May 7, 1946. J. KREISELMAN 2,399,643

RESUSCITATOR

Filed April 10, 1943 2 Sheets-Sheet 1

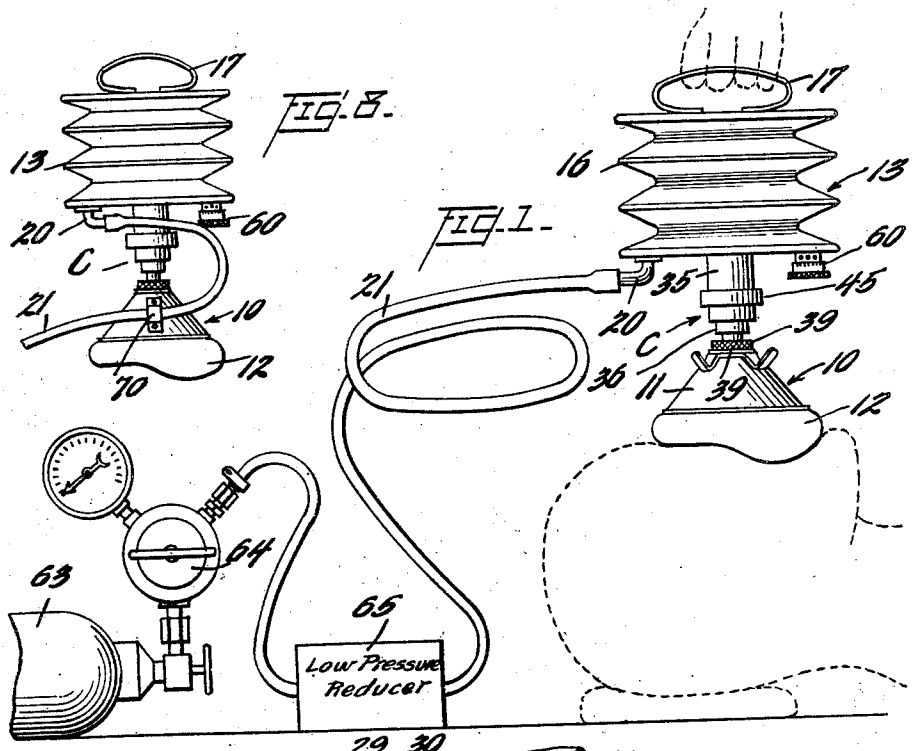

FIG. 3.

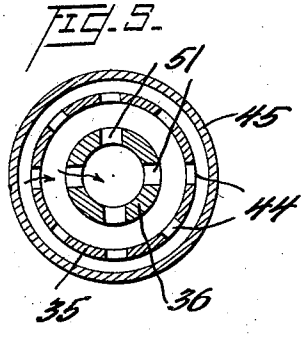

FIG. 1.

FIG. 2.

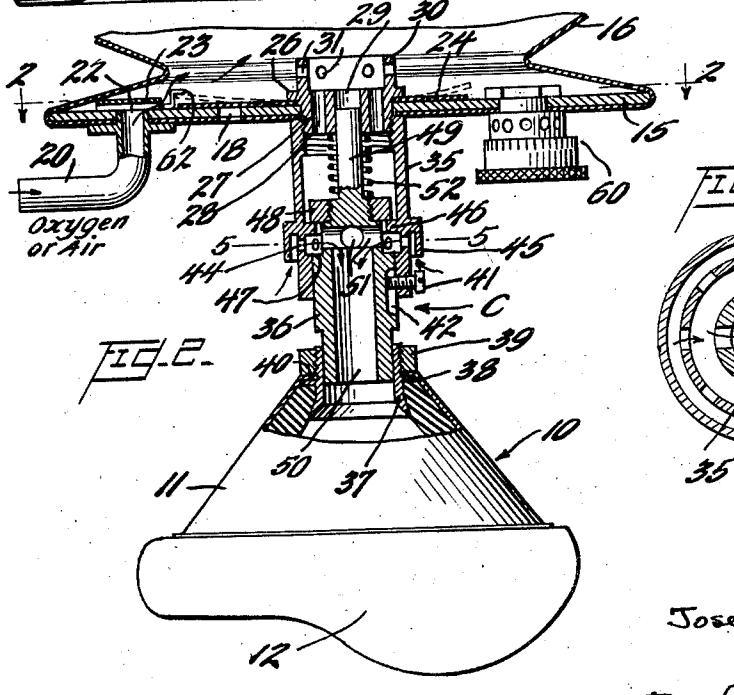

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FIG. 3.

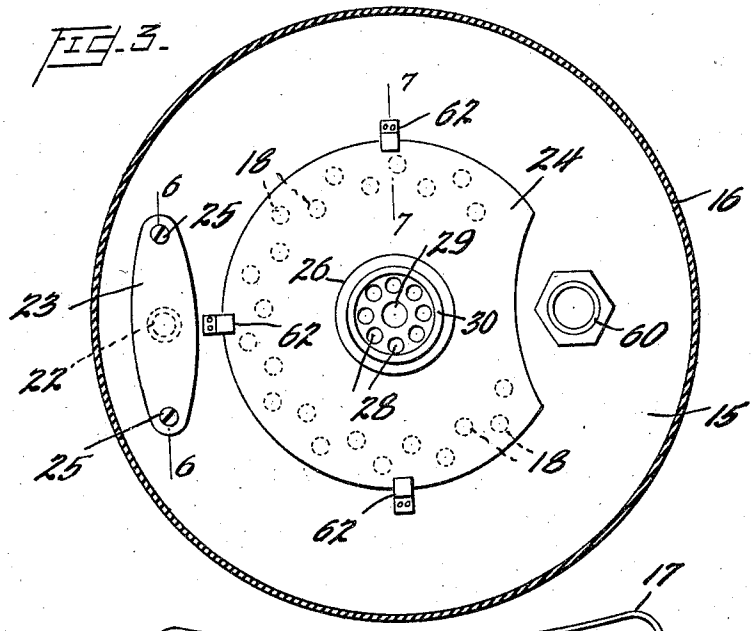


FIG. 4.

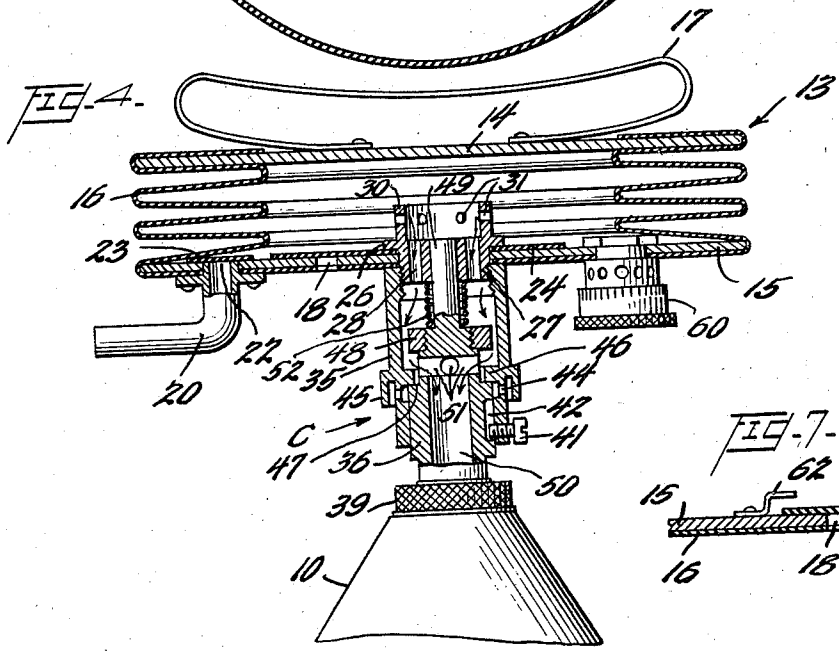
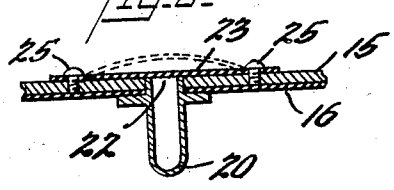


FIG. 7.

FIG. 6.



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2,399,643

RESUSCITATOR

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Application April 10, 1943, Serial No. 482,635

15 Claims. (Cl. 128—29)

This invention relates to apparatus for resuscitation.

Apparatus suitable for use in the resuscitation of persons who have temporarily ceased to breathe has long been known and successfully employed. It is, of course, preferable that oxygen be administered in effecting resuscitation and those instrumentalities for resuscitation which have heretofore been most commonly employed have included means for introducing into the lungs of a patient a current of oxygen under the necessary low pressure. Oxygen is, of course, commonly supplied in transportable containers or flasks, but numerous instances have arisen in which oxygen under pressure has not been available thus making it impossible for one in possession of the apparatus, and having full knowledge of its construction and manner of use, to apply it in the relief of a patient requiring resuscitation.

A primary object of the present invention, therefore, is to provide a resuscitation apparatus of the readily portable type which, while eminently suitable for use in the introduction into the lungs of a patient of a current of oxygen or other gas received from a container or flask in which it is stored under pressure, may likewise be employed to effect the introduction of atmospheric air into the patient's lungs with equal facility. Having in mind the fact that air under atmospheric pressure is universally available the improved apparatus is so designed that it may be instantly applied to a patient who needs resuscitation at any time, quite regardless of whether or not a supply of oxygen is available. Recognizing the desirability of using oxygen, however, whenever oxygen is actually available, the apparatus is so constructed that it may be used to supply oxygen under the close control of the operator, or a mixture of air and oxygen if desired, or air alone as previously stated, no means being provided or necessary to effect the changeover from air to oxygen or from oxygen to air, oxygen being forced into the patient's lungs so long as available and air thereafter, the changeover being automatically effected, manipulation of valves etc., being unnecessary, a feature of great practical importance in those cases, which are many, where the apparatus is to be used under conditions which are far from ideal, as where a skilled operator may or may not be present and a supply of oxygen may or may not be available.

In effecting resuscitation of a patient who has ceased to breathe it is essential that the lungs of the patient be maintained at all times either in free communication with the atmosphere or in communication with an incoming source of air or oxygen under sufficient pressure to effect lung inflation. At no time should the resuscitation apparatus oppose an effort of the patient to breathe naturally and, of course, the instant of commencement of natural breathing is not predictable. It is also important to provide a resuscitation apparatus with means to insure that gases exhaled by the patient are delivered into the atmosphere and not back into the reservoir from which the oxygen is delivered or into the line of communication between the lungs of the patient and such reservoir.

A properly designed resuscitation apparatus must also be of such character that it may be maintained in operative position for sometime after the patient resumes respiration. A reviving patient breathes irregularly and feebly and, of course, may discontinue breathing at any moment. The resuscitation apparatus should, therefore, not only be of such character that it may be kept in position during the initial efforts of the patient to breathe naturally, without impeding such efforts, but should be in condition for instant use either to assist the patient in his own efforts or to resume artificial respiration at once in the event that the efforts of the patient are discontinued.

In accordance with the present invention an apparatus of very simple nature, inexpensive to construct, light in weight, and readily portable, and altogether suitable for use either in the field or the hospital, is provided. Essentially the apparatus comprises an expansible and contractible chamber which, broadly speaking, is a gas pump, having gas inlet ports equipped with non-return valves and a gas outlet port, together with a face-piece to fit over and around the nose and mouth of a patient, and a conduit of novel character leading from the gas discharge port of the contractible and expansible chamber to the face-piece. The conduit is constructed in such manner that it comprises valve means for controlling the flow of gas from the chamber to the face-piece and the flow of gas from the face-piece to the atmosphere, a resilient element being included which normally acts to position the valve means to insure communication between the face-piece and the outside atmosphere. The action of this resilient element, however, is overcome when a relatively light pressure is applied to the contractible and expansible chamber, tending to move the upper chamber wall toward the

face-piece, permitting the valve parts to assume such positions that communication between the face-piece and the atmosphere is interrupted or cut off, and communication between the contractible and expansible chamber and the face-piece established. The yielding element referred to is, however, immediately effective to reestablish communication between the face-piece and the atmosphere, and cut off communication between the face-piece and the gas supply chamber, as soon as the operator ceases to press downwardly upon the chamber wall. The apparatus, therefore, fulfills all theoretical requirements. The patient's lungs are in communication with the gas pumping chamber only so long as that chamber is being utilized to force air into the lungs of the patient. As soon as the chamber ceases to be so used the patient's lungs are immediately brought into communication with the atmosphere so that gases previously forced in may be naturally exhaled and, so that, should the patient commence to breathe naturally, and inhale of his own accord, he may draw into his lungs, from the atmosphere, a current of air through a relatively short conduit.

If oxygen under pressure is available the oxygen source may be connected to the expansible and contractible chamber by any suitable duct or conduit, such as a flexible tube. The port through which the oxygen enters the chamber is likewise provided with a non-return valve, primarily intended to prevent escape of gas through this port upon contraction of the chamber when no oxygen supply is available. In operation with a sufficient supply of oxygen under pressure, and in the event that it is desired to utilize oxygen unmixed with air, the chamber is not expanded by a force applied by the operator but is simply allowed to expand naturally under the influence of the inflowing oxygen. It is, however, contracted by a manually applied downwardly directed force to effect the movement of the desired quantity of oxygen into the lungs of a patient. When the gas being employed is air the chamber will be both expanded and contracted by manually applied force to deliver intermittent gaseous currents into the lungs of the patient.

Naturally it is possible to devise various types of apparatus for performing the functions stated and achieving the results desired. In the accompanying drawings, and in the following detailed description, a preferred form of such apparatus is disclosed by way of example. It will be understood, however, that the design and arrangement of the component elements of the disclosed apparatus may be substantially varied without departing from the invention, in adopting the invention for various special uses.

In the drawings:

Figure 1 is a rather diagrammatic view showing the apparatus in side elevation as applied to a patient, the apparatus including an attached oxygen supply means;

Figure 2 is an illustration, partially in side elevation and partially in section, of portion of the apparatus, including the face-piece, part of the contractible and expansible chamber, and interconnecting valve equipped gas conduit, the valve parts being shown in the positions which they normally occupy, due to the action of the resilient element or spring;

Figure 3 is a section on line 3—3 of Figure 2;

Figure 4 is a view similar to Figure 2, but showing the gas chamber in partially contracted condition and the valve parts in positions different from those in which they are shown in Figure 2;

Figure 5 is a section on line 5—5 of Figure 2;

Figure 6 is a section on line 6—6 of Figure 3;

Figure 7 is a section on line 7—7 of Figure 3; and

Figure 8 is a side elevation of a slightly modified form of apparatus.

The face-piece is generally indicated at 10 and it will be understood that this element of the apparatus may be varied as conditions will require insofar as its details of construction are concerned. Preferably it includes a frusto-conical metal base member 11 provided with a face-engaging part 12, preferably of rubber or other resilient material and the continuous lower edge of which is adapted to engage the face of a patient and to encircle his nose and mouth. The expansible and contractible chamber is generally indicated at 13 and comprises essentially two parallel discs 14 and 15, respectively, together with an intermediate bellows-like wall circular in cross section, indicated at 16, this wall being fabricated of some gas-tight flexible material such for instance as rubber so that the chamber may be expanded or enlarged by separating the heads 14 and 15, or contracted by moving these heads together, the chamber being shown in its expanded condition in Figures 1 and 2 and in partially contracted position in Figure 4. A handle member 17 affixed to the upper disc 14 enables the operator to raise and lower the upper disc 14 manually, as he may desire, the face-piece being retained in position during such movements. The lower disc 15 of the chamber is provided with gas inlet and discharge ports while the upper disc 14 and the flexible wall 16 are imperforate.

The ports 18, of which there may be a substantial number, as indicated in Figure 3, permit the inflow of atmospheric air into the chamber when the discs 14 and 15 are moved apart. A second port, spaced outwardly of the circular series of ports 18, receives the upper end of a short tubular member 20 to which the end of a flexible oxygen conduit 21 may be attached, the upper end of this tube defining, in effect, a port 22 through which oxygen may pass into chamber 13. Non-return valves are provided for both the single oxygen inlet port 22 and the series of air inlet ports 18, these valves being preferably simple flap valves such as indicated at 23 and 24, respectively. Valve 23 which overlies port 22 comprises, in the form of the invention shown, an elongated piece of sheet rubber the ends of which are attached to the disc 15 by screws 25 or other suitable securing devices. The valve 24 likewise conveniently comprises a rubber sheet, substantially annular in shape as shown in Figure 3. The circular inner margin of this sheet is securely clamped between the upper face of disc 15 and the clamping flange 26 of a cylindrical member 27 which passes through and closely fits within an axial circular opening formed in the head 15. The gas discharge apertures of the chamber are formed in member 27, these apertures or ducts 28 being preferably arranged in a circular series about a central cylindrical aperture 29 extending axially of member 27. The tubular prolongation 30 of member 27 extends upwardly of disc 15 and comprises a stop limiting the movement of disc 14 toward disc 15, this extension 30 being provided with a plurality of annular ports 31 in its wall to assure communication at all times between ports 28 and the interior of chamber 13, even

though the lower face of disc 14 be moved downwardly into close engagement with the upper end of stop member 30.

That portion of the cylindrical member 27 which projects below the lower disc 15 of chamber 13 is exteriorly threaded to receive the interiorly threaded upper end of the conduit, generally indicated at C which connects the chamber 13 and the face-piece, the face-piece being generally indicated at 10. Conduit C comprises two concentric telescoping members, an upper and outer member 35 having threaded connection to the lower end of member 27 as previously described, and an inner and lower member 36 rigidly connected to the face-piece by any suitable means. The form of connection between member 36 and face-piece 10 which is disclosed includes a sleeve 37 rigidly secured to the lower end of member 36, this sleeve being provided with an annular peripheral outwardly projecting flange 38 and the upper portion being threaded to receive a nut 39. The annular inwardly projecting flange 40 of the metallic shell 11 of the face-piece is clamped between the flange 38 of tubular member 37 and the nut 39.

Members 35 and 36 of the conduit C are relatively slidable axially to a limited extent but are prevented from relative rotation by reason of the provision of a screw 41 which passes through an aperture formed in member 35 and extends into, at all times, a slot 42 formed in the outer face of member 36. Tubular member 35 is provided with an annular series of circular ports 44 opening to the atmosphere, these ports being encircled by a guard 45 which comprises an integral portion of member 35 and which prevents the direct entry of dirt and other solid matter into ports 44 while at all times permitting the free flow of gas through these ports. Member 35 is likewise provided with an internal annular flange 46 the annular upper and lower surfaces of which are adapted to alternately seat against annular surfaces of the inner member 36, flange 46 in reality comprising a single valve member which is adapted to seat against one or the other of two spaced valve seats.

The lower valve seat which valve 46 is adapted to engage is an upwardly facing annular surface 47 of member 36 and the upper seating surface for valve 46 is the annular downwardly facing surface of the cylindrical nut 48 which is threaded onto the base of the axial spindle 49 which comprises an integral portion of the lower member 36 of conduit C. The upper end of spindle 49 is slidably received within the central cylindrical aperture 29 formed in member 27 previously described, cylindrical recess 29 comprising a guide for spindle 49 which assists in maintaining the telescoping parts 35 and 36 of the conduit C in coaxial and freely sliding relationship to each other at all times. The central bore 50 of tubular member 36 is open at its lower end and communicates at its upper end with a plurality of laterally extending ducts or ports 51. A helical compression spring 52 has its upper end in constant engagement with the lower surface of member 27 and its lower end in constant engagement with the upper surface of nut 48 this spring being sufficiently strong to normally maintain valve 46 in close engagement with nut 48, as shown in Figure 2, when the hand of the operator is removed from the chamber 13, the weight of the chamber being insufficient to compress the spring. With the parts in the positions in which they are shown in Figure 2 chamber 13 is not in communication with the face-piece 10 and the interior of the face-piece is in communication with the atmosphere through the series of ports 51 and 44, respectively. With the valve means so positioned gas may be exhaled from the lungs of the patient or, should the patient suddenly inhale, he may draw atmospheric air freely into his lungs.

When pressure is applied to the upper disc 14 of the collapsible chamber by the operator, the lower disc 15 of the chamber will be driven downwardly by the gas pressure upon its upper surface and the helical spring 52 will be compressed. The upper tubular port member 35 of conduit C will slide downwardly relatively to the lower portion 36 of this conduit until the lower face of annular valve 46 comes to rest upon the lower annular seating surface 47 for this valve. When this condition is realized communication between the duct 50 leading to the face-piece and the ports 44 leading to the outer air is interrupted while communication between the interior of the chamber 13 and the interior of the face-piece is established, direct communication between the interior of the chamber 13 and the lungs of the patient being thus brought about so that a current of gas is forced into the patient's lungs. When a sufficient volume of gas has thus been introduced into the patient's lungs the downward movement of the upper disc 14 is halted whereupon the spring 52 will expand, no longer being opposed by the pressure of gas against the upper face of disc 15, the conduit C will be extended to the position in which it is shown in Figure 2, communication between the chamber 13 and the lungs of the patient being again interrupted and communication with the outer air reestablished. This cycle of operations may be continued as long as necessary, the chamber 13 serving as a pump and the valve means associated with the gas conduit C operating automatically and in timed relationship to the pump operations.

In order to safeguard the patient against the sudden introduction into his lungs of an excessive pressure a pressure relief means 60 is associated with the chamber 13. This pressure relief device is of adjustable nature and may be regulated conveniently to prevent the building up in the chamber 13 of a greater than desired pressure. The details of the pressure relief device may be varied widely, comprising no portion of the present invention. The flap or non-return valve 23 associated with the oxygen inlet port will be lifted when the discs 14 and 15 of the chamber 13 are separated, as will likewise be a flap valve 24 of the air ports 18, a possible extreme position of valve 23 being indicated in dotted lines in Figure 6. As it may be necessary to make use of the apparatus with the face-piece 10 below the pump chamber 13 it is desirable to provide means for limiting the movement of the flap valves away from the apertures with which they are associated. The screws 25 serve this function in the case of flap valve 23 and, to limit the movement of the larger flap valve 24 in a direction away from the disc 15 a plurality of bracket devices or limiting stops 62 are provided. The apparatus may be usefully employed quite regardless of the position of the head of the patient although, in the usual case, the patient will face upwardly and the apparatus will be positioned as it is shown in Figure 1.

When oxygen is available the oxygen tube 21 will be connected to the short fixed tube 20 but otherwise this tube will serve as an air inlet sup-

plementary to the air inlet ports 18. Oxygen tube 21 receives oxygen at the desired rate of flow from a source of oxygen which may be a flask 63 in which it is stored under pressures up to 2000 pounds per square inch. Flask 63 is provided with a high pressure reducer 64 and, preferably, between the high pressure reducer 64 and the chamber 13, there is a low pressure reducer such as that diagrammatically illustrated at 65. The low pressure reducer may be so adjusted that the oxygen flowing to the expansible chamber 13 will have a pressure of up to 20 mm. of mercury, averaging perhaps 15 mm. of mercury. This pressure is sufficient to expand the chamber 13 if the operator ceases to apply pressure against its upper wall and hence, when an ample supply is available, the operator will not manually draw the upper and lower discs 14 and 15 apart but will permit the upper disc to be raised by the pressure of the oxygen which freely flows into the chamber. Intermittently the operator will, of course, depress the upper disc 14 to force oxygen into the patient's lungs but after each such depression the disc 14 will be automatically lifted in the manner stated. By manipulating the chamber in this way the air ports 18 remain closed at all times so that pure oxygen only will be forced into the patient's lungs. If it is desired to mix, in the chamber 13, with any gas such as oxygen passing through port 22, some atmospheric air, this can be accomplished by manually elevating the upper wall 14 of the chamber, thus drawing both air and gas from port 22 into the chamber.

Resuscitation with the aid of the apparatus described can be facilitated by the introduction into the mouth of the patient of a tubular member of a type well known and which insures a free airway between the face-piece and the patient's lungs, past the base of the tongue. This tube may be of any conventional type and is not illustrated.

Where there is likelihood that the unsupported weight of the tube depending from the chamber 13 may be so great that the spring 52 will be compressed without the application of manual pressure upon the bellows top, thus causing the lungs of the patient to be inadvertently brought into communication with the chamber 13 and cut off from the outside air at a time when the chamber is not being contracted, special means to support the tube and prevent its weight from being imposed on the spring is provided. For instance, the tube may be clamped to the metallic shell of the face-piece at a point relatively close to the fitting 20, as by a clamping or securing member 70. Only a small part of the weight of the tube is, therefore, transmitted to the chamber 13, and thence to the spring, so that the normal function of the spring in maintaining the duct between the face-piece and the atmosphere open will not be interfered with. That portion of the tube intermediate the clamp 70 and fitting is either curved or longitudinally contractible and expandible so that it will not interfere in any way with the elongation or contraction of conduit C.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. Resuscitation apparatus comprising a face-piece, an expansible and contractible chamber having a port in the wall thereof for the ingress of gas and a second port for the discharge of gas under pressure, valve means associated with said first mentioned port for permitting the inflow of gas when the chamber expands and closing the port to prevent the escape of gas when the chamber contracts, and means associated with said chamber and face-piece for transmitting a current of gas under pressure from said chamber to the face-piece when the chamber is undergoing contraction and for interrupting communication between the face-piece and chamber, and establishing communication between the face-piece and the atmosphere, when the force applied to the chamber wall for the purpose of contracting the same is released.

2. Resuscitation apparatus comprising a face-piece, an expansible and contractible chamber having a port in the wall thereof for the ingress of gas and a second port for the discharge of gas under pressure, valve means associated with said first mentioned port for permitting the inflow of gas when the chamber expands and closing the port to prevent the escape of gas therethrough when the chamber contracts, and means associated with said chamber and face-piece for transmitting a current of gas under pressure from said chamber to the face-piece when the chamber is undergoing contraction and for interrupting communication between the face-piece and chamber, and establishing communication between the face-piece and the atmosphere, when contraction of the chamber ceases, said last mentioned means including a resilient element which normally tends to maintain said means in such condition that the face-piece is in communication with the atmosphere.

3. Resuscitation apparatus comprising a face-piece, an expansible and contractible chamber having a port in the wall thereof for the ingress of gas and a second port for the discharge of gas under pressure, valve means associated with said first mentioned port for permitting the inflow of gas when the chamber expands and closing the port to prevent the escape of gas therethrough when the chamber contracts, and means associated with said chamber and face-piece for transmitting a current of gas under pressure from said chamber to the face-piece when the chamber is undergoing contraction and for interrupting communication between the face-piece and chamber, and establishing communication between the face-piece and the atmosphere, when contraction of the chamber ceases, said last mentioned means including a conduit for leading gas from the chamber to the face-piece and having an aperture in its wall, valve means for controlling the flow of gas through said aperture and through the conduit, and a resilient element normally holding said valve means in such position that gas flow through the conduit is interrupted while gas flow through said apertures is permitted.

4. Resuscitation apparatus comprising a face-piece, an expansible and contractible chamber having a port in the wall thereof for the ingress of gas and a second port for the discharge of gas under pressure, valve means associated with said first mentioned port for permitting the inflow of gas when the chamber expands and closing the port to prevent the escape of gas therethrough when the chamber contracts, and means associated with said chamber and face-piece for transmitting a current of gas under pressure from said chamber to the face-piece when the chamber is undergoing contraction and for interrupting communication between the face-piece and

chamber, and establishing communication between the face-piece and the atmosphere, when contraction of the chamber ceases, said last mentioned means including a telescopic conduit having two coaxial tubular parts relatively movable axially through a predetermined distance, resilient means normally maintaining said conduit extended but permitting its contraction upon the application of axial pressure, and valve means for preventing escape of gas from said chamber through said conduit when the conduit is extended and establishing communication between the face-piece and the atmosphere, and interrupting communication between the face-piece and the atmosphere and establishing communication between the face-piece and the chamber when said conduit is contracted.

5. The combination set forth in claim 4 in which the outer part of the conduit includes a valve with two seating surfaces and the inner part includes two spaced seating surfaces to be alternately engaged by said valve.

6. The combination set forth in claim 1 in which said last mentioned means constitutes the sole connection between the face-piece and chamber and maintains said face-piece and chamber in predetermined relationship.

7. Resuscitation apparatus comprising, a face-piece, a bellows type gas pump, and means associated with said pump and face-piece and maintaining them in approximately fixed relationship at all times with the face-piece in alignment with the direction of movement of the movable wall of the pump, said means transmitting the current of gas discharged from the pump to the face-piece when the movable wall of the bellows is moved toward the face-piece, and bringing the face-piece into communication with the atmosphere when such movement is interrupted.

8. The combination set forth in claim 7 in which the movable wall, which is remote from the face-piece is provided with an operating handle.

9. In a resuscitation apparatus, in combination, an expansible and contractible chamber having a gas discharge port and separate inlet ports for air and oxygen respectively, non-return valves associated with said last mentioned ports for preventing the escape of gas therethrough, a face-piece, and means for conducting gas issuing from said discharge port to said face-piece.

10. The combination set forth in claim 9 in which said chamber is provided with pressure relief means to prevent transmission of gas under excessive pressure to said face-piece.

11. In a resuscitation apparatus, in combination, a bellows type gas pump having relatively movable heads, gas inlet and discharge ports formed in one of said heads, a stop for preventing the other head from so closely engaging the ported head as to prevent gas flow from the inlet to the discharge port, a face-piece, and a conduit for leading gas discharged from the discharge port of the bellows to said face-piece.

12. The combination set forth in claim 1 in which a tube is provided for conducting gas to the chamber from a source of supply, said tube being attached to the said face-piece at a point closely adjacent that end which is attached to the chamber, that portion of the tube intermediate the said point of attachment and the chamber being flexible for the purpose set forth.

13. Resuscitation apparatus comprising a face piece, an expandible and contractible gas chamber, a first duct through which gases pass into or out of the face piece, a second duct in constant communication with the atmosphere, a third duct in constant communication with the gas chamber, and valve means for establishing communication between the first and second ducts and interrupting communication between the first and third ducts when moved to one position, and for establishing communication between the first and third ducts and interrupting communication between the first and second ducts when moved to a second position, said valve means being responsive to relative movement of the face piece and gas chamber.

14. Resuscitation apparatus comprising a face piece, an expandible and contractible gas chamber, a first duct through which gases pass into or out of the face piece, a second duct in constant communication with the atmosphere, a third duct in constant communication with the gas chamber, and valve means for establishing communication between the first and second ducts and interrupting communication between the first and third ducts when moved to one position, and for establishing communication between the first and third ducts and interrupting communication between the first and second ducts when moved to a second position, said valve means being normally positioned to permit communication between said first and second ducts and only establishing communication between the first and third ducts when the gas chamber is subjected to pressure tending to move it toward the face piece.

15. Resuscitation apparatus comprising a face piece, an expandible and contractible gas chamber, a first duct through which gases pass into or out of the face piece, a second duct in constant communication with the atmosphere, a third duct in constant communication with the gas chamber, and valve means for establishing communication between the first and second ducts and interrupting communication between the first and third ducts when moved to one position, and for establishing communication between the first and third ducts and interrupting communication between the first and second ducts when moved to a second position, said valve means including a spring which normally maintains the same in position to permit free communication between the first duct and second duct, said spring being overcome when the gas chamber is pressed toward the face piece so that the first and third ducts are brought into communication, and serving to cut off said third duct and re-establish communication between the first and second ducts when said pressure is discontinued.

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