ARTIFICIAL BREATHING MACHINE

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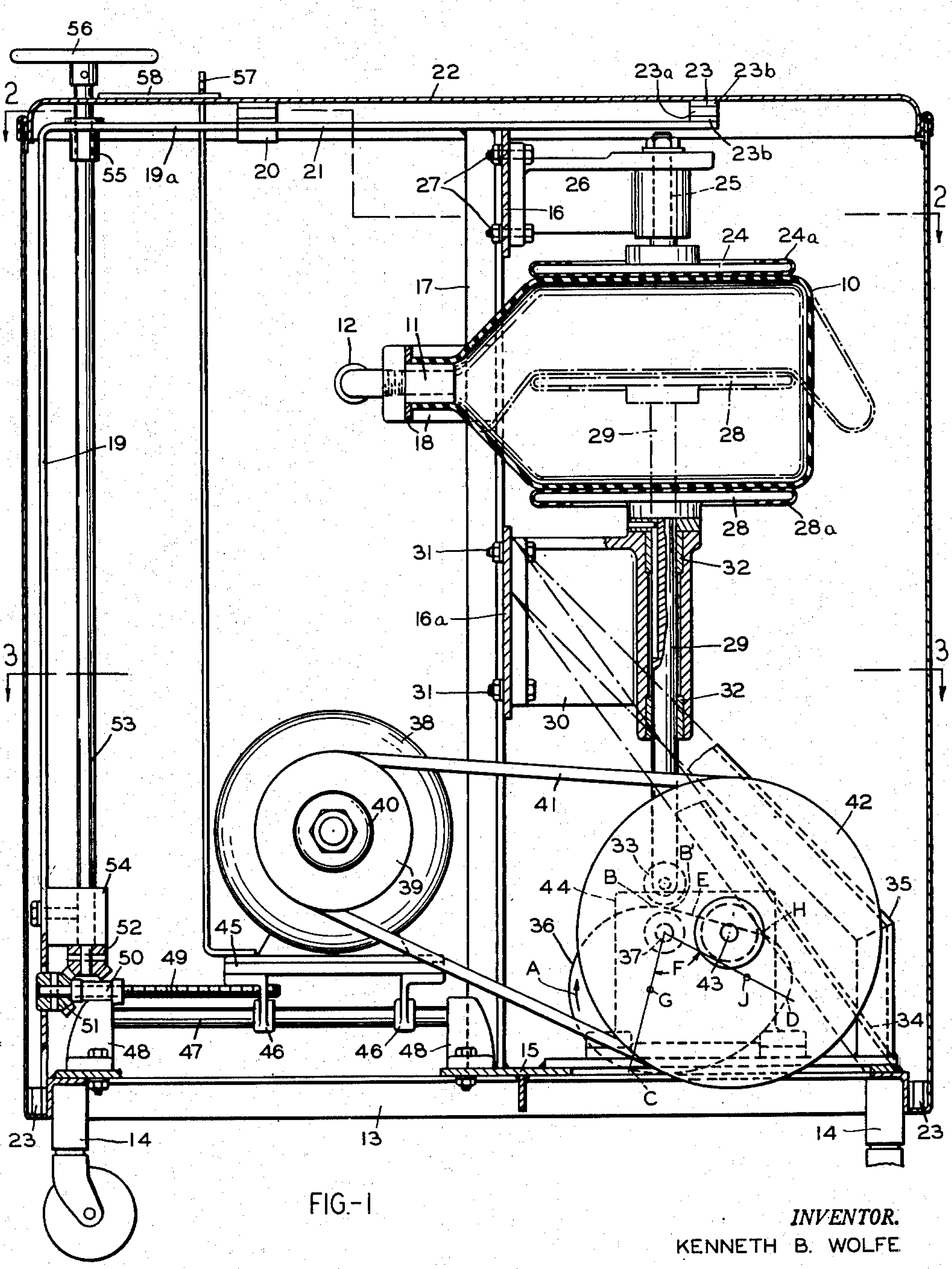

FIG.-1

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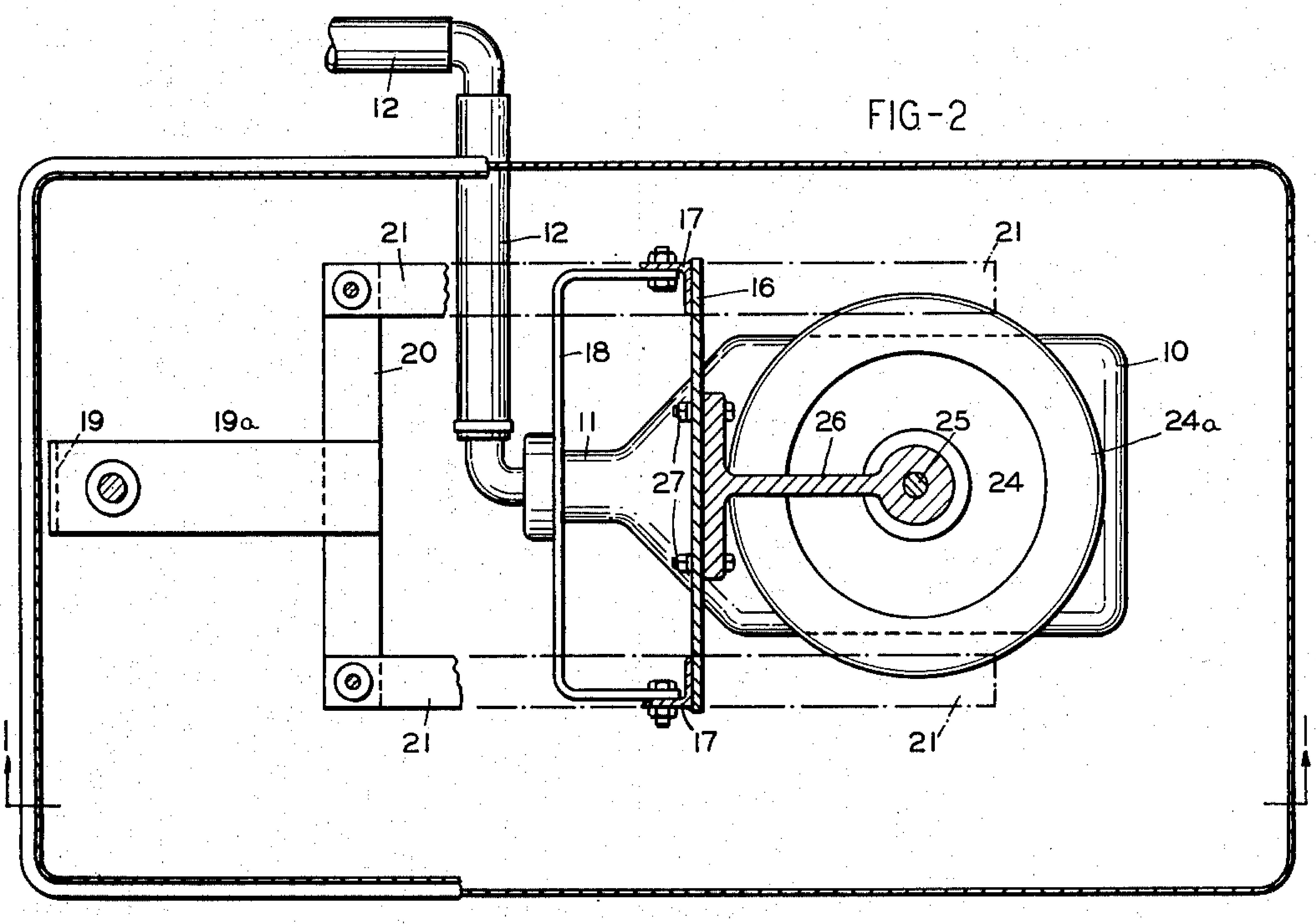
FIG-2



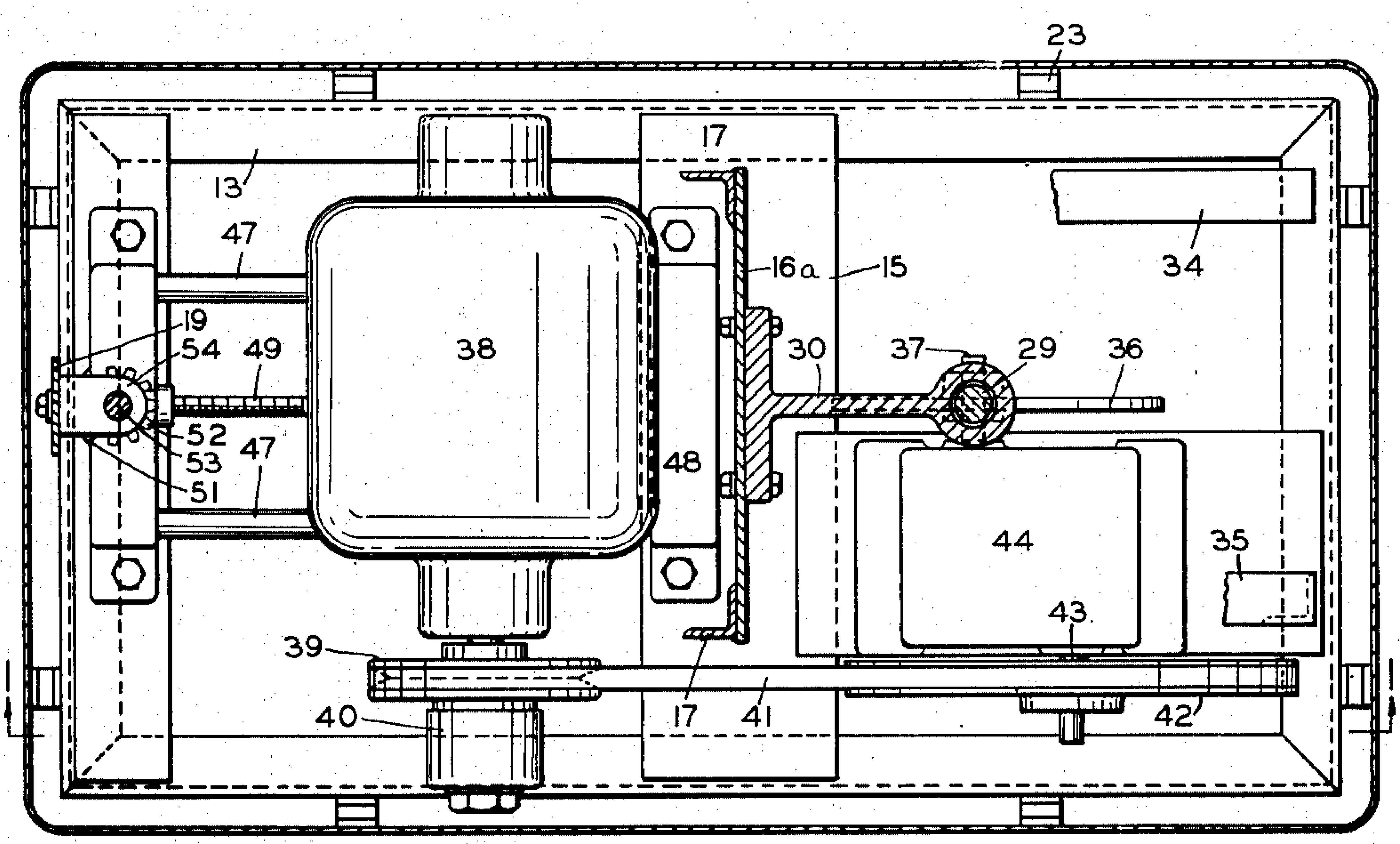


FIG-3

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ARTIFICIAL BREATHING MACHINE

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6 Claims. (Cl. 60—62.6)

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This invention relates to improvements in an artificial breathing machine.

One of the objects of the present invention is to provide artificial means for reproducing the pressure pattern of an inhaling-exhaling cycle of the human lungs in connection with a gas or anesthesia machine used to maintain the operation of a patient's lungs while on an operating table or the like.

Another object of the present invention is to provide an artificial breathing machine comprising a flexible bag having an outlet to a lung-connected system and including means for positively contracting and expanding the bag by means of a cam which reproduces the pressure pattern of a typical inhaling-exhaling cycle of the human lungs.

Another object of the present invention is the provision of an artificial breathing machine adapted to reproduce the normal breathing cycle of the human lungs and including means for driving the mechanism at various rates so as to coordinate the action of the machine with the desired action of the patient's lungs.

Other objects and advantages of the present invention will be apparent from the accompanying drawings and description and the essential features will be set forth in the appended claims.

In the drawings—

Fig. 1 is a sectional view taken generally along the lines 1—1 of Figs. 2 and 3 with parts broken away to more clearly show the construction;

Fig. 2 is a transverse sectional view taken along the line 2—2 of Fig. 1; while

Fig. 3 is a transverse sectional view taken along the line 3—3 of Fig. 1 with parts broken away to more clearly show the structure.

My improved artificial breathing machine is shown in an embodiment designed for use with a standard gas or anesthesia machine of a known character wherein a closed system includes the lungs of the patient, a source of supply for air or a mixture of air and oxygen with or without the addition of anesthetic agents, and generally including a soda-lime chamber for the absorption of carbon dioxide from the closed system. Such a system is substantially closed even though the tracheal tube in the patient's windpipe is sealed by means of a cuff and slight leakage might take place there. The flexible bag 10 of the present machine has its sole outlet 11 through a fitting connected with tubing 12 which connects with the closed system above described including the patient's lungs. Normally, the tubing 12 is connected to the bottom of the soda-lime chamber.

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For mounting the improved mechanism of the present invention I provide a base 13 formed of suitable structural steel members welded together and supported on legs 14 which contain casters for portability. Across the central portion of the base there is fixed a horizontally extending plate 15 as clearly shown in Figs. 1 and 3. Two vertically extending plates 16, 16*a* are supported at opposite sides by means of the vertical structural angles 17 welded to the plates 16, 16*a*. Angles 17 are welded to plate 15 at the bottom. A U-shape bracket 18, as best seen in Figs. 1 and 2, is bolted to the angles 17 and is secured to the fitting 11 previously mentioned so as to support it rigidly. The upper end of the vertical frame 16—17 is braced by means of a structure which comprises a strap 19 rigidly connected at its lower end to the base 13 and extending upwardly along the left side of the machine as shown in the various views, then bending horizontally along the portion 19*a* at the top of the machine, which portion is rigidly secured to a crossbar 20 which in turn is rigidly secured to the parallel arms 21, which in turn are welded to the upper ends of the angles 17 and the plate 16. The entire machine is surrounded by a cabinet 22 and between this cabinet and the various portions of the frame there are interposed spacer blocks 23, each of which comprises a metal piece 23*a* on each side of which there is a layer of rubber-like material 23*b* so that vibration of the machine will not be reproduced in the walls of the cabinet. Each of the blocks 23 is secured to the frame by means of a bolt or other securing means not shown.

Abutments are furnished above and below the flexible bag 10 with means for causing relative approach and separating movement of these abutments so as to control the movement of the bag. In the present instance, above the bag 10 there is provided a fixed abutment 24 comprising a circular metal plate having a fixed central stem 25 which passes upwardly through a bracket 26 which in turn is bolted at 27 to the plate 16. Below the bag 10 there is a movable abutment 28 comprising a round plate fixed to a depending stem 29 which is supported in a suitable bracket 30 which is bolted to plate 16*a* at 31. Suitable bearings 32 are provided in the bracket 30 to support the stem 29 for relatively frictionless movement. On the lower end of stem 29 is rotatably mounted a follower 33 for a purpose presently to be described.

For securing the advantages of positive movement of the bag 10 as will be presently described, we prefer to secure the bag 10 to the abutments

24 and 28 in a positive manner. Each abutment is provided with a flexible covering 24*a* and 28*a* respectively covering the side of the abutment adjacent the bag and extending over onto the opposite side of the abutment for security. Where the bag 10 is of rubber-like material, the coverings 24*a* and 28*a* are of similar material which is bonded or vulcanized to the flexible bag 10 over the area of the respective abutments.

As best seen in Figs. 1 and partly broken away in Fig. 3, diagonal braces 34 and 35 extend upwardly from the base 13 to the plate 16*a* approximately opposite the top of the bracket 30 so as to firmly support the bracket 30 and the attendant mechanism for operating the bag. These braces are welded to the parts at their opposite ends so as to make the entire structure rigid.

The means here provided for reproducing the pressure pattern of an inhaling-exhaling cycle of the human lungs comprises a cam 36. This cam is shown in Fig. 1 in the position where abutment 28 and stem 29 and follower 33 are in their lowermost position and means to be later described is provided for rotating the cam 36 in the direction of the arrow A of Fig. 1 whereby the cam engages the follower 33 to lift the stem 29 and abutment 28 to the dot-dash position of Fig. 1 so as to compress the flexible bag 10.

The cam 36 must be constructed very carefully so as to reproduce the natural action of the human lungs. The cam is attached to a shaft 37 and is rotated in the direction of the arrow A as previously mentioned. Starting at the position of Fig. 1, the cam very shortly contacts the follower 33 at approximately the point B. The continuing motion then raises the stem 29 and abutment 28 as the cam traverses the portion from the point B to the point C. This bag compressing operation takes approximately 180 degrees of cam movement. That portion of cam 36 between points C and D is on an arc about the center of shaft 37 and therefore during this period of cam travel the flexible bag 10 remains stationary in the dot-dash position of Fig. 1. Cam travel from the point D to the point E results in the lowering of abutment 28 and stem 29 from the dot-dash position of Fig. 1 to the full line position. It will be noted that this expansion of the bag 10 is allowed to occur much more rapidly than the contraction of the bag which occurs between the points B and C on the cam. This bag expansion operation takes approximately 30 degrees of cam movement from D to H for slow expansion, and approximately 75 degrees of cam movement from H to B' for sudden expansion movement. The cam traverses the angle F between points C and D which is approximately 75°. Counting a few degrees on each side of the points C and D where very little motion of abutment 28 takes place, the result is that the flexible bag 10 remains in its contracted or dot-dash position for approximately one-quarter of the complete cycle.

Means is provided for rotating the cam 36 constantly so as to repeat the cycle described above. In the present instance, this means comprises an electric motor 38 which drives a V-shape pulley 39 which is of a known type made in two halves yieldably urged toward each other by a spring in the housing 40. A V belt 41 connects pulley 39 to a pulley 42 which in turn is connected to the input shaft 43 of a speed reducing gearing in housing 44. The shaft 37, previously mentioned, is the output shaft for this reduction gearing and on it is secured cam 36 for rotation with shaft 37.

Means is provided for moving motor 38 back and forth in a horizontal direction as seen in Fig. 1 so as to cause the V belt 41 to ride in various positions with respect to the center of pulley 39 in a known manner so as to vary the speed with which motor 38 drives the pulley 42. To this end, the motor 38 is mounted on a base 45 which in turn is provided with brackets 46 embracing two guide rods 47 secured to brackets 48 on the base 13. A screw 49 is threaded into bracket 46 and mounted for rotation in a bearing 50 on one of the brackets 48. The other end of the shaft having the thread 49 has mounted thereon a bevel gear 51 which meshes with bevel gear 52 mounted on vertical shaft 13 for rotation therewith. This vertical shaft has bearings in brackets 54 at the bottom and 55 at the top. Bracket 54 is bolted to strap 19 and bracket 55 is supported in the strap portion 19*a*. The upper end of shaft 53 is supplied with a hand wheel 56. By turning hand wheel 56 when motor 38 is running, the screw 49 is rotated in its receiving bracket 46 so as to cause the motor base 45 to move horizontally along the supporting rods 47. As previously mentioned, this is a known manner of causing the V belt 41 to change its position relative to the center of pulley 39 so as to change the speed with which motor 38 drives the pulley 42.

Preferably, the movable base of motor 38 is provided with an indicating arm 57 extending to a point above a plate 58 on top of the cabinet. This plate is calibrated in terms of respirations per minute so that the machine may be readily adjusted for the number of respirations per minute which are desired.

It should be understood that the flexible bag 10 is so chosen as to size and the stroke of the abutment 28 is so designed, along with the other factors of the gas machine, so that when the abutment 28 is moved to the dot-dash position of Fig. 1 there is created in the patient's lungs and the closed system connected therewith a pressure of around 15 millimeters of mercury or slightly less. The arrangement is such also that when the parts are in the full line position of Fig. 1 the pressure in the closed system including the patient's lungs drops to about zero or even to a suction of a few millimeters of mercury. Motor 38, pulleys 39 and 42 and reduction gearing 44 are so chosen that the motor may be set to drive cam 36 to produce the number of respirations per minute required for this duty. Normally this would be from about 14 to about 28 respirations per minute. Normally an adult will be given about 16 to 18 respirations per minute on this machine with children a little bit higher in the neighborhood of 20 to 22 respirations per minute.

The operation of our improved machine should now be readily understood. With the tubing 12 connected to the gas machine as previously described, the machine is set in motion by a supply of electricity to motor 38 from a source not shown. The hand wheel 56 is set to provide that number of respirations per minute required by the patient under consideration. The bag 10 will then be given regular expansions and contractions according to the pattern of the cam 36. The lungs will first be filled slowly, then held filled for approximately 25% of the cycle and then more rapidly allowed to collapse or exhale.

As an illustration of a cam adapted to reproduce a suitable action in the human lungs, I may state that the cam 36 has a periphery from B to C comprising the arc of a circle of $2\frac{3}{16}$ inches radius about the center G. From C to D, the cam is constructed on a radius of $3\frac{3}{4}$ inches about the center line of shaft 37. From D to H, the cam has an arc of about 1¼ inches radius about the center J and the points H and B′ are connected by a straight line.

I prefer to allow the follower 33 to clear the cam 36 slightly in the full line position of the parts in Fig. 1 so as to be certain that the bag 10 is fully expanded at this point. The weight of the stem 29 and connected parts are sufficient to return the flexible bag downwardly from the dot-dash position to the full line position of Fig. 1. A spring might be provided to aid in this movement if desired. However, there is normally a residual pressure in the gas machine which aids in moving the bag 10 toward the full line position of Fig. 1.

What I claim is:

1. An artificial breathing machine comprising a flexible bag having an outlet, a frame, a pair of abutments on said frame on opposite sides of said bag, means mounting at least one of said abutments for movement toward and away from the other of said abutments, a cam having an operative connection with said movable one of said abutments, drive means operatively connected with said cam for rotating it, and said cam having a contour controlling movement of said bag to reproduce in said system the pressure pattern of an inhaling-exhaling cycle of the human lungs.

2. The combination of claim 1 wherein said abutments are secured to said bag, and means is provided for causing movement of said movable abutment away from the other of said abutments, whereby to induce an exhaling effect when said outlet is connected with a patient's lungs.

3. The combination of claim 1 wherein said abutments are secured to said bag, and a weight is connected with said movable abutment and acted upon by gravity to cause relative separation of said abutments, whereby to induce an exhaling effect when said outlet is connected with a patient's lungs.

4. The combination of claim 1 wherein said abutments are positioned respectively above and below said bag, said upper abutment is relatively fixed, means mounting said lower abutment for vertical movement including a bar extending downwardly, a bearing embracing said bar, and said cam engaging the lower end of said bar.

5. The combination of claim 1 including control means operatively connected with said drive means for setting the latter at any one of various speeds.

6. In an artificial breathing machine comprising a flexible bag, and relatively movable abutment means engaging said bag on opposite sides to compress and expand said bag, the combination therewith of a cam rotatable continuously in one direction and operatively connected with one of said abutment means and controlling movement of said bag, said cam having a portion for compressing said bag steadily through approximately 180 degrees of cam travel, said cam having a next succeeding dwell portion for approximately 75 degrees of cam travel, said cam having a next succeeding portion for permitting expansion of said bag through approximately 105 degrees of cam travel, said last named portion being formed to first permit slower expansion and to later permit faster expansion, and means for rotating said cam.

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