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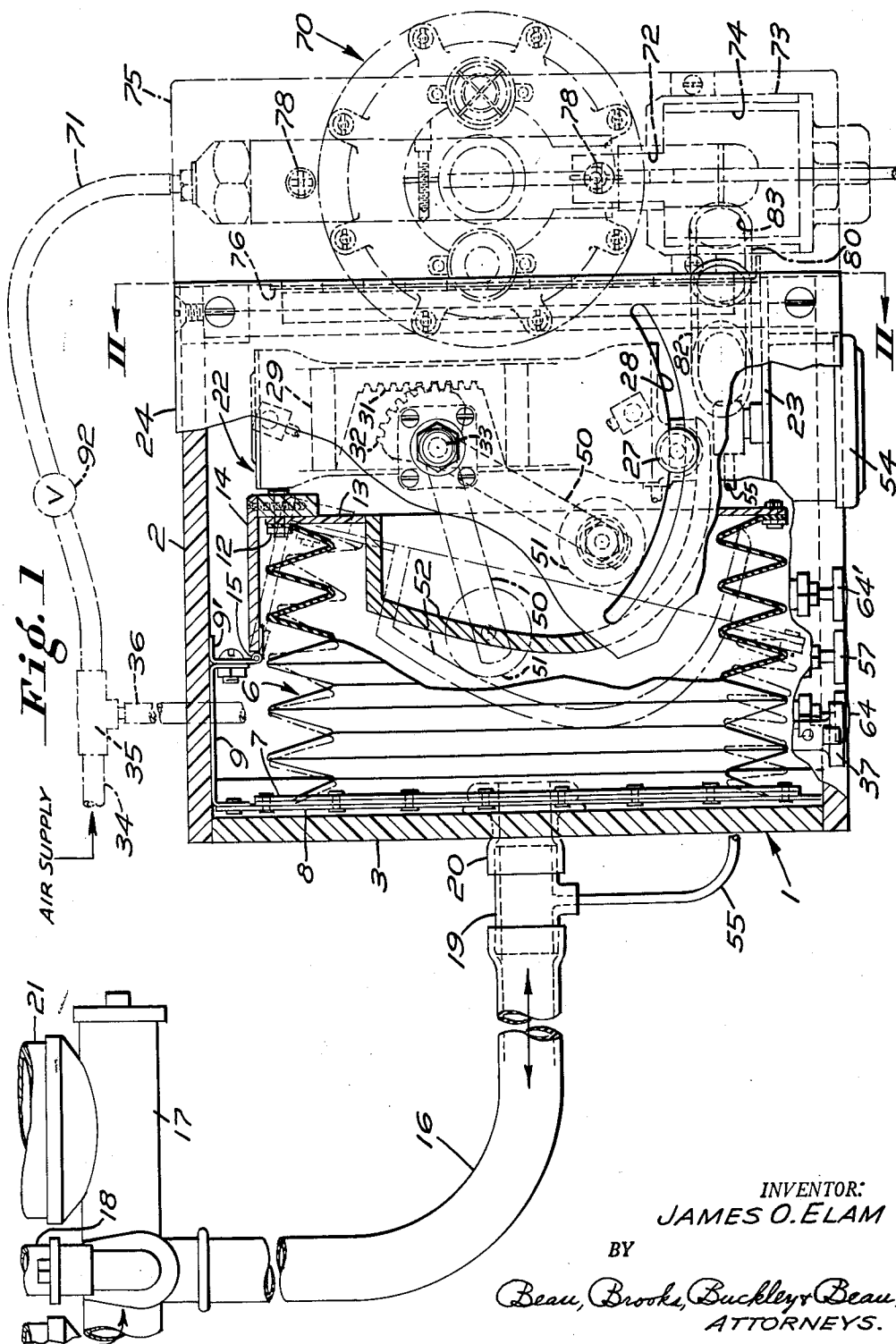
J. O. ELAM

2,923,290

RESPIRATOR

Filed March 14, 1955

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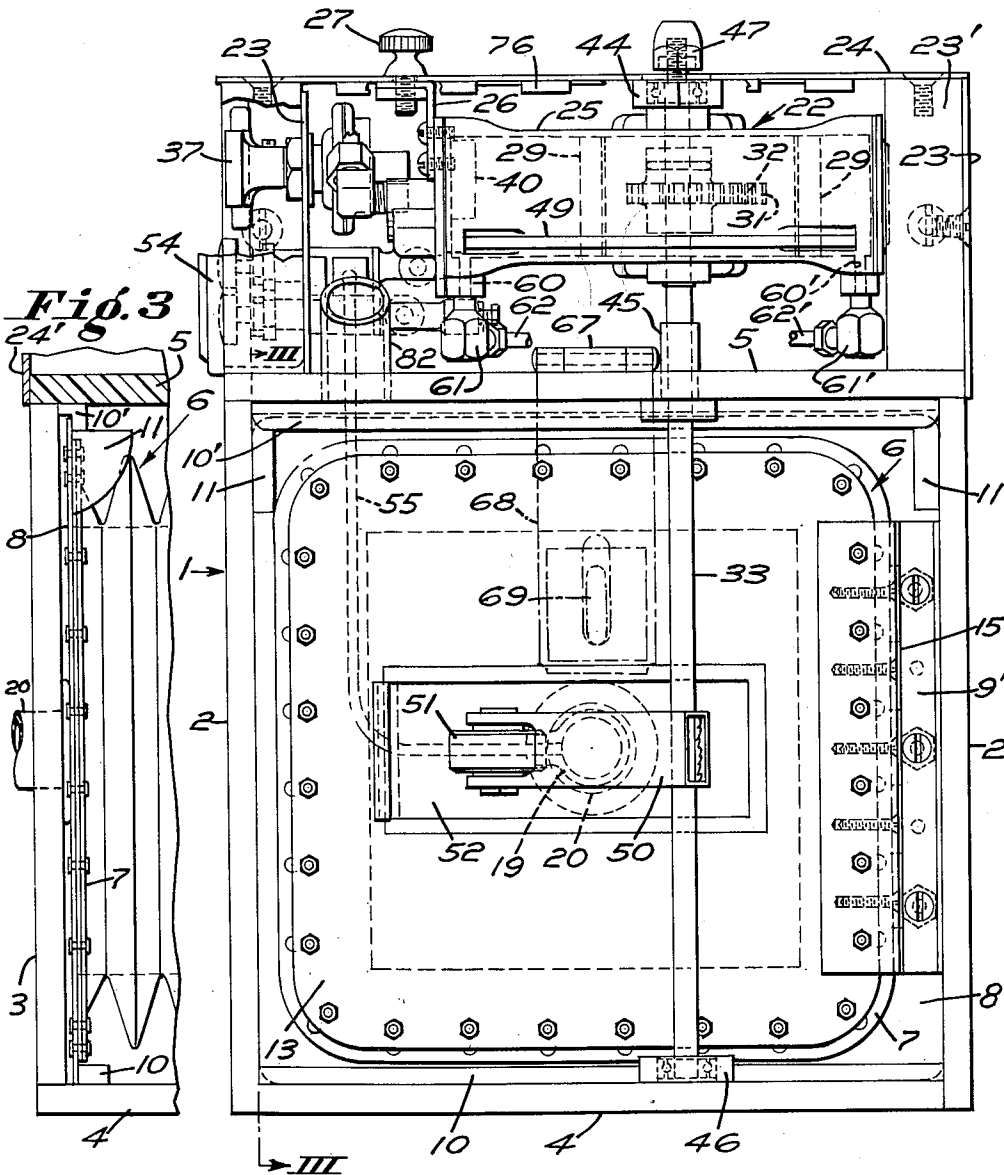
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Fig. 2



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FIG. 4.

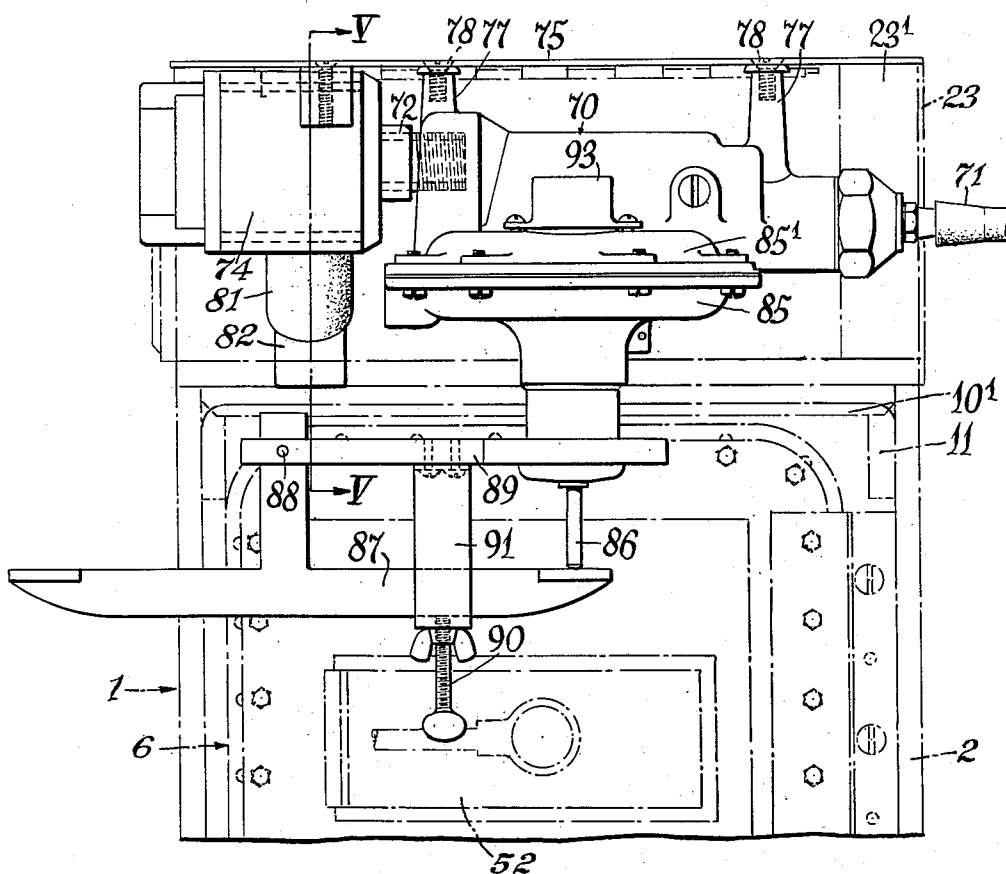
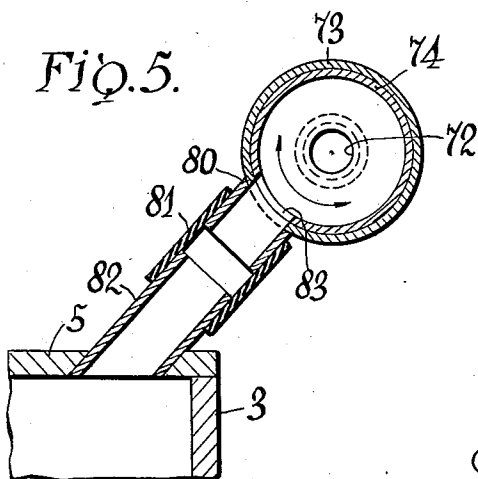


FIG. 5.



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2,923,290

RESPIRATOR

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Application March 14, 1955, Serial No. 493,870

18 Claims. (Cl. 128—29)

This invention relates generally to the field of artificial respiration, and more specifically to a new and useful respirator adapted to maintain respiration in a patient incapable of normal breathing.

While many respirators previously have been developed, it has been my experience that they have certain disadvantages and are not entirely satisfactory in many instances. For example, many prior art respirators are not sufficiently adjustable to provide the pattern of breathing desired in certain cases.

Accordingly, it is a primary object of my invention to provide a respirator which is readily adjustable over a wide range to provide a desired pattern of respiration.

A further object of my invention is to provide a respirator which is readily adjustable to selectively vary the overall duration of inspiration and/or expiration and to provide either symmetrical or nonsymmetrical patterns of inspiration and expiration.

Still another object of my invention is to provide a respirator which is readily adjustable to selectively vary the speed of inspiration and expiration.

It is also an object of my invention to provide a respirator which is readily adjustable to selectively vary the volumetric displacement during inspiration and expiration.

A still further object of my invention is to provide a respirator adapted to provide a pattern of flow, during inspiration and expiration, which is selectively variable as to the periods of high peak flow, steady flow and no flow during the cycle.

In addition, it is also an object of my invention to provide a respirator which is adapted for use with patients capable of some natural breathing.

Another object of my invention is to provide a respirator adapted to function in the manner of a spirometer, and which is adapted to deliver a known volume of air which is measured and indicated continuously.

Still another object of my invention is to provide a respirator which is in all respects highly practical, being compact, neat in appearance, easily handled, and extremely durable and dependable in operation.

A respirator in accord with my invention is broadly characterized in one aspect thereof by the provision of a flexible bellows, means for admitting fluid to and from the interior of the bellows and which can communicate with the patient's airway, a reciprocating drive arm, and operatively related cam parts connected to the bellows and to the drive arm for translating the reciprocating movements of the drive arm into excursions of the bellows. More specifically, my invention is further characterized in this aspect thereof by the provision of control means for selectively varying the pattern of respiration.

In accord with another aspect thereof, a respirator in accord with my invention is characterized by the provision of a fluid-tight housing enclosing a flexible bellows, together with means responsive to natural breathing by the patient for admitting pressure fluid into the housing to assist the patient in collapsing the bellows and for

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permitting pressure fluid to escape from the housing to facilitate expansion of the bellows.

The foregoing and other objects of a respirator according to my invention will become clearly apparent from the following detailed description of a presently preferred embodiment thereof, taken together with the accompanying drawings wherein like reference numerals denote like parts throughout the various views and wherein:

Fig. 1 is a plan view of a respirator in accord with my invention, certain parts being broken away and others being shown in section for greater clarity;

Fig. 2 is a view in front elevation taken about on line II—II of Fig. 1, the front end plate of the bellows housing being removed for greater clarity;

Fig. 3 is a fragmentary detail view taken about on line III—III of Fig. 2;

Fig. 4 is another view in front elevation showing the relation of certain parts to others;

Fig. 5 is an enlarged fragmentary detail sectional view taken about on line V—V of Fig. 4;

Fig. 6 is a schematic showing of the motor control arrangement of a respirator according to my invention;

Fig. 7 is a schematic view illustrating the pattern of operation provided by placing the actuating motor in one position; and

Fig. 8 is a schematic view similar to Fig. 7 but showing the pattern of operation provided by placing the actuating motor in a different position, this figure, together with Fig. 7, also illustrating the means for increasing or decreasing the volumetric displacement produced by the respirator.

Referring now to the presently preferred embodiment shown in the accompanying drawings, a respirator in accord with my invention includes a housing generally designated 1 having opposed side and end wall members 2 and 3, respectively, a bottom wall member 4 and a top wall member 5. Wall members 2 through 5 are adapted to provide a substantially air tight chamber, for reasons which will become apparent hereinafter, and to this end appropriate sealing gaskets, not shown, will be inserted therebetween in a conventional manner.

A flexible bellows member 6 is positioned within of housing 1 and comprises an accordion type flexible bellows having one end thereof secured, as by rivets, between a ring 7 and a plate 8 which latter is secured to a spacing bracket 9 bearing against one of the side wall members 2.

Stops 10 and 10', the latter being of angle form, are carried by wall members 4 and 5, respectively. Stop 10 extends transversely of wall member 4 at a point spaced from the rear end wall member 3, and stop 10' extends transversely of wall member 5 with its horizontal flange adjacent rear end wall member 3 and with its depending flange spaced therefrom. Therefore, as shown perhaps more clearly in Fig. 3, when top wall member 5 is removed bellows 6 can be slipped into housing 1 with the bottom edge of plate 8 fitting between rear wall member 3 and stop 10. Upon replacing top wall member 5, the top edge of plate 8 fits between rear wall 3 and the depending flange of stop 10'. Thus, stops 10 and 10' hold bellows 6 in proper position in the housing while facilitating the insertion and removal thereof and without requiring actual connection of the bellows to the housing wall members. Blocks 11 are carried by plate 8 adjacent the upper corners thereof and aid in properly positioning bellows 6 in housing 1.

The forward end of bellows 6 is secured, as by rivets, between a ring 12 and a plate 13 which latter is fixed to a bracket 14 hinged, as at 15, to a spacing angle bracket 9' secured to bracket 9 and also bearing against the housing side wall 2. This provides an enclosed flexible bel-

lows having a movable front end wall and a rear end wall positionally fixed closely adjacent the rear wall member 3 of the housing. Spacing brackets 9 and 9' maintain the proper normal spacing between the front and rear end walls of bellows 6, and assist in holding the bellows in proper position in housing 1.

Communication between the patient's airway and the interior of bellows 6 is provided by a tube 16 connected adjacent one end thereof to a conventional carbon dioxide absorbing device 17 having an outlet to the patient's airway through the tube 18. At its other end tube 16 is connected to a T 19 which is in turn connected to a coupling 20 extending through the housing rear end wall member 3 and plate 8, to which it is attached. Air is forced into the patient's lungs upon collapsing bellows 6, and the bellows expands as air is drawn from the patient's lungs.

The carbon dioxide absorber 17 is conventional, forming no part per se of the instant invention, and air passes to the patient through tube 18 and is withdrawn from the patient through absorbing filters in the canisters 21.

Bellows 6 is caused to alternately collapse and expand in the following manner. A source of driving power in the form of a fluid pressure responsive motor 22 is mounted in a partially enclosed housing surmounting the bellows chamber defined by housing 1 and comprising opposed side plates 23, a top plate 24 and a back plate 24', plates 23, 24 and 24' being secured to positioning blocks 23' as by screws. One side plate 23, shown at the left in Fig. 2, is set inwardly for a purpose to be described and it, together with blocks 23', rests on the housing top wall member 5 with the other side plate 23 and back plate 24' overlapping wall member 5.

Motor 22 can comprise, for example, a conventional fluid pressure operated windshield wiper motor which I have slightly modified in one respect, as hereinafter described, for purposes of the invention.

Motor 22 has an elongated, generally cylindrical casing 25 secured adjacent one end thereof to an angle bracket 26 which is in turn secured to top plate 24 by a nut and bolt device 27 extending through an arcuate slot 28 therein. A pair of piston members 29, interconnected by a rack 31, are mounted interiorly of motor casing 25 for longitudinal sliding movement therein, rack 31 engaging a pinion gear 32 carried by a drive shaft 33. Motor 22 is connected to a source of pressure fluid, not illustrated, through a conduit 34 connected to a T 35 having one of its branches connected to a conduit 36 which is in turn connected to a main control valve 37. A conduit 38 extends between control valve 37 and a connection 39 on motor 22 for passing pressure fluid thereto. An exhaust conduit 41 extends from motor 22 to an exhaust control valve 42.

In operation, upon opening valve 37 pressure fluid is admitted to the interior of motor 22 and applied against one side of one piston 29 while the opposite side of the other piston 29 is exhausted to the atmosphere through the conduit 41 and valve 42. The pressure differential thus created causes the pistons 29 and rack 31 to move bodily as a unit lengthwise of motor casing 25, and as they reach the end of their stroke in that direction an automatic valve mechanism, schematically indicated at 40, trips and causes the fluid pressure differential on the piston and rack unit to be reversed whereby the rack and piston unit automatically moves in the opposite direction. Pressure fluid passes to and is exhausted from the side of the rack and piston unit remote from conduits 38 and 41 through a passage 49 under the control of valve mechanism 40. This automatic reversing action occurs at the end of each stroke and causes the rack and piston unit to reciprocate within motor casing 25 in a manner well known in that art.

It is believed that the details of motor 22 shown in the drawing and described above are sufficient for an

understanding of my invention, it being understood that the motor and automatic valve mechanism as described above are conventional and are not, per se, a part of my invention. For a more complete description of the automatic valve mechanism 40, and of this type of motor, reference is made to United States Reissue Patent No. 15,502 granted to W. M. Folberth on December 5, 1922, and particularly to Figure 8 thereof.

Drive shaft 33 is journaled for rotation adjacent its upper end in a suitable bearing 44 carried by top plate 24 and adjacent its lower end in a bearing 46 carried by bottom wall member 4. Intermediate its ends, shaft 33 extends through top wall member 5, being journaled in a suitable air tight bearing 45. Adjacent its upper end, shaft 33 has an exteriorly threaded extension passing through top plate 24, and a nut 47 threadedly engages that extension of shaft 33 on the bearing 44.

Shaft 33 has a laterally extending arm 50 secured thereto at a position intermediate its ends and within housing 1 approximately in alinement with the center of bellows 6, arm 50 moving with shaft 33. Adjacent its outer end, arm 50 carries a roller 51 in the nature of a cam follower. The bellows front end plate 13 is provided centrally thereof with a cam track 52 extending inwardly of the bellows. Cam track 52 is of non-uniform curvature as clearly shown in Fig. 1 and for a purpose to be described, and is alined with arm 50 and roller 51 as shown in Fig. 2.

Therefore, as the piston-rack unit of motor 22 reciprocates, the straight line motion thereof is translated by gear 32 and shaft 33 into oscillations causing arm 50 and roller 51 to reciprocate with a rotary motion, with roller 51 bearing against cam track 52 and thereby further translating the reciprocating straight line motion of motor 22 into excursions of bellows 6.

This action is clearly shown in Fig. 1 wherein the normal, expanded position of bellows 6 is shown in full lines. Movement of arm 50 in a clockwise direction from its position at the beginning of the motor stroke, shown in dotted lines, to its position at the end of that motor stroke, shown in broken lines, causes roller 51 to bear against cam trackway 52 and move therealong forcing plate 13 inwardly and collapsing bellows 6 to the position thereof shown in broken lines in Fig. 1. Collapsing bellows 6 in this manner forces air therefrom into the patient's lungs through conduit 16. Upon the return stroke of motor 22, arm 50 swings back to its position illustrated in dotted lines in Fig. 1 permitting bellows 6 to expand to its position shown in full lines in Fig. 1 under the influence of the natural resiliency of the patient's rib cage and of the bellows, this action causing air to be withdrawn from the patient's lungs through the carbon dioxide absorber 17. Continued reciprocation of arm 50 by motor 22 causes alternate inspiration and expiration in the above manner to provide the breathing function.

It is believed desirable to provide spring means, as indicated schematically at 100 in Fig. 8, biasing bellows 6 to expanded position to insure that contact is maintained between roller 51 and track 52 in order to achieve a reliable control of the volumetric displacement. Alternatively, counterweight means could be used, comprising a line connected to bellows 6 and training over a suitable pulley to suspend a weight therefrom. Preferably, the spring is adjustable, for reasons appearing hereinafter, and is positioned exteriorly of the bellows as between an extension of plate 13 and a part fixed to housing 1.

A respirator according to my invention as thus far described possesses certain very significant advantages which are very worthy of attention. For example, it should be noted that bellows 6 is not tied to the driving mechanism whereby if at any time the patient should suddenly begin to resume natural breathing he can pull the bellows away from the motor 22 and arm 50.

Another significant advantage of my respirator, as

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thus far described, resides in the fact that the volume of air displaced by collapsing the bellows can be varied at will. This is accomplished merely by loosening bolt device 27 and sliding the same along the arcuate slot 28 in the top plate 24. This causes motor 22 to pivot about the axis of shaft 33 and thereby varies the position of motor 22 and of the stroke of arm 50 with respect to cam track 52. In other words, while the length of the stroke of arm 50 remains constant, and arm 50 reciprocates through a predetermined path, the position of the arm stroke or path along track 52 can be selectively varied in this manner and, because track 52 is non-uniform, the volumetric displacement of bellows 6 is thereby varied.

This adjustment is schematically illustrated in Figs. 7 and 8 which show the results of moving motor 22 to opposite sides of the position thereof shown in Fig. 1. Thus, Fig. 7 shows motor 22 rotated approximately $7\frac{1}{2}^\circ$ clockwise from its position shown in Fig. 1, and it is seen that roller 51 will engage trackway 52 earlier than is the case with the parts positioned as shown in Fig. 1 and will extend further therealong, causing a greater volumetric displacement from bellows 6 with the same stroke of arm 50. Conversely, if motor 22 is moved in the opposite direction, as for example 24° counterclockwise from its position shown in Fig. 1 to its position shown in Fig. 8, it is seen that roller 51 does not engage track 52 until later in its stroke resulting in a considerably lesser volumetric displacement from bellows 6. In each of Figs. 1, 7 and 8 the volumetric displacement from bellows 6 is indicated by the space between the expanded position of the bellows, shown in full lines, and the collapsed position thereof, shown in broken lines. Thus, because of the adjustable mounting of motor 22 a respirator according to my invention is readily adjusted to selectively vary the volumetric displacement of the bellows to suit the needs of a particular patient. Because of the shape of cam track 52, the pattern of flow also can be varied in this manner.

Also, further variations in volumetric displacement, and variations in the pattern of flow to and from the bellows can be provided merely by substituting for track 52 a cam track of different shape.

Also, it should be noted that three different types of pressure cycles can be provided with the respirator operating either at the same or at different stroke volumes, as follows: (1) positive pressure against the bellows during inspiration and ambient pressure thereon during expiration; (2) positive pressure on the bellows during inspiration and negative or subambient pressure thereon during expiration; and (3) relatively high positive pressure on the bellows during inspiration and lower positive pressure thereon during expiration. These variations are achieved by varying, or removing, the biasing spring means, or the pulley-counterweight means if such are used, and by adjusting the rate of oxygen inflow into the system communicating with the interior of the bellows.

To indicate the pressure within bellows 6 and in the patient's lungs, an aneroid manometer 54 is carried by the motor casing inset side plate 23 and communicates with conduit 16 through a conduit 55 extending from the manometer 54 to the T 19. Also, a conventional pop off valve can be provided in the exhale line from the patient, in known manner, to relieve any excess pressure.

In addition, means can be provided to indicate the volume of flow to and from bellows 6 as by measuring the displacement thereof.

Valves 37 and 42 are conventional needle valves, valve 37 being adapted, upon movement of its control member 56, to selectively place conduit 36 in communication with conduit 38 to admit pressure fluid to motor 22. Valve 42 has a control member 57 movable to place exhaust conduit 41 in communication with the atmosphere through an outlet 58. These valves also

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regulate the rate of admission of pressure fluid to and of exhaust of pressure fluid from motor 22 and therefore provide a further control adjustment in that they enable the speed or rate of movement of pistons 29, and consequently of arm 50 and bellows 6, to be selectively varied, whereby the speed of inspiration and of expiration can be selectively varied to suit the needs of a particular patient.

I also provide means for varying the symmetry of inspiration and expiration. To this end, I provide bleed passages 60 and 60' through the motor casing 25 adjacent each end thereof, to provide a bleed passage on each side of the rack and piston unit. Passage 60 communicates with a coupling 61 to which is connected a conduit 62 leading to a conventional needle valve 63 having a control member 64, whereby upon appropriate manipulation of control member 64, conduit 62 and passage 60 will be opened to the atmosphere through outlet 65. The other passage 60' communicates with a coupling 61' connected to a conduit 62' leading to a conventional needle valve 63' having a control member 64', whereby upon manipulation of control member 64' conduit 62' and passage 60' are exposed to the atmosphere through outlet 65'. These bleed passages and their associated couplings constitute the only modifications made in the aforesaid motor, and the purpose of these bleed passages is to selectively bleed off a portion of the pressure fluid admitted to the motor 22 in order to reduce the pressure differential acting on the rack and piston unit and thereby slow down the same during its movement in a particular direction.

For example, with members 56 and 57 set to provide a predetermined speed of the motor, if member 64 is manipulated to open bleed passage 60 to the atmosphere then, when pressure fluid is applied to that side of the rack and piston unit a portion thereof will bleed through conduit 62 to correspondingly reduce the pressure differential on the rack and piston unit and thereby reduce its speed during its stroke away from that end of the motor casing. Upon tripping the valve mechanism 40 at the end of its stroke in that direction, to reverse the fluid pressure differential thereon, that side of the rack and piston unit will be exposed to the atmosphere through the usual exhaust conduit 41 and the rack and piston unit will move at said predetermined speed during its return stroke. Conversely, by manipulating member 64' the pressure fluid will bleed through passage 60' and the speed of travel of the rack and piston unit during said return stroke will be correspondingly reduced.

This ability to provide an adjustable nonsymmetrical pattern of inspiration relative to expiration is particularly desirable because in many situations a symmetrical pattern is not desired and will not suit the needs of the particular patient.

It is also a feature of a respirator in accord with my invention, in another aspect thereof, that it can be used to assist a patient capable of some natural breathing. As previously noted, bellows 6 is not tied to motor 22 and can be moved by the patient independently thereof. I provide means for assisting the patient in collapsing and expanding the bellows in accord with his natural rhythm of breathing.

To this end, housing 1 is substantially airtight, as previously noted, whereby bellows 6 is enclosed within a substantially airtight chamber. Means are provided for holding top wall member 5 in position on housing 1, which means can comprise conventional hasps at the front and rear of housing 1 and including parts 67 fixed to wall member 5, and parts 68 hinged thereto and depending therefrom for attachment to bracket parts 69 carried by the opposite end wall members 3 of housing 1. Of course, any suitable means for holding top wall member 5 in position on housing 1 can be used.

For assisting the patient in expanding and collapsing bellows 6, I provide an assistor valve generally designated

70 and which can be of conventional form. A conduit 71 extends between the T 35 and assistor valve 70 for the delivery of pressure fluid to the latter, and valve 70 has an outlet 72 communicating with a manually operable rotary valve comprising an outer casing 73 and a valve member 74 mounted for rotation therein. Casing 73 and member 74 are concentric sleeves of tubular form.

Assistor valve 70 is secured to a plate 75 extending outwardly from plate 24 and secured thereto as by a piano type hinge 76 so as to be readily removable therefrom. Valve 70 has two upstanding parts 77 in the form of posts which are secured to plate 75 as by screws 78.

Casing 73 communicates through its side wall with a conduit 80 coupled by a sleeve 81 to a conduit 82 extending through the top wall member 5 of housing 1, and member 74 has an opening 83 in its side wall. When member 74 is rotated to align opening 83 with conduit 80, the assistor valve outlet 72 is placed in communication with the interior of housing 1.

Valve 70 is of conventional form and is not per se, a part of the invention, whereby a detailed description thereof is believed to be unnecessary. The function of valve 70 is to admit pressure fluid to the interior of housing 1 automatically whenever bellows 6 begins to collapse, and to shut off further admission of pressure fluid into housing 1 automatically upon a predetermined resistance to further collapsing of the bellows and permit fluid to escape from housing 1. In this way, valve 70 operates automatically in response to the patient's natural breathing efforts to provide pressure fluid when needed to assist the patient in taking a breath, and to relieve the pressure fluid upon exhalation by the patient.

To this end, valve 70 has a diaphragm between the housing parts 85 and 85', which diaphragm is connected through appropriate linkage to a valve interposed in the inlet passage of valve 70, one side of the diaphragm being exposed to the interior of housing 1 and the other side thereof being exposed to the atmosphere, and the diaphragm being spring-biased to a position closing the inlet passage valve. Upon a predetermined decrease in pressure within housing 1, caused by collapsing movement of the bellows, the diaphragm will move to open the inlet valve and permit pressure fluid to flow therethrough and through outlet 72, valve 74 and conduit 82 into housing 1 to assist in collapsing the bellows. Upon a predetermined increase of pressure in housing 1, caused by predetermined resistance to further collapsing of the bellows, the pressure differential on the diaphragm will move the same to close the inlet valve to stop. A check valve is interposed in the inlet of valve 70, to prevent reverse flow therethrough, and a check valve 93 permits the escape of pressure fluid from housing 1 as bellows 6 expands.

A plunger 86 depends from the diaphragm through the bottom of valve 70, and is adapted to abut one end of an arm 87 pivoted, as at 88, to an extension 89 from the valve housing, the balance arm 87 and plunger 86 providing a manual control for the diaphragm and serving to regulate position thereof through a set screw device 90 carried by a bracket 91.

Thus, a respirator according to my invention is adapted for use either to provide complete artificial respiration or to assist the natural breathing of a patient.

Oxygen is added to the system in a conventional manner, or, if oxygen is used as the pressure fluid, the motor exhaust can be used as the source of oxygen.

A cut off valve 92 can be provided in conduit 71 to prevent the admission of pressure fluid to valve 70, this being in addition to valve 74 which will prevent the admission of pressure fluid from valve 70 to housing 1.

Therefore, it is seen that a respirator in accord with my invention fully accomplishes the aforesaid objects and provides an extremely compact and highly durable unit which is readily adjustable to meet the particular needs of a wide variety of situations.

While only one embodiment of my invention has been disclosed herein, I do not intend to be limited to the details thereof which can be varied without necessarily departing from my invention. Instead, I intend that the scope of my invention be defined by the appended claims.

Having fully disclosed and completely described my invention, together with its mode of operation, what I claim as new is:

1. A respirator comprising a flexible bellows, means for admitting air to and from said bellows, and means acting on said bellows for maintaining a pattern of respiration including a drive arm, means for reciprocating said drive arm through a predetermined path, cam track means connected to one of said drive arm and said bellows, and cam follower means connected to the other of said drive arm and said bellows in operative relation to said cam track means, whereby said bellows is collapsed during movement of said drive arm in one direction and expands during the return movement of said drive arm.

2. A respirator as set forth in claim 1, wherein said means for reciprocating said drive arm are adjustable to selectively vary the rate of motion of said drive arm.

3. A respirator comprising flexible bellows means, means for admitting fluid to and from said bellows means, and means for flexing said bellows means including a drive arm, drive means for reciprocating said drive arm, a first cam part connected to said bellows, and a second cam part connected to said drive arm and adapted to engage said first cam part, whereby said bellows means is collapsed by movement of said drive arm in one direction and expands during return movement of said drive arm.

4. A respirator as set forth in claim 3, together with means for selectively varying the position of the path of movement of said drive arm relative to said first cam part.

5. A respirator as set forth in claim 3, wherein said drive means are adjustable to selectively vary the rate of motion of said drive arm in one direction relative to its rate of motion in the opposite direction.

6. A respirator comprising a flexible bellows, means for placing the interior of said bellows in communication with the airway of a patient, cam track means connected to said bellows at one end thereof, a drive arm having cam follower means adapted to bear against said cam track means, and drive means for reciprocating said drive arm with said bellows being collapsed during the stroke of said drive arm in one direction and expanding during the return stroke of said drive arm, said bellows being movable independently of said drive arm.

7. A respirator comprising, a flexible bellows, means for admitting fluid to and from the interior of said bellows, and drive means for collapsing said bellows including a fluid motor, piston means mounted for reciprocation in said motor, means for creating a fluid pressure differential against said piston means to move the same through its stroke in one direction, means automatically reversing the fluid pressure differential against said piston means at the end of its stroke in each direction, drive shaft means connected to said piston means for movement thereby, a drive arm connected to said drive shaft means for movement therewith, a first cam part carried by said bellows, and a second cam part carried by said drive arm in operative relation to said first cam part to alternately collapse and permit expansion of said bellows.

8. A respirator as set forth in claim 7, together with means mounting said motor for selective positional adjustment thereof about the axis of said drive shaft means to selectively vary the position of the path of movement of said second cam part relative to said first cam part.

9. A respirator as set forth in claim 7, wherein the fluid pressure differential is created by admitting pressure fluid to said motor on one side of said piston means

while exhausting pressure fluid from said motor on the opposite side of said piston means, together with means for selectively bleeding off a portion of the pressure fluid passing to either side of said piston means to thereby selectively vary the rate of movement of said piston means during its stroke in either direction

10. A respirator comprising a flexible bellows, means for passing fluid to and from the interior of said bellows, and means acting on said bellows for maintaining a desired pattern of respiration including a drive arm, means for reciprocating said drive arm, track means connected to one of said bellows and said drive arm for movement therewith, and follower means connected to the other of said bellows and said drive arm for movement therewith, said track means and said follower means being operatively related so that as said drive arm reciprocates said bellows is alternately collapsed and permitted to expand.

11. A respirator adapted to assist a patient in maintaining a natural pattern of respiration comprising, a substantially air-tight housing, a flexible bellows within said housing, means for placing the interior of said bellows in communication with the airway of the patient, means admitting pressure fluid into said housing automatically in response to inspiration by the patient to assist the patient in collapsing said bellows, means permitting the escape of pressure fluid from said housing automatically in response to expiration by the patient to facilitate expansion of said bellows by the patient, and means for continuously measuring and indicating the volumetric displacement of said bellows.

12. A respirator adapted to assist a patient in maintaining a normal pattern of respiration comprising, a substantially fluid-tight housing, a flexible bellows within said housing, means adapted to place the interior of said bellows in communication with the patient for collapsing and expanding said bellows in response to respiration by the patient, means including pressure responsive valve means communicating with the interior of said housing for admitting pressure fluid into said housing automatically upon predetermined collapsing of said bellows and shutting off the admission of pressure fluid thereto automatically upon predetermined resistance to further collapsing of said bellows, means permitting the escape of pressure fluid from said housing upon expansion of said bellows, and means for continuously measuring and indicating the volumetric displacement of said bellows.

13. In a respirator adapted to assist a patient in maintaining a normal pattern of breathing, a flexible bellows, means for placing the interior of said bellows in communication with the patient's airway, whereby the volumetric displacement of said bellows substantially equals the volume of fluid displaced by the patient during respiration, drive means including demand responsive control valve means for collapsing said bellows automatically in response to an inspiration effort by the patient, and means continuously measuring and indicating the volumetric displacement of said bellows.

14. The combination set forth in claim 13, together with means operatively associated with said bellows for

collapsing the same according to a predetermined pattern in the absence of a demand by the patient, whereby said respirator is adapted to completely take over the function of respiration.

15. A respirator adapted both to assist a patient in maintaining a natural pattern of respiration and to assume the complete respiratory function for the patient comprising, a flexible bellows, means for placing the interior of said bellows in communication with the airway of the patient, means for forcibly collapsing said bellows at predetermined intervals in the absence of an inspiration effort by the patient whereby to provide controlled respiration of the patient, and means including demand responsive control valve means for forcibly collapsing said bellows automatically in response to an inspiration effort by the patient whereby to assist a patient capable of some natural breathing.

16. In a respirator adapted to assist a patient in maintaining a normal breathing pattern, a flexible bellows, means for placing the interior of said bellows in communication with the patient's airway, whereby the volumetric displacement of said bellows substantially equals the volume of gas displaced by the patient during respiration, means continuously measuring and indicating the volumetric displacement of said bellows, drive means including demand responsive control valve means for collapsing said bellows automatically in response to an inspiration effort by the patient, and means operatively associated with said bellows for collapsing the same at predetermined intervals to deliver a predetermined volume of gas to the patient in the absence of an inspiration effort by the patient, whereby said respirator is adapted to completely assume the function of respiration.

17. A respirator adapted both to assist a patient in maintaining a natural pattern of respiration and to assume the complete respiratory function for the patient comprising, a flexible bellows, means for placing the interior of said bellows in communication with the airway of the patient, means for forcibly collapsing said bellows to deliver a predetermined volume of gas to the patient at predetermined intervals in the absence of an inspiration effort by the patient, thereby providing controlled respiration of the patient, and means including demand responsive control valve means for forcibly collapsing said bellows automatically in response to an inspiration effort by the patient, thereby to assist a patient capable of some natural breathing.

18. A respirator as set forth in claim 17, together with means for selectively varying the volumetric displacement of said bellows during such controlled respiration.

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