratory stroke, a main inlet valve for said inspiratory cylinder, an outlet valve for said inspiratory cylinder, a gas outlet tube in which said inlet valve and said outlet valve respectively are disposed and in communication with said inspiratory cylinder, a rod connecting said inlet valve with said outlet valve whereby one is open while the other is closed and vice-versa, a mask having a gas receiving space, a hose connecting said outlet valve with said mask space, a diaphragm chamber isolated from said hose, a suction hose connecting the mask space with said diaphragm chamber, a tube connecting said diaphragm chamber with said expiratory cylinder, a suction valve for said expiratory cylinder between said expiratory cylinder and said diaphragm chamber and disposed in said tube, a pressure actuated diaphragm in said chamber, valve actuating means operated by said diaphragm and connected with said valves so as to open said suction valve and said inlet valve while closing said outlet valve during one stroke of the connected pistons and to open said outlet valve and close said suction valve and said inlet valve during the other stroke of said pistons.

13. The apparatus as in claim 12 and further including, a member frictionally fitted around said depending tube, a push rod connected with said diaphragm and extending into said inspiratory cylinder adjacent to said member; said member disposed to be moved along said depending tube to strike said rod to operate said diaphragm to close said inlet valve and said suction valve and open said outlet valve when the piston of said expiratory cylinder travels a predetermined distance, and means for returning said member to normal position.

MONROE H. GOODNER.