

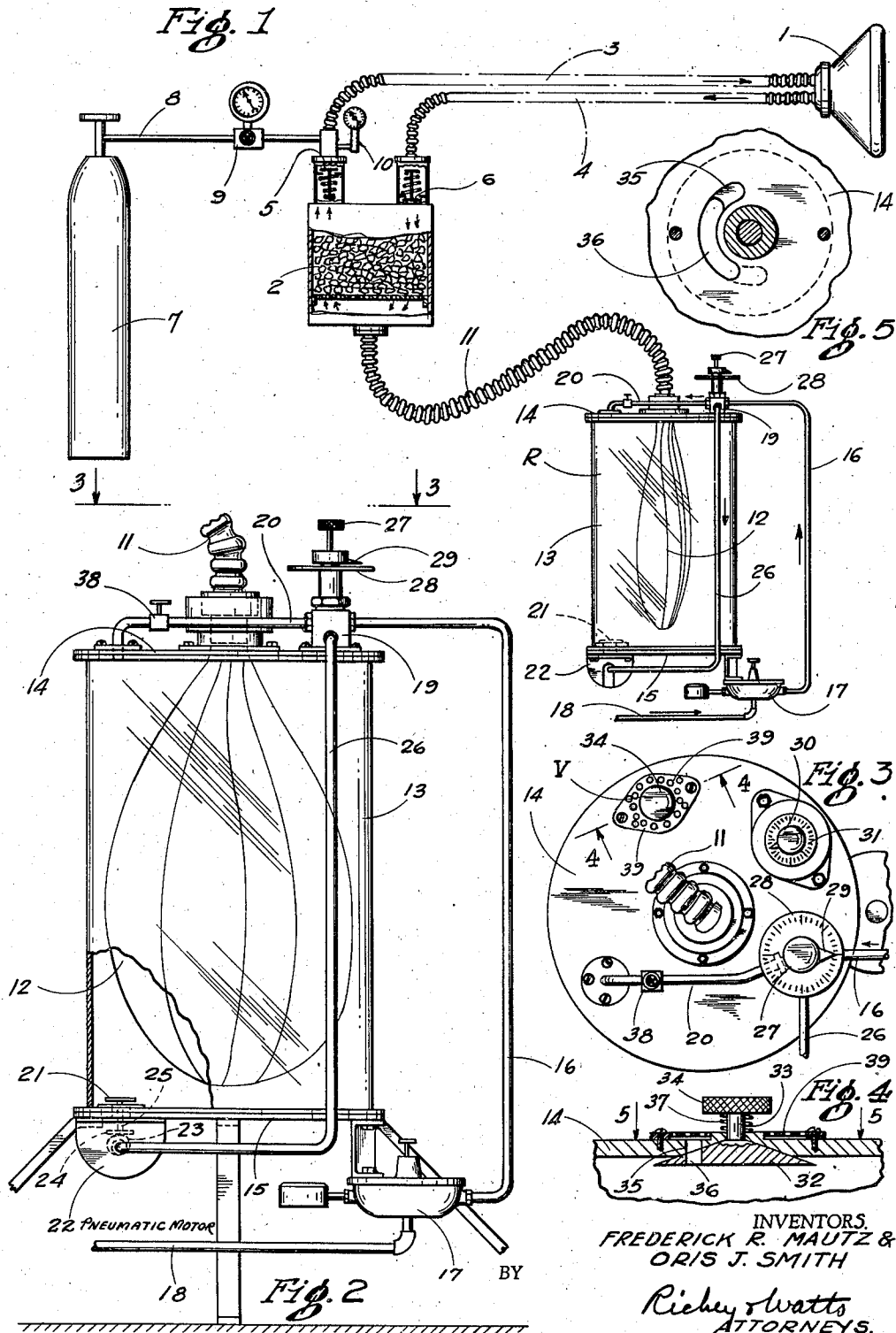
June 2, 1942.

F. R. MAUTZ ET AL

2,284,964

MECHANICAL RESPIRATOR

Filed July 26, 1940



UNITED STATES PATENT OFFICE

2,284,964

MECHANICAL RESPIRATOR

Frederick R. Mantz and Oris J. Smith, Cleveland Heights, Ohio, assignors to Air Reduction Company, Incorporated, New York, N. Y., a corporation of New York

Application July 26, 1940, Serial No. 347,814

10 Claims. (Cl. 128—191)

This invention relates to apparatus for maintaining artificial pulmonary ventilation, and more particularly to a mechanical respirator especially adapted for use during surgical operations.

Occasionally during surgical operations there may occur serious respiratory or cardiac failure. Artificial pulmonary ventilation by mechanical means has proved very helpful in such cases. In thoracic surgery, particularly in the presence of an open pneumothorax, the desirability of assisting natural respiration or maintaining full artificial respiration has been established, and it is among the objects of our present invention to provide an improved mechanical respirator which may be used in association with the usual closed system anaesthetizing equipment.

Other objects of our invention include: the provision of a mechanical respirator which can instantaneously be placed in operation when the occasion demands but which will not interfere with the patient's natural respiration at other times; the provision, in a mechanical respirator, of means for accurately and promptly controlling the rate of respiration; the provision in a mechanical respirator of means for accurately and promptly controlling the maximum pressure applied to the patient's lungs; the provision of a mechanical respirator which can be attached at the point where the breathing bag is normally secured in an anaesthetizing machine and which is always ready for instant use; the provision of an extremely simple respirator having a minimum of moving parts and which may be operated entirely by compressed air from any suitable supply; and the provision of a respirating apparatus for operating rooms which will establish and maintain any desired rate and depth of respiration for any desired length of time and which may be employed to facilitate an exchange of oxygen or anaesthetizing agents between the machine and the patient's alveoli during periods of respiratory depression.

The above and other objects of our invention will appear more fully from the following description of one embodiment thereof, reference being had to the accompanying drawing which illustrates our improved respirator apparatus in more or less diagrammatic form, and in which—

Figure 1 is a diagrammatic layout of our improved respirator attached to an anaesthetizing machine.

Figure 2 is an enlarged side elevation of our respirator.

Figure 3 is a plan view of the apparatus shown in Figure 2, taken on line 3—3 of Figure 2.

Figure 4 is an enlarged vertical cross-sectional view through the "on and off" and manual operation control valve, taken on line 4—4 of Figure 3.

Figure 5 is a horizontal cross-sectional view taken substantially on line 5—5 of Figure 4.

In Figure 1 our respirator is illustrated as attached to one type of closed system anaesthetizing machine in which the usual face mask, which tightly covers the patient's nose and mouth, is shown at 1. A soda-lime canister 2 is employed in well known manner for removing carbon dioxide. A flexible supply tube 3 leads from the canister 2 to the mask 1, and a flexible return tube 4 leads from the mask 1 back to the canister 2. Suitable check valves 5 and 6 are inserted in the conduits 3 and 4 adjacent the canister 2 so that, as the patient inhales, air flows to the mask 1 through the pipe 3, but cannot be drawn into the pipe 4 because of the check valve 6. During exhalation air flows through the pipe 4 into the canister 2, but is prevented from flowing through the pipe 3 into the canister 2 by the check valve 5. A tank of oxygen or anaesthetizing gas is shown at 7 connected to the inlet pipe 3 through a connecting conduit 8 in which is inserted a pressure regulating valve 9. It is understood that the above describes, in very simple form, the general arrangement of an anaesthetizing machine and it will be further understood that the machine may include a plurality of tanks similar to the tank 7 containing compressed anaesthetizing gases, etc., to be supplied to the patient.

A pressure gauge 10 indicates the pressure in the conduit 3 being supplied to the patient. By observing this gauge, the operator of the apparatus can tell the exact maximum pressure being applied to the patient's lungs when the respirator is in operation.

A flexible conduit 11 extends from the bottom of the soda-lime canister 2 to the respirator unit which is indicated at R in Figure 1.

Referring now particularly to Figure 2, it will be observed that the conduit 11 connects directly to the flexible rubber bag 12 which is disposed in a cylindrical vessel, preferably having a glass or other transparent side wall 13. The hose 11 is provided with an air-tight connection through the top 14 of the cylindrical pressure vessel. This connection is preferably made by any suitable quickly detachable means so that the rubber bag 12 can readily be withdrawn from the

cylindrical chamber and replaced when desired. The cylindrical wall 13, the top plate 14 and the bottom plate 15 provide an air tight chamber in which the bag 12 is disposed. When the respirator is not operating and the apparatus of Figure 1 is being used merely as an anaesthetizing machine, the bag 12 performs the function of the usual breathing bag and the bag contracts and expands in the usual manner in accordance with the patient's respirations.

In order to provide means for artificial respiration, we supply air under pressure to the pipe 16. In the illustrated form of our invention, an air pressure regulating valve is shown at 17 and a compressed supply air line at 18, but it will be understood that in instances where air under suitable standard pressure is available, the pressure regulating valve 17 may be eliminated.

The pipe 16 leads to the valve housing 19 and thence through a pipe 20 directly into the interior of the pressure chamber. At the bottom of the pressure chamber is a poppet valve 21, shown in closed position in Figure 1 and in open position in Figure 2. This valve controls an opening from the interior of the respirator pressure chamber directly to the atmosphere and is adapted to be opened and closed periodically by means of a motor 22. As illustrated, this motor is of the fluid pressure actuated type and its shaft carries a cam 23 which engages the head 24 of the plunger 25 which carries the poppet valve 21 at its upper end. Thus, as the motor 22 operates, the cam 23 will alternately lift the valve 21 off of its seat, opening the pressure chamber within the cylindrical wall 13 to the atmosphere, and permit the valve 21 to close, shutting off the pressure chamber from the atmosphere. The valve housing 19 contains a regulating valve which controls the flow of air through the pipe 26 to the motor 22. This valve is operated by a rotatable knob 27 and the disc 28 is preferably graduated to indicate respirations per minute. By adjusting the knob 27, the pointer 29 will indicate the speed at which the motor 22 is operating and, as the dial 28 is calibrated in respirations per minute, will indicate to the operator the rate of action of the respirator.

An adjustable pressure relief valve, of any suitable type such as a spring loaded poppet type safety valve, is indicated at 30 in Figure 3. The dial 31 of this valve is graduated in millimeters of mercury and the control range of the valve is set to cover the possible variations in pressure which may be desired to be applied to the patient's lungs.

In Figures 4 and 5 we have illustrated in some detail a "start and stop" control valve which is also adapted to permit manual control of the operation of the respirator when it is desired to synchronize the pulsations of the respirator with the patient's natural breathing. This valve is indicated at V in Figure 3, and as seen in Figures 4 and 5, comprises a generally conical seat member 32, carried by a stem 33 having an operating knob 34 at its upper end. The stem 33 extends through the top 14 of the pressure chamber which is formed with a conical recess in its underside to conform to and fit the upper conical surface of the member 32. An arcuate slot 35 extends through the top plate 14. This slot extends for somewhat less than 180° in circumference and a corresponding arcuate slot 36 is formed in the conical valve member 32. In order normally to maintain the tapered conical valve member 32 in engagement with its seat on

the top plate 14, a spring 37 is provided which exerts a lifting force against the underside of the operating knob 34.

In explaining the preferred use of our improved respirator, it will be assumed that the mask 1 is applied to and held in position over the patient's nose and mouth. When an operation is started compressed air is applied through the pipes 16 and 20 and the control valve 38 in pipe 20 is opened. Such supply of air is maintained at a pressure in excess of the greatest pressure that is ever desired to be applied to the patient, and the motor speed control valve 19 is adjusted by turning the knob 27 to cause the poppet valve 21 to be lifted off of its seat and reseated at the proper rate to give the desired number of respirations per minute.

Assuming that the patient has been anaesthetized and is breathing normally without need of artificial respiration, the valve 32 will be in open position as shown in Figures 4 and 5 with a clear opening through the coinciding slots 35 and 36 and the holes in the protective cover plate 39. Under these circumstances the air which is discharged into the pressure chamber through pipe 20 will pass out freely through the valve 32 and substantially atmospheric pressure will be maintained inside of the respirator chamber. This will permit normal operation of the breathing bag which will contract and expand without undue resistance under the influence of the patient's respiration.

During this time, the motor 22 continues to operate at the desired rate, for example 18 respirations per minute, and the relief valve 30 will be set at a value, for example 12 mm. of mercury, which rate and value would be suitable for the patient if artificial respiration were desired.

Now if it becomes advisable to supply artificial respiration to the patient, it is only necessary to turn the valve 32, through its operating knob 34, into "closed" position in which the apertures 35 and 36 do not overlap. Under these circumstances, the only outlet for air from the respirator chamber is through the poppet valve 31. As this valve intermittently opens and closes, it will be seen that each time the valve 21 is closed, pressure within the respirator chamber, on the outside of the rubber bag 12, will rise to whatever value is permitted by the relief valve 30. As soon as the pressure in the chamber reaches the value at which the relief valve 30 is set, this valve will open and permit discharge of excess air pressure. Under the influence of the greater than atmospheric pressure in the respirator chamber the bag 12 will be collapsed, as indicated in Figure 1, and gas forced through the canister 2 and pipe 3 into the patient's lungs. When the valve 21 is opened by the action of the cam 23, pressure within the respirator chamber will immediately drop to atmospheric and exhalation will be permitted through the pipe 4 and the canister 2 into the bag 12, causing it to inflate. Next, the valve 21 closes, the pressure in the respirator chamber builds up to the value permitted by the control valve 30, and the bag collapses. This cycle continues as long as the valve 32 remains off or closed but will immediately cease upon again turning the valve 32 into the open position shown in Figures 4 and 5. Preferably the motor 22 is permitted to continue to operate throughout the period during which the respirator may possibly be required, and thus the apparatus can instantaneously be placed in action by merely turning the single valve 32.

In some instances it may be desired to assist the patient's normal respiration. This can be accomplished by closing the valve 19 so that the motor 22 stops with the valve 21 closed. Then, with the valve 32 in closed position, i. e., with the slots 35 and 36 out of alignment, the operator pushes on the knob 34, depressing the conical valve 32 away from its seat and permitting air to escape through the opening 35 in the top of the respirator housing. This depression of the valve 32 will open the respirator chamber to the atmosphere and permit expansion of the bag 12. By releasing the pressure on the knob 34 the valve 32 will close, pressure will build up in the respirator chamber to the permitted value, and gas will be supplied to the patient's lungs. By alternately manually depressing and releasing the valve operating knob 34, the respirator may be operated in any desired time cycle, either regular or irregular, as required by the patient's condition.

In some instances it may be desirable to use positive intra pulmonary pressure, for example 6 mm. of mercury, and maintain this pressure with a minimum of fluctuation during the pulmonary cycle. This may conveniently be accomplished by closing the valves 21 and V and setting the pressure regulating relief valve 30 at 6 mm. of mercury. With this setting of the valves the pressure determined by the valve 30 will be maintained substantially constant within the respirator chamber.

The gauge 10 indicates the pressure which is controlled by the pressure relief valve 30. This gauge is preferably located as close as possible to the mask 1 in order that a true indication of the pressure applied to the patient may be obtained and the dial 31 of the adjustable pressure relief valve 30 is preferably calibrated to correspond to the readings of the gauge 10. The gauge is largely provided as a safety feature to check the operation of the valve 30.

Although we have illustrated our respirator as connected directly to the soda-lime canister of an anaesthetizing machine, it will be understood that the tube 11 might be connected directly to a face mask and artificial respiration effected independently of the anaesthetizing equipment. Also, our respirator may be connected into an anaesthetizing system at a point other than the bottom of the soda-lime canister. For example, it might be connected directly into the intake pipe 3 of the mask.

With our improved mechanical respirator, air at a definite pressure is supplied continuously to the respirator chamber and the operation of the respirator is controlled by merely opening and closing an atmospheric connection to the respirator chamber. This requires a minimum of apparatus and only the most simple forms of valves. By our instantaneous "on and off" valve V, the respirator can be put into action immediately as the motor 22 and valve 21 will normally be operated continuously during the course of an operation in which the respirator may possibly be needed.

By providing means for adjusting, not only the rate of respiration, but also the pressure applied to the patient's lungs, an extremely sensitive and complete control is available. When attached to an anaesthetizing machine the rubber bag 12 of our apparatus serves as a breathing bag during the ordinary maintenance of anaesthesia, and also as means for effecting mechanical ven-

tilation of the patient's lungs without interfering with the simultaneous supply of oxygen or anaesthetic to the patient.

Although we have described the illustrated embodiment of our invention in considerable detail, it will be understood by those skilled in the art that variations and modifications may be made in the type and arrangement of parts without departing from the spirit of our invention. We do not, therefore, wish to be limited to the specific form herein described, but claim as our invention all embodiments thereof coming within the scope of the appended claims.

We claim:

1. In a mechanical respirator, walls defining a closed chamber, a flexible container in said chamber, a conduit leading from said flexible container, a face mask connected to said conduit, means for supplying air under pressure to said chamber outside of said flexible container, and independent means for intermittently connecting said chamber to the atmosphere and closing said chamber from the atmosphere.
2. In a mechanical respirator, walls defining a closed chamber, a flexible container in said chamber, a conduit leading from said flexible container, a face mask connected to said conduit, means for supplying air under pressure to said chamber outside of said flexible container, means for intermittently connecting said chamber to the atmosphere and closing said chamber from the atmosphere, and independent manually operable valve means for opening or closing said chamber to and from the atmosphere.
3. In a mechanical respirator, walls defining a closed chamber, a flexible container in said chamber, a conduit leading from said flexible container, a face mask connected to said conduit, means for supplying air under pressure to said chamber outside of said flexible container, means for intermittently connecting said chamber to the atmosphere and closing said chamber from the atmosphere, independent manually operable valve means for opening or closing said chamber to and from the atmosphere, and an adjustable relief valve adapted to control the maximum pressure obtainable within said chamber.
4. In a mechanical respirator, walls defining a closed chamber, a flexible container in said chamber, a conduit leading from said flexible container, a face mask connected to said conduit, means for supplying air under pressure to said chamber outside of said flexible container, valve means for connecting said chamber to the atmosphere and closing said chamber from the atmosphere, motor means for operating said valve means, independent manually operable means for opening or closing said chamber to and from the atmosphere, and means for regulating the rate of operation of said motor means.
5. In apparatus of the type described, anaesthetizing means including a face mask, a container for a carbon dioxide absorbing agent, a conduit from said face mask to said container, a flexible bag, a conduit connecting said bag and said container, means for supplying a gas to said anaesthetizing means, a vessel enclosing said flexible bag, means for connecting a source of fluid pressure to said vessel, means for varying the pressure within said vessel in a repeating cycle by periodically opening a pressure relief valve on said vessel, and independent valve means for connecting said vessel to or closing said vessel off from the atmosphere.
6. In apparatus of the type described, anaesthe-

tizing means including a face mask, a container for a carbon dioxide absorbing agent, a conduit from said face mask to said container, a flexible bag, a conduit connecting said bag and said container, means for supplying a gas to said anesthetizing means, a vessel enclosing said flexible bag, means for connecting a source of fluid pressure to the interior of said vessel outside of said bag, means for varying the pressure within said vessel in a repeating cycle by periodically opening a pressure relief valve on said vessel, independent valve means for connecting said vessel to or closing said vessel off from the atmosphere, and adjustable relief valve means for controlling the maximum pressure which may be established in said vessel.

7. In a mechanical respirator, a vessel, a flexible bag in said vessel, a conduit leading from said bag through a wall of said vessel, a conduit connecting a source of supply of air under pressure to the interior of said vessel outside of said bag, said vessel having an outlet opening through a wall thereof, mechanically periodically actuated valve means for controlling said opening, and means for operating said valve in a repeating cycle.

8. In a mechanical respirator, a vessel, a flexible bag in said vessel, a conduit leading from said bag through a wall of said vessel, a conduit connecting a source of supply of air under pressure to the interior of said vessel outside of said bag, said vessel having an opening through a wall thereof, mechanically periodically actuated valve

means for controlling said opening, said vessel having a second opening through a wall thereof, and manually operable valve means for controlling said second opening.

9. In a mechanical respirator, a vessel, a flexible bag in said vessel, a conduit leading from said bag through a wall of said vessel, a conduit connecting a source of supply of air under pressure to the interior of the vessel outside of said bag, said vessel having an outlet opening through a wall thereof, a check valve resiliently seated over said outlet within said vessel, and means extending to the exterior of the vessel for unseating said valve.

10. In a mechanical respirator, a vessel, a flexible bag in said vessel, a conduit leading from said bag through a wall of said vessel, a source of supply of air under pressure, a conduit connecting said source to said vessel, said vessel having an opening through a wall thereof, manually operable valve means for controlling said opening, said valve means including a seat, a closure member adapted to engage said seat, said opening in the vessel wall extending through said seat and said closure member having an opening adapted to be moved into and out of alignment with said vessel opening, resilient means for holding said closure member against said seat, and an operating member for said valve whereby said closure member may be moved away from said seat against the action of said resilient means.

FREDERICK R. MAUTZ.
ORIS J. SMITH.

CERTIFICATE OF CORRECTION.

Patent No. 2,284,964.

June 2, 1942.

FREDERICK R. MAUTZ, ET AL.

It is hereby certified that error appears in the above numbered patent requiring correction as follows: In the grant, line 2, and in the heading to the printed specification, line 4, for "assignors" read --said Smith assignor--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 14th day of July, A. D. 1942.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.