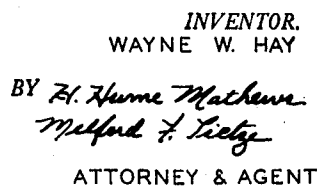


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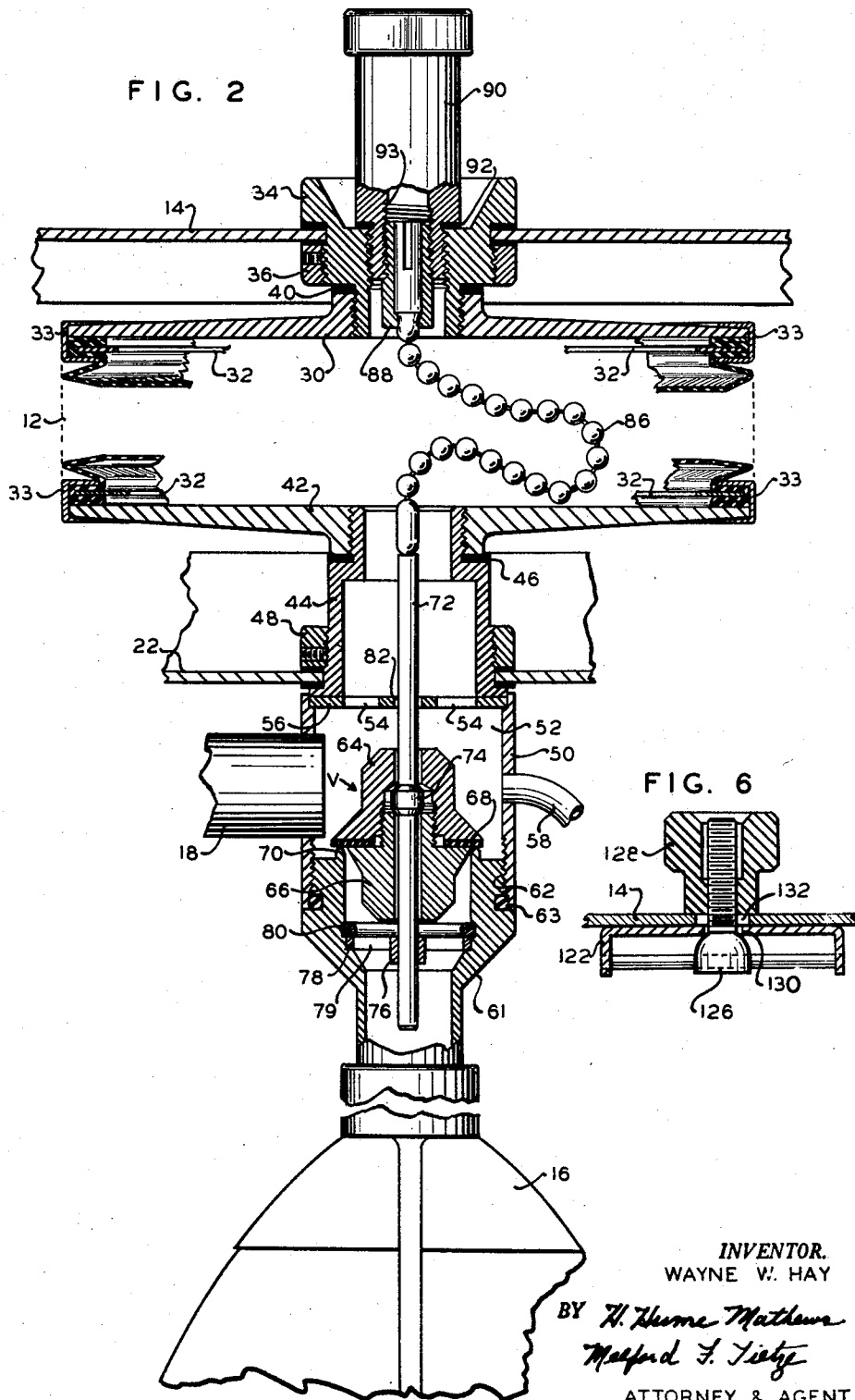
Oct. 6, 1959

W. W. HAY
APPARATUS FOR PRODUCING ARTIFICIAL
RESPIRATION DURING ANESTHESIA

2,907,322

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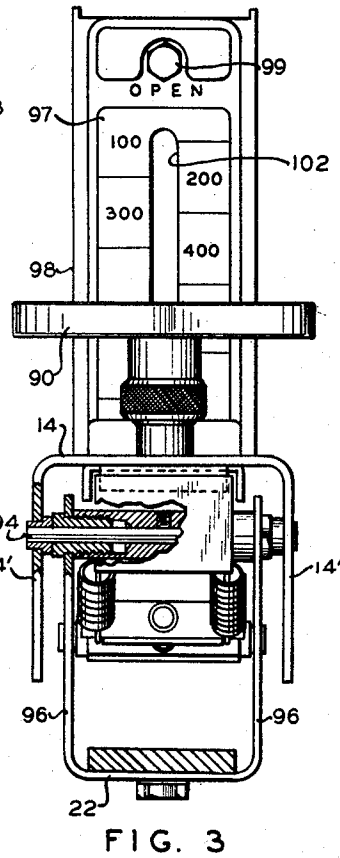
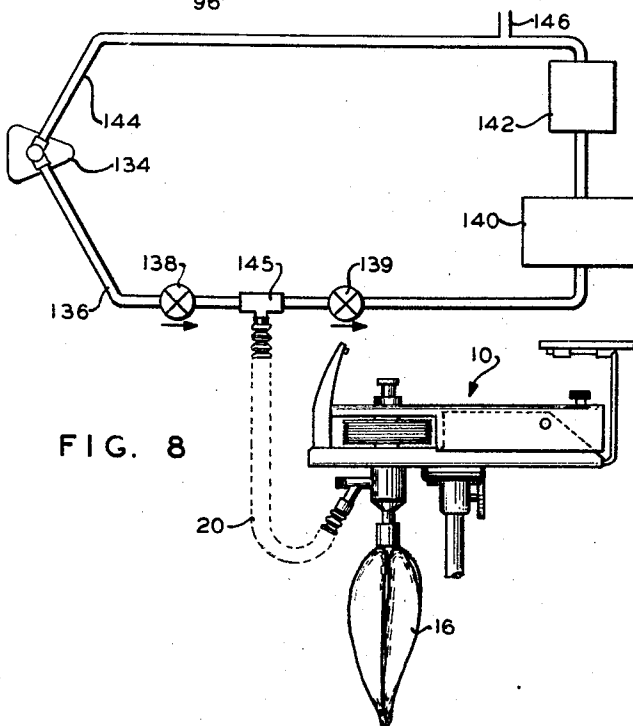
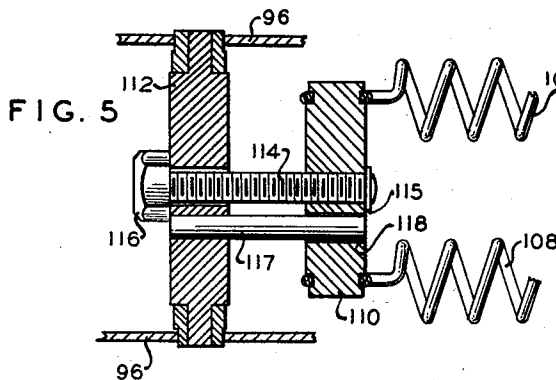
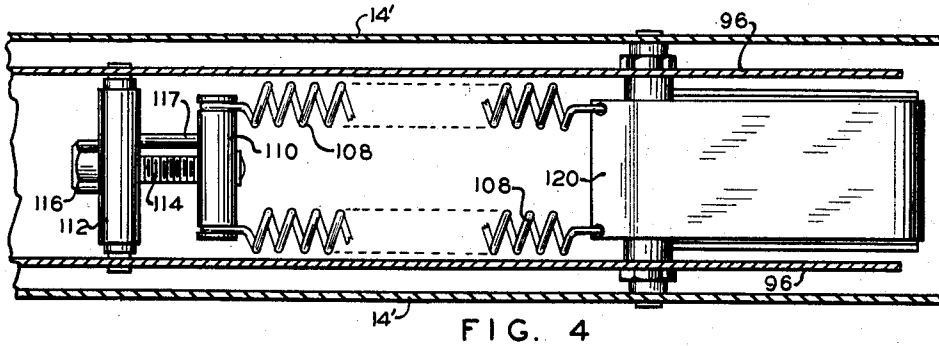
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3 Sheets-Sheet 3



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2,907,322

APPARATUS FOR PRODUCING ARTIFICIAL RESPIRATION DURING ANESTHESIA

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Application November 26, 1956, Serial No. 624,417

19 Claims. (Cl. 128—29)

This invention relates to apparatus for the administration of inhalant anesthetics and particularly to apparatus of this type adapted to produce artificial respiration while the patient is under anesthesia.

In many cases, the volumes of inhalation and exhalation exchanged by the patient's spontaneous respiration are inadequate and it is necessary to assist, in some way, the normal breathing effort. This may be true, for example, in an aged patient or a patient of sub-normal physical stamina. Since advancements in surgical techniques have made it possible to treat such patients with greater safety, the problem of adequate pulmonary ventilation in such type patients, now is encountered more frequently. In addition, there is an increasing use of adjunctive drugs in anesthesia that depress the patient's respiratory reflexes and require either partial assistance or complete control of the patient's breathing.

It has been a common practice, when the need arises, for the anesthetist to squeeze the rebreathing bag of the anesthetic administering circuit which produces a positive pressure that aids the patient's spontaneous inhalation. By intermittently squeezing and releasing the breathing bag, the anesthetist has been able to produce artificial respiration while the patient is under anesthesia. Alternatively, mechanical devices have been used which operate automatically to produce artificial respiration by intermittent positive pressure during inhalation, or by positive pressure during inhalation and negative pressure during exhalation.

While both of these methods have special advantages for particular applications, many anesthetists prefer to use the rebreathing bag whenever possible and to manually apply directly to the rebreathing bag any pressure needed to assist the patient's respiration. This preference is associated with a traditional concept of the anesthetist that such physical contact with the rebreathing bag permits the "feel" of the patient to be retained as distinct from purely mechanical or automatic devices in which this is not possible. The manipulation of the rebreathing bag, however, has certain disadvantages and involves some objectionable difficulties. Thus, for example, the volume of inhalation and of exhalation accompanying this mode of respiration, generally, may only be approximated. Further, the repeated flexing of the anesthetist's hand over a sustained period is fatiguing and inclined to interfere with the anesthetist's over-all duties. In addition, with the usual types of apparatus, the method is limited to the inhalation phase and offers no augmentation of the patient's exhalation. While there have been modifications of the typical anesthetic devices seeking to avoid some of these difficulties, the resulting apparatus frequently have imposed added resistance to the patient's spontaneous respiration, involved preliminary adjustments before operation could commence, or in some instances incurred loss of anesthetic gases to the atmosphere or undesired dilution of the anesthetic circuit gases.

It is an object of the present invention to provide a

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manually operable respirator for anesthetic administering apparatus effective to permit retention of the "feel" of the patient during respiration while overcoming many of the disadvantages heretofore encountered by intermittent manual compression of the rebreathing bag for this purpose.

It is another object of this invention to provide anesthetic administering apparatus permitting spontaneous respiration of a patient under normal conditions and operable when desired, without preliminary adjustments, to produce artificial respiration.

It is a further object of this invention to provide such an anesthetic administering apparatus operable to apply positive pressure inflation during inhalation and/or a negative pressure during exhalation.

It is a further object of this invention to provide such an anesthetic administering apparatus having an expansible-contractible chamber member operable by manual displacement to produce artificial respiration and adjustable biasing means therefor effective to reduce the exertion required for manual operation of said chamber member.

It is a further object of this invention to provide such apparatus in a compact unit operable to afford control of a patient's respiration rate, tidal volume, inhalation and exhalation pressures and flow rates, and the pattern of the breathing cycle.

It is a further object of the invention to provide such an anesthetic administering apparatus having calibrated scale means associated with said expansible-compressible respirator chamber member to indicate the volumes of gases breathed by the patient, operable during spontaneous respiration and during artificial respiration.

It is a further object of this invention to provide an anesthetic administering apparatus operable for permitting spontaneous administration or for producing artificial respiration, having a variable volume breathing chamber member forming a part of the breathing circuit, means forming an opening in the circuit, and normally closed valve means controlling said opening, actuated by said breathing chamber member at a predetermined maximum displacement thereof and responsive to a predetermined pressure differential acting thereon, to be opened.

It is a further object of this invention to provide an anesthetic administering apparatus having a rebreathing bag connected in the circuit, an expansible-contractible respirator chamber operable to provide volumetric exchange in the patient's lungs during inhalation and exhalation, and valve means normally isolating said rebreathing bag from the circuit, actuated by said respirator chamber.

It is a further object of this invention to provide such an apparatus wherein a gravity-loaded valve means is employed, said valve being mechanically unseated when the respirator chamber member exceeds a predetermined maximum displacement and also being unseated when the pressure differential acting thereon, corresponding to a predetermined negative circuit pressure, produces a force exceeding the weight thereof.

It is another object of this invention to provide a portable, detachable respirator unit for use in conjunction with an anesthetic administering circuit.

It is another object of this invention to provide such a respirator unit having both an expansible-contractible bellows and a detachable rebreathing bag adapted to be connected through a common conduit with a breathing circuit, and valve means normally isolating the rebreathing bag, adapted to be opened in response to a predetermined negative pressure in the breathing circuit and operatively connected with said bellows to be opened when the bellows exceed a predetermined maximum expansion,

whereby a patient may be permitted to breathe spontaneously or, alternatively, be artificially respired by actuation of said bellows.

It is a still further object of this invention to provide such a respirator unit which is adapted to be applied to a standard, closed or semi-closed, breathing circuit, permitting normal operation of said apparatus during spontaneous respiration, and operable to produce artificial respiration when desired without preliminary adjustments.

It is a still further object of this invention to provide a manually operated respirator unit for anesthetic administration which will avoid discharge or dilution of the circuit gases in closed circuits and reduce the discharge of gases in semi-closed circuits.

It is a still further object of this invention to provide a manually operated respirator unit for anesthetic administration having a bellows and an associated, normally closed valve means, actuated thereby in response to a predetermined displacement of said bellows, and a compensating linkage connected to said bellows, including a variable resilient means for variably loading said bellows, adapted to urge the bellows resiliently to expanded position, to open said normally closed valve means.

Further objects and advantages of the invention will be more fully understood by reference to the following description of a preferred embodiment thereof and the accompanying drawings, in which:

Fig. 1 is a side elevation view, partially in section, showing a respirator device embodying the present invention;

Fig. 2 is an enlarged sectional view of the bellows, rebreathing bag and associated valve means seen in Fig. 1;

Fig. 3 is a right-end elevation view of the respirator device seen in Fig. 1;

Fig. 4 is a partial, sectional plan view, taken substantially along the line IV—IV in Fig. 1, looking upwardly;

Fig. 5 is an enlarged sectional view taken along the line V—V in Fig. 1, showing the tension adjustment for the bias springs of the bellows actuating linkage seen in Fig. 1;

Fig. 6 is an enlarged sectional view of the bias control knob governing the loading of the bellows taken along the line VI—VI in Fig. 1;

Fig. 7 is an enlarged sectional view of the vertical scale post showing the adjustable stop carried thereon, taken along line VII—VII in Fig. 1; and,

Fig. 8 is a schematic illustration of a standard closed anesthetic circuit, showing the manner of attaching the respirator device seen in Fig. 1, thereto.

Referring now to Fig. 1, a respirator device is shown generally at 10 which is adapted to be employed as hereinafter described in conjunction with an anesthetic administering circuit to permit resuscitation or respiration of a patient during anesthesia. The respirator includes a flexible bellows 12 having a pivoted actuating arm 14 connected thereto, a detachable rebreathing bag 16 and a connector fitting 18 for receiving a conduit such as the hose 20 through which the respirator is adapted to be connected with an anesthetic administering circuit. The bellows and its actuating lever and the connector and rebreathing bag are supported in a fixed frame 22 mounted on a pedestal 24. The frame is removably attached by means of locknuts 26 to a fixture 27 which in turn is vertically adjustable on the pedestal and locked in position by a handcrew 28.

Referring now to the enlarged view of Fig. 2, it may be seen that the flexible bellows has, at its upper end, a movable end plate 30. The attachment of the end plate is accomplished by means of an inner ring 32 inserted between two adjacent pleats of the bellows and an outer ring 33 whose upper edge is crimped over the plate 30. A retainer bolt 34 is threadedly secured in the movable plate 30, and a locking ring 36 is threadedly received on

the shank thereof to clamp against the pivoted arm 14 to thereby attach the upper end of the bellows to the actuating arm. A gasket 40 is provided between the shank of retainer bolt 34 and movable bellows plate 30 producing a gas-tight seal. The lower end of the bellows is received on a fixed plate 42 in substantially the same manner as the opposite end of the bellows is to plate 30. The fixed plate is threadedly seated on a nipple fixture 44, having a sealing gasket 46, which, in turn, is secured to the support frame 22 by a locking ring 48. A housing 50 connects with the bottom of the supporting nipple 44 and is supported thereby at the bottom of the frame 22. The housing forms a valve chamber 52 which communicates with the connecting fixture 18 and thereby with the breathing circuit to which the respirator device is connected. Openings 54 in the valve guide web 56 connect the valve chamber with the bore passage of the mounting nipple 44 and thus with the interior of the respirator bellows 12. A tube 58, Fig. 1, forms a pressure tap adapted to be connected by conduit 59 with a gauge cavity 60 which is adapted to receive a conventional pressure gauge affording a reading of the pressure in the apparatus. The gauge has not been shown in order better to illustrate the respirator.

The rebreather bag 16 is frictionally seated on a connector piece 61 having a threaded shoulder 62 which is received in the bottom of the valve body 50. An O ring type gasket 63 disposed therebetween creates a gas-tight seal.

Within the valve body is a vertically movable valve element V comprising two threaded parts 64 and 66. The upper valve segment 64 is provided with a bottom face having a compressible gasket member 68 which is arranged to be seated on an annular nozzle 70 formed at the upper end of the rebreather bag connector 61. The valve element V is carried on a vertical stem 72 having an enlargement 74 which is retained between the valve parts 64 and 66 so that the valve may be lifted by the rod. There is slight play in this junction to permit self-alignment of the valve element with the seat 70. The valve stem is guided at its lower end in a bushing 76 disposed substantially centrally in the connector 61 by means of a ring 78 having a plurality of radial ribs 79 supporting the bushing 76 at the center thereof and held in place by a spring clip 80. An opening 82 in the valve guide web 56 acts to center the upper end of the stem. By this construction, it will be seen that the valve V normally rests under the influence of gravity against the valve opening 70 thus isolating the rebreather bag from the valve chamber 52 and connector fitting 18. Under the influence of upward vertical displacement of the valve stem 72, however, the valve element is raised from the seat 70 placing the rebreather bag in communication with the gas circuit.

At its upper end, the valve stem is connected to a bead chain 86 which in turn is attached to a vertically adjustable retainer bushing 88. The bushing 88 is carried by handle 90 threaded into the retainer bolt 34. A gasket 92 provides a sealing engagement therebetween. The handle 90, as may best be seen in Fig. 3, is constructed to facilitate oscillation of the actuating lever by the anesthetist. As will be hereinafter more fully described, the chain 86 is of a predetermined length such that, when the head end of the bellows is displaced a predetermined distance, the chain will have reached the limit of its length and further expansion of the bellows causes the valve stem to be raised and the valve V to be unseated. The point at which the chain 86 becomes taut may be adjusted by threading the retainer bushing 88 which is accessible for this purpose through the top of bore 93 in handle 90 in which the bushing is received.

Referring to Figures 1, 3 and 4, it will be seen that the actuating lever 14 has down-turned sides 14' which are pivoted on a pin 94 supported between the up-turned stanchions 96 of the supporting frame 22. At its outer end, the actuating lever describes an arc closely approximating the curved face 97 of an upright post 98.

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A calibrated scale is provided on the face 97 such that the position of the actuating arm 14 with respect thereto gives a reading of the displacement of the bellows during its normal operation. This reading corresponds substantially to the volume of the patient's inhalation and exhalation when the respirator is being operated to assist the patient's respiration. It may also be employed as herein-after more fully described to measure the patient's tidal volume during spontaneous breathing.

The post 98 carries a fixed stop 99 approximately at the top thereof which is disposed to obstruct upward movement of the actuating lever 14 and limit the expansion of the bellows. An adjustable stop 100 is arranged to limit the downward displacement of the bellows. The stop 99 as best seen in Fig. 7 comprises a screw 101 projecting through a vertically elongated slot and having an enlarged head 103 forming the obstructing element. A lock nut 104 threads onto the screw from the opposite side of the faceplate 97 to clamp the stop in position along the length of the slot 102. Both of the stop members have rubber rings 105 acting as bumpers. The adjustable stop may be set so that actuation of the lever 14 by the anesthetist will produce a desired tidal exchange during each oscillation. The bottom-most position of the lever corresponding to the maximum tidal volume is at the fully contracted position of the bellows. The valve V may be set by adjustment of the bushing 88 as before described, to open at a point in the stroke of the actuating lever, corresponding substantially to that shown in dotted lines in Fig. 1. Should the patient's exhalation exceed this setting, the bellows will be further expanded, but not beyond the limit stop 99, opening the valve V and allowing the excess volume to dump into rebreathing bag 16. Patient's inhalations in excess of the allowable downstroke of the bellows are withdrawn from the rebreathing bag by the resulting suction which raises the valve V from the seat 70. The valve V is constructed such that its weight may be overcome by a small predetermined negative circuit pressure allowing gases to enter the valve chamber 52 from the rebreathing bag.

Referring to Figures 1, 3 and 4, it may be seen that a pair of biasing springs 108 are stretched between the opposite end of the lever arm 14 and a pin 110 which is adjustably secured to a transverse anchor bar 112 mounted between the side plates 96 of frame 22. The adjustable anchor bar assembly is shown in greater detail in the enlarged sectional view of Fig. 5. The pin 110 is adjustably connected to the anchor bar by a screw 114 which is threadably received therein and equipped with a washer 115 to prevent disengagement. An enlarged bore is provided in the bar 112 so that adjustment of the screw through the tool receiving head 116 causes the pin 110 to move to the right or the left, selectively varying the tension in springs 108. A guide rod 117 projects from the anchor bar and is slidably received in a bore 118 in the pin 110 which prevents twisting of the pin when the adjusting screw is being threaded. The opposite ends of the springs 108 are attached to an elongated metal plate 120 which has an intumed lip 121 that catches against the edge of a retaining plate 122. The plate 122 butts against a stop 124 and is held upwardly, in opposition to the tension of springs 108, by a retaining screw 126 which extends through the top of arm 14 and is received in an adjusting nut 128. The screw 126 and its retaining nut 128, seen in greater detail in the enlarged section view of Fig. 6, provide a "bias control" for variably loading the bellows 12. Referring to Fig. 6, it may be seen that the head of the screw 126 is rounded off to facilitate its engagement with an opening 130 in the plate 122. An enlarged opening 132 is provided in the arm 14 which enables longitudinal displacement of the bias control screw therein. This opening also may be in the form of an elongated slot if desired, the longitudinal dimensions being determined, in both cases, by the amount of displacement required for the biasing screw.

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The operation of the bias control and its effect on the operation of the bellows may be seen by referring to Fig. 1. As shown, the plate 122 is in raised position, flush against arm 14. In this position the spring force acts along the line between the axis A of anchor bar 112 and the point of contact P of the rim 121 and plate 122. With the bellows collapsed, as shown, this line passes just below the axis B of pin 94 on which the actuating lever 14 is pivoted. The tensile force produced by the bellows when collapsed is zero so that the line of force, AP, is just far enough below the axis B to compensate for any unbalance in mass in the linkage system and to render the bellows substantially weightless insofar as the operator is concerned. The tension of the springs may, of course, be adjusted in conjunction with this position of the biasing plate 122 to achieve such result. This position corresponds substantially to the minimum bias. It will be seen that as the lever arm 14 is raised, the point P will move downwardly on an arcuate path about the axis B as center. Consequently, the line of force AP of the counter-balancing springs will progressively move away from axis B as the bellows is expanded, thus increasing the "lever distance" at which the springs act on arm 14. This increases the counter torque on the actuating arm. There is an accompanying, slight decrease in distance between points A and P, but the spring tension remains substantially unchanged. Furthermore, the increase in the distance at which the force acts about pivot point B on the lever 14 more than compensates for such reduction in spring force so that the net effect is that of a progressively increasing counter torque. Thus, the clockwise movement as viewed in Fig. 1, produced by the springs 108 over the "lever distance" between the line AP and pivot B, is approximately proportional to the movement of the bellows which, in turn, is likewise approximately proportional to the tensile force developed in the bellows by such movement. The result is that the bellows may be expanded and compressed with substantially little or no effort. This is exceptionally useful when the bellows is being used during the spontaneous respiration of the patient to indicate the volume of breathing, since the mechanism eliminates restriction of the patient's breathing and reduces the breathing effort that otherwise would be required. Such bias also reduces the net effort and facilitates manual operation of the bellows during artificial respiration. If desired, the "bias control" may be adjusted to produce an initial force tending to lift the bellows. This may be done by unthreading the bias knob 128 allowing the plate to be pulled angularly downwardly about its fixed end under the tension of the springs 108, as represented by the dotted line position in Fig. 1. As the plate 122 moves arcuately during such adjustment, the enlarged dimension of the opening 132 in arm 14 permits longitudinal displacement of the screw member 126 therein. Such adjustment, it will be seen, increases the initial moment applied to the lever 14 and permits an initial loading, or "bias," on the bellows up to the maximum amount allowable by the length of the retaining screw 126. This maximum adjustment is adequate to impose a force sufficient to expand the bellows, without other assistance, and maintain the lever 14 resiliently in raised position in contact with the fixed stop 99. With this maximum bias, the bellows will, of course, not respond to the patient's breathing, but spontaneous breathing may go on in the usual manner, since both the bellows and the rebreathing bag are connected with the breathing circuit. Should it be desired to assist the patient's breathing at any time, it is merely necessary, manually, to operate the lever 14, forcing gases into and/or out of the patient's lungs under the control of the operator. It will be seen that such operation for producing assisted or completely artificial respiration may be commenced immediately, in any condition or position of the bellows, without prior adjustments in order to ready the apparatus to convert to such use. The bias may be

set, also, at any intermediate value that may be desired by the operator to supply a particular degree of assistance in the expansion of the bellows. Such intermediate settings are highly useful during manual operation of the bellows, particularly for extended periods, in which it has been found that the force required to expand the bellows has an especially tiring effect. Although additional force is required by the operator to compress the bellows under such circumstances, the assistance during expansion has been found to produce an overall effect requiring less net effort and creating less fatigue.

The respirator unit designated generally at 10 may be associated with an anesthetic circuit as illustrated in the schematic circuit diagram of Fig. 8. As shown in this diagram, a typical closed anesthetic circuit is provided for the administration of the inhalant gas mixtures to a patient. The gases are breathed by the patient through a face mask shown at 134 having an exhalation conduit 136 connected through an exhalation check valve 138 and inhalation check valve 139 with an absorber unit 140 and vaporizer 142. The gases containing anesthetic vapors are then returned to the patient through an inhalation conduit 144. In the circuit shown, a fitting 145 is provided intermediate the check valves 138 and 139 which in conventional apparatus would be provided with a rebreathing bag so that the circuit thus provided would constitute a closed loop in which the patient's gases are continuously recycled together with any necessary addition of makeup oxygen or supply of any other gaseous agent that might be desired. Make-up gases may be introduced for example through an inlet 146 fed from a conventional anesthetic machine. Various arrangements of such circuits and the possible variations in the arrangement of the rebreathing bag for such circuits will be well understood to those skilled in the art. In accordance with the present invention, the respirator device 10 is connected by means of the conduit 20 to the fitting 145 of the closed anesthetic circuit shown so that the respirator unit replaces the usual rebreathing bag. The respirator may then be arranged, as before described, to permit normal operation in which the rebreathing bag 16 thereof functions identically with the usual rebreathing bag of the anesthetic circuit, or it may be employed to measure the patient's tidal volume or afford artificial respiration.

Although the respirator unit here has been shown as forming a part of a closed type anesthetic circuit, which may be an apparatus, such as illustrated, for example, by the apparatus shown in the Heidbrink Patent No. 2,121,196, it will be understood that the respirator may be substituted for the rebreather bag of any of the conventional types of administering circuits wherein it is possible when using such apparatus to apply artificial respiration by compression of the rebreathing bag. One such circuit for example may be the type of circuit referred to as the "to" and "fro" circuit wherein a carbon dioxide absorber unit is immediately attached to a face inhaler and which usually is provided with a rebreather bag at its outer end. In such a circuit, the patient's exhalation gases pass through the absorber into the rebreather bag and thence are returned by passing again through the absorber during inhalation. The anesthetic agent may be supplied to the breathing mixture by means of a conduit connecting at any convenient point as will be understood to those skilled in the art. Such apparatus, generally, have the usual pressure relief valve embodied therein. A positive pressure relief valve of conventional design is incorporated in the present respirator unit and is situated in the connector fitting 18 as shown at 150 and may be set, as is well known, to operate in the circuit where the administering apparatus employed in conjunction with the respirator unit 10 may not have such a relief valve.

It will now be seen that when the respirator unit 10 is attached to an anesthetic circuit as described above,

the bias control knob 128 may be adjusted so that the actuating lever 14 is raised to its upper limit and held there by the negative bias of springs 108. In this position the chain 86 raises the valve element V so that the rebreathing bag 16 is placed in communication with the breathing circuit. The apparatus then operates, essentially, as a normal rebreathing bag. However, if it should be desired for example to measure the tidal volume or the volume of gases inhaled and/or exhaled by the patient, the negative bias may be reduced allowing the lever 14 to be lowered and the valve V to drop downwardly to its closed position, as shown in Figure 2, on the seat 70 thus isolating the rebreathing bag 16. Then the gas breathed by the patient expands the bellows 12 during each exhalation and causes them to collapse during each inhalation, the displacement during each phase corresponding to the volume of the exhalation and inhalation gases. These volumes may be read directly from the scale 97 by observing the limits of the movement of actuating lever 14. Generally, when employed for this purpose the "bias control" is adjusted just to compensate for the weight and tension of the bellows. However, a negative bias may be applied when desired.

Should it at any time be desirable or necessary to assist the patient's breathing, it is merely necessary for the anesthetist to grasp the handle 90 and physically compress and expand and bellows at a rate corresponding to the desired rate of respiration. It will be seen, inasmuch as the valve V is normally seated and closes off the rebreathing bag 16, that as the bellows is compressed by downward movement of the actuating lever, a volume of gas corresponding to its displacement will be forced through the conduit 20 and the connecting breathing circuit into the patient's lungs. If desired, the anesthetist, following such forced inhalation, merely may relax the externally applied force and allow normal exhalation in which the tension of the patient's chest cavity will force the exhalation gases outwardly and cause expansion of the bellows 12. It is possible, however, also, to assist the patient's exhalation in a positive manner by manually raising the lever 14, which removes the weight of the bellows and associated linkage and, depending upon the rate of displacement, creates negative pressure suction. The degree of negative pressure which can be created in the circuit by manual expansion of the bellows will be limited in the present apparatus substantially by the weight of the valve element V and the size of the opening 70, since upon the production of a negative pressure, having a net differential with respect to the pressure in the rebreathing bag sufficient to overcome the weight of the valve V, the valve will be raised from its seat. Gases then will be additionally supplied from the rebreathing bag so that normal movement of the bellows will not produce a further increase in the negative pressure. The magnitude of the negative pressure may also be controlled by the rate of movement of the bellows during expansion since it will be seen that the bellows must be moved at a rate greater than the spontaneous exhalation of the patient to produce a negative pressure and that the more rapid the movement of the bellows, the greater the negative pressure produced, up to the maximum negative pressure obtainable.

In order further to facilitate manual operation of the bellows, an armrest 152 is provided, as shown in Fig. 1. By thus supporting the operator's arm, the device may be operated for extended periods without tiring.

The respirator unit 10 also may be used as a semi-closed circuit in which the conduit 20 similarly is attached in place of the usual rebreathing bag. Such circuits which are well known and need not be described in detail, are normally operated by opening the exhalation valve on the mask, or by reducing the venting pressure of the relief valve. A supply of fresh oxygen is continuously added, in this technique, so that gas is continuously dis-

charged to the atmosphere during all respiration phases except inhalation. During assisted respiration, with the normal apparatus, discharge to the atmosphere also occurs during inhalation. When the respirator unit 10 is employed in this technique, the rebreathing bag 16 is removed and the relief valve is left in its normal setting. Under these circumstances, while fresh gas is continuously supplied, gases will be "dumped" from the circuit only after the bellows has been expanded to a position to open the valve V. No gas will be vented, or "dumped" during forced inhalation, since valve V is closed. This reduces the consumption of gas over normal semi-closed systems and loses less anesthetic vapors to the atmosphere.

Having now described the above preferred embodiment of this invention, it will be seen that the present invention affords an extremely useful anesthetic administering apparatus affording a great many significant advantages, making it possible to note at all times the volume of the patient's respiration and being instantaneously operable to convert from normal operation to the application of artificial respiration. It is particularly advantageous that the invention affords means for simplification of respirator apparatus for anesthesia and that it provides a device enabling the retention of the "feel" of the pressure in the breathing circuit while at the same time minimizing as much as possible the effort required by the anesthetist for its operation. When employed in a closed circuit, the gases may be maintained isolated without venting to the atmosphere or drawing in atmospheric gases even though the tidal volume differs from the displacement of the bellows chamber. It will be understood that the invention is not limited to the present preferred embodiment hereinbefore described, but it may be used in other ways without departing from its spirit as defined by the scope of the following claims.

I claim:

1. Apparatus for administering inhalant gases to patients having means for assisting respiration comprising means defining a breathing circuit in which a patient's inhalation and exhalation gases are conducted, an expansible-contractible chamber forming a part of said circuit adapted to be expanded and contracted to assist respiration, a port through which gases may be discharged from or admitted to said circuit, valve means normally acting against and closing said port, responsive to a predetermined differential pressure acting thereon, resulting from negative pressure, in said breathing circuit, to open said port, and valve actuating means forming an operable connection between said expansible-contractible chamber and said valve means, operative to open said port by actuation of said valve means in response to a predetermined displacement of said expansible-contractible breathing chamber.

2. Apparatus as set forth in claim 1 wherein said port connects with a rebreathing bag and said breathing circuit forms a circuit in which the patient's exhalation gases are recycled.

3. Apparatus as set forth in claim 2 having adjustable biasing means operatively connected with said breathing chamber to adjustably vary the load acting thereon to thereby vary the force required for expansion and contraction thereof.

4. Apparatus as set forth in claim 3 where said biasing means comprises resilient means effective to retain said expansible chamber in a maximum position during normal employment of said apparatus and which permits compression of said chamber by externally applied force when said apparatus is operated to produce artificial respiration.

5. Apparatus as set forth in claim 4 where said expansible chamber comprises a flexible bellows having one end movable with respect to the other, and said biasing means comprises a lever connected with the movable end of said

bellows, acting thereon in a direction counter to the normal contraction of said bellows.

6. Anesthetic administering apparatus forming a closed anesthetic circuit comprising a compressible chamber adapted normally to be responsive to a patient's breathing and arranged to be operated manually to produce artificial respiration, a rebreathing bag connected to said circuit through a normally closed valve means and valve actuating means operatively connecting said valve means with said compressible chamber to open said valve means at a predetermined displacement of said compressible chamber.

7. An anesthetic administering apparatus including a counterbalanced bellows having biasing means rendering said bellows responsive to a patient's respiration substantially without restriction, a rebreathing bag connected with said breathing circuit to receive and deliver to and from said breathing circuit gases breathed by the patient in excess of a predetermined maximum exchange volume of said bellows, and valve means, normally closing said rebreathing bag from said circuit, mechanically connected to said bellows for actuation by said bellows to place said rebreathing bag in communication with the breathing circuit when the patient's respiration exceeds said exchange volume of said bellows.

8. An anesthetic administering apparatus according to claim 7 wherein said valve means comprises a gravity loaded type valve alternatively operable independently of said connection thereof with said bellows to be unseated by negative pressure differential acting thereon when the patient's inhalation exceeds the exchange volume of said bellows.

9. A respirator unit for attachment to an anesthetic administering circuit comprising means forming a first chamber adapted to be connected in a breathing circuit, a compressible chamber, having movable wall portions, communicating with said first chamber, an opening in said first chamber, valve means normally closing said opening, responsive to a predetermined reduction of pressure in said first chamber, below atmospheric pressure, to be opened, and linkage means connecting said movable wall portions of said compressible chamber and said valve means, operable to open said valve means when displacement of said compressible chamber exceeds a predetermined amount.

10. A respirator unit for attachment to anesthetic administering apparatus comprising a housing defining a first chamber adapted to be connected to a breathing circuit, a bellows having a fixed portion attached to said housing and communicating with said first chamber, said bellows being adapted by operation thereof to apply positive and negative pressure pulses to said chamber, a flexible reservoir bag connected to said chamber, valve means, normally disposed in closed position to isolate said flexible reservoir bag from said first chamber, and means operatively connecting said valve means with said bellows responsive, upon a predetermined displacement of said bellows, to be actuated by said bellows to open said valve means and place said bag in communication with said chamber.

11. A volumetric exchange device for attachment to anesthetic administering apparatus comprising a housing defining a breathing chamber, means adapted to receive a conduit for connecting said chamber in a breathing circuit, an opening in the top of said chamber, a compressible bellows connected to said opening having one end fixed with respect to said housing and its opposite end movable toward and away from said opening, a second opening in the bottom of said chamber having a circumferential valve seat, a valve element disposed normally to rest on said valve seat to close said second opening, and tension means connecting the movable end of said bellows with said valve element, operable under tension at a predetermined upward displacement of said bellows to raise said valve element from said valve seat.

12. A device according to claim 11 wherein said housing is mounted in a supporting frame having an actuating lever pivoted in said frame and operatively connected with the free end of said bellows for effecting expansion and compression thereof, biasing means acting on said lever effective to adjustably vary the loading on said bellows and an upright column having a recording face, contingent along its length with the path defined by the free end of said actuating lever, bearing indicia showing the displaced volume of said bellows corresponding to the positions of said actuating lever.

13. A respirator unit according to claim 12 wherein said upright column is provided with a stop at its upper end cooperating with said actuating arm to limit expansion of said bellows and with a vertically adjustable stop adapted to obstruct downward movement of said actuating lever to limit the extent of the compression of said bellows.

14. An anesthetic administering apparatus comprising an expansible-contractible bellows, one end thereof being fixed and the other end movable with respect thereto, forming a part of a breathing circuit, adapted to be manipulated externally by expansion and contraction to assist respiration, said bellows being elastic and normally biased toward contracted position such that resistance to expansion thereof increases substantially in proportion to the outward displacement of said movable end thereof, spring biasing means, including a spring member and linkage means, operatively connected to said movable end of said bellows urging said end outwardly and producing a tensile force tending to expand said bellows, said spring biasing means producing a progressively increasing tensile force substantially in proportion to the expansion of said bellows, and means for selectively adjusting the initial tensile force of said spring biasing means.

15. An anesthetic administering apparatus comprising a bellows forming a part of a breathing circuit, having a fixed part and a movable part, the latter being arranged for displacement toward and away from said fixed part to produce volumetric exchange in said breathing circuit, a lever operatively connected with said movable bellows part, spring means forming an expandable linkage secured to a fixed point at one end and connected to said lever at its other end, said linkage producing a force acting on said lever in a direction to expand said bellows, along a line offset from the pivot axis of said lever, and arranged such that said offset distance and the resultant torque applied to said lever increase substantially in proportion to the expansion of said bellows, and adjustable means for selectively varying the initial torque exerted by said spring means.

16. An anesthetic administering apparatus according to claim 15 having stop means limiting the expansion of said bellows, and wherein said spring means is capable of initial adjustment to provide a force sufficient to yieldingly expand said bellows against said stop means.

17. An anesthetic breathing apparatus comprising a flexible reservoir bag, an expansible-contractible respirator chamber operable to provide a volumetric exchange in a patient's respiratory tract during inhalation and exhalation, a common chamber communicating with said

reservoir bag and with said expansible-contractible respirator chamber adapted to be placed in communication with a patient's respiratory tract to receive and deliver a patient's respiratory gases, valve means normally isolating said reservoir bag from said chamber, and means forming a connection between said valve means and said expansible-contractible chamber operable to actuate said valve means in response to a predetermined expansion of said expansible-contractible chamber and place said reservoir bag in communication with said chamber.

18. Apparatus for administering inhalant gases to patients having means for producing artificial respiration, comprising means defining a circuit in which a patient's inhalation and exhalation gases are conducted and the patient's exhalation gases are recycled, a bellows, having a fixed end and an end movable with respect thereto, connected to said circuit, adapted to be compressed and expanded to assist respiration, an opening through which gases may be admitted to or discharged from said circuit connected with a rebreathing bag, valve means normally closing said opening, operable by said bellows at a predetermined displacement thereof and in response to a predetermined pressure differential acting thereon as a result of negative pressure in said breathing circuit, and adjustable biasing means operatively connected with said bellows to adjustably vary the force required for expansion and contraction thereof, said biasing means comprising a lever connected with said movable end of said bellows, acting thereon in a direction counter to the normal contraction of said bellows, and including a spring and means for varying the line of force produced by said spring on said lever such as to change the fulcrum distance thereof from the pivot axis of said lever to thereby adjust the counter torque applied thereto.

19. Apparatus for administering inhalant gases to patients having means for assisting respiration, comprising means adapted to be placed in communication with a patient's respiratory tract, forming a closed breathing system in which the patient's inhalation and exhalation gases are confined, a bellows forming a part of said closed system responsive to expand and contract in unison with a patient's inhalation and exhalation therein, scale means disposed in relation to said bellows to indicate the tidal exchange volume of the patient by reference to the displacement of said bellows, external means for actuating said bellows independently of the patient's respiration to assist respiration, a port through which gases may be discharged from or admitted to said circuit, valve means normally acting against and closing said port responsive to a negative differential pressure acting thereon to be opened, and valve actuating means forming an operative connection between said bellows and said valve means to open said valve in response to a predetermined displacement of said bellows.

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