Oct. 4, 1949.

M. H. GOODNER

2,483,698

RESUSCITATOR

Filed Oct. 24, 1947

3 Sheets-Sheet 1

Fig. 1.

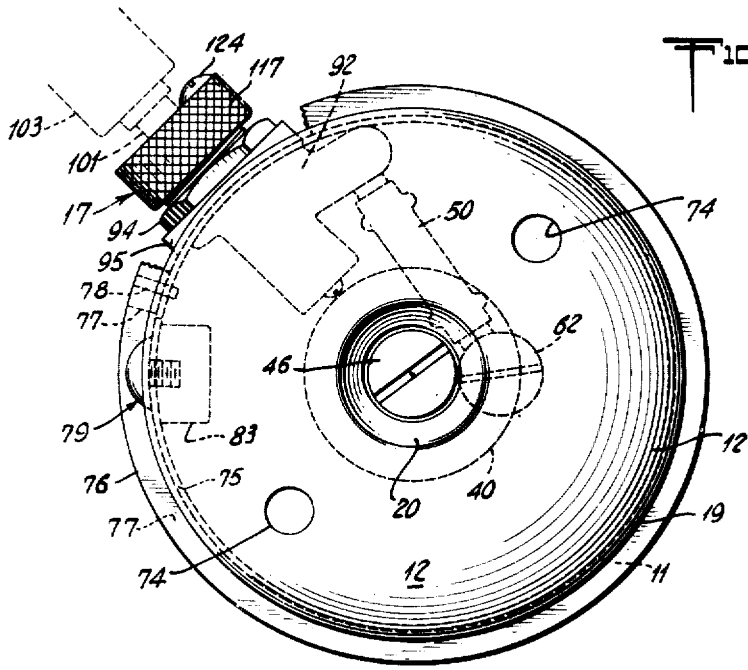
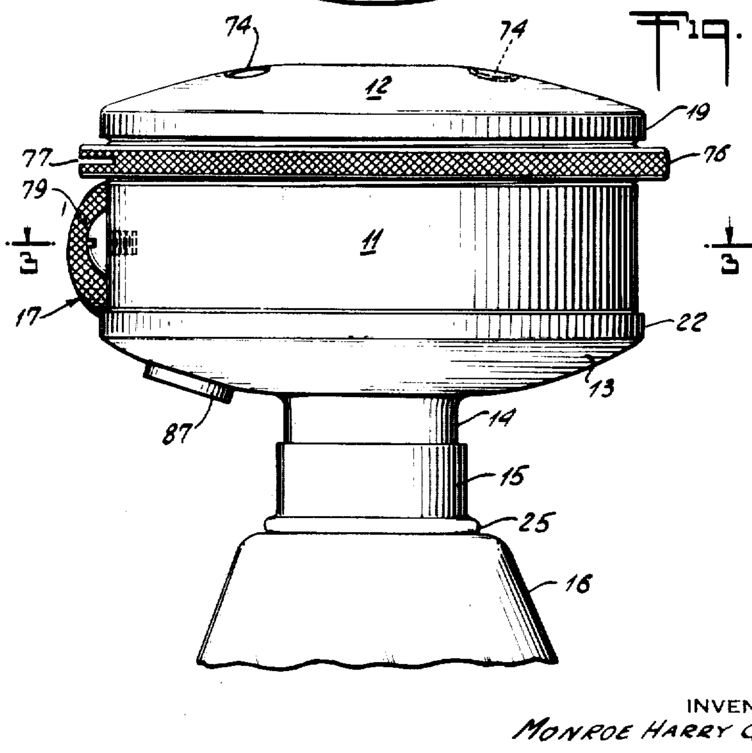


Fig. 2.



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RESUSCITATOR

Fig. 3.

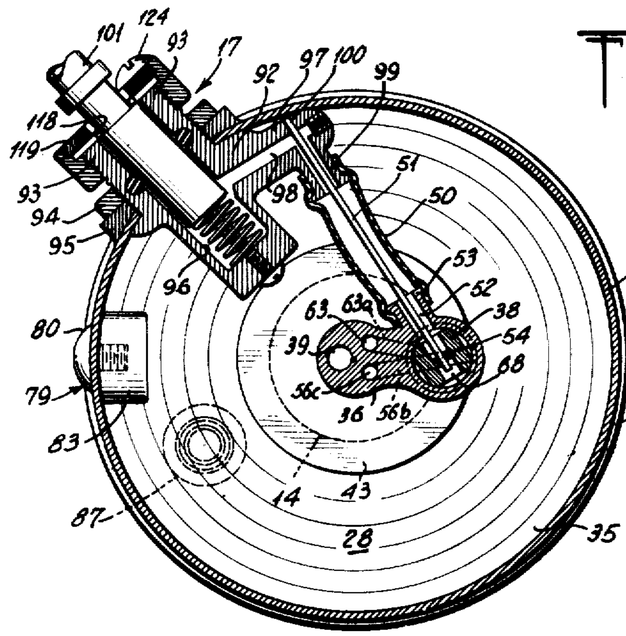
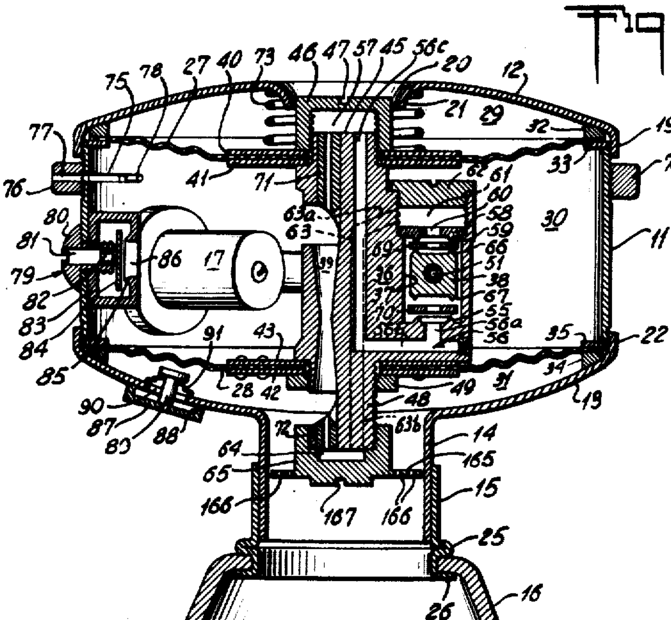


Fig. 4.



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3 Sheets-Sheet 3

Fig. 5.

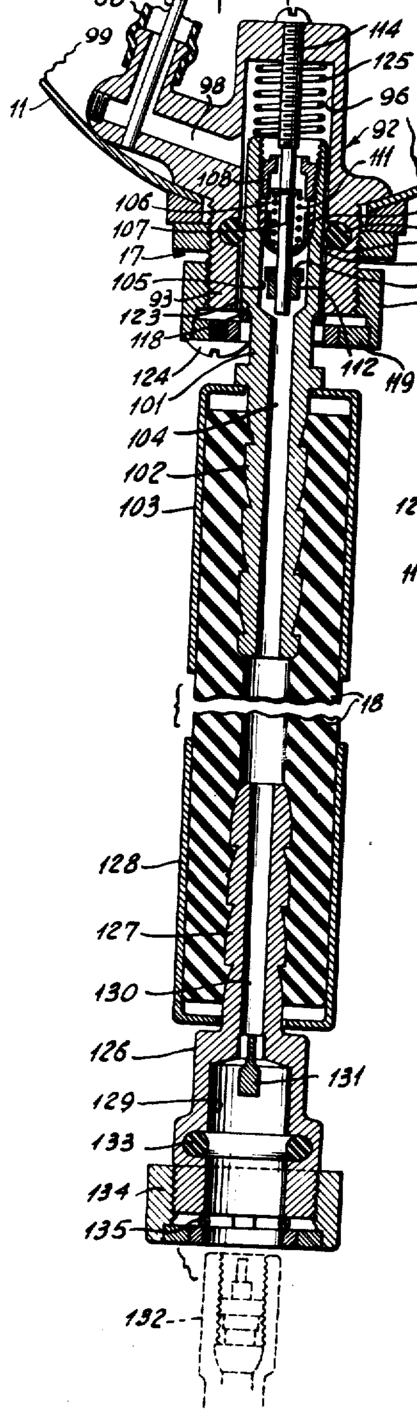


Fig. 7.

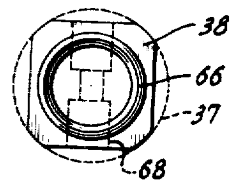


Fig. 8.

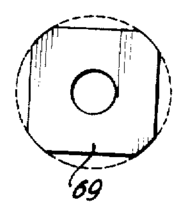


Fig. 10.

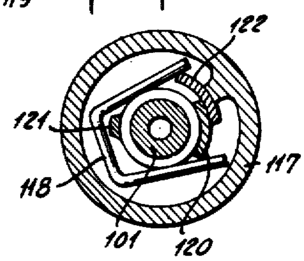


Fig. 9.

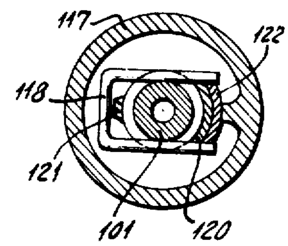
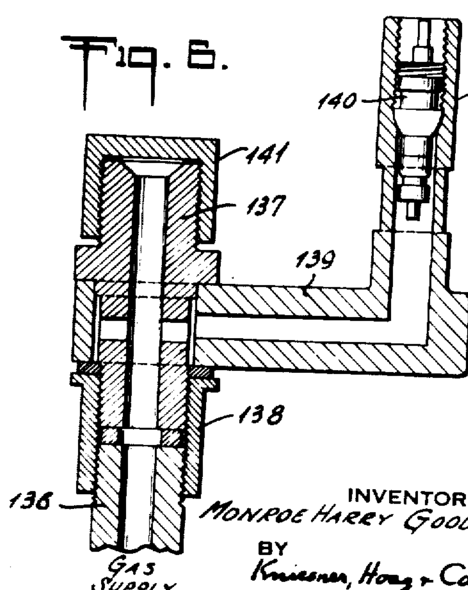


Fig. 6.



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Patented Oct. 4, 1949

2,483,698

UNITED STATES PATENT OFFICE

2,483,698

RESUSCITATOR

Monroe Harry Goodner, Glendale, Calif., assignor to Stephenson Corporation, Red Bank, N. J., a corporation of New Jersey

Application October 24, 1947, Serial No. 781,903

25 Claims. (Cl. 128—29)

This invention relates to artificial breathing devices, and more particularly to resuscitators, inhalators, and the like.

This application is a continuation in part of prior filed co-pending application Serial No. 756,839, for resuscitators, filed June 25, 1947.

An object of the invention is to improve artificial breathing devices and apparatus, and devices for producing artificial respiration. Another object is to improve devices for administering oxygen or other gases to a human being or an animal with the application of pressure variations or alternations to induce artificial respiration or to promote breathing. A further object is to improve devices for administering gas such as oxygen, air, or other gases to facilitate breathing or for other purposes.

An additional object is to provide a compact and portable resuscitator or resuscitator and inhalator device, which may be attached directly to an oxygen mask. A further object is to provide a compact, portable device which is capable of alternately applying positive and negative gas pressures to a patient to induce an artificial action similar to the patient's natural breathing. Another object is to provide a device for use in aiding human beings or animals in instances where breathing is hindered or requires artificial aid or stimulation such as in cases of asphyxiation, caused by accident, sickness, drowning, gas asphyxiation, poliomyelitis, or the like.

A still further object is to provide a device which is capable of use as an inhalator to supply a relatively constant flow of oxygen, air, or other gas to a patient.

Another object is to provide a compact oxygen or gas administering device having means for mixing the gas being administered with another gas, such as air, and for varying or adjusting the proportions of each. A further object is to provide a device for producing artificial respiration and for adjusting or varying the rate or periodicity of such respiration.

Yet another object is to improve artificial breathing and gas administering devices and the parts thereof, such as valves, pressure regulating members, metering devices, gas mixing jets and chambers, control elements, gas conduits and other parts. Other objects of the invention will be apparent from the following description and accompanying drawings taken in connection with the appended claims.

In the accompanying drawings in which are shown by way of illustration several possible embodiments of my invention;

Figure 1 is a top view of a resuscitator and inhalator embodying features of the present invention;

Figure 2 is a side elevation thereof;

Figure 3 is a transverse section taken on the line 3—3 of Figure 2;

Figure 4 is a diametral section of the device taken on the line 4—4 of Figure 1;

Figure 5 is a fragmentary section of the device together with a longitudinal section of a gas supply hose and the coupling members therefor associated with the device;

Figure 6 is a fragmentary section of a gas supply coupling and valve assembly to which the hose coupling of Figure 5 may be connected;

Figure 7 is an end view of a valve closure element comprising part of the device shown in Figures 1 to 4;

Figure 8 is a face view of a pliable washer comprising part of the valve assembly of the device;

Figure 9 is a section on the line 9—9 of Figure 5 showing the details of the locking arrangement for the hose coupling;

Figure 10 is a section similar to that of Figure 9 showing the locking arrangement actuated to permit unlatching of the hose coupling.

While features of the present invention have more general application, the invention has its preferred embodiment in a relatively small, compact, portable device which is preferably arranged for direct connection to a gas administering mask arranged for positioning over a patient's face, or nose and mouth, to administer oxygen, air, or other gas for inducing or promoting respiration, aiding breathing or other purposes. It is obvious, however, that many variations of construction can be made without departing from the invention, such as changes in shape and construction of the parts, the inclusion of a flexible hose or other coupling between the device and the mask, and the elimination of the means to convert the device into an inhalator, where such arrangement is not required.

While a preferred embodiment of the invention is described herein, it is contemplated that considerable variation may be made in the method of procedure and the construction of parts without departing from the spirit of the invention. In the following description and in the claims, parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

Referring to the drawings, the resuscitator and inhalator shown in Figures 1 to 4 comprises, in general, a substantially cylindrical sheet metal casing formed of a short section of sheet metal tubing 11 provided with a pair of generally rounded or dome-shaped ends 12 and 13, the end 13 having its center drawn out into a tubular section 14 which is fitted into a tubular ferrule 15 comprising part of gas administering mask 16. Gas is supplied to the device through a gas inlet coupling assembly 17 to which is coupled a gas supply hose 18 (Figure 5) connected to a source of regulated gas supply. In some instances the device can be of a relatively small size, for example, a resuscitator and inhalator constructed as shown in the drawings has been made having a diameter of only 2½ inches, and weighing eight ounces.

Tubular portion 11 of the casing comprises a short piece of thin-walled tubing externally threaded at each end. While the device may be used in any position, end wall 12 will be described, for convenience, as the top of the device. End wall 12 comprises a dome-shaped pressed sheet metal cap having a cylindrical internally-threaded flange 19 at its outer edge adapted to screw onto the upper end of tubular section 11. A round central opening 20 is provided in top wall 12, the material of the wall bordering on the opening being curved inward to provide a smoothly contoured recess or wall 21.

Bottom wall 13 carries a flange 22 its outer edge formed similarly to flange 19 to screw onto the lower end of tubular casing wall 11 and the center of dome-shaped bottom wall 13 is drawn out to form tubular section 14 of a relatively large diameter projecting axially outward from the unit.

Mask 16 may be of conventional form and construction and may be made, for example, of sheet plastic material moulded or formed into the desired shape to be fitted over a person's face or the nose and mouth regions, and may be provided with a border member of soft rubber, or an inflated rubber ring member, not shown. Ferrule 15 comprises a section of metal tubing which is permanently crimped into the central aperture in the mask as shown in Figure 4 by drawing annular flange 25 around the ferrule at an intermediate point to provide a folded external shoulder for engaging the outer face of the mask and spinning the lower end of ferrule outwardly to provide a second flange 26 which engages the inside face of the mask thereby clamping the ferrule securely in the mask aperture.

A pair of diaphragms comprising an upper diaphragm 27 and a lower diaphragm 28 are clamped in horizontal position within the casing, dividing it horizontally into three chambers, namely an upper chamber 29, a middle chamber 30 and a lower chamber 31. Diaphragms 27 and 28 may be formed of any suitable flexible impervious material such as impregnated cloth, or thin corrugated metal. They are clamped on at their outer circular edges between clamping members 32 and 33, and 34 and 35 respectively, which members in turn are clamped between ends of tubular casing wall 11 and upper and lower end walls 12 and 13. Clamping rings 32 and 34 are provided with beveled surfaces to match the inner dome-shaped faces of end walls 12 and 13 respectively and have their other faces adapted to clamp against the outer faces of the diaphragms. Members 33 and 35 comprise flat ring washers which rest against the ends of tubular casing section 11 and clamp against the inner faces of the diaphragms at their outer edges.

A valve housing 36 is floatingly carried by diaphragms 27 and 28, the valve housing being suspended between the centers of the diaphragms. Housing 36 comprises a metal casting provided with suitable gas passages and a valve cylinder 37 in which a slidable valve closure element 38 is carried. The valve housing 36 also carries a venturi 39 and the valve assembly 37, 38 serves to direct gas through suitable passages in the housing 36 to the venturi for purposes of supplying positive and negative gas pressures to the patient, as will be more fully described.

Diaphragms 27 and 28 each have central apertures and are each clamped in their central areas by a pair of clamping washers or discs. For example, diaphragm 27 is clamped between circular metal washers 40 and 41 which are held against the two faces of the diaphragm and which have central openings registering with the central opening in the diaphragm. Diaphragm 28 is similarly clamped between washers 42 and 43. The upper end of floating valve housing 36 has an external projection 45 which extends through the central aperture provided in diaphragm 27 and clamp washers 40 and 41 and a hollow internally threaded screw cap 46 is screwed onto end 45 thereby clamping the upper end of housing 36 in the central opening in the diaphragm. Hollow screw cap 46 is provided with a screwdriver slot 47 to permit ready assembly. The lower end of housing 36 carries threaded axial projection 48 which extends downward through the central aperture provided in diaphragm 28 and is clamped thereto by clamp nut 49 which is tightened against lower clamp washer 42. An internally threaded lower cap 65 is screwed onto projection 48. Cap 65 has an integral circular flange 165 which extends to within a short distance of the inside wall of tubular portion 14 and is provided with perforations 166 so that the flange protects the inside of the casing from the entrance of foreign particles and still permits free gas passage through and around the flange. A screwdriver slot 167 on cap 65 permits ready removal for cleaning the Venturi passages.

Diaphragms 27 and 28 provide the only support or suspension for floating valve housing 36 but it is connected by a section of flexible rubber or plastic tubing 50 (Figure 3) to gas coupling assembly 17 in order to convey gas from the supply source to the floating valve housing. In addition, a valve control arm 51 comprising a straight piece of spring metal rod is rigidly supported in the casting of gas coupling assembly 17 and extends axially through gas supply tube 50 and the gas passage 52 of gas inlet nipple 53 comprising part of valve housing 36, into cylinder 37 where the end of valve control arm 51 is received in central hole 54 in valve closure element 38, so that element 38 is supported by spring arm 51.

Valve cylinder 37 has its axis parallel to the axis of the device and hence parallel to the direction of motion of floating valve housing 36 as diaphragms 27 and 28 are flexed. Gas inlet passage 52 enters cylinder 37 in the mid-portion of its cylindrical side wall. The bottom wall of cylinder 37 is provided with an annular ridge 55 surrounding gas passage section 56*a* which together with sections 56*b* and 56*c* makes up a gas passage leading from the valve to chamber 57 inside cap 46. A plate 58 carrying an annular ridge 59 similar to ridge 55 is screwed into the internally-threaded upper end of valve cylinder 37 and seats against a shoulder at the lower end of the threaded section to provide a second valve seat. Plate 58 has a central opening 60 leading into a small chamber 61 above the plate which is closed by a screw cap 62 threaded into the top of the cylinder. A gas passage 63 made up of sections 63a and 63b drilled through the casting forming housing 36 extends down to lower end 48 of the casting communicating with a small chamber 64 inside lower cap 65 which is threaded onto the externally-threaded lower end 48 of the casting, as clearly seen in Figure 4.

Valve closure element 38 comprises a sliding metal block of generally rectangular shape having annular ridges 66 and 67 on its upper and lower faces opposing ridges 59 and 55 respectively at the ends of the cylinder. As seen most clearly in Figure 7 the four corners of block 38 are rounded off to provide cylindrical bearing portions which can slide on the inside cylindrical wall of cylinder 37 while still permitting gas to freely pass around the element 38 from gas inlet passage 52. Element 38 is drilled with a central transverse passage 54 which is of reduced diameter at its mid-portion to form a loose socket into which the end of valve control arm 51 extends as seen in Figure 3.

Interposed between element 38 and stationary valve seat ridges 59 and 55 are a pair of flexible washers 69 and 70 having a generally rectangular shape with the corners cut off to provide cylindrical bearing surfaces engaging the inside wall of cylinder 37 as shown in Figure 8. It will be evident that valve closure element 38 is suspended on control arm 51 in a relatively stationary position so that as floating valve housing 36 moves up and down in response to motion of diaphragms 27 and 28 element 38 will be shifted into contact with one or the other of washers 69 and 70, these washers in turn being held against ridges 59 and 55 to cut off the gas flow through one or the other of passages 63 and 56. Valve control arm 51 is sufficiently resilient, however, to permit it to yield slightly so that, as long as the gas pressure in cylinder 37 exceeds that in the passage which is closed by element 38 by an amount sufficient to overcome the restoring force of spring arm 51, the valve will remain closed. However, when the movement of housing 36 has been sufficient to build up a restoring force equal to the gas pressure the valve will suddenly be snapped from one end of the cylinder to the other, thereby to open one passage and close the other.

Casting 36 comprising the valve housing is drilled along one side to provide a Venturi passage 39 having one end opening into the middle chamber 30 between diaphragms 27 and 28 and the other end opening into gas administering chamber 31 beneath diaphragm 28. Holes are also drilled in casting 36 from both the upper and lower ends in alignment with the Venturi passage and a pair of tubes 71 and 72 are affixed in these holes to provide jet passages of the required diameter extending from chambers 57 and 64 respectively. The material of casting 36 is cut away in a smoothly rounded manner at the ends of venturi 39 to deflect gases issuing from the venturi while still permitting either of jet tubes 71 and 72 to project a jet of gas into the venturi on the opposite cycle.

A helical compression spring 73 is interposed between upper clamp plate 40 which is clamped against the top face of upper diaphragm 27 and the inside of casing top member 12 surrounding aperture 20 to apply a downward bias to the assembly of diaphragms and floating housing 36. This bias normally holds closure element 38 and washer 69 against valve seat 59 at the upper end of cylinder 37 so that passage 63 leading to jet 72 will be closed at the start of operation while passage 56 leading to jet 71 will be open so that when gas is first supplied jet 71 will come into operation to project the gas downward through venturi 39 from chamber 30 to chamber 31. Upper chamber 29 is open to the atmosphere by virtue of the space between central opening 20 and cap 46 and the presence of additional vent holes 74.

An adjustable gas vent is provided in wall 11 of middle chamber 30 comprising a slot 75 cut part way around wall 11 and a threaded ring 76 which is threaded onto the upper threaded portion of cylindrical wall 11 below flange 19 of the top wall. Ring 76 is provided with a slot 77 corresponding to slot 75 in the casing wall and the outer surface of the ring is knurled to permit the ring to be turned manually to bring slot 77 into register with slot 75 to a greater or lesser extent. A short pin 78 extends in from ring 76 through slot 75 to limit the rotation of the ring to a few degrees in either direction. When ring 76 is turned to one extreme slot 75 will be closed by the ring while at the other extreme a passage for the entrance and exit of air or other gases is provided by the aligned slots 75 and 77.

A one-way valve 79 is also provided in the wall of chamber 30 and comprises a hollow screw 80 having a gas passage 81 extending through its stem, the inner end of the stem being notched at 82 to prevent closure of the passage. Screw 80 passes inward through wall 11 and screws into a small valve chamber 83 containing a rectangular valve disc 84 of mica or other light sheet material which seats against an annular ridge 85 surrounding an opening 86 leading from the valve chamber into chamber 30. When the gas pressure outside chamber 30 exceeds the pressure inside disc 84 will be pressed against ridge 85 to close the valve and prevent entrance of air through the valve. However, when the gas pressure inside the chamber exceeds that outside, disc 84 will be moved away from the ridge to permit air to pass out through chamber 83 and gas passage 81. Thus air can find access to the chamber 30 only through aligned slots 75 and 77, but gas can leave the chamber through the aligned slots and also through valve 79.

Gas administering chamber 31 is provided with a safety valve 87 to release the pressure in chamber 31 if it exceeds a pre-determined value. Valve 87 comprises a circular metal disc having an inturned flange 88 which rests against the outside of wall 13. The disc carries a central headed pin 89 which extends into chamber 31 through an opening 90. A conical spring 91 is compressed between the head of pin 89 and the inside face of closure wall 13 so that the flange 88 of the closure disc is normally held by spring pressure against the outer wall of the casing. However, should the internal gas pressure exceed the force of spring 91, disc 87 will be forced outward to allow gas to escape.

Gas coupling assembly 17 comprises a metal casting 92 mounted against the inside of cylindrical wall 11 in middle chamber 30 and having a threaded nipple 93 extending out through an accomodating opening in wall 11. The casting is clamped in the opening by a nut 94 threaded onto nipple 93 and bearing against a washer 95 shaped to conform to the outer surface of wall 11. A cylindrical passage 96 extends into the casting through nipple 93 and terminates in a closed recess. Casting 92 has a side arm 97 carrying a branch passage 98 communicating with cylindrical passage 96 and the end of side arm 92 carries a nipple 99 directed toward nipple 53 on floating valve housing 36. Flexible tube 50 is fitted over nipples 53 and 99 thereby providing a continuous gas passage to valve chamber 37 from the outside of the device through gas coupling assembly 17 and tube 50. Valve control arm 51 extends through the gas passage of nipple 99 to the intersection with gas passage 98 and is supported at its fixed end 100 in a hole drilled through the wall of arm 97 by a press-fit or by brazing, thereby affording a rigid support for the fixed end of arm 51.

The gas supply hose 18 and coupling members therefor are illustrated in Figures 5, 6, 9 and 10. Hose 18 is a length of rubber or composition tubing of any desired length made to withstand the gas pressures involved, which may amount to 20 pounds per square inch, or more. The end of hose 18 which is intended to be attached to the resuscitator device is provided with a tubular nipple member 101 having a corrugated or annularly ribbed portion 102 inserted in the end of tube 18, the tube being held tightly compressed against portion 102 by a tight-fitting clamp ring or ferrule 103. The free end of nipple 101 has its internal passage 104 widened out to provide a housing portion 105 for a gas valve 106 which may be a conventional pneumatic tire valve. This comprises a central stem 107 over which is disposed a threaded sleeve 108 which is threaded into the internally threaded end of nipple 101. Sleeve 108 carries an annular rounded sealing ring 109 of rubber or similar material which seats against a complementary shoulder 110 on the inside of enlarged passage portion 105. A coil spring 111 urges stem 107 outwardly and the stem carries a small fixed collar 112 having a seat ring 113 of rubber or similar material which can seat against the inner end of sleeve 108 to close the valve.

Screw 114 is provided in casting 92 extending axially of the cylindrical passage 96 from its closed inner end so that when nipple 101 is inserted in cylindrical passage 96 screw 114 will engage the outer end of stem 107 pressing it inward against the resistance of coil spring 111 to open the valve, thereby permitting gas pressure entering through gas supply hose 18 to pass into branch passage 98 of the casting and hence through rubber tube 50 to the floating valve housing 36. The inside of cylindrical recess 96 is provided with an annular groove 115 in which is loosely held packing ring 116 of rubber or similar material having a circular cross-section and an internal diameter slightly smaller than the outside surface of nipple 101 so that when the nipple is inserted the packing ring is stretched slightly to effect a gas seal between the nipple and the inside wall of cylinder 96.

Nipple 101 is locked in place after insertion by a collar 117 and a snap spring 118 whose operation is shown most clearly in Figures 9 and 10. Snap spring 118 is generally U-shaped spring which is held in a small space between the end wall 119 of collar 117 and the outer end of nipple 93 comprising part of casting 92. The nipple

carries a pair of projections 120 and 121 on its outer end over which snap spring 118 is fitted and collar 117 has an arc-shaped projecting portion 122 which is normally disposed against the outside surface of projection 120 on the nipple as shown in Figure 9. In this position the two side arms of snap spring 118 lie against the aligned sides of projections 120 and 122 so that these side arms, which are spread apart by nipple 101 when it is first inserted in cylindrical recess 96, can snap inward over shoulder 123 provided on nipple 101. Snap spring 118 thereby latches nipple 101 in place in cylinder 96 in a position to hold valve 106 open, thus insuring a gas supply to the distributor valve cylinder 37. A large headed screw 124 is mounted on the face of flange 119 of the collar, the head of the screw extending into the path of shoulder 123. To close valve 106 it is simply necessary to turn collar 117, which is suitably knurled to afford a hand grip, so that projection 122 is turned out of alignment with projection 120 on the end of nipple 93 thereby spreading the two side arms of snap spring 118 sufficiently to allow nipple 101 to slide outward thereby moving valve stem 107 away from screw 114 so that the valve will close. However, the head of screw 124 prevents complete removal of nipple 101 from the recess 96 so that the members remain connected as long as collar 117 is in place.

A coil spring 125 is seated in the bottom of cylindrical recess 96 surrounding screw 114 to engage the end of nipple 101 when it is inserted. This is for the purpose of aiding in retracting the nipple when snap spring 118 is opened and in holding the nipple in retracted position until it is intentionally pressed in with sufficient force to overcome the spring resistance and again open the valve. Release of the nipple by snap spring 118 can be effected by rotation of collar 117 in either direction.

The supply end of hose 18 is provided with means for connecting it with a source of gas supply such as the outlet coupling of a pressure regulator attached to a tank of oxygen or other gas, or the air pressure nipple leading from an emergency air pump. The hose is also adapted for connection to the auxiliary gas outlet provided on the front of the larger resuscitator described and claimed in my co-pending application Serial No. 756,839 filed June 25, 1947 as shown in Figure 6, of the present application.

The nipple 126 provided at the supply end of the hose is fitted into the end of the hose with a corrugated portion 127 similar to portion 102 of nipple 101 and the end of the hose is clamped in collar or ferrule 128. Nipple 126 has a cylindrical recess 129 in its outer end communicating with the gas passage 130 extending through the body of the nipple and a small pin 131 is mounted in the base of recess 129 to engage the stem of a pneumatic tire valve provided in the coupling of the gas supply source 132 shown in dotted lines in Figure 5. Recess 129 carries a rubber ring packing seal 133 and a lock collar 134 which is generally similar in construction to collar 117 and has a lock spring 135 similar to spring 118. Thus the nipple 126 can readily be attached to the gas supply coupling and the valve opened to permit the gas to enter the hose.

Figure 6 shows a coupling arrangement for a gas supply unit which, while of general application, is especially well adapted for connection to the auxiliary gas outlet designated by reference numeral "39" in the drawing of my prior filed co-pending application mentioned above, and here designated by reference numeral 136. The coupling comprises an extension sleeve 137 attached by a collar 138 to the gas supply outlet 136 and clamping a side tube 139 which carries a tire valve 140 to which nipple 126 of the gas supply hose may be attached. Sleeve 137 is provided with gas passages leading to side tube 139 and also has a passage leading to the end of the sleeve which is provided with a cap 141 which can be removed when desired to obtain a gas supply for other equipment, such as an aspirator or the like.

Operation

In the operation of the device as a resuscitator hose 18 is connected to a source of gas supply, such as oxygen or air, by connecting female nipple 126 to a cooperating male coupling provided on the gas supply source, such as member 139 of Figure 6. If oxygen gas is supplied from a pressure tank it is desirable that a pressure regulator be connected between the tank and the coupling to reduce the gas pressure to a suitable value for use, such as 20 pounds per square inch, and maintain a constant supply of gas at that pressure. If the gas supply coupling is provided with a valve such as 140 in Figure 6 the pin 131 in nipple 126 will engage the stem of the valve to open it and thereby extend the gas pressure through hose 18 to valve 106 at the other end of the hose.

The hose is coupled to the resuscitator by inserting male nipple 101 into cylindrical recess 96 of casting 92. The nipple is first inserted before headed screw 124 is screwed into place in the flange of collar 117. After screw 124 is in place the hose coupling nipple 101 cannot be disconnected from the resuscitator without again removing the screw. However, shoulder 123 of the nipple can be retracted to a position in contact with the head of screw 124 so that valve 106 will remain closed and gas will not be supplied to the resuscitator. When it is desired to start operations, nipple 101 is forced inward against the resistance of spring 125 until spring clip 118 snaps under shoulder 123 to latch the nipple in its inner position, screw 114 at the same time opening valve 107. The gas supply is thereby extended through passage 98 and flexible gas conduit 50 into valve chamber 37 through passage 52.

At the time gas pressure is first supplied to the valve chamber, valve closure element 38 will be in contact with washer 69 seated against valve seat 59 closing gas outlet passage 63 leading to Venturi jet 72 while gas passage 56 leading to jet 71 will be open. Gas flow through this passage creates a jet of gas issuing from jet 71 into the mouth of venturi 39. The venturi and jet combination functions as an injector pump to drive gas downward through the venturi into gas administering chamber 31 and conduit 14 leading to mask 16. If slots 75 and 77 are in alignment to provide a gas inlet passage to middle chamber 30, gas issuing from jet 71 will draw with it through the venturi a certain proportion of air. In some cases an amount equal to about three times the amount of gas issuing from the jet so that approximately four times the volume of gas is delivered to chamber 31 as issues from jet 71. If pure oxygen is being supplied to jet 71 and air is admitted through slot 75, the air will dilute the oxygen in the example given to a proportion of 25% oxygen and 75% air. The proportion of oxygen to air is regulated by the operator by rotating valve ring 76 by hand to close slot 75 to a greater or lesser extent. With slot 75 entirely closed no air can enter chamber 30 and hence the gas passing into chamber 31 from the venturi will consist of pure oxygen. However, the volume of gas passing through the venturi is proportionally reduced as the oxygen concentration is increased. Valve ring 76 and casing wall 11 may be provided with cooperating marks or indicia to indicate the percentage of oxygen in the mixture supplied to the patient, since this percentage is proportional to the amount of slot 75 which is left open. This indicia can also serve as an approximate indicator of the resuscitator's speed since the speed is inversely proportional to the oxygen concentration. Valve 79 remains closed during this phase of the cycle as disc 84 will be held seated against valve seat 85 by the excess of external pressure over the partial vacuum created in chamber 30 by jet 71 and venturi 39.

The oxygen or oxygen-air mixture entering gas administering chamber 31 passes through gas administering conduit 14 to mask 16 and hence to the patient. The gas pressure will increase in chamber 31 at a rate dependent upon the amount of gas issuing from the venturi, the increased pressure gradually lifting diaphragm 28 to move valve housing 36 along with diaphragm 27 upward against the force of spring 73. Since the gas pressure in valve chamber 37 is much greater than the pressure in valve chamber 61 behind closed valve seat member 58, the closure element will be held against the upper valve seat 59 by the gas pressure and resilient support arm 51 will be deflected upward as the diaphragm raises the valve housing. The areas of diaphragm 28 and valve seat 59 are related to the pressure of the gas supply in such a manner as to permit the restoring force in spring arm 51 to overcome the pressure holding element 38 against the valve seat when the pressure in chamber 31 which is being supplied to the patient reaches pre-determined value, such as one-quarter pound per square inch. Thus, if the gas supply is at a pressure of 20 pounds per square inch the area of diaphragm 28 may be approximately 80 times the area of valve seat 59, since 20 pounds per square inch is 80 times one-quarter pound per square inch. The bias of spring 73 will change this ratio slightly, increasing the pressure on the patient during the positive phase just described and decreasing the negative pressure slightly on the opposite phase of the cycle.

The ratio of positive to negative gas pressures supplied to the mask can be made of any desired value by adjusting the strength of spring 73 and the relative areas of valve seats 59 and 55. Thus, if equal pressures on both phases of the cycle are desired, the area enclosed by valve seat 59 will be made slightly smaller than that of seat 55 to compensate for the pressure added to diaphragm 28 by spring 73. The absolute pressure supplied to the patient can also be made of any desired value by making diaphragm 28 of suitable area with respect to the areas of the valve seats.

When the pressure in chamber 31 being supplied to the patient reaches the predetermined value required to trip valve closure element 38, resilient arm 51 will snap the closure element away from valve seat 59 and move it quickly downward into contact with lower washer 70 resting on valve seat 55, thereby to close gas passage 56 leading to jet 71 and stop the gas flow downward through the venturi. Gas is now permitted to enter chamber 61 and thence through passage 63 to lower jet 72 which projects a stream of gas upward through the venturi to function as an ejector to remove gas from chamber 31. The jet will draw with it up to three times its own volume of gas and the combined gases will issue into chamber 30 and from there pass out to the atmosphere through the gas passage provided by aligned slots 75 and 77 and also through one-way valve 79 which will be opened by the excess of internal gas pressure over the atmospheric pressure. If slot 75 is completely closed, the only exit for gas will be through one-way valve 79 whose passage 81 is so proportioned in relation to the size of jet 72 as to accommodate approximately one-quarter the maximum output of venturi 39. Hence when slot 75 is closed the negative phase will take approximately four times as long as when slot 75 is open, the same as the positive phase, and hence both negative and positive phases of the respiration cycle remain approximately equal for all settings of valve ring 76. When sufficient gas has been drawn out of chamber 31 by the ejector jet 72 the Venturi diaphragm 28 will be lowered to a point where closure element 38 will be snapped back to its initial position by arm 51 after which the cycle will be repeated.

When it is desired to use the device as an inhalator to supply continuous stream of oxygen-air mixture to the patient, the operator presses cap 46 downward with his finger to hold valve closure element 38 stationary against seat 58 thereby providing a constant flow of gas downward through the venturi to the patient. In this operation the percentage of oxygen can also be varied by adjusting valve ring 76 and auxiliary valve 79 will remain closed.

While the present invention, as to its objects and advantages, has been described herein as carried out in specific embodiments thereof, it is not desired to be limited thereby but it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. A resuscitator comprising a casing, a pair of spaced flexible diaphragms dividing the interior of said casing into three chambers, a floating valve housing suspended by said diaphragms, said housing having a cylinder therein whose axis is perpendicular to said diaphragms, a gas inlet coupling extending into said casing between said diaphragms and a flexible gas conduit within said casing connecting said inlet coupling to said cylinder, said floating housing carrying a pair of gas passages communicating with the respective ends of said cylinder, a valve closure element slidable in said cylinder and a support arm therefor supported on said inlet coupling and extending through said flexible gas conduit into said cylinder, whereby axial movement of said floating valve housing will shift said valve closure element between the ends of said cylinder, alternatively to close said respective gas passages, said valve housing including a Venturi passage extending between the middle one of said three chambers and a second of said chambers, and a first Venturi jet fed by the one of said gas passages which is closed by movement of said valve housing in a direction away from said second chamber and a second Venturi jet fed by the other of said gas passages, said first Venturi jet being directed into said Venturi passage to drive gas from said middle chamber to said second chamber and said second jet being directed into said Venturi passage to drive gas from said second chamber into said middle chamber, a gas administering conduit extending from said second chamber, said casing having an atmospheric opening into the third of said chambers, and a gas escape valve leading out of said middle chamber.

2. A resuscitator as claimed in claim 1, in which said casing is apertured over the third of said chambers and said diaphragm and floating valve housing assembly is manually accessible through said aperture to apply a manual bias to said diaphragms and valve housing to hold the second of said valve openings closed by said valve closure element under manual control of the operator.

3. A resuscitator as claimed in claim 1, in which a manually adjustable vent is provided in an enclosing wall of said middle chamber.

4. A resuscitator as claimed in claim 1, in which a gas administering mask is coupled directly to said gas administering conduit.

5. A resuscitator as claimed in claim 1, in which a pressure relief valve is provided in an enclosing wall of said second chamber.

6. A resuscitator comprising, in combination, a casing including a gas administering chamber having a wall thereof comprising a flexible diaphragm, a valve comprising a housing element having therein a valve chamber and a gas supply passage entering said chamber and first and second gas outlet passages leaving said chamber from opposite ends thereof and having valve seats surrounding said outlet passages, a valve closure element in said chamber movable with respect thereto between said ends alternatively to close said first and second gas outlet passages, one of said elements being coupled to said casing independently of said diaphragm and the other of said elements being coupled to the central area of said diaphragm for movement thereby to shift said valve closure element between the ends of said valve chamber to close said first outlet passage responsive to positive gas pressure in said gas administering chamber and close said second outlet passage responsive to negative gas pressure in said chamber, a gas injector fed by said first outlet passage for injecting gas into said gas administering chamber and a gas ejector for ejecting gas from said chamber fed by said second outlet passage.

7. A resuscitator as claimed in claim 6, in which a spring is included in the coupling between one of said elements and its actuating support, whereby said valve closure element will be held closed against each of said valve seats by gas pressure in said valve chamber during movement of said diaphragm until the restoring force of said spring overcomes said gas pressure whereupon said valve closure element will be rapidly shifted to the opposite valve seat.

8. A resuscitator as claimed in claim 7, in which said housing element is mounted directly on said diaphragm and said spring comprises a resilient arm supported at one end by said casing and extending into engagement with said valve closure element through said gas supply passage, and a flexible gas supply conduit surrounds said arm and connects to said gas supply passage to supply gas thereto.

9. A resuscitator as claimed in claim 8, in which a second spring is interposed between said diaphragm and said casing to bias said diaphragm toward one end of its stroke in the absence of opposing gas pressures.

10. A resuscitator as claimed in claim 9, in which said valve seat which is engaged by said closure element responsive to the bias of said second spring in the absence of gas pressures is smaller in area than the opposite valve seat whereby substantially the same ratios of gas pressure against said diaphragm to gas pressure against said valve closure element will effect shifting of said element in one direction as in the opposite direction.

11. A resuscitator device comprising an inlet conduit adapted to be connected to a source of gas supply, Venturi means including first and second jets for creating positive and negative gas pressures respectively, a distributing valve housing having a valve chamber fed by said inlet conduit and having first and second jet supply passages leading to said first and second jets, respectively, and a valve element movable between two positions in said valve chamber for alternatively closing said jet passages, the gas pressure in said valve chamber resisting the opening of the closed valve passage in both positions of said valve element, a gas chamber supplied with positive and negative gas pressures by said Venturi means, one of the walls of said chamber being movable, said valve housing being coupled thereto for control thereby, and a resilient support arm for said valve element mounted independently of said valve housing, to shift said valve element from the first to the second of said positions responsive to negative gas pressure in said gas chamber and from the second to the first of said positions responsive to positive gas pressure in said gas chamber.

12. A resuscitator comprising, in combination, a hollow casing having a gas administering chamber therein, a flexible diaphragm in said casing comprising a wall of said chamber, a valve housing carried by said diaphragm and having a valve chamber therein, a flexible gas supply conduit leading into said valve chamber, a gas injector jet directed into said gas administering chamber and a gas ejector jet directed out of said chamber, said valve housing having first and second gas passages leading from said valve chamber to said jets, respectively, and a shiftable valve closure element in said valve chamber movable with respect to said valve chamber between a first position for closing said first passage and a second position for closing said second passage, a support for said valve closure element mounted in said casing independently of said diaphragm, whereby movement of said valve housing by said diaphragm will shift said closure element.

13. A resuscitator as claimed in claim 12, in which said valve closure element closes said first gas passage responsive to increased gas pressure in said gas administering chamber, and closes said second gas passage responsive to decreased gas pressure in said gas administering chamber.

14. A resuscitator as claimed in claim 13, in which the gas pressure in said valve chamber resists the opening of the valve closure element.

15. A resuscitator as claimed in claim 14, in which said support is resilient to effect a snap action shift of said valve closure element when the resistance of said gas pressure is overcome.

16. A resuscitator as claimed in claim 12, in which a spring is interposed between said casing and said diaphragm to bias said valve housing toward one end of its stroke.

17. A resuscitator comprising, in combination, a gas chamber having gas administering means connected thereto, a wall of said chamber being movable in response to changes in the difference of gas pressure on the two sides thereof, a housing carried by said movable wall having a valve chamber therein, a first jet for projecting gas into said gas chamber, a second jet for pumping gas out of said gas chamber, said housing having a first gas passage extending from said valve chamber to said first jet and a second gas passage extending from said valve chamber to said second jet, a gas supply conduit for supplying gas to said valve chamber, a valve closure element in said valve chamber and a support therefor independent of said movable wall, said closure element closing said first gas passage responsive to outward travel of said movable wall and said housing, and closing said second gas passage responsive to inward travel of said wall and housing.

18. A resuscitator comprising, in combination, a casing having a gas chamber therein, a flexible diaphragm supported by said casing and comprising a wall of said gas chamber, a gas administering conduit leading from said chamber, a valve housing carried by the center of said diaphragm and having a valve chamber therein, a flexible gas supply tube connected to said housing for supplying gas to said valve chamber, a first jet for projecting gas into said gas chamber, a second jet for pumping gas out of said gas chamber, said housing having a first and second gas passage extending from said valve chamber to said first and second yet, respectively, a valve closure element in said valve chamber and an arm, supported by said casing and extending through said gas supply tube into said valve chamber, said valve closure element being supported thereon, said valve housing being movable relative to said arm, whereby said closure element will close said first gas passage responsive to outward movement of said diaphragm and said second gas passage responsive to inward movement thereof.

19. A resuscitator as claimed in claim 18, in which said arm is resilient, thereby to shift said valve closure element with a snap action.

20. A resuscitator comprising, in combination, a first gas chamber, a second gas chamber having a gas administering conduit leading therefrom, a venturi extending from said first to said second gas chamber, a first jet in said first chamber for projecting a gas into said venturi, a second jet in said second chamber for projecting a gas into said venturi, a valve for supplying a gas alternatively to said first and second jets, said first chamber having a gas inlet and outlet passage communicating with the atmosphere and an adjustable valve for regulating the rate of gas flow through said passage, thereby to control the rate of gas flow through said venturi.

21. A resuscitator as claimed in claim 20, in which a one-way valve is provided between said first chamber and the atmosphere for permitting outlet of gas independent of said adjustable valve.

22. A gas administering device for administering a mixture of gases, comprising, in combination, a first gas chamber, a second gas chamber having a gas administering conduit leading therefrom, a diaphragm separating said chambers, a venturi extending from said first to said second gas chamber, a jet in said first chamber for projecting a first gas into said venturi, said first chamber having a gas inlet passage for admitting a second gas thereto, and an adjustable valve for regulating the rate of gas admission through said inlet, thereby to regulate both the rate of gas flow and the composition of the gas mixture passing through said venturi.

23. A resuscitator comprising, in combination, a gas administering chamber, an oxygen supply conduit, a gas injector and a gas ejector for injecting and ejecting gas from said chamber, and a valve for alternately directing oxygen from said conduit to said injector and said ejector, a pressure responsive element for shifting said valve to supply gas to said ejector responsive to a predetermined increase in gas pressure in said gas administering chamber and to supply gas to said injector responsive to a predetermined decrease in gas pressure in said chamber, and an adjustable valve to supply air to said injector to dilute said oxygen supply.

24. A resuscitator as claimed in claim 23, in which said adjustable valve also functions as a discharge part for controlling the rate of gas discharge by said ejector, whereby a richer oxygen supply is fed to said gas administering chamber at slower respiration speeds and a more dilute oxygen supply is provided at faster respiration speeds.

25. A resuscitator as claimed in claim 24, in which an auxiliary one-way valve is provided to accommodate part of the gas discharge from said ejector.

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