Aug. 12, 1941. K. CONNELL 2,251,986

APPARATUS AND METHOD FOR THE ADMINISTRATION OF GASES

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Fig. 1.

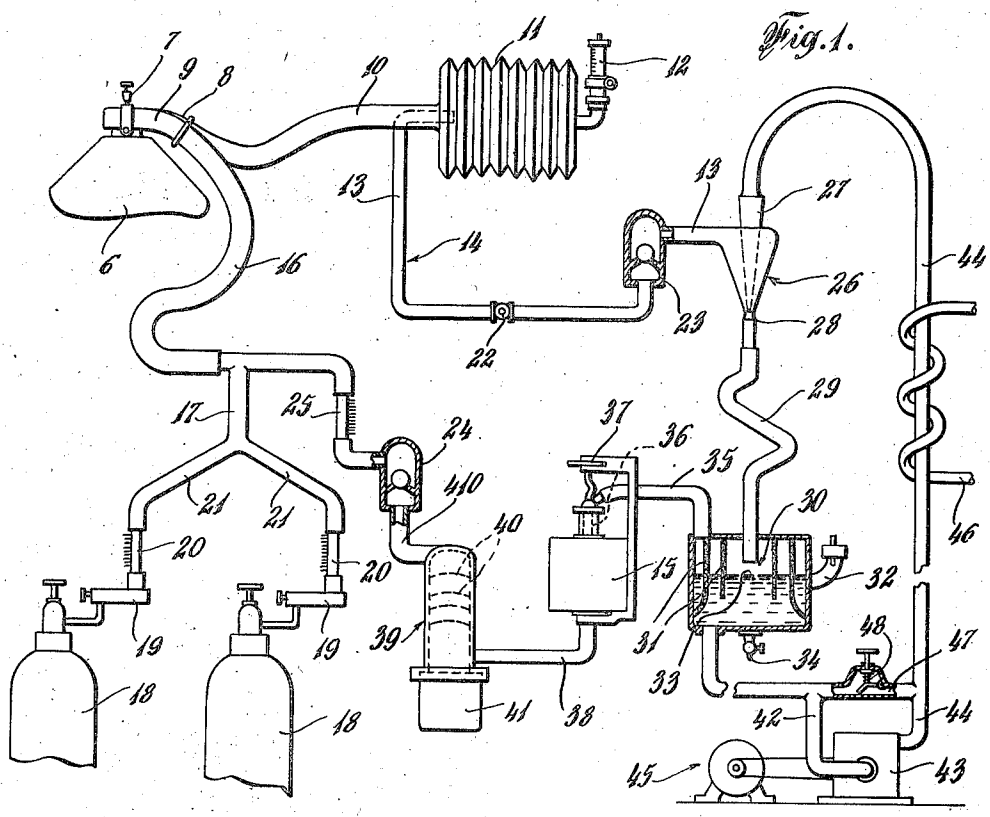
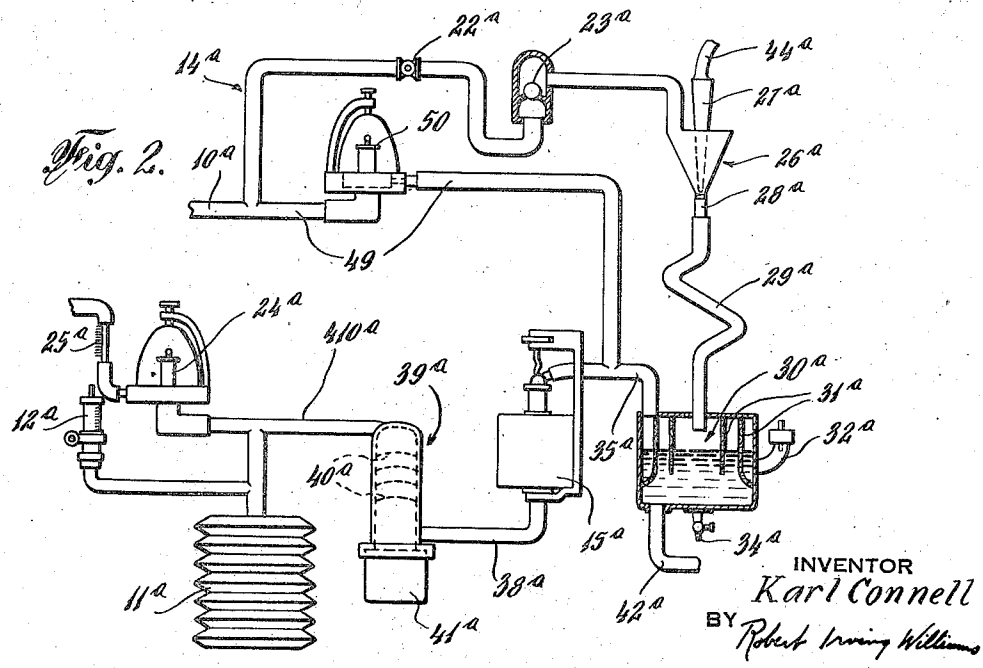


Fig. 2.



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Fig. 3.

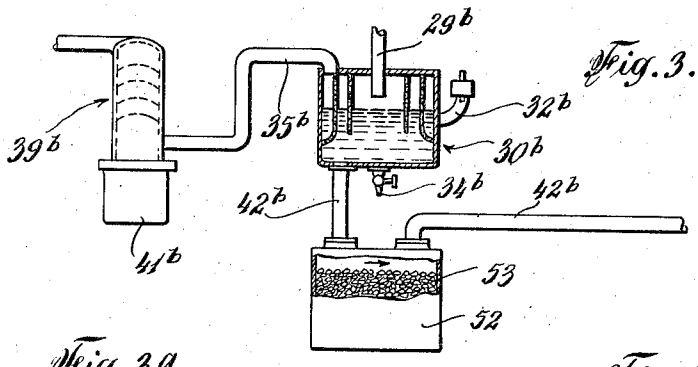


Fig. 3a.

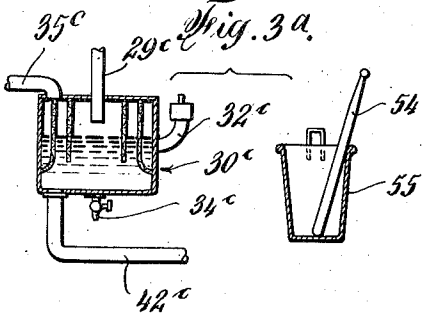


Fig. 3b.

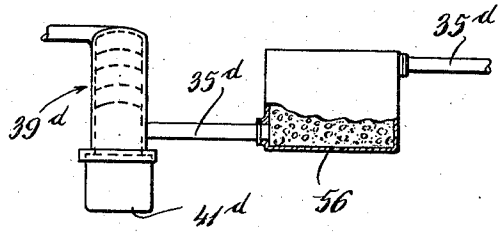


Fig. 4.

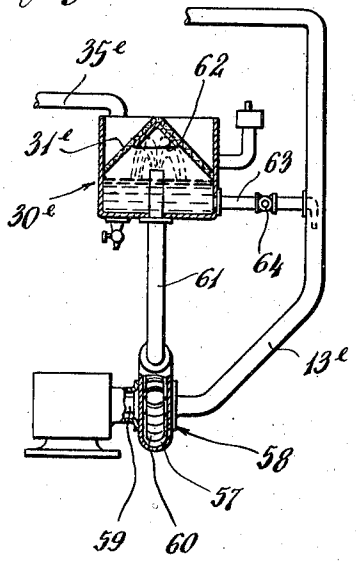


Fig. 5.

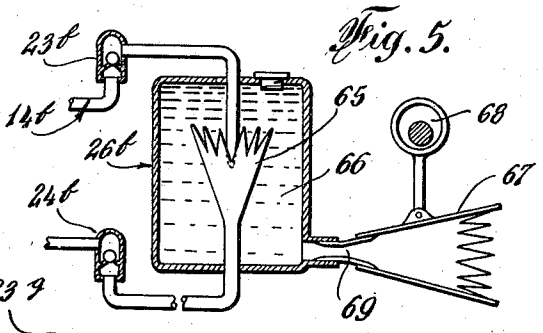
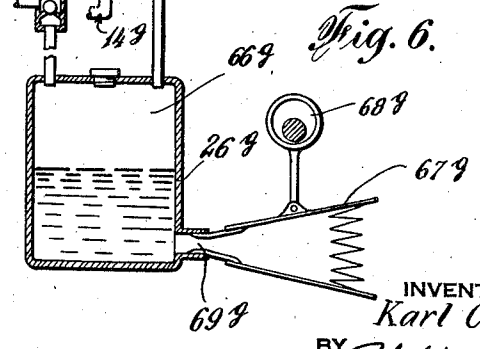


Fig. 6.



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UNITED STATES PATENT OFFICE

2,251,986

APPARATUS AND METHOD FOR THE ADMINISTRATION OF GASES

Karl Connell, Branch, N. Y., assignor to Air Reduction Company, Incorporated, a corporation of New York

Application May 7, 1938, Serial No. 206,506

4 Claims. (Cl. 128—191)

This invention relates to apparatus and methods for the administration of gases, such for instance as utilized for anesthesia and for various therapeutic purposes.

An object of the invention is the provision of anesthetic apparatus and apparatus of similar nature which is simple in construction, and effective and economical in operation, and wherein a desired gas movement may be safely maintained independently of the act of breathing.

A more specific object is the provision of efficient and effective gas-movement-causing means of such character that the gas will not be subjected to explosive tendencies.

A further object is the provision of improved means whereby gas in a closed breathing system may be treated, as for the reduction of the carbon-dioxide content thereof.

An additional object is the provision of improved methods utilizable in the art of administering a gas.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

In the administration of anesthetic and other therapeutic gases, great economies are effected by the use of a closed breathing system. In such systems, however, there is a tendency for the amount of carbon dioxide in the confined gas to build up to the point where it undesirably stimulates breathing; and, accordingly, means are commonly provided to eliminate a suitable proportion of the carbon dioxide. Such means usually comprise a canister containing an absorption agent (ordinarily soda-lime granules) inserted in a conduit thru which the gas is caused to move. Commonly the breathing effort itself is relied on to cause movement of the gas thru the absorption means. This results in imposing on the patient additional effort to overcome the resistance of the absorption means. In a to-and-fro system, this resistance must be overcome twice during each breathing cycle, and, in addition, there is sometimes a tendency for the caustic dust from the soda-lime to reach the patient and to be inhaled, and also the presence of the heat and bulk of the soda-lime near the patient's face is disadvantageous. When a breathing circuit is employed, the resistance of the soda-lime is supplemented by the resistance of the channels composing the circuit, and also the inertia of the air and of the valves employed is weighted onto the patient. The normal volume of tidal breathing is about 6 to 8 liters per minute, and the usual resistance in the absorption means, connecting tubes, flutter valves, etc., in a correctly designed apparatus, is upward of 1 mm. of mercury. The resistance rises greatly under abnormal conditions, such as exaggerated breathing and various other factors. It is highly desirable that effort be lifted from the patient, especially in debilitated and in deeply anesthetized subjects. However, the anesthetic gases most commonly employed, such as ether, ethylene, and cyclopropane, are combustible, and with the admixture of oxygen are highly sensitive to ignition and tend to ignite with explosive violence. Accordingly, proposals for the utilization of ordinary mechanical means, such as used for the circulation of gas in oxygen tents for the treatment of pneumonia, to provide the desirable gas movement thru an absorptive agent or other gas-conditioning means are unsatisfactory due to the generation of static, the thermal effects of sudden compression, the danger of sparking from rapidly moving metallic parts, and from friction and the proximity of electric motors.

With the foregoing and other considerations in view, the present invention contemplates the provision of apparatus for the administration of gases comprising a closed breathing system and means for conditioning and causing movement of a gas, and including liquid-utilizing gas-movement-causing means; and in certain of its aspects contemplates the provision of various interrelated features and procedures whereby a gas may be desirably and safely moved and/or treated without undue effort on the part of the patient.

The invention accordingly comprises the features of construction, combinations of elements and arrangement of parts, and the several steps and the relation and order of one or more of such steps with respect to each of the others thereof, all of which will be exemplified hereinafter and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

Figure 1 is a somewhat diagrammatic side view of one form of apparatus embodying the invention;

Fig. 2 is a fragmentary view corresponding to a portion of the apparatus of Fig. 1 and illustrating a modification;

Fig. 3 is a fragmentary view corresponding to a portion of the apparatus of Fig. 1 and illustrating another modification;

Fig. 3*a* illustrates a modification of a portion of the apparatus shown in Fig. 3;

Fig. 3*b* illustrates a modification of another portion of this apparatus;

Fig. 4 is a fragmentary view corresponding to a portion of the apparatus of Fig. 1 and illustrating still another modification;

Fig. 5 is a fragmentary view corresponding to a portion of the apparatus of Fig. 1 and illustrating an additional modification; and

Fig. 6 is a similar view illustrating another modification.

The invention as considered from an apparatus standpoint will be described in connection with the particularly exemplified embodiments of the invention illustrated in the drawings, and the invention as considered from a method standpoint will be exemplified in connection with such description.

The form of apparatus exemplified in Fig. 1 comprises a breathing member, in the form of a mask 6, and a connector element 7 having branches 8 and 9, all of which as exemplified are similar to the corresponding elements disclosed in my Patent No. 2,099,841, issued November 23, 1937. From the branch 8 a conduit 10 leads to an expansible reservoir bag 11, equipped with a blow-off valve 12. From the interior of the bag 11 there extends a tube 13 forming a part of a circuit 14 which, in the present instance, includes an absorption means in the form of a soda-lime canister 15, and apparatus including gas-movement-causing means hereinafter to be described, as well as the branch 8, conduit 10, the interior of the bag 11, and a conduit 16 leading to the branch 9.

From the conduit 16 there extends, in the present instance, a branch 17 thru which anesthetic gas is introduced into the system from tanks 18 thru the medium of decompression valves 19, gage tubes 20, and sub-branches 21. In the present instance, the flow gages embodying the gage tube 20 are of a character such as exemplified in my Patent No. 1,965,333, issued July 3, 1934. In the circuit 14, there is provided, in the present instance, a control valve 22, check valves 23 and 24, and a flow gage 25 which is of a character such as exemplified in my said Patent No. 1,965,333.

Included in the circuit 14 is an injector pump 26 of the Bunsen type which includes a nozzle 27 adapted to eject water in a direction toward the absorption means 15 and into a restricted orifice 28, wherein the liquid and gas are intermixed, intermixture continuing in a passageway 29 which leads to a separating chamber 30 containing separating screens 31 of suitable wire mesh or perforated material. An intimate and extensive mixing is secured. A vent 32 provides a means for supplying water. The normal level of the water is indicated at 33. A drain-cock 34 permits the water to be emptied. A conduit portion 35 leads to a bore 36, in a movable bracket 37; and the bore 36 opens into one end of the canister 15, which may be removed and replaced upon the movement of the movable bracket 37. From the other side of the canister a tube 38 leads in the present instance to a supplemental separating chamber 39 containing fine screens 40 adapted to catch mist of condensation and to allow it to drip into a removable glass cup 41, it being important under certain conditions, such as connections into the trachea, that no sensible water be carried to the patient. A conduit 410 extends from the chamber 39 to the check valve 24.

The injector pump 26 may, of course, be of any well-known or suitable variation of the exemplified form, and may be adapted for the usual movement of 8 to 16 liters of gas per minute under the usual resistance to circulation of about 4 to 6 mm. of mercury pressure. The pump may be installed in multiple units where the limited viscosity of water renders multiple small-size injectors more economical or effective in operation than a single larger size injector.

While the introduction of water may, in accordance with the invention in its broader aspects, be from any suitable source of water power, and may, in certain instances, continually utilize fresh water, it is advantageous, and ordinarily of considerable importance, that the water be continually reutilized, in order to prevent loss of the anesthetic gas which is dissolved by the water and for other reasons. Accordingly there is provided means in closed continuity with the nozzle and the separating means for causing movement and reutilization of the water. Such means, in the present instance, includes a tube 42 leading to a pump 43, which may be of any suitable type of ordinary centrifugal pump, and a tube 44 leading from the pump to the nozzle 27. The pump 43 is driven from an electric motor 45, which, in the present instance, is completely enclosed so that it may safely be utilized in proximity to the breathing system without danger of penetration of any spilled gas into the interior of the motor, and is magnetically shielded so as to be electrically remote from the breathing system. Suitable cooling means, such as a cooling coil 46 may be associated with the tube 44. In the present instance, the tubes 42 and 44 are interconnected by means of tube 47 embodying an adjustable pressure relief mechanism 48 which permits the motor and the pump to be run at any desirable speed and any water not desired for introduction at the nozzle to be merely circulated past the relief mechanism 48.

By the use of water as the gas-movement-causing means, no static is generated, the slight compression of a gas is made isothermal in a quenching medium without danger of spontaneous combustion, and movement is without friction dangers or the possibility of abrasive sparks thru contact of rapidly moving parts. Aside from causing gas movement, the injection of water has additional advantages in that the gas is chilled and cleaned of circulating particles of sputum and other impurities, and the total water-vapor pressure lessened.

The conduit 10 is substantially resistance-free. If it is of sufficient capacity to contain ⅔ of the exhaled volume and is of sufficiently small bore to prevent substantial mixture of purified gas with exhaled gas during the idle third of the respiratory cycle (see my Patent No. 2,073,192 issued March 9, 1937) then a circulation thru the circuit 14 of eight liters per minute of conditioned air will insure that the inhaled volume will be satisfactorily free from carbon dioxide content. In arrangements wherein a breathing bag, such as 11, approximates the face of the patient, the purified stream from the circuit 14 tends to commingle with the exhaled gas and a rate of circulation (thru the circuit 14) above twelve liters per minute is desirable under usual conditions.

As exemplified in Fig. 1, the apparatus comprises a closed breathing system which is of the to-and-fro type wherein the exhaled gases pass thru the branch 8 and the conduit 10 and into the bag 11, and wherein during inhalation gas may be drawn from the bag 11 back thru the conduit 10, as well as from the pipe 16. Except for the presence of the gas-flow-causing means 26, all gas reinhaled would be drawn back thru the conduit 10. While such an arrangement embodies the invention in its preferred form for many purposes; the invention in other of its aspects is

to be adapted to be embodied in a form of construction comprising a breathing circuit, such for example as that exemplified in my said Patent No. 2,099,841.

One form of construction of this type is exemplified in Fig. 2, only so much of the apparatus as differs from the apparatus of Fig. 1 being shown. Similar parts are indicated by similar reference numerals distinguished by the subscript *a*. In this form of construction, the breathing bag **11***a* instead of being disposed at the end of the conduit **10** is connected to the conduit **410***a*, and the check valve **24** is replaced by a flutter-valve construction **24***a* which may be similar to that exemplified in my said Patent No. 2,099,841. The portion of the circuit **14***a* which extends from the conduit **10***a* to the conduit **35***a* is similar to the corresponding portion of the circuit **14** of Fig. 1. By-passing this portion of the circuit, however, there is a conduit **49** extending from the end of the conduit **10***a* to the conduit **35***a* and including a flutter-valve arrangement **50** similar to the flutter-valve arrangement **24***a* and arranged to permit gas movement on exhalation in a direction similar to the direction in which gas is moved thru the circuit **14***a* by the gas-movement-causing means **26***a*. There is thus provided an arrangement similar to the arrangement illustrated in my said Patent No. 2,099,841, but wherein circulation thru the absorption means may be carried on by the gas-movement-causing means independent of or supplementary to the movement resulting from the force of breathing. While the gas-movement-causing means of Fig. 2 is exemplified as by-passing the valve **50** in the circuit thru which gas is adapted to move in response to the patient's breathing, the gas-movement-causing means may be disposed to connect other suitable portions of the circuit, as for example, to connect the conduit **410***a* with the conduit which extends from the valve construction **24***a* to the gage **25***a*, so as to by-pass the valve construction **24***a* of Fig. 2.

While in certain of its aspects the invention contemplates the provision of gas-movement-causing means for assisting or inducing gas flow thru an absorption means, the invention in other of its aspects contemplates the provision of liquid-utilizing means wherein the liquid utilized to cause gas-movement contains an absorbent chemical, For example, caustic soda or caustic potash may be employed; suitable means, such for instance as a canister filled with small glass balls or with neutralizant granules, being preferably utilized thereafter to assure that all sensible mist will be eliminated from the gas before it reaches the patient. The presence of such means may be avoided in such instances by the use of relatively non-irritating chemicals, as for instance bismuth hydrate; it being appreciated that various types of chemicals suitable for uses in particular instances may be employed in accordance with the invention. In some instances, pulverized soda-lime may be employed.

In Fig. 3, there is exemplified one form of arrangement embodying this feature of the invention. In this form of construction the parts not particularly exemplified may be similar to those shown in the other figures, and, as particularly illustrated, the portion shown is adapted to be utilized in the form of construction shown in Fig. 1. Similar parts are designated by similar reference numerals distinguished by the subscript *b*. In the form of construction of Fig. 3, the conduit **35***b* leads directly from the separating chamber **30***b* to the mist-removing chamber **39***b*, no soda-lime canister being provided. The tube **42***b* is enlarged at one portion to include a removable portion providing a chamber **52** which is filled with a suitable chemical shown at **53**. The operation of the liquid-circulating pump (such as **43**) causes the water to flow over the chemical in the container **52** and to dissolve or otherwise embody the same, so that gas moving past the injector nozzle and thru the passageway **29***b* will be subjected to the action of the chemical in the water to cause the absorption of carbon dioxide thereby.

In accordance with the invention in its broader aspects the chemical may be mixed with the water in any suitable manner, as for instance by a stirrer **54** in a bucket **55** as shown in Fig. 3*a*, the water being introduced into the water-circulating unit thru the vent **32***c*, or otherwise, and being removed, as thru the drain-cock **34***c*, when the absorptive action of the chemical has undesirably diminished.

In certain instances, such for instance as above indicated, it is desirable that the treated gas be subjected to the action of means which will serve with particular effectiveness to eliminate chemical-laden moisture from the gas before it reaches the patient. In Fig. 3*b* there is exemplified an arrangement wherein there is provided a supplemental eliminating means, exemplified as a canister **56** which may desirably contain granules of a chemical which will serve as both an eliminator for the mist and a neutralizant for the alkali. As exemplified, this canister is inserted in the tube **35***d* which extends from the separating chamber **30***d*. It may, of course, be otherwise suitably provided, as for instance being mounted similarly to the canister **15** or being inserted in place of the chamber **39**, or at a suitable point in the circuit beyond this chamber.

In certain instances liquid-utilizing mechanical means may be employed to cause gas-flow and/or mixing of a liquid with the gas. One such form of construction is exemplified at Fig. 4 wherein parts similar to those of Fig. 1 are designated by similar reference numerals distinguished by subscript *e*. In this form of construction there is provided a mixing pump, over the parts of which water is continuously flowing. In the form of construction particularly exemplified, a tube **13***e* leads to the chamber **57** of a centrifugal pump **58** comprising a rotor **59** having blades **60**, the rotating unit being free-running within the chamber. The chamber is provided with an outlet thru which the blades drive water, and from which a pipe **61** leads to the separating chamber **30***e* containing a baffle **62** and water-eliminating screens **31***e*. A pipe **63**, having a control valve **64**, leads from the bottom of the separating chamber to the pipe **13***e*, so that water from the separating chamber will flow back into the chamber **57** wherein water and gas are intimately and extensively mixed and forced into the separating chamber, whence the gas moves out thru the pipe **35***e*.

In certain cases, liquid-utilizing gas-movement-causing means which have no substantial mixing action may be employed. In accordance with the invention such means may embody propulsion means which are suitably safe-guarded by the presence of water or other liquid. In Fig. 5, there is exemplified one such form of arrangement which may, in certain instances, be substituted for other types of gas-movement-causing means previously exemplified. The gas-move-

ment-causing means 26f of Fig. 5 comprises an expansile contractile chamber particularly exemplified as wet-leather bellows 65, the interior of which forms a portion of the circuit 14f. The bellows 65 is disposed in a chamber 66 having rigid walls.

Water or other fluid is intermittently introduced thru and withdrawn from the chamber 66 by suitable reciprocal motive means, such as bellows 67 operated by a cam construction 68 and acting to move fluid to and fro thru a channel 69 to exert alternating pressure and suction on the wet-leather bellows 65, thus providing a source of fluid power. The movement of the bellows 65 causes gas movement thru the conduit, the direction of this movement being determined by the valves 23f and 24f.

In Fig. 6 there is exemplified another form of propulsion means of somewhat similar construction. In this form, mechanical means corresponding to the bellows means 65 is omitted, the water or other liquid utilized effecting the propulsion action directly. In the present instance a bellows 67g operated by a cam construction 68g alternately drives water or other liquid thru a channel 69g in a chamber 66g which forms a part of the circuit 14g. As the level of the water rises in the chamber 66g gas will be expelled therefrom, and as the level of the water falls gas will be drawn into it. The valves 23g and 24g serve to assure gas movement in the proper direction in response to the expulsion of gas from the chamber and the suction of gas into it.

Gas-movement-causing means such as exemplified in Figs. 5 and 6 may desirably be employed in pairs, each unit being a part of the circuit such as 14f or 14g, as the case may be, and the units being arranged in parallel with the action of the units so coordinated that the flow of gas in the circuit 14f or 14g will be substantially continuous. For example, the cam construction 68g of one unit may be arranged to compress its bellows 67g while the cam construction 68g in a successive unit is lifting its bellows 67g. The path of gas flow thru the circuit 14g will in this arrangement be divided into branches before entering the units, one branch going to each unit, and will be brought together again after leaving the individual units thru individual branches; suitable means being provided to prevent gas from flowing back and forth between the units, as for instance by inserting valves of the type of the valves 23 and 24 in the inlet and outlet branches of each unit.

It is to be noted that the invention not only serves to relieve the patient of breathing effort, but also permits the absorption of carbon dioxide or other treating effect to be increased above that which would ordinarily be obtained when breathing alone is relied on to cause gas-movement.

As will be appreciated, while only one type of gas-movement-causing means will ordinarily be utilized with any given apparatus, and while the arrangement of Fig. 3, whether utilized as indicated or as modified, will ordinarily only be utilized in connection with means wherein water is mixed with the gas, as in Figs. 1, 2 and 4; the various modifications exemplified may be utilized in various combinations, and, in particular, the modifications exemplified in the various figures may be advantageously embodied, except ordinarily, as above indicated, in apparatus such as shown in Fig. 1 or in apparatus such as that of Fig. 1 as modified in accordance with showings of one or the other of the figures, and either an arrangement such as shown in Fig. 3*a* or one such as shown in Fig. 3*b*, or both, may be substituted for the corresponding portion shown in Fig. 3, without departing from the invention in at least certain of its various aspects. It is to be understood that the terms "gas," "gases," and the like are used herein generically to include various types of gas regardless of whether the particular gaseous medium employed in a particular instance consists of a single chemical element or of a mixture of a plurality of chemical elements.

Since certain changes may be made in the constructions set forth and in carrying out the above method, and different embodiments of the invention may be provided without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which as a matter of language might be said to fall therebetween.

I claim:

1. Apparatus for the administration of gases, comprising a closed breathing system, a liquid-circuit, a conduit common to said breathing system and said liquid-circuit, injector means included in said liquid-circuit and adapted to discharge liquid into said conduit in a direction which will cause gas movement therethru, means to propel liquid thru said liquid-circuit, and means for associating said liquid with an absorbent chemical during its movement thru said liquid-circuit.

2. Apparatus for the administration of gases, comprising means providing a closed breathing system, a circuit forming at least a part of said system, means to introduce water into a portion of said circuit so as to propel gas thru said circuit, means to remove the water from the said circuit, means to associate an absorptive agent with the water, means to conduct said water from said removing means to said associating means and from said associating means to said introducing means, and means to propel said water thru said conducting means for the re-utilization of said water, and means to empty and refresh the water.

3. In the art of administering gas, a method of removing carbon dioxide from gas breathed by a patient which comprises injecting into a circuit forming at least a part of a closed breathing system and in a direction which will cause gas-flow therethru a liquid which contains an absorbent chemical.

4. In the art of administering a gas, the method of removing carbon dioxide from gas breathed by a patient which comprises injecting into a portion of a breathing system and in a direction which will cause gas-flow therein a liquid which contains an absorbent chemical, removing the liquid from said portion, associating additional chemical with said liquid, and reinjecting said liquid into said portion.

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