Fig. 1.

Fig. 2.

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Patented Sept. 24, 1946 2,408,136

UNITED STATES PATENT OFFICE

RESUSCITATOR INSUFFLATOR ASPIRATOR
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Application December 7, 1942, Serial No. 468,079

3 Claims. (Cl. 128—29)

This invention relates to portable resuscitators which may be selectively operated as a resuscitator, an insufflator and an aspirator.

United States Letters Patents Nos. 2,138,845 and 2,269,604 granted to C. N. Erickson on December 6, 1928 and January 13, 1942 respectively, show machines relative to which the present invention embodies certain improvements, particularly as to reduction of weight, size, and bulk; greater nicety of control, dependable operation over a greater range or respiratory rates than heretofore, a novel valvular control means affording simultaneous resuscitation and aspiration operations as well as selective operation of the machine as a resuscitator, an insufflator and an aspirator, together with other improvements and advantages which will be hereinafter pointed out.

One of the objects of this invention is to provide in a machine of the character described a breathing indicator in which an indicating member such as a ball confined in a transparent tube will rise and fall in correspondence to the inhalation and exhalation cycles of the machine during a resuscitation operation to show the depth of breathing of the patient; said ball “fluttering” rapidly when an obstruction is present in the respiratory tract of the patient, and in all, serving as an effective tell-tale whereby the operator may readily regulate the operation of the machine to best suit the conditions at hand in a far more satisfactory manner than heretofore.

Another object of this invention is to provide in a machine such as described an indicator which when the machine is operated as an insufflator will indicate the rhythm of the patient’s breathing, the ball of the indicator remaining elevated when the patient is receiving too much oxygen but rising and falling in correspondence with the breathing of the patient when the proper amount of oxygen is supplied, and not being elevated when too little oxygen is supplied thereby indicating accurately at all times the manner in which the machine is operating and permitting the operator to make the necessary regulatory adjustments to insure the best possible operation for the particular patient.

Another object of this invention is to provide a machine of the character described in which the “head” of the machine is made as a compact casting embodying a central body portion in which is provided a two-stage pressure regulator and to which is connected, in compact arrangement, the valves, diaphragm, Venturi devices and all other working parts; there being a yoke projecting from opposite sides of the body portion for supporting in connection with the machine two medicinal valve tanks for oxygen, which tanks are suspended in such manner as to eliminate all possibility of breakage at the low pressure joints. Moreover, with this arrangement the yoke and reducing valve are made in a single high pressure casting wherein there are only three high pressure joints, one at the joint where the usual pressure gauge is screwed in, and two at the joints where the check valve bodies are screwed in.

One of the objects of my invention is to provide a resuscitator of the character described in which the negative pressure effective of the exhalation action of the machine is created by means of a Venturi device of such form and arrangement that the improvements embodied herein are achieved in a particularly efficacious manner with the added advantages of a most dependable operation with proper rhythm at a much lower “pulmometric” rate than heretofore.

Another object of my invention is to provide a resuscitator such as described in which the oxygen or gas pass to the patient through the Venturi on the inhalation cycle of the machine without intaking atmospheric air through the Venturi and consequently objectionably diluting of the oxygen or gas.

Another object is to provide a Venturi type of resuscitator wherein the Venturi will instantly respond to a small amount of gas to create the desired negative pressure under a precise control by the operator.

With the foregoing objects in view, together with such other objects and advantages as may subsequently appear, the invention resides in the parts and in the combination, construction and arrangement of parts hereinafter described and claimed, and illustrated by way of example in the accompanying drawings, in which:

Fig. 1 is a fragmentary front elevation of a machine embodying the present invention;

Fig. 2 is a fragmentary bottom plan view of the machine shown in Fig. 1 with parts broken away and parts in section for clarity of illustration;

Fig. 3 is a fragmentary elevation of the machine with the tanks and other parts shown in Fig. 1 omitted, certain parts being broken away and other parts shown in section;

Fig. 4 is a fragmentary rear elevation of the machine shown in Fig. 3 with parts omitted, broken away and shown in section for clarity of illustration;

Fig. 5 is a bottom plan view of the venturi
taken with a diagrammatic showing by means of dotted lines and arrows of the course of the oxygen or fluid during the operations of said tubes:

Fig. 6 is a fragmentary bottom plan section of the machine similar to Fig. 2 but with parts omitted, broken away and in section to illustrate the two stage pressure regulator;

Fig. 7 is a fragmentary bottom plan sectional view similar to Fig. 2 but showing the machine as when operating on the exhalation cycle, particularly the positions of the control valves and the paths of the fluid;

Fig. 8 is a fragmentary rear elevation of the cover part of the toggle chamber;

Fig. 9 is a front elevation of the toggle and diaphragm chamber;

Fig. 10 and Fig. 11 are semi-schematic fragmentary sectional views of the toggle-diaphragm unit and the valves operated thereby and other control valves showing such parts as when the machine is operating on the inhalation (pressure) and exhalation (suction) cycles respectively during an ordinary resuscitation operation of the machine;

Fig. 12 is a fragmentary sectional view of the hose connection with the mask showing the manner in which the gas enters and discharges from the mask;

Fig. 13 is a semi-schematic section similar to Figs. 10 and 11 and showing the position of the toggle and valves related thereto and other control valves as when the machine is operated as an insufflator and during the inhalation cycle;

Fig. 14 is a view corresponding to Fig. 13 but showing the parts and valves as when the patient is exhaling following insufflation.

**General description**

Referring to the drawings more specifically, it is seen that one embodiment of my invention generally includes a body portion A made as a casting having a plate-like elongated horizontal top portion 1 the ends of which are formed as yokes 2 for supporting oxygen tanks 3 in suspended relation to the body portion on opposite sides of an integral cylinder or chamber 4. This chamber depends from the top portion as best shown in Figs. 1, 2, 3 and 4 and is horizontally disposed and supported in a compact arrangement all of the working parts of the machine.

Embodied in the cylinder 4 is a two-stage pressure regulator B while at the forward end of the cylinder in a removable toggle-diaphragm chamber C, as shown in Figs. 2, 10 and 11, is a diaphragm-operated valve means D which responds to variations of the pressures in the patient's lungs to automatically control the inhalation and exhalation phases of the resuscitation cycle of the machine.

With reference to Figs. 1 and 2, it is seen that on the outer face of chamber C is the resuscitator control knob 5 for a resuscitator control valve 6 while adjacent said knob are the insufflator control knob 7 for the insufflator valve 8, and the aspirator control knob 9 for the aspirator valve 10. On opposite sides of and opening into the chamber C are safety check valves 11 and 12 which open to the atmosphere responsive to predetermined positive and negative pressures, respectively, the valve 11 opening when the positive pressure reaches for example six ounces while the valve 12 opens at a negative pressure of four ounces.

The chamber C is connected to the mask M by means of flexible hose lines 13 and 14 (see Figs. 1 and 10 to 14 inclusive). These hose lines are mounted one within the other to conserve space and protect said lines and are connected to the chamber C by means of concentric hose connections 15 and 16 on the lower side of said chamber. The mask is provided with a resuscitation control valve 17 the purpose of which will be hereinafter described.

A breathing indicator I, is positioned on the outer face of the chamber C to indicate the breathing action of the patient and the manner in which the machine operates as will be hereinafter described.

The usual pressure gauge P is mounted on the body portion A to show the oxygen tank pressure.

A Venturi or injector tube unit V for creating negative pressure on the resuscitation cycle is mounted on the lower side of the cylinder 4 in a convenient horizontal position and is controlled by the resuscitator valve 6. A smaller Venturi tube unit V' for creating negative pressure on the aspiration cycle is mounted on the cylinder 4 and controlled by the aspirator valve 10.

**Two-stage pressure regulator**

As shown in Figs. 1, 2 and 6, oxygen or pressure fluid from the tanks 3 passes through the usual valved fittings 19 in the yokes 2, said fittings including valve operating stems 20, into a fitting 21 opening into horizontal passages 22 leading through the top portion 1 to a centrally located vertical passage 23 which continues into a vertical web or partition 24 in the cylinder 4 and opens at an outlet 25 into the first stage chamber 26. A separate cylinder section 27 is bolted to the rear end of the cylinder proper and provides a second stage or low pressure chamber 28, there being an end wall 29 separating said first and second stage chambers.

A cross head 30 carried by rods 31 slidable in the web or partition 24 supports a compressible disc valve 32 for controlling the outlet 25. The rods 31 are carried by a piston 33 including an imperforate rubber cup 34 between two metal disks 35. A spring 36 between the wall 29 and the cross head 30 tends to seat the valve 32 whereas a stronger spring 37 between the piston and wall 38 of the cylinder 4 operates to hold the valve open. The force of these springs is such that at a predetermined pressure, say sixty pounds per square inch, the valve 32 will be closed by the action of the piston.

In the wall 29 is an opening 39 controlled by a valve 40 on a stem 41 slidable through said opening. This stem is carried by a piston 42 located in the chamber 28 and identical with piston 33. Springs 43 and 44 are so arranged in the chamber 28 and have such force that at a predetermined pressure, say fifteen pounds, to the square inch, piston 42 will close the valve 40.

A safety valve 45 including a copper membrane 46 which will blow at, say 100 pounds pressure, is connected with the first stage chamber as shown in Fig. 6.

**Resuscitator Venturi Unit**

Referring to Figs. 2, 6 and 7, it is seen that oxygen or other gas as the case may be, at approximately fifteen pounds pressure, pounds pressure, enters the second stage chamber 28 through a port 47 into a short pipe or conduit 48 extending between fittings 49 and 50. The fitting 50 is formed on the head 51 of the Venturi unit which head
is bolted to cylinder 4. A valve seat 52 for the resuscitator valve 5 is provided in the fitting 50, said valve being of the needle type and including a screw threaded stem 53 operating in a screw threaded bore 53' in said head and fitting. When valve 5 is opened, gas will flow from bore 53' through a passage 54 into one end of a Venturi nozzle 55, a Venturi tube 56, and a tubular housing 57 which telescopes the tube 56 and extends beyond the outlet end of said tube. Gas discharging into the outer end of the housing 57 from the Venturi tube 56 passes through a perforated restrictor disk 58 and thence through a fitting 59 into the wall 61 of the Venturi unit head 61. The passage 61 leads into a valve chamber 62 in the head 51, said chamber having an opening 63 opening to atmosphere through passage 64, and also provided bore 65 and passage 66 in the peripheral wall 67 of the toggle-diaphragm chamber C. The openings 63 and 65 are controlled by the valve means D as will be hereinafter more fully described. The passage 66 as seen in Fig. 2 intersects a port 68 extending at right angles thence through the wall 61 and into the center coupling 15 to which the inner hose 13 is connected, thereby supplying gas directly to the mask M from the second stage or low pressure chamber 28 of the pressure regulator.

**Insufflator valve**

The outer end of passage 66 opens into a valve chamber 69 for the insufflator valve 8. The valve 8 at all times closes the outer end of passage 66 and controls the insufflation operation and the operation of the indicator as will be hereinafter described. The knob 1 for valve 8 is threadedly adjustable in the chamber 69 and operates against a disk 60 on the valve, said disk having a guide pin 71 operating in a guide tube 72 in the knob. The screwing of the knob in and out will control the valve 8 and disk 70 as will be hereinafter described.

**Inhalation phase of resuscitation cycle**

It is now apparent that with the control valves in the positions shown in Figs. 2 and 10, the resuscitator valve 63 being open and the insufflator valve 63 and aspirator valve 29 closed, the inhalation phase of the resuscitation cycle takes place. In this phase the gas flowing at approximately fifteen atmospheres pressure per square inch flows from the second stage chamber 28 of the pressure regulator as follows: (referring to Fig. 6) through port 47, conduit 48, (refer now to Fig. 2) valve seat 52, bore 53, passage 54, Venturi nozzle 55, Venturi tube 56, Venturi tube housing 57, restrictor disk 58, conduit 60, passage 61, valve chamber 62 in the Venturi unit head 51, opening 65, passage 66 (refer now to Fig. 10), port 68, fitting 15, and inside hose line 13 to mask M, the valve 17 on the mask being then closed as shown in Fig. 11.

**Diaphragm-toggle operated valve means D**

In the valve chamber 62 as shown for example in Figs. 2 and 10, is the valve means D consisting of a single stem 73, a valve member 74 thereon to control the opening 63 to the atmosphere, and a valve member 75 also on said stem to control the opening 65 which allows gas to flow direct to the mask as aforesaid. The stem 73 is slidable through the wall 38 into the chamber C where it is connected as at 76 to one end of a spring-loaded toggle lever 77 best shown in Figs. 9, 10 and 11. The toggle joint 80 is connected to a post 79 on a diaphragm 80 in the chamber C as best shown in Fig. 11. The toggle lever, spring 81 thereof, and diaphragm are originally installed so that they appear as shown in Fig. 10 with the toggle joint and diaphragm extended outwardly with the valve stem likewise disposed and valve member 74 closed while valve member 75 is open thereby routing the gas through opening 85 and into passage 66 instead of allowing the gas to escape to atmosphere through the opening 63.

**Operation of toggle-diaphragm unit to change from inhalation phase to exhalation phase of the resuscitation cycle**

When the gas supplied to the patient on the inhalation cycle builds up a positive pressure in the lungs of the patient and back through the mask openings 14 leading into the outer hose 14 as a shown in Fig. 12, and ports 83 opening (see Figs. 2 and 10) into the chamber C, of say approximately four ounces (13 mm. of Hg), the diaphragm 80 in said chamber is forced inwardly and trips the toggle lever past center into position shown in Figs. 7 and 11. This shifts the double valve D so that valve member 75 thereof closes opening 65 while valve member 74 opens the openings 63 and passage 64 to the atmosphere.

**Exhalation phase of resuscitation cycle**

It should be noted that the Venturi tube 56 has its exhausting or vacuum port 84 as shown in Figs. 2 and 7 communicated with a vacuum passage 82 leading through the head 51 and the end wall 61 directly into the diaphragm chamber C and that the evacuation action of the Venturi tube, during the previously described inhalation phase, is ineffectual due to the return of gas under pressure (up to four ounces) to the chamber C through the outer hose 14, there being anything but a momentary circulation of pressure gas through passage 82 which becomes a part of the pressure gas circulating system until the four ounce positive pressure is reached in the chamber C and the diaphragm-toggle unit trips and moves the valves 74 and 75 into position shown in Figs. 7 and 11 as aforesaid. The exhalation phase commences with this movement of the valves 74 and 75 into position shown in Figs. 7 and 11 for the Venturi tube 56 then operates to evacuate the chamber C through passage 82, the Venturi tube 56, housing 57, conduit 80, passage 61, valve chamber 62, opening 65 and passage 64 to the atmosphere. When the mask valve 17 is closed, the chamber C is communicated with the mask, through the outer hose 14, and ports 83, and it is seen that the gas supplied to the lungs of the patient will be evacuated to the atmosphere in the manner next above stated during the exhalation cycle. When during this phase, a negative pressure of say three ounces (9.75 mm. of Hg) in the lungs of the patient and in the chamber C is reached, the diaphragm 80 responds to atmospheric pressure through port 80' open to atmosphere, and trips the toggle lever so that the valve member 75 returns to position shown in Figs. 2 and 10 and the inhalation phase is repeated. The rate of operation of the machine as a resuscitator is regulated by turning knob 5 to vary the opening of the valve 6.
Indicator operation during resuscitation

Referring to Fig. 10, it is seen that the stem 8 of valve 8 is set to close port 88 leading from the passage 86 into the lower end of a transparent upright indicator tube 87. When valve 87 is set to open, the mask M, large hose 14 and port 83, passes from chamber C into the lower end of the tube 87 through a port 89 and encounters a light bulb indicator 90 having a working fit in the tube, thereby elevating the ball as shown in Fig. 10. The ball will rise in correspondence to the rate of inhalation of the patient and will obviously drop in accordance with the rate of exhalation as the pressure becomes negative in chamber C and tube 87. Should the ball fluctuate or flutter this is an indication of the presence of an obstruction in the throat or pulmonary tract of the patient or in the machine. At all events this indicator affords an easily and readily readable and true indication of the manner in which the machine is operating per patient, and makes possible ready and accurate adjustments or changes in the operation of the machine to best suit the particular patient.

Insufflation

To prepare the machine for operation as an insufflator the knob 92 for the mask valve 17 is unscrewed (see Fig. 13) to uncover vent ports 93 in the housing 84 for said valve and to set the spring 85 so that it will hold the disk valve member 17 closed over a port 86 opening into the mask until a positive pressure is reached in the mask below that required to shift the diaphragm 80 and toggle lever 77. If the spring 85 will yield to allow the valve member 17 to unseat at pressure under four ounces which is the pressure at which the diaphragm-toggle unit in chamber C will live, it will remain in position holding valve 75 open to feed gas to the mask in a steady flow, while atmosphere vent valve 74 remains closed. This condition will obtain as long as the valve member 17 is adjusted as set to operate as shown in Fig. 13 and as a result of the predetermined unscrewing of the knob 92.

After adjusting knob 92 for the mask valve 17 the insufflator valve 8 is adjusted to position shown in Fig. 13 by unscrewing the knob 7 until the disk 70 is spaced from guide tube 72 on the knob and said disk and the valve stem 8 are subject to being moved into the open position shown in Fig. 14, by the pressure of the gas being routed to the mask. The disk 70 acts as a valve for opening and closing the inner ends of like vent passages 57 in the knob 7, which passages open to atmosphere on the side of the knob. When knob 7 is unscrewed as shown in Fig. 13 the passages 57 are opened by the retraction of the knob from the disk 70 and the chamber C is subject to communication with the atmosphere through a passage 98 leading into the valve chamber 58. This arrangement provides for the breathing of the patient through the vent passages 57 in a normal manner after responding to the oxygen insufflation treatment as will be hereinafter described.

Now assuming the mask valve 17 and the insufflator valve 8 have been adjusted as shown in Fig. 13 and the resuscitator valve 6 is properly open, it is seen that the gas under pressure passes from the regulator chamber 28 through conduit 48, valve seat 52, bore 53, passage 54, Venturi nozzle 55, housing 51, conduit 56, passage 57, passage 62, opening 65, passage 66, port 98, inside hose line 13 to mask in a steady flow to the patient. When the patient exhales, the valve member 17 opens and allows the exhaled gas to escape to the atmosphere. Valve member 17 will remain at a pressure less than that of the insufflator and will be opened before gas can reach the pressure in chamber C at which the diaphragm responds.

In this connection it should be noted that the resuscitator valve 6 should be set so that the amount of gas flowing to the mask during insufflation is comparatively small and is in the most part inhale by the patient. In other words, the insufflation operation should be carried out at a lower pressure than during resuscitation, due to the fact that the patient is breathing the gas during such treatment. The indicator hereof affords an accurate and ready setting of the valve 6 to prevent waste of gas and assures the proper insufflation operation, as will now be described.

Indicator operation during insufflation

When the insufflation operation is started the pressure of the gas in the passage 86 forces the insufflation valve stem 8' outward and opens port 88 as shown in Fig. 14, leading into the tube 87 thereby making the ball indicator 90 responsive to the pressure of the gas. If the valve 8' (see Fig. 2) is set correctly the ball 90 will rise to the top of the tube, while the gas is flowing to the mask. If the ball does not rise to the top of the tube this indicates that the valve 6 is not set correctly to supply the proper amount of gas. When the patient inhales, the ball 90 will drop since pressure thereon is then removed. If the ball does not drop responsive to this inhalation of the gas by the patient, this indicates that too much gas is passing to the mask and the valve 6 should be adjusted to reduce the flow. When the patient exhales, the valve 17' on the mask opens and allows the patient to exhale through ports 93. At this time the ball is in down position and when the patient ceases to exhale, the spring 85 closes valve 17' whereupon the ball will again rise. If the valve 8' (see Fig. 2) is set correctly the breathing of the patient and afford an accurate indication of the respiratory rate whereby the valve 6 may be opened or closed promptly and accurately to regulate the insufflation operation to best suit the patient. After the patient has recovered and no longer requires the oxygen therapy, the valve 6 is slowly shut off until the more or less normal breathing of the patient causes disk valve 70 to respond and allows a normal breathing of atmosphere through vents 97, passage 98, chamber C and ports 93 and large hose 14, connected between the mask and the ports 83.

Operation of machine as an aspirator

The machine may be operated as an aspirator to withdraw fluids and obstructions from a patient's lungs at any time regardless of whether or not the machine is at the same time being operated as a resuscitator or an insufflator.

To operate the machine as an aspirator the knob 9 is opened to open the valve 19 as shown in Fig. 7 and gas from the first stage chamber 26 of the pressure regulator will flow through a passage 100 (see Figs. 5, 6, and 7) into the Venturi unit V' which discharges into the atmos-
A suction port 101 (Fig. 7) leads from the venturi V' to an aspirator hose connection 102 on the front of chamber C as shown in Figs. 1 and 3. An aspirator hose 103 leads from connection 102 to the usual aspirator nozzle and receptacle both of which are here omitted inasmuch as these elements and the manner of their use are well known to the skilled in the art.

Due to the fact that the aspirator elements of the machine are independent from the other elements it is seen that the aspirator may be operated at any time whether or not the resuscitator or the insufflator is in operation.

It is important to note that the Venturi unit V by reason of the housing 57 providing a chamber beyond the tube 56, the restriction of the flow of gas from said chamber through the small orifices in the disk 58, the arrangement of the valve members 74 and 75 on a common stem connected to the toggle lever, and the suction passage 84 being at all times open to the chamber C, the rate of operation of the machine as a resuscitator may be controlled with a greater nicety and the desired respiratory rate may be had at a very slow speed or speeded up as desired. It has been difficult if not impossible to operate at a slow speed, as is often desirable, resuscitators having a venturi which discharges oxygen directly to the atmosphere from the tube itself and wherein the suction passage to the venturi is closed on the inhalation phase of the resuscitation cycle. The particular construction and arrangement of the above noted parts in my machine make for a greater range of respiratory rates than heretofore, and particularly a very slow operation for infants and premature babies.

Another important improvement afforded by my machine is the accurate visual indication of the operation of the machine responsive to the patient on both resuscitation and insufflation cycles. The indicator hereof in indicating the rate and extent of flow of gas into and out of the patient's lungs, may be quickly and easily seen, and make possible a ready adjustment to correct any undesirable operation of the machine. Accuracy and reliability of performance of the machine hereof is enhanced by the useable of a single valve unit in which the valves 74 and 75 on a single stem having a simple connection with the spring-loaded toggle lever. Thus the entire toggle-valve-diaphragm unit is simplified and improved as to accuracy and reliability of performance by reason of the construction and arrangement thereof as here provided.

While I have shown and described a specific embodiment of my invention I do not limit myself to the exact details of construction set forth, and the invention embraces such changes, modifications and equivalents of the parts and their formation and arrangement as come within the purview of the appended claims.

I claim:

1. In a machine for selectively effecting resuscitation and insufflation, a supply of gas under pressure, a body structure having a hose connection on the body structure, a mask, a hose line leading from said hose connection to said mask, an insufflation means including one of said hose lines for conducting gas from said supply to said mask; a pressure port and in another position the pressure port is closed, a spring loaded
toggle in said diaphragm chamber connected to said valve stem, a diaphragm in the chamber therefor connected to said toggle and being responsive to predetermined positive and negative pressures therein, an exhalation port through which the patient exhales to the atmosphere the gas supplied to the patient during operation of the machine as an insufflator, a valve means manually adjustable for closing said exhalation port during a resuscitation operation of the machine and manually adjustable for opening responsive to a positive pressure developed in the mask below the pressure required to operate the diaphragm and said toggle, a transparent upright indicator tube, a passage connecting the lower end of said tube with said diaphragm chamber to create positive and negative pressures therein responsive to the inhalatory and exhalatory phases of operation of the machine as a resuscitator, and a visual indicator member mounted in said tube to rise and fall responsive to the positive and negative pressures created as aforesaid to indicate the rate and depth of breathing of the patient; another passage leading from said passageway into the lower end of said indicator tube, a valve manually movable from a position closing the second named passage to said tube to a position opening said second named passage to cause the indicator member to respond to pressure changes during insufflation whereby the indicator will move in correspondence to the breathing of the patient on insufflation as well and during resuscitation operations.

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