

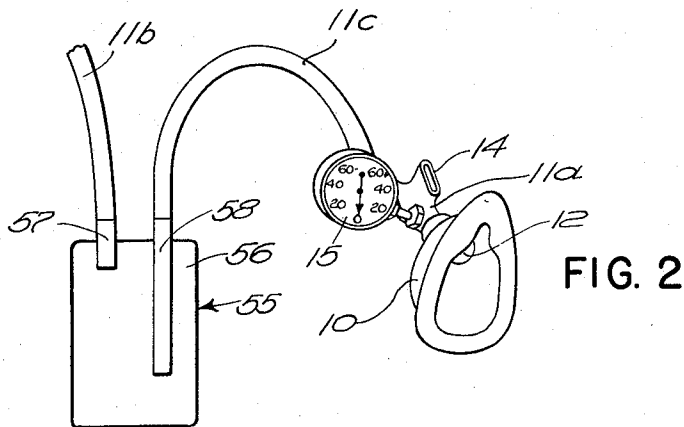
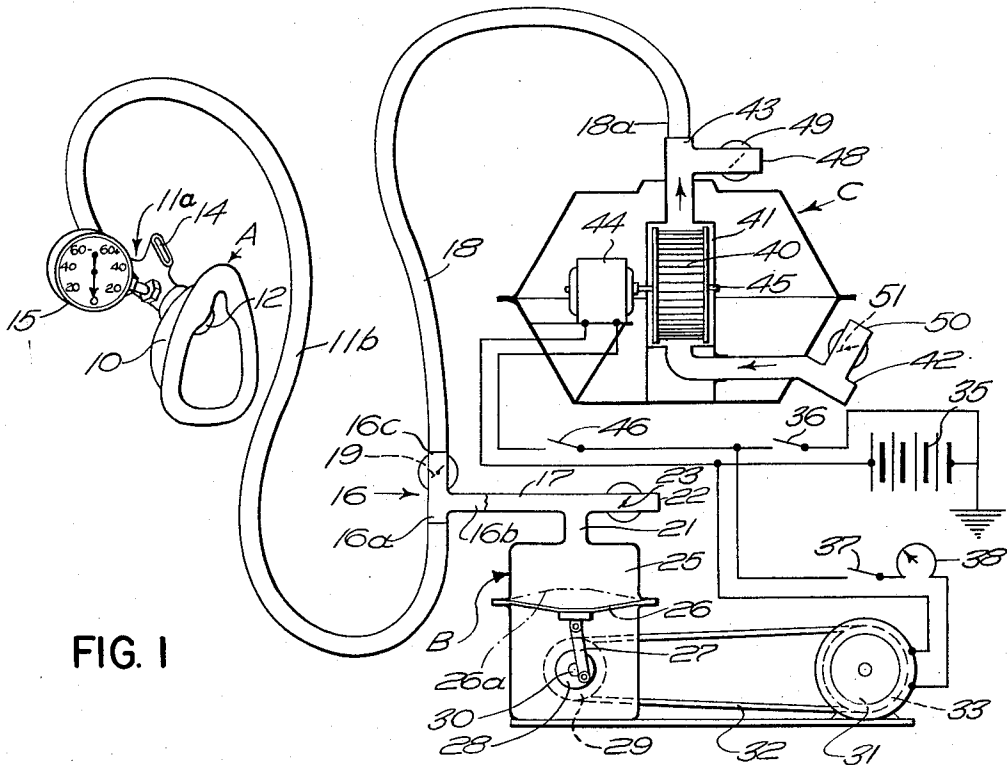
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APPARATUS FOR VIBRATING PORTIONS OF A PATIENT'S AIRWAY

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APPARATUS FOR VIBRATING PORTIONS OF A PATIENT'S AIRWAY

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This invention pertains to an apparatus for treating a patient by vibrating a column of gas which is in communication with his airway, the column being vibrated at a rate which is greater than the patient's normal rate of inhalation and exhalation, thereby to vibrate the patient's airway and the organs associated therewith. The invention also relates to a method of vibrating a column of gas.

As used herein the term "gas" includes any gas or combination of gases which a patient may breathe or which he is induced to breathe artificially such as air, oxygen, anesthesia gases, aerosols and the like.

As used herein the term "airway" includes the patient's nose, mouth, throat, windpipe and lungs and any other of his internal chambers or passages through which gas passes during movement to and from the patient's lungs.

The method and apparatus of the present invention may be used to vibrate a column of gas during both the period of a patient's inhalation and the period of his exhalation or during either of said periods. The column of gas which is vibrated may be under positive, negative or atmospheric pressures and it may be either static or in motion inwardly or outwardly of his airway and such motion may be created by his own natural breathing or by the application of positive or negative pressures to the column.

The vibration of the column of gas provided by the present invention is in addition to the patient's respiration, natural or artificial, and at a much more rapid rate, for example, from 100 to more than 1500 vibrations per minute as compared to respiration rates of from 15 to 60 times per minute (a baby inhales from 25 to 60 times per minute).

All uses and benefits of vibrating a column of gas in communication with a patient's airway are not known but it has been found that the method and apparatus herein disclosed provides an effective means of exercising and massaging the airway and associated organs and of loosening and removing mucous therefrom. In addition, vibrating the column of gas doubtless causes the gas to diffuse more rapidly within the airway and therefore aids in the breathing function by circulating the gas more thoroughly to and from the walls of the lungs.

One use of the invention which has proven effective is its use with a patient whose pharynx has become paralyzed or partially paralyzed as a result of polio. With such patients the vibration of the column of gas exercises the muscles of the pharynx and relieves muscle spasms of the pharynx. Vibrations of between 500 and 1500 times per minute have been found useful for this application.

Usually polio patients with a paralyzed or partially paralyzed pharynx are able to breathe by themselves and the apparatus of the present invention is adapted to vibrate the column of gas which the patient thus inhales and exhales. However, with patients who are unable to breathe by themselves, the apparatus may be adjusted to supply

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a column of gas which is under either positive or negative pressures to induce or assist inhalation or exhalation.

When positive pressure is thus applied, either the patient himself or an attendant intermittently interrupts the positive pressure cycle to permit an exhalation and during each such interruption the column of gas is placed in communication with the atmosphere so as to permit him to exhale naturally, but the apparatus is capable of use to vibrate the column of gas during both the inhalation phase and the exhalation phase or during either phase.

The apparatus is capable of use in the same manner when the column of gas is under negative pressure. In this case the negative pressure cycle aids in removing mucous and during the intermediate intervals the patient's airway is connected through the column of gas to the atmosphere to supply fresh air for inhalation, the vibration of the column of gas being carried on during both periods or either period as desired.

During each period of inhalation, the column of gas may be connected to a supply of oxygen, anesthesia gases or other type of gas without departing from the spirit of the present invention.

One object of the present invention is to provide a novel and efficient apparatus for and a method of vibrating a column of gas which is in a conduit, one end of which is in communication with a patient's airway.

Another object is to provide an apparatus and method capable of placing a column of gas under an adjustable amount of positive pressure and in communication with a patient's airway to cause or assist a patient to inhale and of intermittently causing or permitting the patient to exhale and rapidly vibrating said column of gas at a rate which is substantially in excess of the rate of breathing of the patient.

Still another object is to provide an apparatus and method capable of placing a column of gas under an adjustable amount of negative pressure and in communication with a patient's airway and of intermittently causing or permitting the patient to inhale from a suitable source of gas and rapidly vibrating said column of gas at a rate which is substantially in excess of the rate of breathing of the patient.

Another object is to provide an apparatus and method which may be used to expand the lungs of new born babies when their lungs are initially stuck together, thereby to start the natural breathing process.

Another object is to provide such an apparatus and method which are economical and efficient to produce and use or practice.

Further objects and advantages of the method and apparatus of the present invention will be apparent to persons skilled in the art from the following description and accompanying drawings in which:

Fig. 1 is a schematic view of an apparatus embodying the present invention and which is suitable for use in practicing several methods embodying the present invention; and

Fig. 2 is a diagrammatic view of a mucous trap and a face mask which are suitable for use in connection with an apparatus embodying the invention and in practicing another method embodying the present invention.

Referring to Fig. 1 of the drawings, the apparatus there shown comprises generally a face mask A, a vibrating apparatus B and a pressure creating apparatus or pump C which is adaptable to create either positive or negative pressure and to control the intensities of either.

The face mask A comprises a concave trough-shaped face piece 10 which fits over a patient's nose and mouth to place the patient's airway in communication with the interior of the connecting member 11a which comprises

a longitudinally extending passage, one end of which opens into the face mask 10 through an opening 12 and the other end of which (not shown) communicates with the interior of the tube or conduit 11b.

The connecting member 11a is provided with an upwardly extending tubular portion which forms a branch passage affording communication between the end opening 14 and the aforesaid longitudinally extending passage in the member 11a. The opening 14 may be left fully open to permit the patient to inhale and exhale atmospheric air naturally through said opening or it may be entirely or partially closed periodically by the patient's or an operator's thumb to allow the patient to exhale naturally between periodic applications of positive pressure or to inhale naturally between periodic applications of negative pressure as more fully explained hereafter.

A pressure gauge 15 is connected with the passage of the connecting member 11a and it measures or indicates the pressure of the gas in said longitudinally extending passage in centimeters of water.

When positive pressure is supplied in the tube 11b to aid in expanding a patient's lungs, the aperture 14 will be closed or partially closed so that the amount of pressure will normally be controlled to build up not more than from 20 to 60 centimeters of water in the patient's lungs and airway during each period of inhalation. The patient or the attendant may watch the gauge and he removes or partially removes his thumb from the opening 14 when the pressure becomes excessive.

The flexible hose or tube 11b is connected to an arm 16a of the hollow shaped member 16.

The member 16 has three tubular arms 16a, 16b and 16c. The arm 16a is connected to the conduit 11b and the arm 16b is connected to the tube 17, the interior of which communicates with the interior of the vibrating apparatus B. The arm 16c is connected to the tubular conduit 18 which in turn is connected to the pressure creating apparatus C. A valve 19 in the arm 16c is arranged to open or close the passage in the arm 16c whereby communication between the member 16 and the conduit 18 may be shut off when the apparatus is operated without using the pressure creating apparatus C.

The interior of the tube 17 communicates through the passage 21 with the chamber 25 of the vibrating device B. The open end 22 of the tube 17 provides a passage to the atmosphere and the valve 23 in the tube is arranged to control the size of this passage to the desired amount. Opening the valve 23 decreases the strength or intensity of the vibrations which are transmitted from the vibrating device B through the conduit 17 to the column of gas in the conduit 11b and closing the valve completely produces the maximum intensity of vibrations therein.

The vibrating device B comprises the chamber 25 having a movable wall or diaphragm 26 made of rubberized fabric or other air impervious flexible material and which when moved upwardly and downwardly varies the volume of the chamber and the pressure of the air therein. The chamber 25 opens into the tube 17 through the passage 21 and as the volume of the chamber is varied vibrations or pulsations are created in the gas in the tube 17 causing the gas to move first in one direction and then in the opposite direction. These vibrations are transmitted to the column of gas in the conduit 11b which communicates with the face mask A and the patient's airway.

The wall 26 is moved from the full line position to the dot dash position 26a by the link 27 which has one end pivotally attached to a central rigid member of the wall and its other end pivotally attached eccentrically on the disk 28. The disk 28 is secured to the pulley 29 and they are mounted for rotation in unison with the shaft 30. The motor 31 rotates the pulley 29 through a

V-belt 32 which is passed around the motor pulley 33 and the pulley 29.

The motor 31 is an electric motor energized by connecting it to any suitable source of electric current indicated at 35, such as the electric outlet of a house or hospital circuit. The master switch 36 is arranged to connect or disconnect the line to the source of electric current. The auxiliary switch 37 and rheostat 38 are arranged to control the speed of the motor. Thus the rheostat 38 may be adjusted to increase or decrease the speed of movement of the wall 26 and to increase or decrease the number of vibrations produced per minute in the column of gas in the conduit 11b. An equivalent speed control may be provided by supplying a series of additional pulleys like the pulley 29 but of varying diameters and by shifting the belt 32 from one to another.

For the operation of the apparatus according to the present invention the number of vibrations per minute must be substantially greater than the patient's normal number of inhalations or exhalations per minute. Children, who have higher rates of inhalation than adults, inhale from 25 to 60 times per minute whereas adults inhale from 15 to 25 times per minute. The apparatus of the present invention is arranged to produce from 100 to substantially more than 1500 vibrations per minute.

The pressure creating apparatus C, by which positive or negative pressure may be supplied to the conduits 18 and 11b, comprises a rotor 40 in a chamber 41 which has an inlet conduit 42 and an outlet conduit 43. An electric motor 44 is connected through a shaft 45 to drive the rotor 40 so that the rotor draws air in from the atmosphere through the inlet conduit 42 and expels it under positive pressure through the outlet conduit 43.

The electric motor 44 may be energized from the source of electric current 35 through a circuit which includes the switch 46 so that the pressure creating apparatus C may be turned off and on independently of the vibrating device B.

The conduit 18 connects the apparatus C to the member 16 and has its end 18a connected to the outlet conduit 43 when it is desired to apply positive pressure to the conduit 11b. To supply negative pressure to the conduit 11b the end 18a is connected to the inlet conduit 42.

A conduit 48 affords communication between the conduit 43 and the atmosphere and a valve 49 therein is arranged to open and close the conduit 48 an adjusted amount to provide a controlled leak communicating with the conduit 43 and this provides means by which the amount of positive pressure supplied to the conduit 18 may be adjusted. When the valve 49 is open, the positive pressure in the conduit 43 is dissipated or reduced depending upon the degree to which the conduit 48 is thus opened.

Similarly, a conduit 50 is provided to communicate with the inlet tube 42 and the valve 51 may be used to adjust the intensity of the negative pressure when the end 18a is connected to the inlet tube 42.

It will be appreciated that the pump C of the present apparatus is a conventional type of pump for pumping a gas and that other conventional apparatus adapted for creating positive and negative pressures may be substituted without departing from the spirit of the present invention. A rheostat connected with the electric motor 44 may be used in place of the valves 49 and 51 for adjusting the amounts of positive and negative pressure supplied.

When it is desired to supply oxygen to the patient the end 18a of the conduit 18 may be connected to a tank of compressed oxygen which supplies positive pressure to the interior of the conduit 18.

The apparatus shown in Fig. 1 may be used to vibrate a column of gas into which and from which a patient inhales and exhales naturally. In this case the switch 46 is opened and the switch 36 is closed. The vibrating device C is adjusted by the rheostat 38 to produce the

desired number of vibrations per minute. The valve 23 in the tube 17 is adjusted to adjust the strength of the vibration produced and the valve 19 in the arm 16c of the member 16 is closed to shut off communication between the conduits 18 and 11b so that all the vibration produced will be directed into the conduit 11b.

The face mask A is then placed over the patient's nose and mouth and the opening 14 is partially closed. Breathing naturally, the majority of the inhaled and exhaled gases pass through the opening 14 but the vibration of the column of gas in the conduit 11a is transmitted to the column of gas in the conduit of the member 11 so the column of gas which communicates with the patient's airway is vibrated rapidly and continuously regardless of whether the gas in the airway is standing still, moving in, or moving out.

If the patient is unable to inhale properly by himself, as in atelectasis, gas under positive pressure is applied through to conduit 11b by opening the valve 19, connecting the conduit 18 to the conduit 43, adjusting the valve 49 and closing the switch 46. In this instance the opening 14 is periodically closed or partially closed intermittently to direct the column of gas under positive pressure into the patient's airway to induce inhalations and periodically opened or partially opened to permit exhalations. The opening 14 is thus closed and opened at time intervals to produce the desired rate of breathing of the particular patient upon whom the apparatus is being used.

The operation of the apparatus to supply negative pressure is similar to its operation to apply positive pressure except that the end 18a of the conduit 18 is connected to the inlet tube 42 of the pump C and adjusting the valve 51 therein is used to adjust the intensity of the negative pressure. In this instance the opening 14 is closed or partially closed intermittently to cause or aid in exhalation and is opened or partially opened to permit the patient to inhale air under atmospheric pressure through it. The vibration is created in the same manner as in the previous cases.

Negative pressure applied with rapid vibration is useful to loosen and draw out mucous from a patient's airway. When used for that purpose a mucous trap 55, which may be a glass jar 56, is connected in the conduit 11b as shown in Fig. 2. The cover of the jar 56 is provided with two tubes 57 and 58. The flexible conduit 11b is disconnected from the member 11a and is connected to the tube 57. A flexible conduit 11c is then attached to the tube 58 and to the member 11a to complete the conduit 11 for the column of gas from the pump C through the trap 55 to the face mask A and thence to the patient's airway.

The jar 56 is sealed around the tubes 57 and 58 so that the column of gas under negative pressure is maintained and rapidly vibrated as described above and mucous or other material liberated by the vibrations is drawn into the conduit 11a and trapped or collected in the trap 55 rather than passing on through the conduit 11b into the pump C.

For the pump C, which creates continuous positive or negative pressures, any resuscitation apparatus may be substituted of the types which automatically create intermittent periods of positive pressure or intermittent periods of positive and negative pressures in time with the normal rate of breathing of the patient, for example any of the devices disclosed in United States Patents, 2,481,299, 2,473,416, 2,468,741, 2,364,626, 2,352,523 and 2,268,172. The vibrating apparatus B works equally well when connected to a column of gas created by such an automatic apparatus and such connection may be made at any desired location, either at the face mask itself or at some point in a conduit leading from the pressure creating apparatus to the face mask. The opening 14 is permanently closed when such automotive pressure cycling devices are used.

Various changes and modifications may be made in the above disclosed preferred embodiments of the method and apparatus of the present invention without departing from the scope of the invention as set forth in the appended claims.

I claim:

1. Apparatus for vibrating portions of a user's airway comprising a face piece to cover the user's nose and mouth, a conduit in communication with the interior of said face piece and through which gas is adapted to move to provide for respiration, means for alternately transmitting negative pressure and a higher pressure to said face piece, whereby exhalation and inhalation alternately occur, said negative pressure being transmitted from a source of negative pressure through said conduit, a chamber having a movable wall, means for reciprocating said wall at a rate which is substantially greater than a person's normal rate of breathing and a passage providing communication between the interiors of said chamber and said conduit whereby vibrations of the gas in said chamber created by reciprocation of said movable wall are transmitted to the column of gas in said conduit and thence to the user's airway, the interior of said face mask being in uninterrupted communication with said source of negative pressure while negative pressure is being transmitted thereto during an exhalation and with a source of higher pressure while a higher pressure is being transmitted thereto during an inhalation.

2. Apparatus for moving and vibrating a column of gas comprising a conduit, means for creating negative pressure, means for providing communication between said means for creating negative pressure and said conduit and thereby to create negative pressure in said conduit and move a column of gas in one direction there-through, a chamber having a movable wall, means for reciprocating said wall rapidly, a first passage providing communication between said chamber and said conduit, a second passage affording communication between the first passage and the atmosphere and valve means for controlling the effective size of said second passage whereby the intensity of the vibrations created in the gas in said conduit by reciprocation of said movable wall may be controlled by adjusting said valve means, said means for creating negative pressure being adapted to create said negative pressure in said conduit independently of said movable wall.

3. Apparatus for vibrating portions of a user's airway comprising a face piece to cover the user's nose and mouth, a conduit in communication with the interior of said face piece and through which gas is adapted to move to provide for respiration, means for alternately transmitting positive pressure and a lower pressure to said face piece, whereby inhalation and exhalation alternately occur, said positive pressure being transmitted from a source of positive pressure through said conduit, a chamber having a movable wall, means for reciprocating said wall at a rate which is substantially greater than a person's normal rate of breathing and a passage providing communication between the interior of said chamber and said conduit whereby vibrations of the gas in said chamber created by reciprocation of said movable wall are transmitted to the column of gas in said conduit and thence to the user's airway, the interior of said face mask being in uninterrupted communication with said source of positive pressure while said positive pressure is transmitted thereto during an inhalation period and with a source of lower pressure while said lower pressure is being transmitted thereto during an exhalation period.

4. Apparatus for moving and vibrating a column of gas comprising a conduit, means for creating positive pressure, means for providing communication between said means for creating positive pressure and said conduit and thereby to create positive pressure in said conduit and move a column of gas in one direction there-through, a chamber having a movable wall, means for reciprocating

ing said wall rapidly, a first passage providing communication between said chamber and said conduit, a second passage affording communication between the first passage and the atmosphere and valve means for controlling the effective size of said second passage whereby the intensity of the vibrations created in the gas in said conduit by reciprocation of said movable wall may be controlled by adjusting said valve means, said means for creating positive pressure being adapted to create said positive pressure in said conduit independently of said vibrating means.

5. Apparatus for vibrating portions of a user's airway comprising a conduit adapted to be placed in communication with said airway and through which gas is adapted to move to provide for respiration, means for alternately transmitting negative pressure and a higher pressure to said conduit from a source of negative pressure and a source of higher pressure respectively to induce exhalation and inhalation by said user when said conduit is in communication with said airway, means for vibrating the gas in said conduit at a rate which is substantially greater than a person's normal rate of breathing, said conduit being in uninterrupted communication with said source of negative pressure while said negative pressure is being transmitted thereto during an exhalation and with said source of higher pressure while said higher pressure is being transmitted thereto during inhalation.

6. Apparatus for vibrating portions of a user's airway comprising a conduit adapted to be placed in communication with said airway and through which gas is adapted to move to provide for respiration, means for alternately transmitting positive pressure and a lower pressure to said conduit from a source of positive pressure and a source of a lower pressure respectively to induce respiration by said user, means for vibrating the gas in said conduit at a rate which is substantially greater than a person's normal rate of breathing, said conduit being in uninterrupted communication with said source of positive pressure while said positive pressure is being transmitted thereto during an inhalation, and with said source of lower pressure while said lower pressure is being transmitted thereto during an exhalation.

7. Apparatus for vibrating portions of a user's airway comprising a conduit adapted to be placed in communication with said airway and through which gas is adapted to move to provide for respiration, means for alternately

transmitting negative pressure and a higher pressure to said conduit whereby exhalation and inhalation alternately occur, said negative pressure being transmitted from a source of negative pressure through said conduit, a chamber having a movable wall, means for reciprocating said wall at a rate which is substantially greater than a person's normal rate of breathing and a passage providing communication between the interior of said chamber and said conduit whereby vibrations of the gas in said chamber created by reciprocation of said movable wall are transmitted to the column of gas in said conduit and thence to the user's airway, said conduit being in uninterrupted communication with said source of negative pressure while negative pressure is being transmitted thereto during an exhalation and with a source of higher pressure while a higher pressure is being transmitted thereto during inhalation.

8. Apparatus for vibrating portions of a user's airway comprising a conduit adapted to be placed in communication with said airway and through which gas is adapted to move to provide for respiration, means for alternately transmitting positive pressure and a lower pressure to said conduit, whereby inhalation and exhalation alternately occur, said positive pressure being transmitted from a source of positive pressure through said conduit, a chamber having a movable wall, means for reciprocating said wall at a rate which is substantially greater than a person's normal rate of breathing and a passage providing communication between the interior of said chamber and said conduit whereby vibrations of gas in said chamber created by reciprocation of said movable wall are transmitted to the column of gas in said conduit and thence to the user's airway, said conduit being in uninterrupted communication with said source of positive pressure while said positive pressure is being transmitted thereto during an inhalation, and with a source of lower pressure while said lower pressure is being transmitted thereto during an exhalation.

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