

April 7, 1959

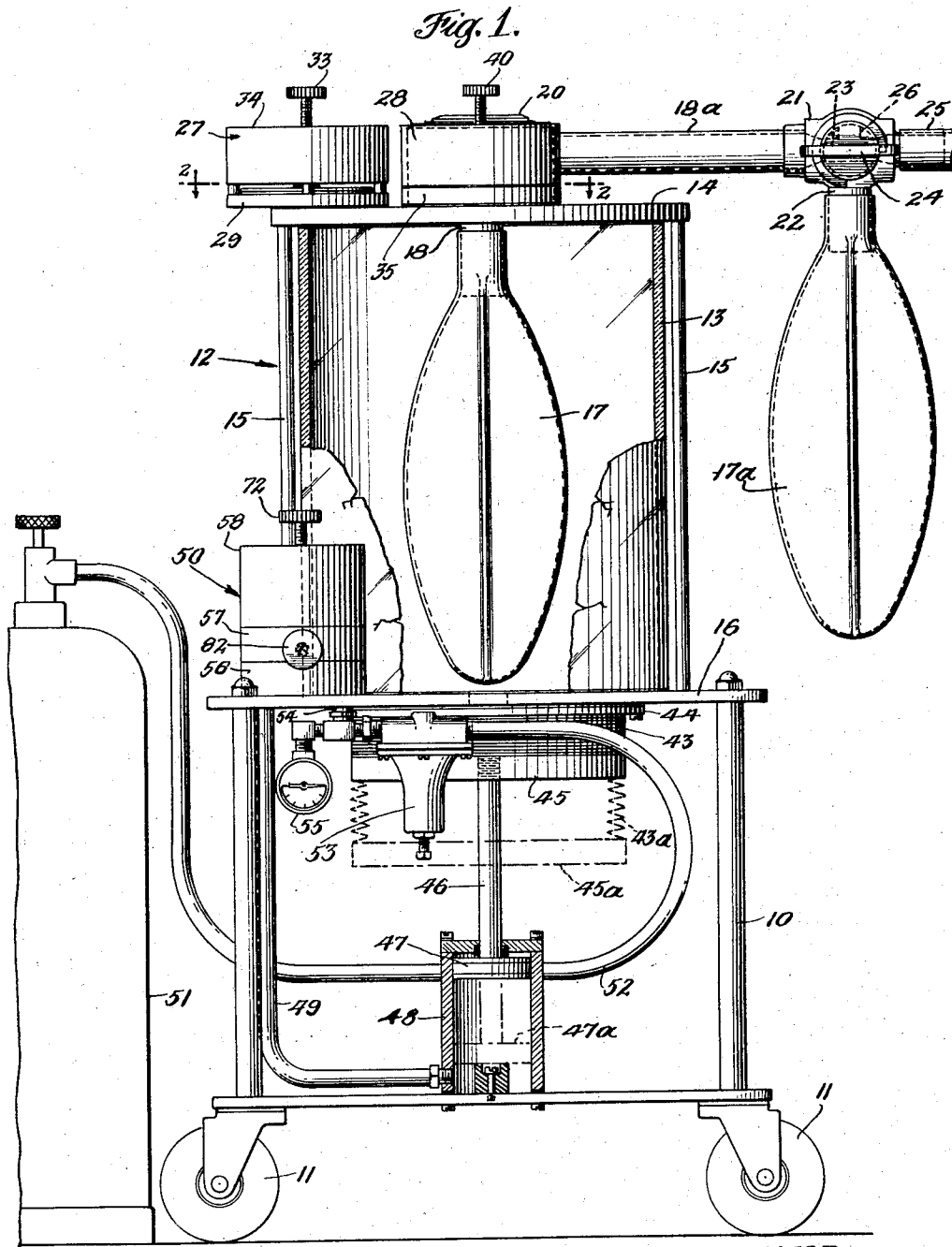
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LUNG VENTILATORS AND TIMING DEVICES THEREFOR

Filed Jan. 31, 1955

3 Sheets-Sheet 1



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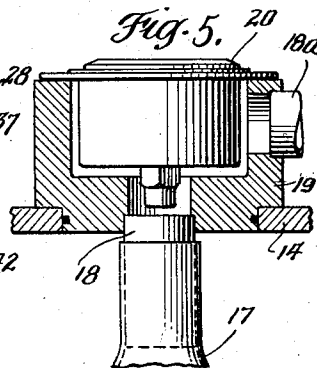
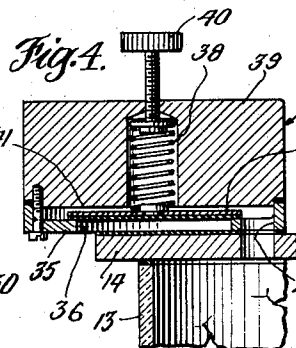
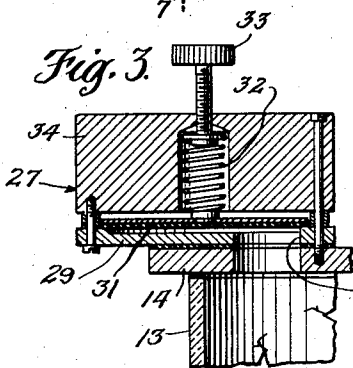
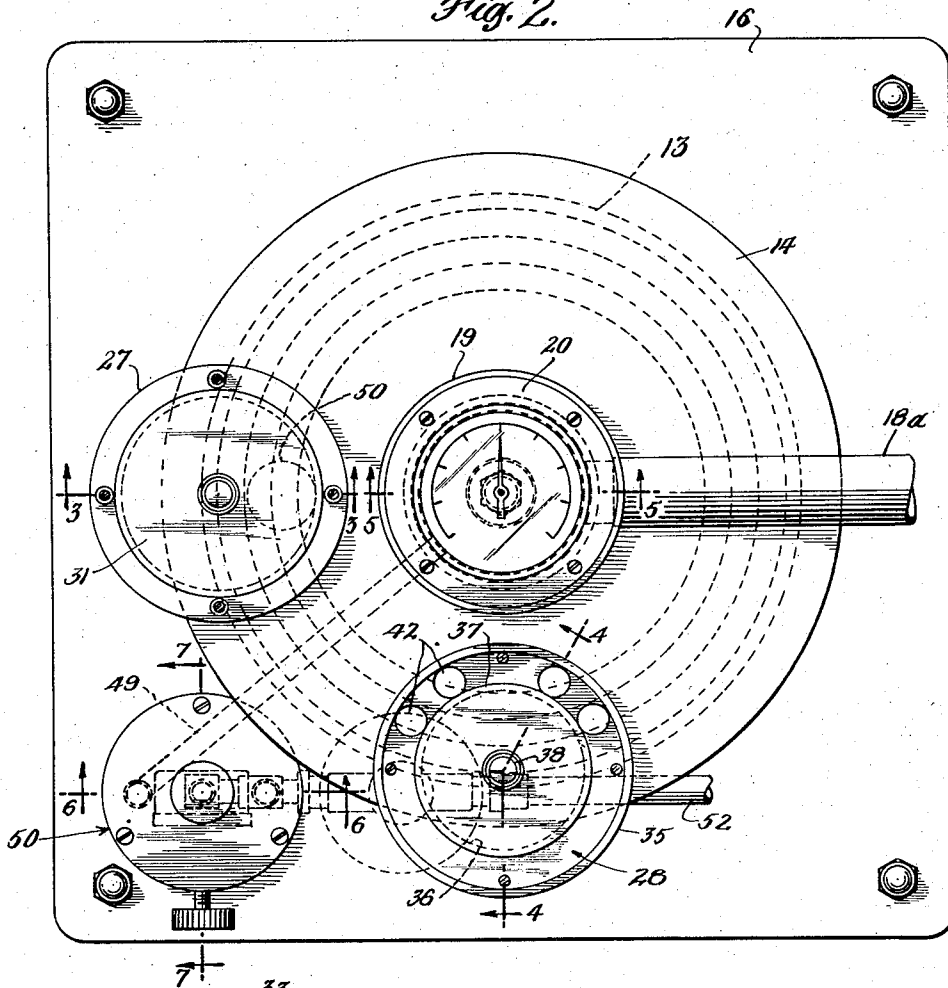
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Fig. 2.



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Fig. 6.

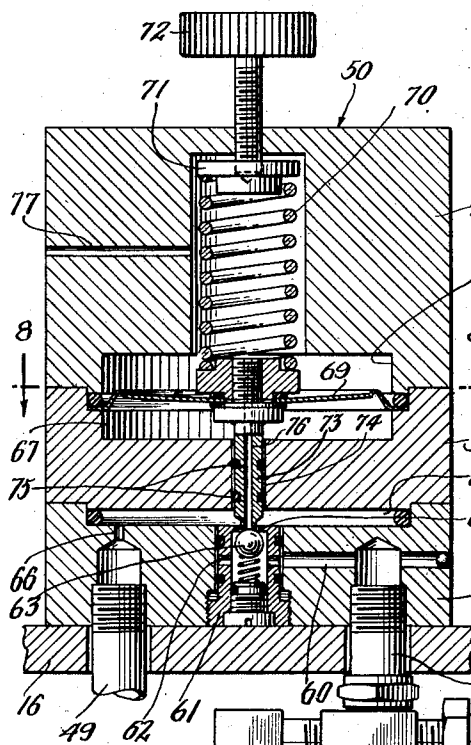


Fig. 7.

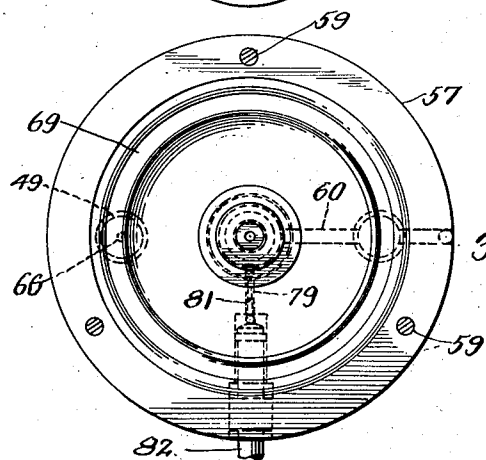
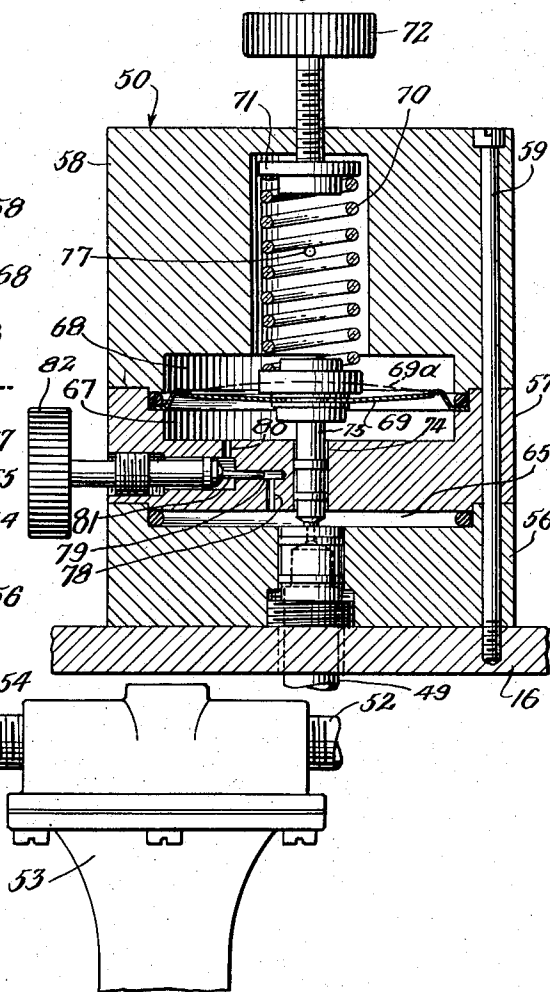
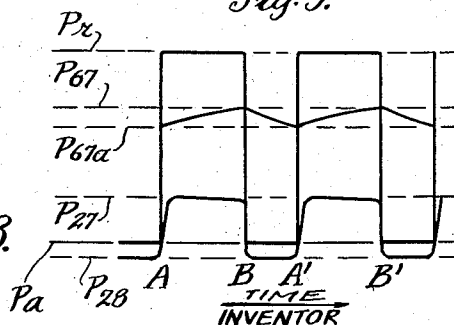


Fig. 8.

Fig. 9.



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LUNG VENTILATORS AND TIMING DEVICES THEREFOR

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15 Claims. (Cl. 128—29)

This invention relates to lung ventilating apparatus and timing mechanism suitable for use therewith and is particularly concerned with equipment capable of applying both the positive pressure phase and the negative pressure phase to the ventilating cycle.

Lung ventilating apparatus of the type with which the present invention is concerned may be used with resuscitating apparatus but is of particular importance for use with anesthesia machines. Most types of anesthesia equipment provide for assisting the breathing of the anesthesia gases by applying a positive pressure to force the gas into the lungs. The natural pressure of the chest muscles is relied upon to force the gas out of the lungs during the exhaling period after which increased pressure is again applied to continue the next cycle. During this type of ventilating action the pressure in the lungs must always remain above atmospheric. It has been found, however, that it is of great benefit to provide lung ventilation during anesthesia which includes a negative pressure phase as well as a positive pressure phase. During the negative pressure phase the gases in the lungs are more adequately scavenged and thus waste products, including carbon dioxide gas, are drawn off. The removal of carbon dioxide from the lungs in this fashion prevents the build up of carbon dioxide concentrations in the blood above normal during operations when the patient is under anesthesia. It has been determined that maintaining normal carbon dioxide concentrations in the blood by the use of this improved anesthesia cycle produces in the patient a more relaxed condition during the operation and recuperation is more rapid afterwards. This control of carbon dioxide is particularly important during open chest operations since in most instances it eliminates the need for the use of drugs for creating a quiet operative field. By means of the improved cycle the more relaxed operative field may be produced and the detrimental after effects produced by the administration of the drugs is thus eliminated. During surgery which requires an open chest the problem of maintaining adequate ventilation is aggravated by the fact that compression of the lungs by the wall of the chest can no longer be accomplished naturally. The negative pressure phase of this apparatus provides a solution to this problem.

It is one of the primary objects of the present invention to provide lung ventilating apparatus for use with anesthesia machines which is adapted to be readily connected to any standard closed circuit anesthesia equipment. This ventilating apparatus functions independently of any initial respiratory effort on the part of the patient.

Another object of the invention is the provision of apparatus which is pneumatically operated and may utilize any convenient source of gas pressure such as a compressed air system or an oxygen cylinder. The present apparatus operates at an unusually high efficiency, thereby providing satisfactory operation with extremely low gas consumption.

A further object of the invention is the provision of a

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machine for developing the positive and negative phases of the cycle and applying them to the anesthesia circuit while maintaining complete separation of the anesthesia gas circuit and that of the controlled pressure circuit. This feature of the invention assures that expensive anesthesia gases are not released to the atmosphere in the controlling action, and further, that the anesthesia gases are isolated from the ventilator mechanism thereby avoiding contamination and hazards.

A still further object is the provision of automatic ventilator equipment having adequate volumetric capacity to handle any normal changes in system capacity and having the ability to adapt automatically to different capacities without disturbing the settings.

An important object is the provision of improved timing mechanism which utilizes any suitable pressurized gas supply for control and which includes adjustments to provide variations in the relative duration of the positive and negative phases. Adjustment of the cycle rate is also included in the timing mechanism. Timing is independent of interference by the patient or by obstruction in the anesthesia circuit.

Another object is the provision of relatively simple equipment which will produce the desired negative pressure values in the controlled pressure chamber while using a driving source with positive pressure only.

A specific object of the invention is the provision of a variable volume chamber having a movable wall which has a mechanical connection to actuate the wall in one direction while actuation in the opposite direction is by the release of energy absorbed during the transmission of the mechanical force.

How the foregoing and other objects and advantages of the invention are attained will be clear from the following description of the drawings, in which—

Figure 1 shows an elevational view of the apparatus of the present invention with certain parts shown in section.

Figure 2 is a plan view of the apparatus to a larger scale.

Figure 3 is an enlarged sectional view taken in the direction of arrows 3—3, Figure 2, showing the construction of the positive pressure relief valve.

Figure 4 is a sectional view taken in the direction of arrows 4—4, Figure 2, showing the construction of the negative pressure relief valve.

Figure 5 is a sectional view in the direction of arrows 5—5, Figure 2, showing the arrangement of the anesthesia gas pressure indicator.

Figure 6 is a sectional view in the direction of arrows 6—6, Figure 2, showing the internal construction of the timing device.

Figure 7 is a sectional view in the direction of arrows 7—7, Figure 2, showing the adjustment control of the timing device.

Figure 8 is a view taken in the direction of arrows 8—8, Figure 6, showing the diaphragm and channel construction.

Figure 9 is a diagram showing curves of the pressures in various parts of the system.

In Figure 1 the apparatus is shown supported on a special cart 10 having caster-type wheels 11. A closed chamber 12 is formed by cylindrical member 13, which is preferably made of transparent material such as glass or plastic, and upper surface 14. Rods 15 hold these parts in assembled relation on the base plate 16. Inside the chamber 12 is supported a flexible walled device such as plastic bag 17 which is attached to the end of pipe 18. This connects through upper surface 14 to an extension pipe 18a which extends horizontally as indicated. As will be more clearly observed in

Figures 2 and 5, pipes 18 and 18a are connected by a fitting 19 supported in surface 14. Fitting 19 in turn supports a pressure gage 20 which indicates at all times the pressure being developed in the bag 17 and its connected system.

Another bag 17a is shown in Figure 1 located outside chamber 12 attached to valve unit 21. Valve 21 is supplied with downwardly extending nipple 22 to which the neck of the bag 17a is fastened. Valve 21 includes a channel 23 which extends horizontally through the valve when the handle 24 is in horizontal position as illustrated. In this position pipe 18a and bag 17 are connected directly to the anesthesia machine system through flexible tube 25. Bag 17a is shut off from the system with handle 24 horizontal as shown. It will be seen that valve 21 incorporates a short transverse channel 26. Thus when valve handle 24 is rotated 90° (clockwise) channel 23 becomes vertical to close off pipe 18a and channel 26 connects bag 17a to tube 25 to provide effective operating connections for normal manual operation of the machine by means of bag 17a. Thus manual operation may be accomplished at any time desired or necessary such as during adjustment of the automatic mechanism or in case of failure in the automatic operation.

The controlled pressure chamber 12 is equipped with a positive pressure relief valve unit 27 and a negative pressure relief valve unit 28. The relative positions of these valves are shown in Figure 2 and the details of construction in Figures 3 and 4. Figure 2 the upper portion of the valves have been removed to show the internal construction. Positive pressure relief valve 27 incorporates a plate 29 which is fastened to plate 14 and includes the connecting opening 30. As will be seen from Figure 3 a large diameter flapper valve 31 is loaded by spring 32. A thumbscrew 33 is mounted in valve cover 34 and engages spring 32 to control the valve opening pressure. Thus positive pressure above a value which is predetermined by the setting of thumbscrew 33 is relieved to provide control of the positive pressure in the anesthesia system since the pressure in chamber 12 is directly transmitted to the anesthesia system through the medium of bag 17. The pressure in the anesthesia system, whether positive or negative, is shown directly by gage 20.

Figure 4 shows the details of the negative pressure relief which is somewhat similar in construction to the positive pressure valve. A plate 35 incorporates opening 36 which projects in part beyond top plate 14. Opening 36 is normally closed by flapper member 37 which is held under proper load by spring 38. Cover 39 supports spring 38 and its adjusting screw 40. In cover 39 above flapper member 37 is a shallow chamber 41 which connects to the interior of chamber 12 by means of openings 42. With this valve when the negative pressure in chamber 12 falls below the adjusted pressure, the difference in pressure between atmospheric and the internal pressure causes flapper member 37 to open and admit air from outside into chamber 12 through openings 42.

Referring again to Figure 1, it will be seen that the lower surface 16 of cylindrical chamber 12 supports a large diameter bellows unit 43 having a flange 44 attaching it to surface 16. The bellows unit 43 is shown in collapsed position by full lines and in extended position by dotted outline 43a. Bellows 43 is provided with a heavy bottom member 45 (also indicated in extended position at 45a). Attached to bottom 45 is rod 46 which in turn is attached to piston 47 mounted in cylinder 48. Lower position of piston 47 is indicated at 47a and corresponds to extended position 43a of the bellows. At the lower end of cylinder 48 a connecting tube 49 is attached. Tube 49 extends to the timing device 50. To complete the system, timing device 50 is also connected to a source of gas pressure such as oxygen tank 51. Interposed in the tube 52 is a pressure regulator

53 of standard construction which is connected to the timing device 50 by short pipe 54. A pressure gage 55 is attached to indicate the pressure of the gas supplied to the timing device 50.

The details of construction of the timing device 50 are clearly shown in Figures 6, 7 and 8. The body of the timing device is composed of three sections, lower section 56, intermediate section 57 and upper section 58. These sections are held in assembled relationship on the plate 16 by bolt members 59. A channel 60 in lower section 56 conducts the constant regulated pressure gas to the centrally located check valve 61. Openings 62 lead the gas to the spring loaded ball valve member 63 which is urged toward opening 64. Between sections 56 and 57 a shallow chamber 65 is formed into which opening 64 leads from the check valve. Chamber 65 is connected by outlet 66 and pipe 49 to cylinder 48.

Between sections 57 and 58 are two chambers 67 and 68 separated by wall 69. This is a two position, snap action or "oil can" type wall or diaphragm which resists pressure until a certain critical value is reached when it snaps to deflected position. This position is maintained until the urging or holding pressure reduces to a value somewhat below the critical value when the wall snaps back to its original position. To supplement the natural spring action of diaphragm 69, a spring 70 is mounted in section 58 and engages the upper side of diaphragm 69. Spring 70 is supported by washer 71 and adjustment screw 72 which permits changing the load in spring 70.

Attached to diaphragm 69 is a downwardly projecting rod 73 which extends through opening 74 between chambers 67 and 65. It will be seen that the position of check valve 61 is adjustable in body 56 to give relative adjustment with respect to rod 73 to control the degree of valve opening. Seals 75 around rod 73 prevent passage of gas between chambers through opening 74. A channel 76 extends completely through rod 73 the top end of which extends into upper chamber 68. It should be noted that chamber 68 is vented to the outside air by opening 77. The lower end of rod 73 is reduced in diameter to form a nipple of smaller diameter than the opening 64 of the check valve 61. In the normal position shown in full lines in Figure 6, i.e., in the lower position of diaphragm 69, the end of rod 73 is in contact with ball 63 and holds it away from its seat to hold the valve open and allow gas under regulated pressure to flow into and through chamber 65. In this position the opening in the end of rod 73 is sealed by virtue of its contact with ball 63.

As will best be seen in Figure 7 lower chamber 65 and chamber 67 are connected by small diameter channels 78, 79 and 80. The horizontal channel 79 is restricted by tapered needle 81, the degree of restriction being controllable by adjustment screw 82 which is threaded into body section 57.

The operation of the timing device in conjunction with the variable volume chamber provides for the application of the desired positive and negative pressure cycle to the anesthesia system. Thus with the check valve member 63 held open by the rod 73, as indicated in Figure 6, pressure is admitted to chamber 65 and to cylinder 48 (see Figure 1). With piston 47 in the lower dotted outline position 47a, as soon as valve member 63 is opened to admit the constant regulated pressure P_r , piston 47 starts to move upwardly at the same time moving bellows 43 to build up the pressure in chamber 12. This pressure is directly transferred to the gas in the bag member 17 and causes it to transfer anesthesia gas to the lungs. The relatively large volume change of chamber 12 allows the pressure to be maintained on bag 17 even though the volume of the bag is reduced considerably by displacement of gas in the anesthesia system. Sufficient pressure is applied to cylinder 48 to develop the pressure desired in chamber 12, as well as

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raise the weight 45. Weight 45 is of sufficient size to develop a return force to produce the desired negative pressure in chamber 12 and to overcome the piston friction and other incidental forces. If desired a suitable spring could be substituted for weight 45 to serve as the medium for energy absorption on the positive pressure phase. The pressure relief valve 27 connected to chamber 12 controls the maximum pressure by bleeding off air when the desired pressure is exceeded.

As soon as pressure P_r is admitted to chamber 65 a slow bleeding of pressure occurs from chamber 65 to chamber 67 through the channel controlled by needle valve 81. Pressure P_r is higher than pressure P_{67} required in chamber 67 to cause "oil can" action of the diaphragm 69 combined with load from spring 70. The setting of needle valve 81 determines the time required for build-up of the required pressure P_{67} . Bellows 43 continues to collapse during this period or phase.

Upon reaching the critical "oil canning" pressure P_{67} diaphragm 69 snaps to its upper position indicated by dotted line 69a, Figure 7. In this position it moves the rod 73 upward an equal amount thus raising the end clear of the valve member 63 to allow it to close opening 64. Chamber 65 is now closed against the application of pressure P_r and at the same time opening 76 provides a direct connection through chamber 68 and channel 67 to the outside atmosphere. Thus the pressure in chamber 65 is immediately released to atmospheric pressure P_a , when "oil canning" to the upper position of diaphragm 69 occurs.

As a result of this reduction to atmospheric pressure piston 47 starts to move downwardly under the influence of weight 45. This downward motion causes expanding action in the bellows and immediately reverses the pressure in chamber 12 from positive to negative value. The value of negative pressure is held substantially constant during the downward stroke and is controlled to the desired value by relief valve 28. Again as in the case of the positive pressure, the negative chamber pressure is transferred to the bag member 17 which is induced to expand and causes a negative pressure in the anesthesia system to effectively withdraw gas from the lungs during this negative pressure phase of the cycle.

Diaphragm 69 will remain in the up position until the pressure in chamber 67 has reduced to a value somewhat less than that required for upward movement. The downward movement of the diaphragm occurs at a pressure P_{67a} . The time required to reach this pressure from its "oil can up" pressure P_{67} is determined by the bleed back from chamber 67 to chamber 65 (pressure P_a) around needle valve 81. Thus as soon as chamber 67 reduces in pressure to P_{67a} diaphragm snaps to down position 69. This moves rod 73 downwards to contact valve member 63 and close opening 76. This again admits pressure P_r to chamber 65 to start the pressure phase of the next cycle.

Adjusting relief valve 27 controls the pressure applied during the positive phase of the cycle and adjusting relief valve 28 similarly controls the pressure during the negative phase. Adjustment of the period of the cycle is controlled by changing the setting of needle valve 81. Change of the relative dwells of the positive and negative phases is by adjustment of the diaphragm spring 70 which changes the required "oil canning" pressure P_{67} of chamber 67.

The manner in which these adjustments operate will be evident by the following relationships, where

Atmospheric pressure = P_a

Pressure delivered to chamber 65 = P_r

Pressure in chamber 67 = P_x

Pressure in chamber 67 to "oil can" up = P_{67}

Pressure in chamber 67 to "oil can" down = P_{67a}

Capacity of chamber 67 = C

Resistance between chambers 65 and 67 = R_{81}

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Rate of pressure build up = $\frac{dP_x}{dt} = \frac{P_r - P_x}{R_{81}C}$

$$dt = \frac{R_{81}CdP_x}{P_r - P_x}$$

Integrating both sides and evaluating between the limits

$$P_x = P_{67a} \text{ and } P_x = P_{67}$$

Time for build up = t_b

$$= R_{81}C[\log_e |P_r - P_{67a}| - \log_e |P_r - P_{67}|]$$

Rate of pressure decay = $\frac{dP_x}{dt} = \frac{P_x - P_a}{R_{81}C}$

$$dt = \frac{R_{81}CdP_x}{P_x - P_a}$$

Again integrating and evaluating between $P_x = P_{67}$ and

$$P_x = P_{67a}$$

Time for decay = t_d

$$= R_{81}C[\log_e |P_{67} - P_a| - \log_e |P_{67a} - P_a|]$$

Total period = $t_b + t_d$

$$= R_{81}C[\log_e |P_r - P_{67a}| - \log_e |P_r - P_{67}| + \log_e |P_{67} - P_a| - \log_e |P_{67a} - P_a|]$$

$$\text{Relative dwell} = \frac{R_{81}C[\log_e |P_r - P_{67a}| - \log_e |P_r - P_{67}|]}{R_{81}C[\log_e |P_{67} - P_a| - \log_e |P_{67a} - P_a|]}$$

It will be seen from these relationships that changing the resistance R_{81} , i.e. adjusting needle valve 81 does not affect the relationship of positive and negative dwell, since both the numerator and denominator are varied equally. It does, however, change the total period of the cycle. To adjust the relative dwell the value of P_{67} is changed by adjusting spring 70. A change in P_{67} pressure changes the rate of pressure build up and the rate of pressure decay in opposite senses. Thus a reduction in pressure P_{67} produces an increase in build-up rate and a decrease in pressure decay rate. The effect on total period is small since it adds to one part of the equation and subtracts from the other.

The complete system pressure relationships are shown in Figure 9. At A the pressure in chamber 67 is at P_{67a} , the diaphragm has just moved to down position. This applies pressure P_r in chamber 65 which in turn develops controlled positive pressure P_{67} in variable chamber 12. Pressure bleeds gradually into chamber 67 until at time B it reaches P_{67} when the diaphragm "oil cans" to up position causing the pressure in chamber 65 and cylinder 48 to drop to atmospheric P_a . This results in expansion of the bellows to cause negative pressure P_{28} to develop in chamber 12. From B to A¹, the pressure in chamber 67 decays until it reaches pressure P_{67a} when the diaphragm 69 "oil cans" to down position to start the cycle over again. Closing the needle valve 81 serves to increase the time both for pressure build-up and pressure decay in chamber 67. This increases the distance A to B and also B to A¹, thus increasing the cycle length. Adjusting spring 70 to increase the pressure to "oil can" up has the effect of raising the level of P_{67} and causes an increase in distance A to B and a decrease in distance B to A¹. Thus increasing the oil canning pressure causes lengthening of the positive phase and shortening of the negative phase of the cycle without change in the total cycle time.

In Figure 9 different scales are used for the operating air system pressures and for the anesthesia gas system, i.e. chamber 12. With the arrangement shown a regulated air pressure, P_r , of 10 p.s.i. is suitable. Chamber 67 pressures, P_{67} and P_{67a} , may vary for example, from 6 p.s.i. for snap-up pressure to 4 p.s.i. for snap-down

pressure. For chamber 12 pressures, a positive pressure of 25 cms. water (P_{27}) to a negative pressure of -10 cms. water (P_{28}) are typical.

From the foregoing it will be evident that I have provided an improved lung ventilating apparatus which may be readily attached to existing anesthesia machines and which will produce a beneficial positive and negative pressure cycle. The equipment may be operated from readily available sources of pressure such as a compressed air system or an oxygen or similar compressed gas cylinder. By the use of a loaded or automatic return bellows apparatus the negative cycle may be produced without direct power application in the return direction and thus the system may be operated by simple mechanism from a positive pressure source. By the use of a diaphragm controlled valve system in conjunction with a single direction power cylinder a relatively simple cycle phase control is possible. The adjustment of the diaphragm response and the adjustment of the bleed control to the diaphragm chamber provide complete control of the cycle frequency and the cycle phase relationships in a fashion which substantially eliminates interacting adjustment effects. It will be evident that this pressure responsive timing mechanism may be useful for other timing purposes, particularly where interrupted gas pressure application is desired. By the use of gas under pressure for the power source as well as to operate the timing mechanism the need for electrical power in such equipment is eliminated, thus avoiding a potential hazard.

I claim:

1. Lung ventilating equipment for use with anesthesia machines including a pressure chamber having a flexible bag element mounted therein, a tube attached to said bag element for connecting the interior thereof to an anesthesia machine system, apparatus for inducing controlled positive and negative pressures in said chamber including a bellows unit having a cylinder and piston, a connection between said piston and said bellows unit to provide movement in one direction under the influence of pressure applied in said cylinder, an energy storing member attached to said bellows to provide movement in the other direction under the influence of energy release, a channel connected to said cylinder for delivering gas under pressure thereto, a device for controlling the delivery of gas under pressure through said channel to provide for controlled periods of high pressure and atmospheric pressure, said device including a check valve, a control chamber having a snap action wall, a tubular member extending from said wall and engaging said check valve to hold it open when said wall is in its normal position, the end of said tubular member being sealed by its contact with said check valve, the control chamber being connected to the gas delivery channel by a restricted channel having an adjustable valve to control the flow, the outer side of said wall being at atmospheric pressure and connected to the gas delivery channel by the passage through said tube when the wall moves to its pressurized position in which the end of said tube moves away from said check valve to permit the valve to close and shut off the pressure to the gas delivery channel and the cylinder.

2. Lung ventilating apparatus for producing a controlled pressure cycle having alternate positive and negative pressure phases including a controlled pressure chamber having a flexible separator membrane therein, a channel member for connecting one side of said membrane with an anesthesia machine channel leading to the lungs, control mechanism for cyclic variation of the pressure in said chamber including a source of regulated pressure gas, a device into which said regulated pressure gas is delivered, a delivery pipe leading from said device, mechanism in said device for changing the pressure of the delivered gas from full regulated pressure to atmospheric pressure in controlled cycles, said device mechanism including a check valve between the regulated pressure portion of the system and the controlled cycle portion, a mov-

able wall having a normal position and a sprung position, one side of said wall being at atmospheric pressure and the other side connected to the controlled cycle portion of said device by a restricted flow channel, a member connected to and movable with said wall, said member contacting said check valve and holding it in open position when said wall is in normal position, a channel leading from the controlled portion of the device to atmospheric pressure, said channel to atmospheric pressure being closed by movement of said wall to normal position and opened by movement to sprung position.

3. A construction in accordance with claim 2 in which said restricted flow channel incorporates a flow control adjustment.

4. A construction in accordance with claim 2 in which the wall is urged to normal position by a spring, adjustment mechanism connected to said spring for changing the effective pressure at which movement to sprung position occurs.

5. Lung ventilating equipment for use with anesthesia machines for producing a controlled pressure cycle having alternate positive and negative pressure phases including a controlled pressure chamber, a flexible walled device mounted in said chamber, one side of said device being connectible with a channel of an anesthesia machine, apparatus for producing cyclic variation of pressure in said chamber, said apparatus including an automatic valve device having an inlet for supply gas thereto under constant pressure, a variable pressure chamber in said valve device having an outlet channel to transfer the variable pressure gas, a second variable pressure chamber in said valve device having a movable wall, said second chamber being connected to said first variable pressure chamber by a restricted flow channel, said movable wall being spring loaded to remain in normal position until a predetermined pressure is built up in said second chamber to move said wall against the spring load, a valve member in said inlet, a connecting element between said wall and said valve member holding said valve member in open position when said wall is in normal position, said first variable pressure chamber having a control channel leading to the atmosphere, said control channel being opened by movement of said wall away from normal position.

6. Lung ventilating equipment for use with anesthesia machines for producing a controlled pressure cycle having alternate positive and negative phases including a controlled pressure chamber, a flexible walled device mounted in said chamber, one side of said device being connectible with a channel of an anesthesia machine, apparatus connected to said chamber for producing cyclic variation of pressure therein, said apparatus including an automatic valve device having an inlet for supplying gas thereto under constant pressure, said valve device having an outlet channel to transmit pressure variations therefrom, a control chamber in said valve device having a movable wall, the inside of said control chamber being connected by a restricted flow channel to said outlet channel, said movable wall being spring loaded to remain in normal position until a predetermined pressure is built up in said control chamber to move said wall against said spring load, a movable valve to shut off pressure to said outlet channel, connecting means between said movable wall and said movable valve for controlling the closing of said valve, a relief channel connectible to said outlet channel when said movable valve is in the shut off position.

7. Lung ventilating equipment for use with anesthesia machines including a variable volume chamber, a movable wall member for said chamber to change the volume and provide controlled positive and negative pressure in said chamber, a piston and cylinder unit connected to said wall member to provide for movement thereof, a source of gas under pressure, a delivery channel from said source to said cylinder and a control device in said

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channel to alternately supply gas under pressure to said cylinder and release the pressure from said cylinder, said device having a movable pressure responsive wall and a control chamber adjacent thereto, a restrictive flow channel between said delivery channel and said control chamber, a valve in said device to alternately open and close said delivery channel and to relieve pressure from said channel when closed and a connection between said valve and said pressure responsive wall to control said valve.

8. Lung ventilating equipment for use with anesthesia machines to supply alternate positive and negative pressure thereto including a chamber, a movable wall member for said chamber to vary the volume thereof and produce positive and negative pressure in said chamber, a gas powered device with actuating connections to said movable wall member, a source of gas under pressure, a delivery channel from said gas source to said device to provide for movement thereof, control mechanism in said delivery channel to alternately deliver gas under pressure and then close off the flow to and relieve pressure from said delivery channel, said mechanism including a valve structure in said delivery channel and a timing device having connecting means to said valve structure to periodically control its opening and closing.

9. Lung ventilating apparatus for use with anesthesia machines including a variable pressure chamber, a pressure varying device with a movable wall having motivating mechanism therefor, said device having means for connecting a source of gas under constant pressure to activate said motivating mechanism, valve structure controlling the build up and release of pressure to said motivating mechanism, timing mechanism for controlling the flow of gas from said source to said motivating mechanism, said timing mechanism having an adjustable valve to control the cycle frequency and an adjustable pressure responsive member to control the timing of the cycle phases.

10. A construction in accordance with claim 9 in which the pressure responsive member is a flexible diaphragm.

11. Timing apparatus suitable for controlling the cycle phases of lung ventilating equipment including a valve device for interrupting the flow of gas, said device having an inlet passage for connecting to a source of gas under regulated pressure, an outlet passage from said valve device, a valve structure between said passages, a relief channel controlled by said valve structure, said apparatus incorporating control mechanism for said valve structure

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including a chamber, a snap action wall member in said chamber, a motion transmitting element between said wall member and said valve structure, an interconnecting passage between said chamber and said outlet passage and an adjustable restrictive valve in said connecting passage.

12. A construction in accordance with claim 11 in which adjustable spring means are attached to said wall member.

13. A construction in accordance with claim 11 in which the motion transmitting element incorporates said relief channel leading to the atmosphere, the movement of opening said valve producing closing of said channel and vice versa.

14. Timing apparatus suitable for controlling cycling of lung ventilating equipment of anesthesia machines including an automatic valve device for controlling the flow of gas, said device being connected by an inlet passage with a source of gas under regulated pressure, said device having a chamber having an outlet passage therefrom, a valve member located in said inlet passage, said apparatus having a control chamber with a restrictive passage leading to said first chamber, a snap action diaphragm forming a wall of said control chamber, a tubular element extending from said diaphragm to said valve, the end of said element contacting said valve to hold it in open position when said diaphragm is in normal position, the end of said element being moved out of contact with said element when said diaphragm moves to its sprung position thereby allowing closing of said valve and opening of the end of said tubular element to connect said first chamber with the atmosphere and release the pressure therein.

15. A construction in accordance with claim 14 in which said restrictive passage incorporates an adjustable valve and said diaphragm is provided with an adjustable spring device to change the amount of pressure required to move the diaphragm to its sprung position.

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