May 21, 1940. C. A. EWALD 2,201,690

RESPIRATOR

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Fig. 1

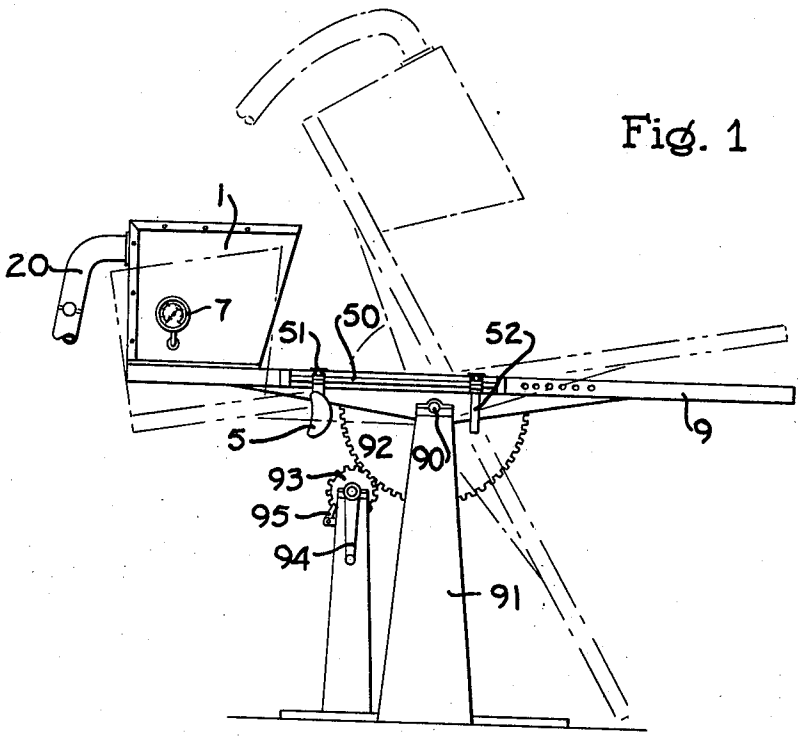


Fig. 2

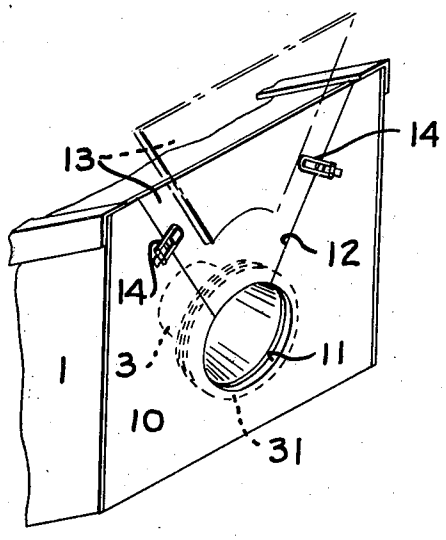
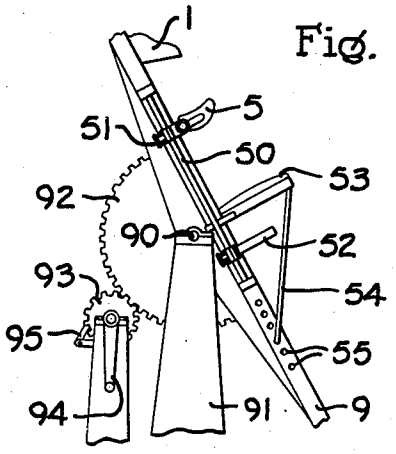


Fig. 3



Inventor

Carl A. Ewald

By Charles L. Reynolds

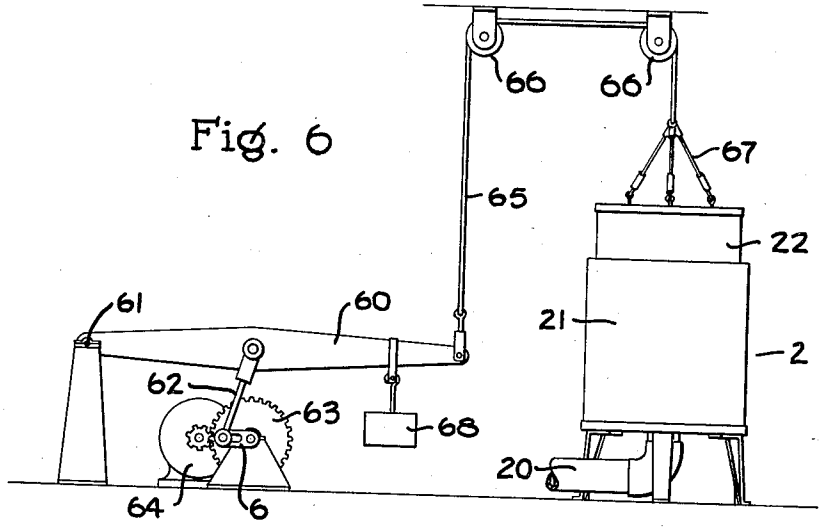
Attorney

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RESPIRATOR

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Fig. 6



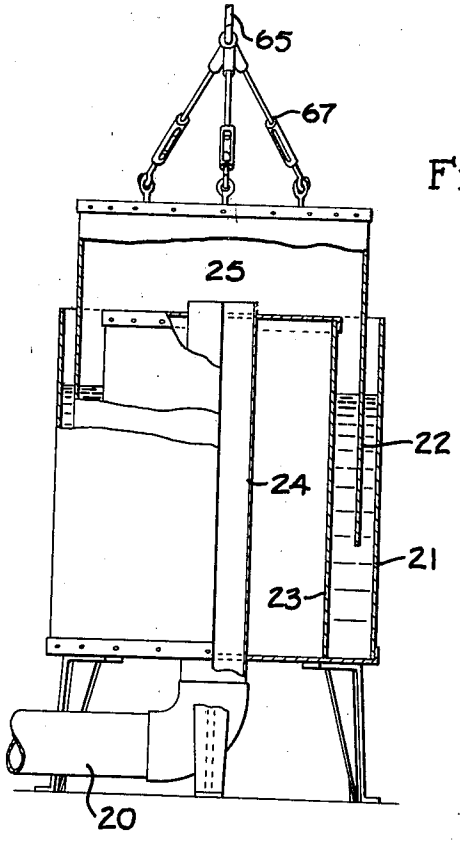


Fig. 7

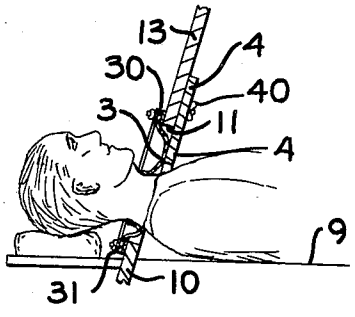


Fig. 4

Inventor

Carl A. Ewald

By Charles L. Reynolds

Attorney

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RESPIRATOR

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Fig. 8

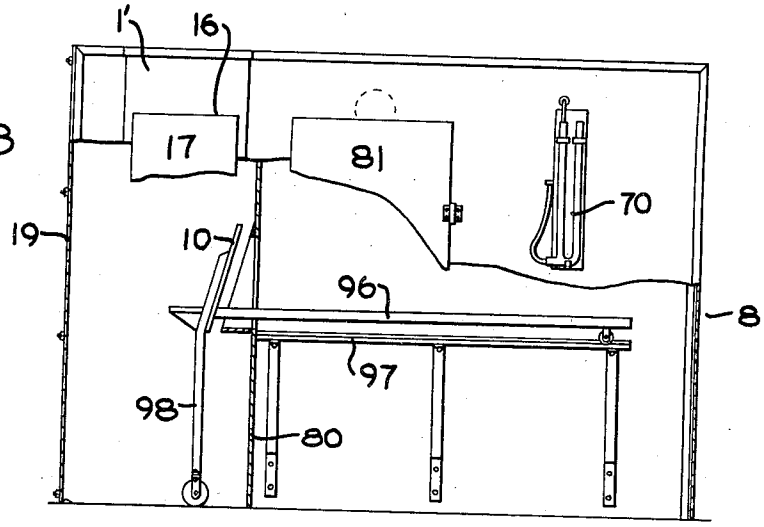


Fig. 9

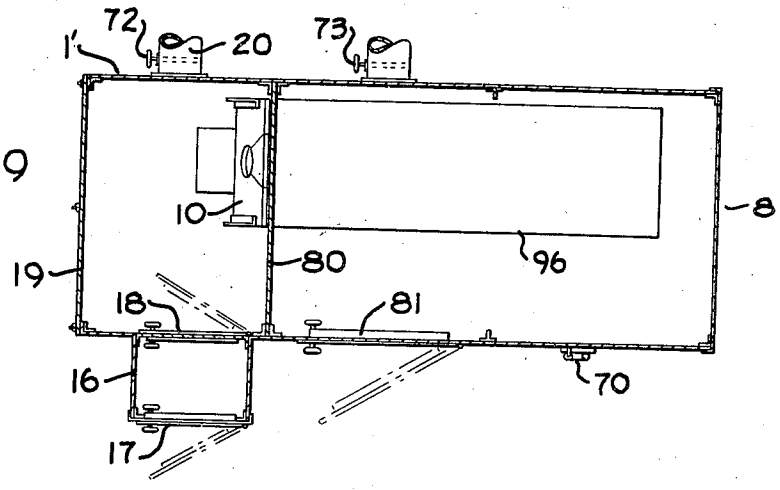
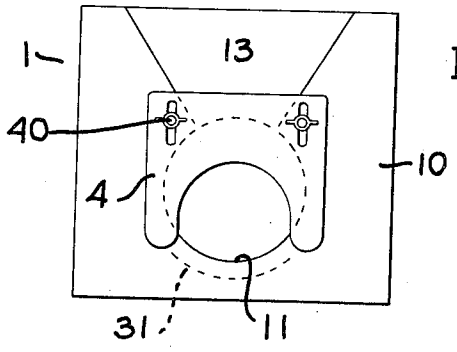


Fig. 5



Inventor

Carl A. Ewald

By Charles L. Reynolds

Attorney

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UNITED STATES PATENT OFFICE

2,201,690

RESPIRATOR

Carl A. Ewald, Seattle, Wash.

Application February 28, 1936, Serial No. 66,256

1 Claim. (Cl. 60—62.6)

My invention relates to artificial respirators, and in particular to a pulsator, for producing pulsating differences in pressure within an enclosed space, for use in such respirators. Certain features herein disclosed may be used in connection with such a respirator as is disclosed in the Drinker and Shaw Patent No. 1,834,580. In certain other respects, particularly in respect to the pulsator, the present invention differs materially from the Drinker and Shaw respirator, commonly called the Drinker respirator.

In the Drinker respirator the patient's entire body, from the neck down, is enclosed, and his head is outside the enclosing cabinet. Pressure within the cabinet is rhythmically lowered below atmospheric and again restored to atmospheric, by centrifugal compressors and control means therefor. Such mechanical devices require constant attention to prevent failure, yet are in constant use over long periods of time, perhaps months.

It is an object of this invention to provide an improved pressure-changing apparatus or pulsator, requiring but a minimum of attention, and unlikely to fail, and further to provide such apparatus which will impose a substantially constant load upon a driving motor.

Such respirators may be of the type wherein pressure is decreased below atmospheric, and then returned to atmospheric, as in the Drinker respirator, and wherein inspiration results from the decreased pressure applied externally to the patient's chest, expiration resulting from the elasticity of the chest walls upon restoration of atmospheric pressure. On the other hand, the respirator may produce superatmospheric pressure, through the nose and mouth, within the lungs, inducing inspiration, and expiration results from natural deflation upon return to atmospheric pressure. It is an object to provide a pulsator suitable for use with either type of respirator, and adaptable to either solely by a change in its mode of operation.

Other objects will appear as this specification progresses.

My invention comprises the novel pulsator, as a whole, the various novel parts thereof, and the novel arrangement of these parts in combination with each other, and in combination with a respirator, all as shown in the accompanying drawings, and as will be hereafter described and more particularly defined by the claim which terminates this specification.

In the accompanying drawings I have shown my invention in illustrative forms, and it will be understood that various changes may be made in the details within the spirit and scope of the invention, as defined in the claim.

Figure 1 is a general elevation of the preferred form of respirator and bed.

Figure 2 is a perspective view of the head panel and part of the cabinet associated therewith.

Figure 3 is an elevation of a part of the bed and various supports associated therewith, and illustrates the means whereby the patient's position may be changed, and he may be supported.

Figure 4 is a section through the head panel and sealing collar, showing the manner in which the patient is supported with relation to these elements.

Figure 5 is an elevation of the head panel and reducer plate.

Figure 6 is an elevation of the pressure-changing apparatus, and Figure 7 is an enlarged view, partly in elevation and partly in section, through the water bellows portion of the same.

Figure 8 is a part section and part elevation of a modified form of the respirator, and Figure 9 is a transverse section through this form.

The respirator as a whole may be formed simply as a cabinet to enclose the head, properly located and associated with a bed, and having means rhythmically producing a positive pressure within the head cabinet, and relief of such pressure, usually to atmospheric. Thus in Figure 1 is shown the head cabinet 1 supported upon the head end of a bed frame 9, and with a conduit or pipe 20 from a pressure source extending into the head cabinet 1.

Such a cabinet is provided with a head panel 10 having an aperture 11 through which the patient's neck projects. Preferably the panel 10 is inclined somewhat with respect to the plane of the bed 9 to give greater freedom of movement to the patient's chin. In order to facilitate the placing of the patient within the respirator I prefer that the upper edge of the panel 10 be notched, as indicated at 12, and that a section 13 be formed separately from the main portion of the panel, but securable in the notch 12 in a reasonably air-tight manner, being secured, for example, by the clamps 14. Thus with the triangular section 13 removed, it is an easy matter to lay the patient's head on one side of the head panel 10, with the remainder of his body on the other side, and then to close the notch 12 with the section 13. The patient's head does not have to be projected through an aperture the margin of which is continuous.

It is necessary, of course, to seal the aperture

11 so that no substantial loss of air pressure will occur by escape through the same, and any suitable means to accomplish this may be provided. I prefer to employ a conical sleeve 3 of flexible impermeable elastic material, for example of rubber, which can be slipped over the patient's head while he is seated. This sleeve has a flange 30 about its larger end, which is adapted to be clamped between rings 31 (see Figure 4), and to be in turn secured about the margin of the aperture 11. The smaller end of the sleeve 3 fits closely about the patient's neck, or may be drawn tighter and held with clamps, and thus the sleeve will seal the aperture.

However, the aperture will usually be large enough to accommodate the largest possible neck, and the sleeve 3, being of flexible material, tends to move in and out through the aperture with change of pressure, to the annoyance of the patient, and disturbing the intended pressure relationship. To prevent this I prefer to employ a reduced plate 4 (see Figure 5) which is adjustably secured upon the panel 10, and which is notched to fit closely about the patient's neck and to reduce the effective size of the aperture to but slightly more than the size of the patient's neck. In this manner bellying movement of the sleeve 3 is restricted or prevented. The reducer plate 4, several sizes of which may be provided, may be adjustable by any suitable means, such as the pin and slot connection illustrated at 40.

The bed I prefer to support upon trunnions 90, carried by a stand 91, and having associated with it a circular rack 92 engageable by a pinion 93 rotatable by a crank 94, the latter held in any given position by the pawl 95. By these or any equivalent means the bed may be tilted to any desired inclination. Indeed it may be tilted to lower the head of the patient, thus to prevent fluids from the mouth running down the trachea, or it may be tilted into a substantially upright position, all as shown in Figure 1. Since the head cabinet 1 is in this form supported on the bed, and is of small size as compared to the bed, the patient suffers no inconvenience nor is it difficult for the attendant to tilt the bed, with the cabinet. However, means must be provided to assist in the support of the patient in any appreciably inclined position. To this end I have shown crutch-like supports 5, supported upon rods 50 which extend lengthwise of the bed, the supports being rotatable on and adjustable along the rods, so that they are securable in any position with respect to the patient by means such as the clamping screw 51. These may be fitted beneath the armpits of the patient. Handles 52 may be similarly supported and adjustable to be grasped by the patient's hands. In addition a seat 53 may be supported on the bed, braced by the brace 54 engageable in any one of several holes 55 in the bed frame, whereon the patient may sit when in an upright position.

Within such a cabinet, or within any other suitable cabinet, pressure is changed by mechanism such as that shown in Figures 6 and 7. In general a water bellows, indicated at 2, is connected by the conduit 20, previously referred to, to the cabinet. It will be understood that such a bellows might be employed for lessening the pressure within the cabinet, or for increasing it, depending upon the manner in which it is operated. The manner of operating the respirator and the pulsator determines the point of connection of the conduit to the cabinet. Two alternative points are shown in Figure 9, one to the head chamber, in which pressure is usually rhythmically increased and returned to atmospheric, and one to the body chamber, in which pressure is usually rhythmically decreased and returned to atmospheric. Valves, represented diagrammatically by the elements 72 and 73, are employed to govern the rate of interchange of pressure, by a greater or lesser degree of closing of the connection which is in use, or to close off completely the unused connection, if desired.

As best shown in Figure 7, such a water bellows comprises an outer upright cylinder 21, an inner cylinder 23, and an inverted cylinder 22 the rim of which depends within the space between the inner and outer cylinders, and is always below the level of water in such space. The spacing of the three cylinders is such that the area of water surface between the inverted and outer cylinders is substantially equal to the area between the inverted and inner cylinders. If we assume that pressure in the space 25, within the inverted cylinder, is equal to atmospheric when the inverted cylinder 22 is raised, the water levels inside and outside the cylinder 22 will be the same.

The water bellows must maintain a seal at all times, hence the difference in water level caused by the rise and fall of the cylinder 22 must not be so great as to reach the lower edge of this cylinder. If equal areas of water are exposed to the pressures inside and outside the cylinder, and a fourteen-inch head of water is desired (corresponding to a pressure difference of about one-half pound per square inch), it is obvious that a seven-inch rise (or fall) inside the cylinder 22 will cause a seven-inch fall (or rise) outside, giving a total of the desired fourteen inches of hydrostatic head. The water in the outside cylinder 21 has changed level but seven inches, however. If, instead of the inside and outside areas being equal, the inside area is considerably the larger, a rise (or fall) of say one inch inside may require a fall (or rise) outside of thirteen inches, to attain the same hydrostatic head. The level in the outside cylinder 21 has therefore changed thirteen inches, instead of seven, to obtain the same change of air pressure within the cylinder 22.

The space 25 within the inverted cylinder 22 is in communication through the conduit 20 with the cabinet, and with the head pressure cabinet described above the connection is past the valve 72. The operation of the bellows, that is, the rhythmical raising and lowering of the inverted cylinder 22, is accomplished preferably by the mechanism shown in Figure 6. A lever 60 is fulcrumed at 61, and is raised and lowered by a pitman 62 adjustably connected to a rotative crank 6. Adjustment of the effective length of the crank, achieved by sliding the end of the pitman, or crank pin, lengthwise of a slot in the crank which receives it, varies the extent of movement of the cylinder 22. The crank 6 is driven through gearing indicated at 63, from a motor 64, at a rate corresponding to the rate of respiration desired. The end of the lever 60 is connected through a cable or belt 65 passing over pulleys 66 to an adjustable harness 67 which is connected to the upper end of the cylinder 22. Thus as the crank 6 rotates, the cylinder 22 is rhythmically raised and lowered, creating a pulsating change in pressure within the space 25 and within the cabinet. To produce suction the cylinder 22 is first raised from its position of Figure 7, whereas to produce pressure it is

depressed from that position; thus it requires only a change in its mode of operation either suction or pressure, as required.

To produce positive pressure the cylinder 22 must be of sufficient weight that it will drop and expel air from the space 25, hence the crank in rising does not perform any work, and since the cylinder 22 in sinking must displace water and compress air, its downward motion will normally be somewhat slower than the corresponding rising motion of the arm 60, with the result that the cylinder 22 in sinking will not cooperate with the motor in raising the arm 60. However, when the crank is going downward it must lift not only the weight of the cylinder 22, but must draw air into the space 25. In order that the motor 64 may be more evenly loaded throughout each revolution of the crank, I prefer to support, upon the lever 60, or at some suitable place in the driving mechanism, a counterweight 68. This is shown supported on the lever 60, and is adjustable along this lever to vary its effect. Now as the crank 6 is rising and the cylinder 22 is dropping, imposing the minimum load on the motor, the crank is lifting the counterweight 68, and as the crank starts to descend, raising the cylinder 22, the counterweight 68 compensates in some measure for the added force required, so that there is a continuous load on the motor 64 and a decreased maximum load.

While I have used the term "cylinder" to describe the elements 21, 22 and 23, and while they will normally be of true cylindrical form, since that is most convenient to make, it should be understood that any equivalent form, as hexagonal sections, will serve the purpose equally well.

The respirator proper so far described in detail has consisted only of a head cabinet wherein the pressure is increased above atmospheric, and in rhythmical succession is restored substantially to atmospheric, then raised again and restored to atmospheric, etc. The result of this is to increase the pressure applicable through the breathing apparatus to the lungs of the patient, and thus to expand his lungs and chest, relying upon equalization of pressures on the thorax and upon the head to expel the air in the lungs through elasticity of chest walls and lungs. This does not produce any harmful or disagreeable effect upon the patient, for the pressure change is of the order of one-half pound per square inch or less. However, if the pulsator is operated to produce a suction in the space 25, the conduit 20 may be connected, past the valve 73, to a cabinet, as indicated at 8 in Figures 8 and 9, which encloses the lower portion of the body below the neck. In this arrangement the head cabinet 1' may remain at atmospheric pressure, or alternately with the body cabinet 8 there may be increased pressure therein, or there may be an alternate reduction of pressure in each of the cabinets 8 and 1'. These two cabinets, it will be understood, are separated by a partition 80 of which the head panel 10 forms a part.

Neither the head cabinet nor the body cabinet need be hermetically sealed against air exchange with the ambient atmosphere. In particular the head cabinets 1 or 1' should not be sealed. That is, sufficient air should be allowed to leak through cracks about the joints to insure that the air within the interior of the system, particularly if such air is to enter the lungs, is constantly renewed by the outside air in order that the oxygen content of the air in the interior of the cabinet may be maintained at a respiration norm. While it is of course possible to install positive means to replenish the oxygen supply, in practice I have not found this necessary as sufficient air is in fact exchanged, as outlined above, through the cracks about the joints and openings to maintain a desirable oxygen content in the interior of the system, and that without interfering with the operation of the device as a respirator. If desired, the cabinet 1' may be supplied with conditioned air, from any suitable source, and admitted at any convenient point, thus accomplishing directly and easily what it would be difficult to accomplish were the patient's head to be in the open air of a room. To conserve the atmosphere within the head cabinet 1', and to enable the patient to be fed and his teeth to be brushed, etc., the cabinet 1' may be large enough for a nurse to enter it, and it is preferably provided with an air lock 16 closed by exterior and interior doors 17 and 18, respectively, through which the attendant enters. The body cabinet 8 may likewise be sufficiently large to enable an attendant to enter, the entrance being closed by the door 81.

The bed 96 in this form of the cabinet may be supported upon a track 97 within the cabinet 8, and by legs 98 on the opposite side of the partition 80. The head panel 10 is still formed as a part of the bed. In order that the bed may be moved out of the cabinet 8 sufficiently to place a patient on it, the end wall 19 of the head cabinet may be made removable or hinged.

Suitable control devices, such as the pressure gauge 7, as seen in Figure 1, or the manometer 70 as seen in Figure 8, may be employed as necessary. While I have not shown details of structure of the cabinets such as would be required to resist changes of pressure, these will be such as good engineering principles will dictate.

What I claim as my invention is:

A pulsator to produce a rhythmic change in pressure, comprising an outer upright water-filled cylinder, an inverted cylinder movable vertically within the outer cylinder, with its lower edge always below the surface of the water therein, a conduit communicating with the air space within the inverted cylinder and adapted for connection to the exterior, means including a rotative crank connected with the inverted cylinder to raise and lower it repeatedly, and a counterweight connected to the latter means to be raised by the crank as the inverted cylinder is lowered, and by its downward movement to assist in raising the cylinder.

CARL A. EWALD.