

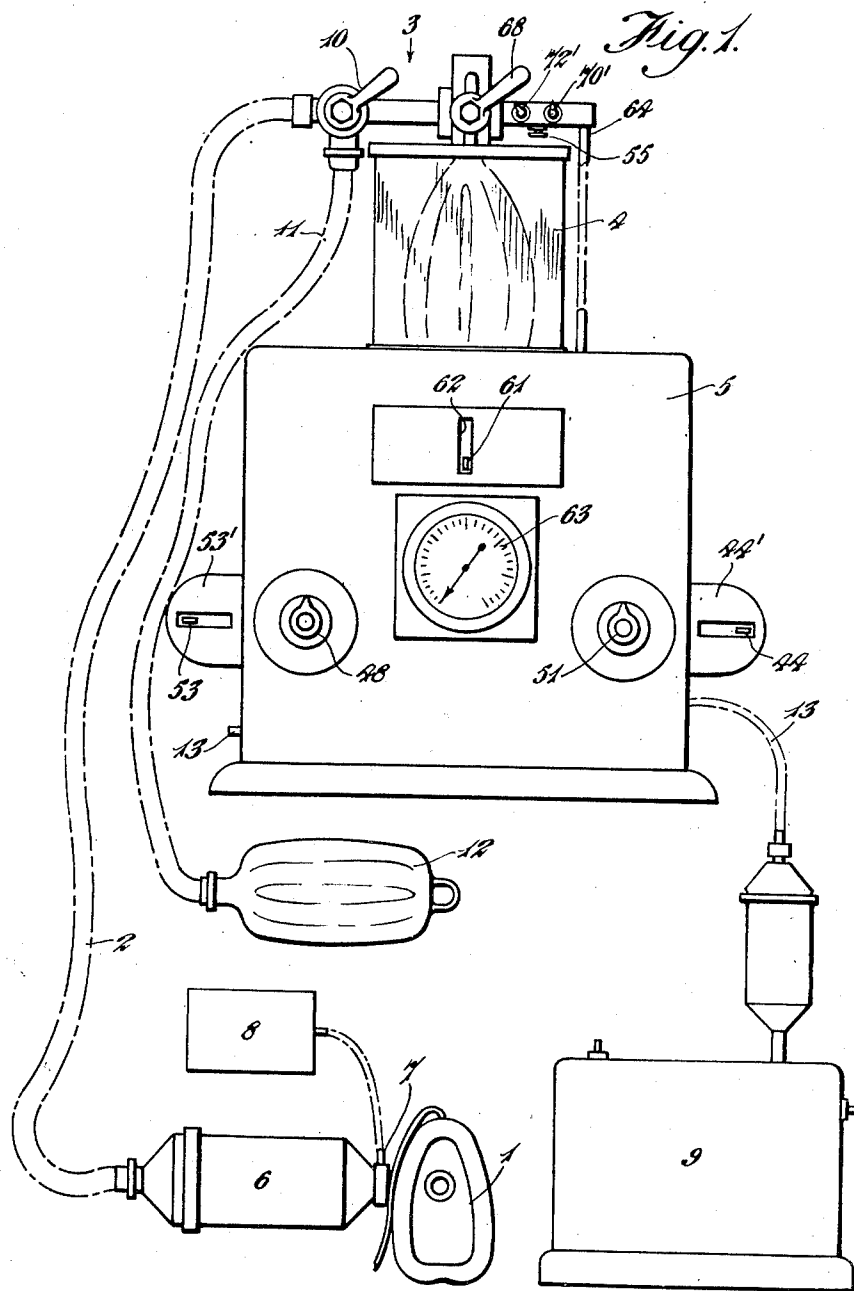
April 1, 1952

J. H. BLEASE
APPARATUS FOR THE CONTROL OF RESPIRATION
RESUSCITATION AND ANAESTHESIA

2,591,120

Filed Nov. 8, 1949

2 SHEETS—SHEET 1



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2 SHEETS—SHEET 2

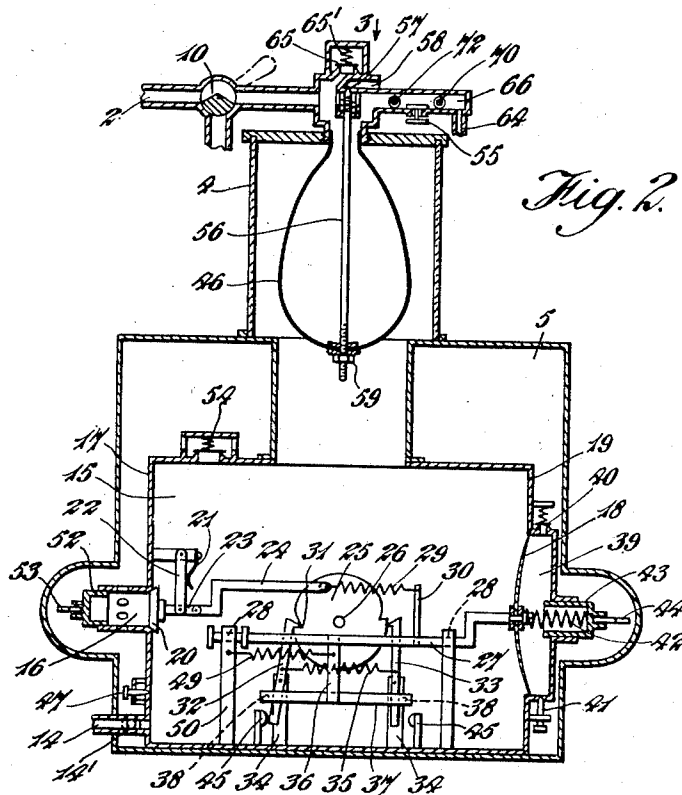


Fig. 2.

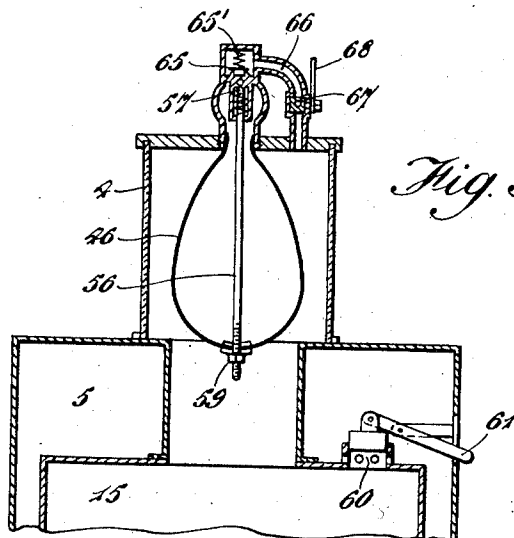


Fig. 3.

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APPARATUS FOR THE CONTROL OF RESPIRATION RESUSCITATION AND ANAESTHESIA

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This invention relates to improvements in apparatus for the control of respiration, resuscitation and anaesthesia, and has for its object to provide apparatus of this kind capable of controlling automatically the respiration of a patient in rhythm with and at the same rate as the normal respiration of the patient.

The improved apparatus is adapted for use with any form of carbon dioxide absorption technique and with any of the anaesthetic agents in general use, and provides a very flexible and complete control of the respiration of a patient.

According to one feature of the invention, the cycle of changes from inspiration to expiration is effected automatically by a flexible diaphragm located within an air chamber and moved against spring pressure by air pressure built up within the chamber by a pump, the diaphragm opening an air outlet valve when a predetermined pressure within the chamber has been reached, and being returned to its initial position by spring means, the apparatus being so constructed as to operate in substantially complete silence.

According to a further feature of the invention, the improved apparatus includes means whereby the automatic control of the respiration of the patient can be rapidly and conveniently be replaced by devices enabling manual control of respiration to be effected.

According to a still further feature of the invention, the improved apparatus also includes means whereby, if desired, air in controlled amount is admixed with the anaesthetic gas administered to the patient, and safety devices are provided to prevent danger to the patient.

There will now be described one form of the improved apparatus in which the above mentioned features are incorporated, by reference to the accompanying drawings, in which

Figure 1 is a diagrammatic view showing generally the arrangement of the improved apparatus,

Figure 2 is an elevation in section showing diagrammatically the operative parts of the improved apparatus, and

Figure 3 is a detail view in section, at right angles to that shown in Figure 2.

As shown in the said drawings, Figure 1, a mask 1 adapted to be held in position over the mouth and nose of a patient is connected by a flexible tube 2 to a valved head indicated generally at 3 and supported on the upper surface of a transparent-walled cylindrical pressure air chamber 4. The air-chamber 4 is mounted upon a casing 5 in which is housed the operating mechanism whereby control of the breathing of the

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patient is effected. Air is supplied to the interior of the casing 5 by a pump driven by an electric motor, indicated generally at 9.

A soda-lime carbon-dioxide absorber unit 6 is connected between the mask 1 and flexible tube 2, and anaesthetic gas may be introduced into the mask 1 through a pipe 7 connected to an anaesthetic gas battery 8 of the known kind. The automatic breathing control apparatus of the invention contained within the casing 5 may be used with any known form of closed circuit anaesthesia, e. g. any known anaesthetizing machine or apparatus may be connected between the mask 1 and the head 3 in substitution for the absorber 6, gas inlet 7 and apparatus 8.

If for any reason, it is found desirable to switch from automatic control of the respiration of the patient to manual control, the automatic control apparatus in the casing 5 may be dispensed with by operating valve 10 in the head 3 to bring the flexible tube 2 out of communication with the head 3 and into communication with a flexible tube 11 leading to a rubber re-breathing bag 12, manipulation of which by the anaesthetist may then be substituted for automatic control of respiration.

Referring now to Figures 2 and 3 of the drawings, in the apparatus employed according to the invention for automatic control of respiration, air is supplied from the pump 9 through suitable tubing 13 to an inlet 14 leading to a main air chamber 15 of rectangular cross-section having an air outlet orifice 16 provided in one end vertical wall 17 thereof and a flexible diaphragm 18 mounted in the other vertical end wall 19 thereof.

A valve 20 seated in the inner face of the end vertical wall 17 of the chamber normally prevents the outward passage of air therethrough, being held on its seating by a leaf spring 21 acting on an arm 22 pivotally mounted on the inner face of this wall. A horizontally arranged rod 24 pivotally attached to the stem 23 of the valve 20 has its other end pivotally attached to one side of a notched disc 25 pivotally mounted on a spindle 26 supported substantially midway between the two end walls 17 and 19 of the chamber by means of lateral struts (not shown).

A second horizontally disposed rod 27 is axially slidably movable in fixed bearings 28, 28 provided therefor, one end of the rod being secured to the centre of the flexible diaphragm 18, and one end of a helical spring 29 being secured to an upwardly extending pin 30 secured to the rod 27, the other end of the spring being secured to a part of the disc 25 above its pivot point 26.

As air is pumped into the air chamber through the air inlet 14 which is preferably fitted with silencer means of the known kind, the diaphragm 18 is forced outwardly, moving the rod 27 attached thereto in a direction away from the disc 25, the spring 29 between the rod and the disc tending to rotate the latter in a clockwise direction. Rotation of the disc 25 is initially prevented by the engagement in a notch 31 provided therein of one of a pair of pawls 32,33 pivotally mounted intermediate their lengths on fixed members 34, and urged towards one another by means of a helical spring 35 held in tension between them, the two pawls being spaced on either side of the disc.

The horizontal rod 27 attached to the diaphragm 18 has a vertical downwardly extending limb 36 on the end of which is carried a horizontal strip 37 having pins 38 extending at right angles therefrom, such pins engaging the free ends of the pivoted pawls 32,33.

On the outer face of the vertical end wall 19 of the chamber 15 in which the diaphragm 18 is mounted is secured a second air chamber 39 provided with a non-return valve 40 permitting the escape of air therefrom to atmosphere, and a manually controlled needle valve 41 controlling the admission of air to this second chamber. A compression spring 42 is provided in a cylinder 43 which is closed at its outer end and is slidably movable in the end wall of the second air chamber. This slidable cylinder 43 is movable by means of a lever 44 pivoted to a lateral extension of the back wall of the air chamber 17 and extending to a slot in an extension 44' of the front wall of the casing 5, the median portion of such lever 44 bearing against the outer end of the spring-carrying cylinder. The lever is held by friction against the edges of the slot, and is movable on its pivot to urge the inner end of the spring 42 against the centre of the outer face of the diaphragm, so as to vary the compression of such spring which thus acts between the outer wall of such chamber and the centre of the diaphragm 18, which forms part of a vertical wall common to the chambers 15 and 39.

The operation of this part of the apparatus is as follows: As air is pumped into the main air chamber 15, the diaphragm 18 is forced outwardly, carrying with it the horizontal rod 27 attached thereto and tending to rotate the disc 25. The outwards movement of the diaphragm 18 is resisted by the compression spring 42 in the second air chamber 39. When the pressure in the main air chamber 15 has built up sufficiently to be able to move the diaphragm 18 outwards to a sufficient distance, one of the pins 38 on the horizontal strip 37 carried by the rod 27 attached to the diaphragm 18 rocks the pawl 32 engaging the notched disc 25 under the pull of the spring 29. The pawl 32 then moves under the pull of the spring 35 into engagement with a second notch or recess in the disc 25 to prevent return or anti-clockwise rotation thereof. The degree of engagement of the ends of the pawls 32, 33 in their corresponding notches or recesses in the disc 25 is controlled by adjustable stops 45 provided with pads of resilient material, so that as the disc 25 is released for rotation in either direction, the pawl entering the recess therein is stopped from bedding sharply down into such recess by the engagement of its free lower end against one of the stops 45, thus preventing any clicking noise which might disturb the concentration of the surgeon during an operation on the patient.

As will readily be seen, rotation of the disc 25 in a clockwise direction as shown in Figure 2 causes movement to the right of the horizontal rod 24 attached thereto, causing the valve 20 to leave its seating, and allowing the built-up air pressure within the chamber 15 to escape into the outer casing 5, which is open to the atmosphere. At the same time as the diaphragm 18 is moving outwardly air is being forced out of the second air chamber 39 through its non-return valve 40.

The interior of the main air chamber 15 is in communication with the transparent-walled cylindrical air chamber 4, in which is mounted a collapsible rubber re-breathing bag 46 of the known kind, the interior of which bag, as shown in Figure 2, is in communication through the valved head 3, through valve 10, with the flexible tube 2 leading to the mask 1.

Thus, while air pressure is being built up in the main air chamber 15, the diaphragm 18 moving outwardly, the same pressure is built up in the chamber 4, compressing the bag 46 and forcing the contents thereof into the patient's lungs. The time taken for the complete outwards movement of the diaphragm, which thus corresponds to the period of inspiration of the patient, is adjustable by means of a needle valve 47 whereby an air-bleeding outlet from the main air chamber 15 is controlled. This needle valve 47 is operated by means of a knob 48 on the outer casing 5.

The release of air pressure in the main air chamber 15 allows the compression spring 42 to return the diaphragm 18 to its normal position, assisted by a spring 49 connecting the rod 36 to a fixed frame member 50. The time of return of the diaphragm 18 to its normal position (which corresponds to the time during which expiration of the lungs takes place) is controlled by manual adjustment of the air inlet needle valve 41 in the second air chamber 39, through a knob 51 on the front of the casing 5.

As the diaphragm returns to its initial position, the second pin 38 on the horizontal strip 37 acts on the pawl 33 and releases it from its recess in the disc 25 to enable the latter to rotate in an anti-clockwise direction, under the influence of the now compressed spring 29, assisted by the leaf spring 21, the rod 24 pivoted thereon moving to bring the air outlet valve 20 on to its seat, the pawl 32 again engaging the disc to restrain it against clockwise rotation, and the air outlet valve 20 being held on its seating by its spring 21.

The air outlet orifice in the main air chamber 15, closed by the valve 20, is advantageously provided on the outer side of the wall 17 of the air chamber with a ported slide valve 52 which is normally in the open position, such valve being however capable of being closed manually by means of a pivoted lever 53, the free end of which extends through a slot in an extension 53' of the outer casing 5. When this valve 52 is in its normal open position, air from the pump entering the chamber 15 moves the diaphragm 18 to bring the air outlet valve 20 on the inside of this chamber to its open position, and the pressure within the air chambers 15 and 4 is released. When the valve 52 is moved to its closed position, the pump continues to inject air into the chamber 15 until a predetermined pressure has been built up in the chamber, and thus also in the lungs of the patient. The lungs of the patient are now held in a still or stationary condition, as may be desired in the course of an operation, the pressure in the lungs being maintained constant at any desired level by permitting excess air to escape to

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atmosphere through a manually controlled outlet valve 60 hereinafter described, which is adjustable to enable this constant pressure in the patient's lungs to be varied, by means of a lever 61 hereinafter referred to. In order to ensure that too great a pressure is not accidentally built up in the patient's lungs, a spring-controlled safety valve 54 is provided in the upper wall of the main air chamber 15.

In accordance with a further feature of the invention, the re-breathing bag 46 in the air chamber 4 is provided with a thin rod or wire 56 secured to the lowermost part of the bag, such rod extending up through the open mouth of the bag into the head 3, where it is attached to the stem of a spring-pressed outlet valve 57 provided in such head. By reason of this device, should the pressure within the re-breathing bag 46 (and therefore in the patient's lungs) rise above a predetermined safe amount, the resulting expansion of the bag draws the valve 57 off its seat and permits the escape to atmosphere of the excess air or gases in the bag through an outlet 58 in the head 3. The operation of this valve 57 also prevents possible over-expansion and bursting of the re-breathing bag 46. The setting of the device may be varied by turning a nut 59 provided on the screwthreaded lower end of the rod 56.

Similarly, in order to ensure that the patient shall be able to continue to breathe in the event of accidental failure of the air or oxygen-supply when the re-breathing bag 46 is in its empty or collapsed condition, a gravity- or spring-controlled safety air inlet valve 55 is provided in the head 3 which permits entry of air from atmosphere into the head and thus into the lungs. On exhalation of the lungs, the air thus introduced is returned into the re-breathing bag.

When the ported slide valve 52 in the outlet orifice 16 of the main air chamber 15 is in its closed position, the diaphragm 18 for automatic control being out of employment, manual control of the respiration of the patient may be carried out by rhythmically raising and lowering the free end of the pivoted lever 61 above referred to, projecting through a slot 52 in the casing 5, such lever opening and closing the manually operated ported slide valve 60 (Figure 3), pressure building up within the chamber 4 to collapse the bag 46 when valve 60 is closed, and when it is open air being allowed to escape in controlled quantities. By this means it is possible to control the patient's rate of respiration by manual and visual adjustment, or where desired to keep the patient's lungs in a stationary condition by partial closing of valve 60 until the amount of air escaping there-through is equal to the amount of air entering chambers 15 and 4 from pump 9.

A further use of the valve 60 is the opening thereof to allow the patient to breathe into and out from the bag 46, automatic control by means of the diaphragm being cut out (since the air chambers 15 and 4 are open to atmosphere through this valve 60). This permits spontaneous operation of the breathing muscles of the patient, i. e. when a return is made to natural breathing on the completion of a surgical operation and the cessation of anaesthesia.

In the head 3 to which the flexible tube 2 leading to the mask 1 is connected there may be also provided valved connections (not shown) for lines whereby anaesthetizing gas and air may be supplied to the system, and a pressure gauge 63, mounted on the front face of the air chamber 15 and the outer casing 5, is connected to the head

by a flexible tube extending from the outlet 64 in the head 3 to enable the operator to see the pressure existing in the re-breathing bag at all times during the use of the apparatus, such gauge being calibrated to show pressures ranging from 0-30 cc. of water.

Air from the pump 9 is supplied to the head 3 by means of a flexible tube (not shown) leading from a branch 14' in the air inlet 14 to a screw-threaded needle valve 70 provided in a branch of the head, such valve being adjustable by a finger-piece 70', and being normally held in its fully-closed position during anaesthesia, the stem of the valve extending across the air passageway in the head connecting the interior of the bag 46 with the outlet 64 to the gauge 63. When it is desired to bring the patient out of anaesthesia and restore natural breathing, this valve 70 may be partially opened to assist such return to spontaneous breathing by the admission of air into the closed circuit.

An outlet to atmosphere from the head 3 is provided by a second screwthreaded needle valve 72, normally held in its closed position, and adjustable by rotation of a fingerpiece 72'.

In order to permit escape of excess gas from the closed anaesthetic circuit between the patient's lungs and the re-breathing bag 46, a valve 65 in the head 3 is held on its seating by a weak spring 65' or by gravity, one side of this valve being in communication with the air passage between the bag 46 and the flexible tube 2 leading to the mask, and the other side of this valve being in communication with an air passage 66 leading to the interior of the air chamber 4. A valve 67, manually controllable by a lever 68, is included in the passage 66. The operation of this excess gas outlet is as follows:

Pressure built up by the pump 9 in the air chambers 15 and 4 causes the bag 46 to collapse, filling the lungs of the patient; the diaphragm 18 moves against the spring 42 to open valve 20 and release the pressure in the air chambers 15 and 4, which at once falls to atmospheric pressure. The patient then breathes back into the bag, but since anaesthetic gas is being introduced into the mask 1 through inlet pipe 7, excess gas is present, and when the bag 46 is substantially entirely full, the patient's lungs are not yet emptied. The pressure from the patient's lungs opens valve 65 against its weak spring and the excess gas is enabled to be discharged into the air chamber 4 (now at atmospheric pressure) through air passage 66, the valve 67 being in the open position.

When the diaphragm 18 returns to close the outlet valve 20, pressure again builds up within the air chambers 15 and 4, but air from the said chambers cannot pass through the valve 65 into the closed circuit comprised by the bag 46 and the lungs of the patient.

Valve 67 is closed when the anaesthetist is working on a closed circuit, i. e. when the input of basal oxygen (with or without a small quantity of gas) is substantially equal in volume to the amount of oxygen absorbed by the patient's blood stream and the amount of carbon dioxide absorbed by the absorber 6.

It will be appreciated that the improved apparatus affords a full and flexible control over the respiration of the patient, either by use of the diaphragm or by operation of the alternative manual controls provided, enabling the length of inspiration and expiration, the working pressure, the degree of assistance to breathing, the rate of

respiration, and the resistance to exhalation, to be varied at will as need arises, while at the same time providing adequate automatically acting safeguards against injury to the patient.

The operation of the apparatus is further not affected during automatic control by means of the movable diaphragm in the event of the patient coughing, as sometimes occurs, since a cough increases the pressure in the air chambers 15 and 4 sufficiently to move the diaphragm 18 outwardly to allow opening of the air outlet valve 20, thus enabling respiration to continue unchecked in synchronism with the patient's normal rate of respiration.

I claim:

1. Apparatus for the control of respiration and anaesthesia, comprising an air chamber, means for introducing air under pressure into said air chamber, means located within such air chamber responsive to increasing pressure and movable thereby, valve means actuated by such pressure-responsive means to reduce the pressure within the air chamber to atmospheric pressure after a pre-determined pressure has been built up within such chamber, a second air chamber communicating with such first-mentioned air chamber, a collapsible bag within such second air chamber, an air passage constructed to connect the interior of such collapsible bag with the lungs of the patient, and means for introducing anaesthetic gas or air into such air passage.

2. Apparatus according to claim 1, wherein the pressure responsive means is returned to its initial position, on actuation of the valve means, by spring pressure.

3. Apparatus according to claim 1, comprising a flexible diaphragm constituting the pressure-responsive means, a notched disc rotatably mounted within the air chamber, pawls restraining said disc from rotation, means attached to the diaphragm whereby the pawls are actuated to free the disc for rotation, a valve connected to such disc, said valve being removed from its seating by rotation of the disc in one direction and returned to its seat by rotation of the disc in the other direction.

4. Apparatus according to claim 1, wherein a valve is connected to a part of the collapsible bag, such valve being operated by excess of pressure within such bag to allow excess gas to escape to atmosphere.

5. Apparatus according to claim 1, wherein an air passage is constructed to connect the interior of the collapsible bag and the lungs of the patient to the interior of the air chamber and a valve provided in such air passage is movable to allow excess gas to escape to atmosphere during the final stages of expiration of the lungs.

6. Apparatus for the control of respiration and

anaesthesia, comprising an air chamber, means for introducing air under pressure into said air chamber, a flexible diaphragm located in one wall of the said air chamber responsive to and movable by increasing pressure, a notched disc rotatably mounted within the air chamber, pawls restraining said disc from rotation, means attached to the diaphragm whereby the pawls are actuated to free the disc for rotation, resilient buffers limiting the movement of the pawls into engagement with the notches in the disc, a valve connected to the disc, said valve being removed from its seating by rotation of the disc in one direction and returned to its seat by rotation of the disc in the other direction, an air passage constructed to connect the seating of such valve with atmosphere, a second air chamber communicating with the first-mentioned air chamber, a collapsible bag within such second air chamber, and an air passage constructed to connect the interior of such collapsible bag with the lungs of the patient.

7. Apparatus according to claim 1, wherein a third air chamber is provided on the exterior of the first air chamber, a flexible diaphragm constituting the said pressure-responsive means being comprised in a wall common to the first and to the third air chambers, a non-return outlet valve to atmosphere is provided in the wall of such third air chamber, and an adjustable air-inlet valve is provided in the wall of such third air chamber.

8. Apparatus according to claim 1, wherein the movement of the pressure responsive means caused by increasing pressure in the first air chamber is resisted by a spring, the compression of which is manually adjustable from the exterior of the apparatus.

9. Apparatus according to claim 1, comprising auxiliary valve means in association with the valve connected to the notched disc, such auxiliary valve means being movable from the exterior of the apparatus from a normally open position to a closed position whereby exhaust of air to atmosphere from the interior of the first air chamber is prevented, a manually controlled air outlet valve being provided to maintain the pressure in the first and in the second air chambers at a desired level.

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