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Arp et al.

[11] **3,788,313**

[45] **Jan. 29, 1974**

[54] **RESPIRATOR APPARATUS**

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[73] Assignee: **said Arp, by said Varnum**

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[21] Appl. No.: **62,753**

Related U.S. Application Data

[62] Division of Ser. No. 597,649, Nov. 29, 1966, Pat. No. 3,530,872.

[52] **U.S. Cl.** **128/145.8**

[51] **Int. Cl.** **A61m 16/00**

[58] **Field of Search**.....128/145.5, 145.6, 145.7, 128/145.8, 188, 145; 137/99

[56] **References Cited**

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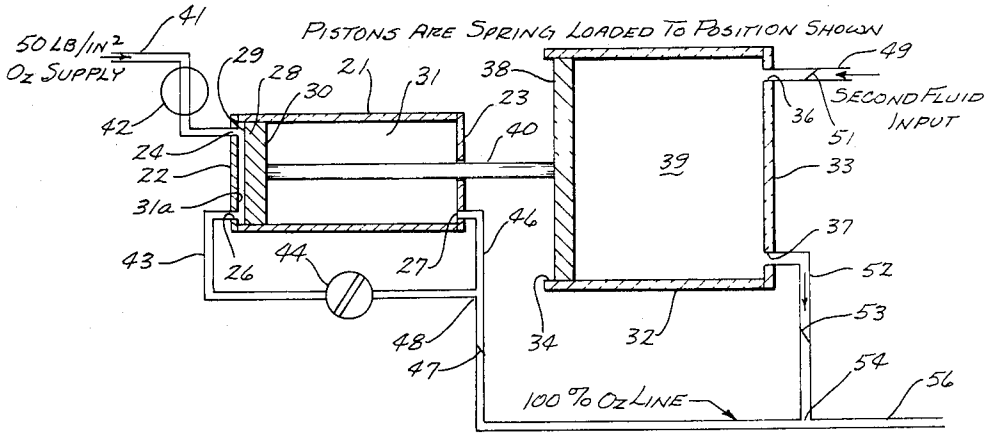
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Assistant Examiner—G. F. Dunne
Attorney, Agent, or Firm—H. Robert Henderson

[57] **ABSTRACT**

A respirator with a pair of cylinders having interconnected pistons. The cylinders are connected by appropriate valve means to provide a device capable of mixing two fluids.

7 Claims, 9 Drawing Figures



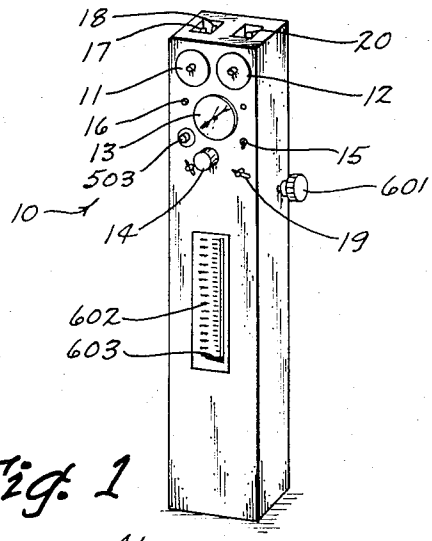


Fig. 1

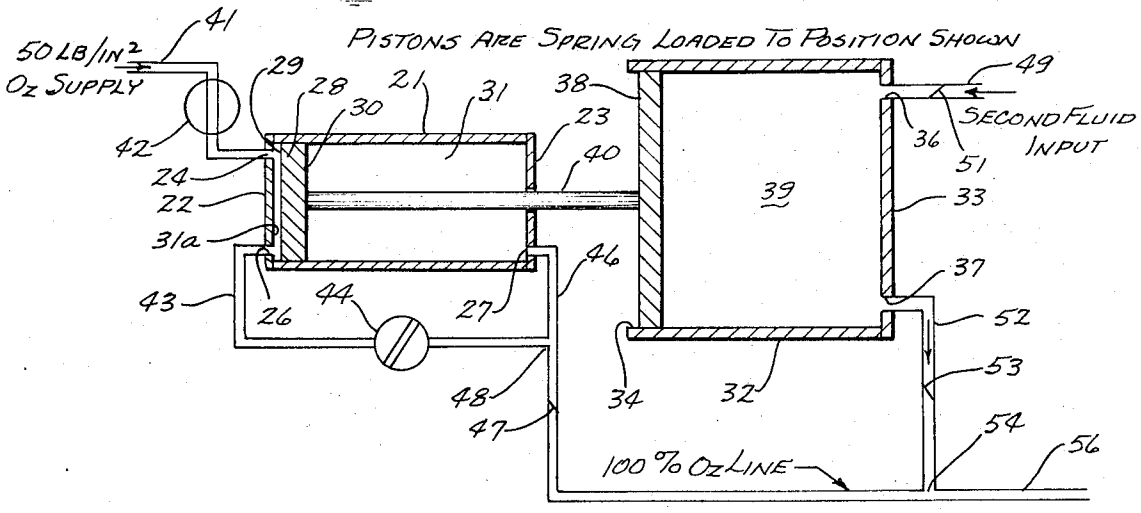


Fig. 2

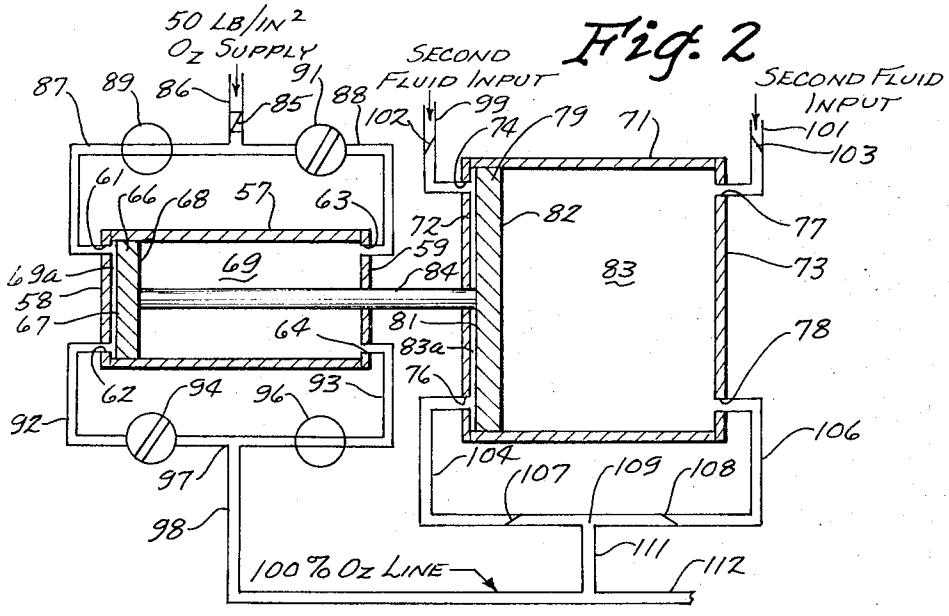


Fig. 3

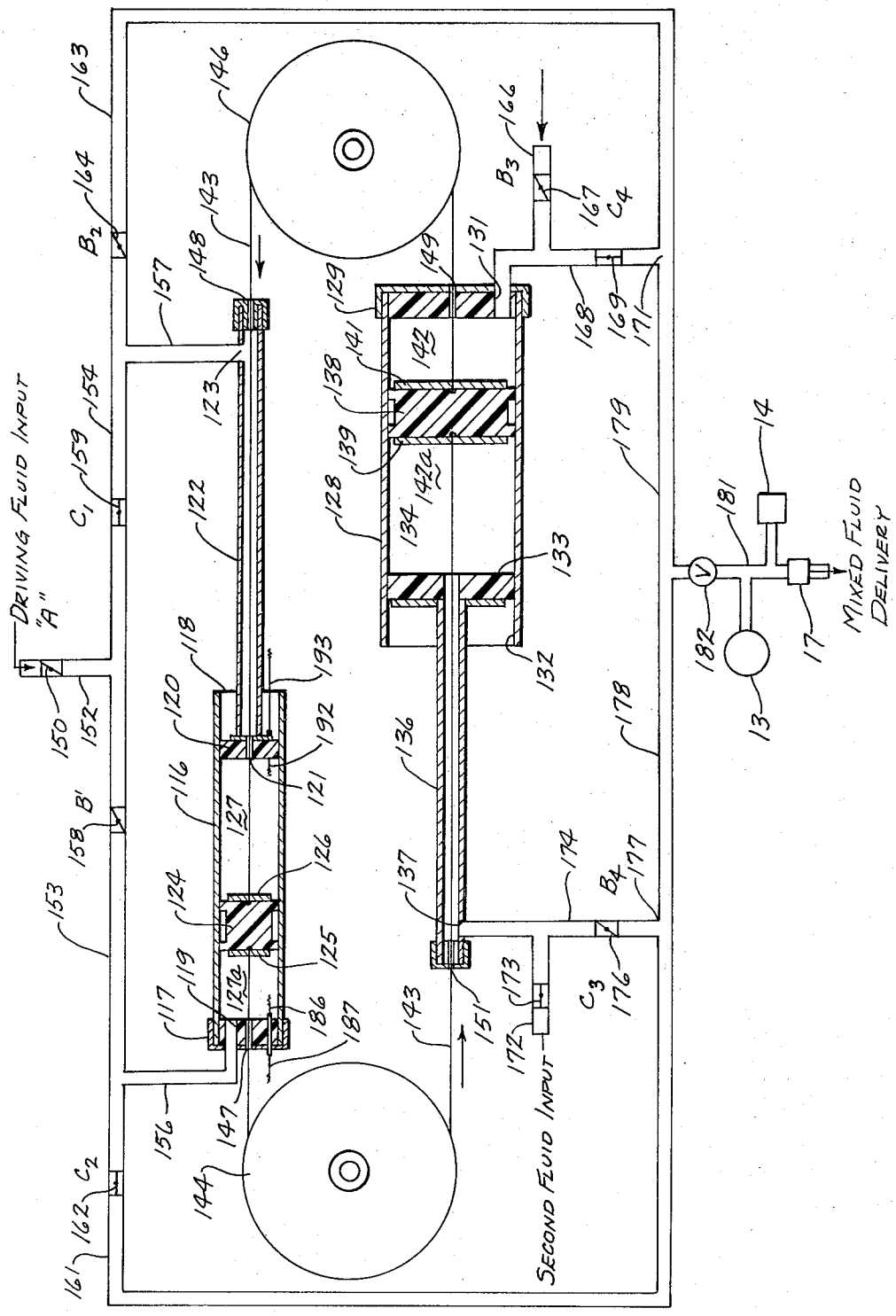

DRIVING FLUID INPUT "A"
SECOND FLUID INPUT
MIXED FLUID DELIVERY

Fig. 4

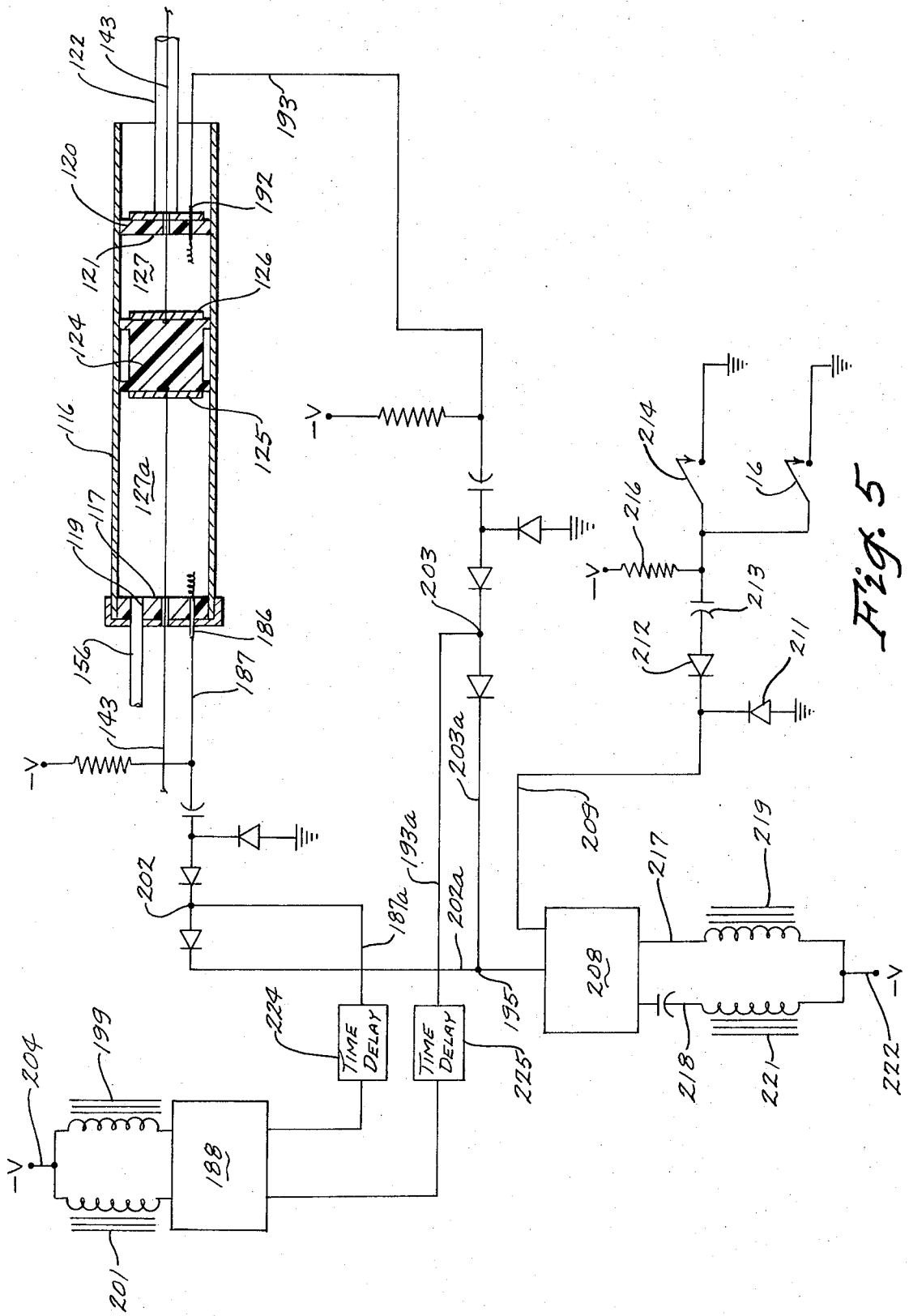

122
143
193
120
192
121
127
126
124
116
125
127a
117
119
186
156
187
143
-V
203
214
216
213
212
211
203a
209
202
193a
187a
202a
217
219
208
224
TIME DELAY
TIME DELAY
195
225
218
221
222
204
199
188
201

Fig. 5

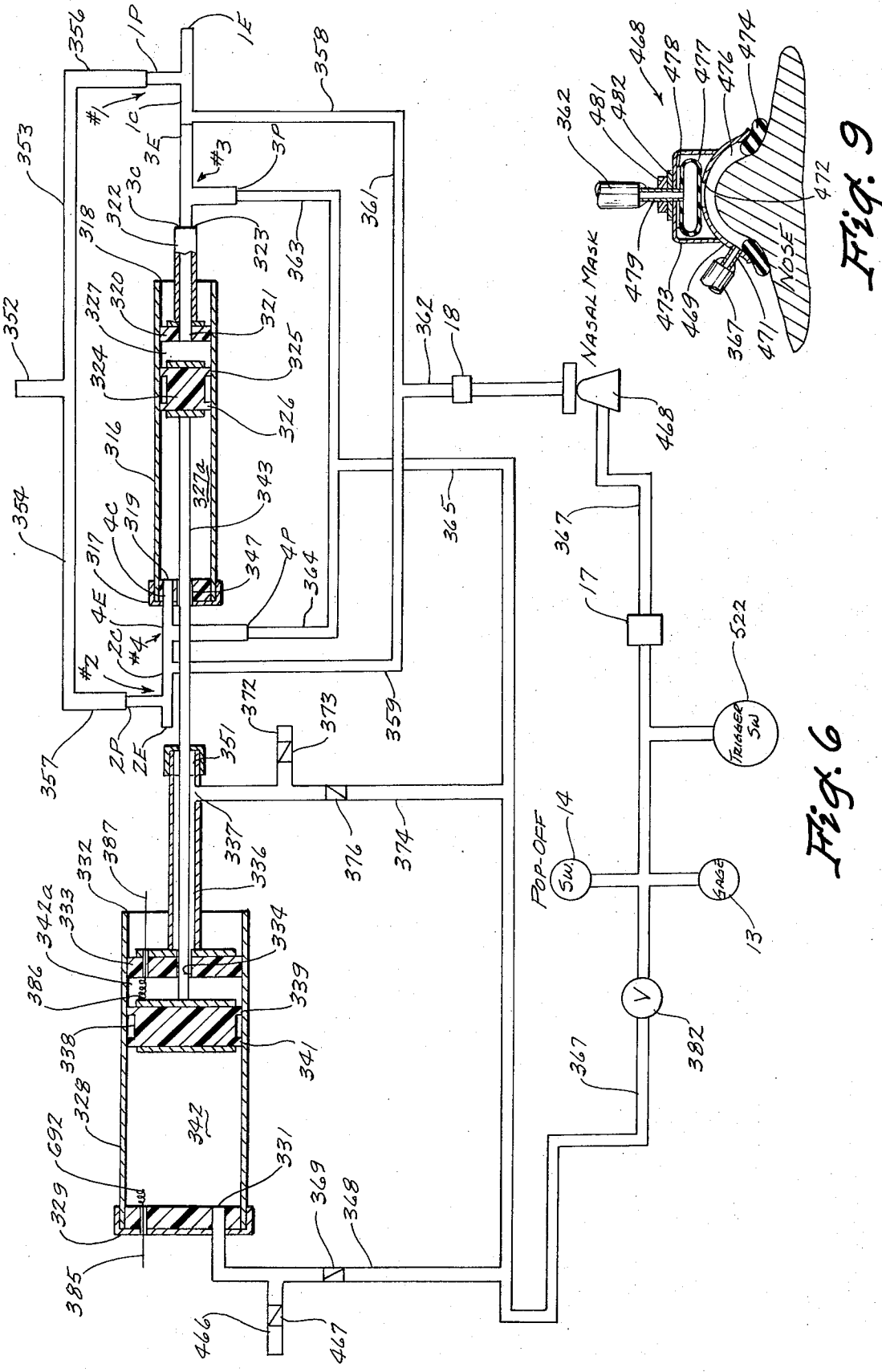


Fig. 6

Fig. 9

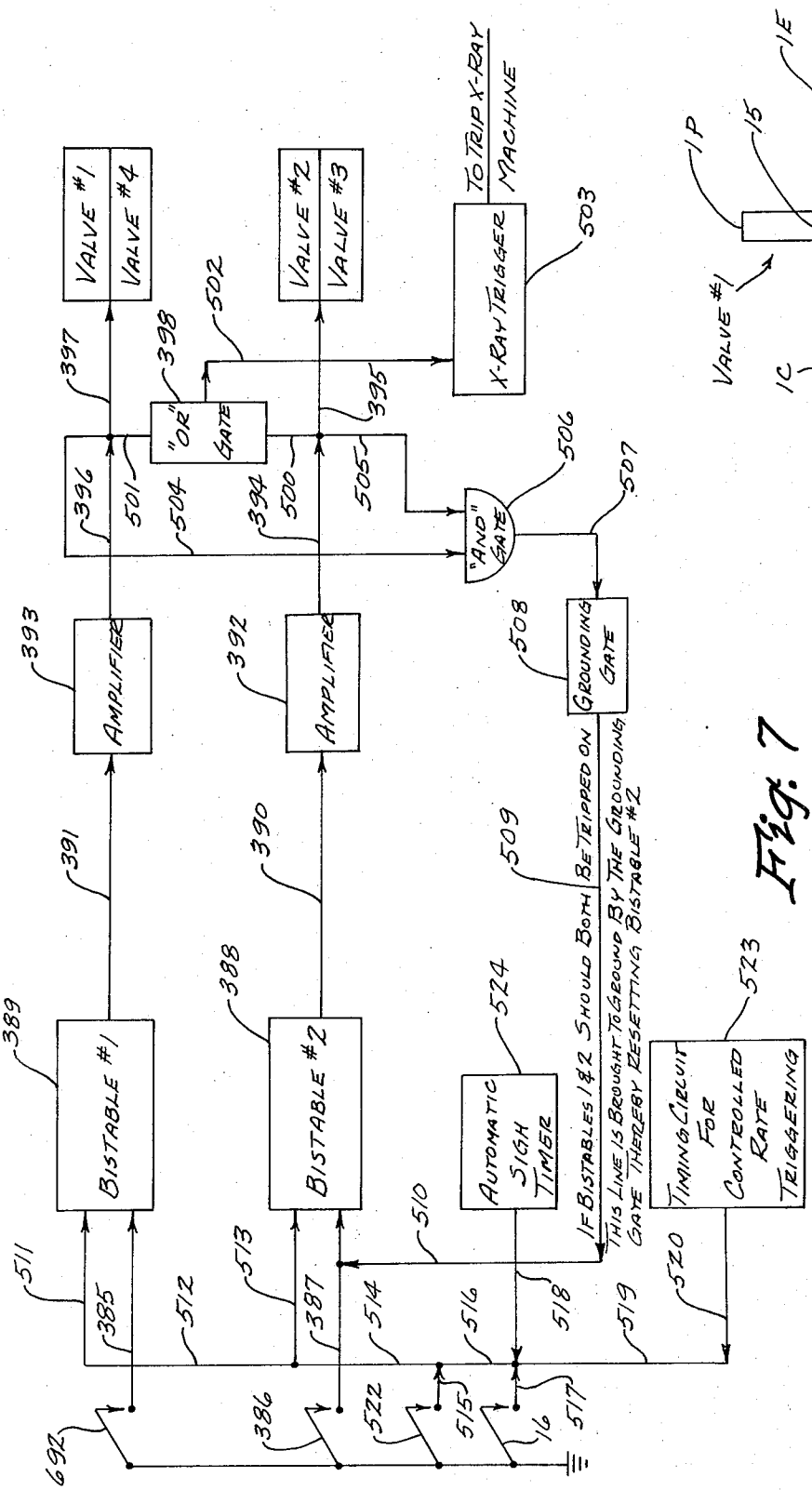

VALVE #1
VALVE #4
VALVE #2
VALVE #3
TO TRIP X-RAY MACHINE
X-RAY TRIGGER
"OR" GATE
"AND" GATE
AMPLIFIER
AMPLIFIER
GROUNDING GATE
BISTABLE #1
BISTABLE #2
AUTOMATIC SIGH TIMER
TIMING CIRCUIT FOR CONTROLLED RATE TRIGGERING
IF BISTABLES 1 & 2 SHOULD BOTH BE TRIPPED ON THIS LINE IS BROUGHT TO GROUND BY THE GROUNDING GATE THEREBY RESETTING BISTABLE #2
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
522
523
524
385
386
387
388
389
390
391
392
393
394
395
396
397
398
500
692
16

Fig. 7

1P
1S
1E
VALVE #1
1C

Fig. 8

RESPIRATOR APPARATUS

This is a divisional application of Ser. No. 597,649 filed Nov. 29, 1966, now U.S. Pat. No. 3,530,872.

This invention relates generally to a fluid mixing apparatus, and more particularly to an apparatus for mixing any two fluids in any proportion.

It is, therefore, an object of this invention to provide a novel apparatus for mixing any two fluids in any proportion.

It is another object of this invention to provide an improved apparatus for utilizing the pressure of one fluid to effect a mixing of a predetermined quantity of the one fluid with a predetermined quantity of a second fluid.

Another object of this invention is to provide an apparatus whereby fluids contained in separate containers can be mixed to any proportion by providing interconnected piston means in said containers.

It is yet another object of this invention to provide an apparatus usable, for example, as a respirator for delivering a predetermined volume of a predetermined mixture of fluid to an infant or adult; a positive pressure, fluid driven apparatus capable of delivering the fluid at a selectable constant flow rate or at a selectable constant pressure.

Still another object of this invention is an apparatus for delivering a predetermined mixture and quantity of any two fluids comprising basically a pair of containers and a pair of interconnected pistons reciprocally movable in the containers' chambers, wherein that delivered can merely be varied by changing the fluids, by varying a cylinder chamber dimension, by varying both, or by varying the rate of movement of one piston relative to the other piston.

Another object of this invention is to provide a respirator apparatus, operable as an assistor or as a controller, wherein the rate of delivering a variable volume of a fluid is selectable, and further wherein the pressure of the delivered fluid is indicated to the operator at all times.

It is another object of this invention to provide an apparatus capable of attaining the above designated objects which is extremely economical to manufacture, simple and rugged in structure, and effective in operation.

These objects, and other features and advantages of this invention will become readily apparent upon reference to the following description, when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view of a housing within which the fluid mixing apparatus of this invention is secured;

FIG. 2 is a schematic illustration of a generic embodiment of the fluid mixing apparatus of this invention;

FIG. 3 is a schematic illustration of a specific embodiment of the invention;

FIG. 4 is a schematic illustration, showing certain container and piston elements in cross-section, of one apparatus for practicing the invention based on the embodiment of FIG. 3;

FIG. 5 is a schematic illustration of an electric circuit for controlling the FIG. 4 apparatus, and wherein the apparatus is used as a patient-triggered respirator;

FIG. 6 is a schematic illustration, showing certain container and piston elements in cross-section, of a modified specific embodiment of the invention;

FIG. 7 is a wiring diagram for said modified embodiment;

FIG. 8 is a schematic illustration of one of several three-way valves used in the modified embodiment; and

FIG. 9 is a vertical sectional view of a nasal mask placed over a patient's nose.

Basically, the apparatus comprises one piston in one cylinder driving another piston in another cylinder, wherein both cylinders can actually be closed only at one end, with the other end closeable by the reciprocating, fluid tight fit of the piston. With at least one closed end of each cylinder double valved to permit alternate charging and discharging of a fluid, and providing a spring return for the interconnected pistons, the driving power of a fluid in one cylinder can effect either a compression of another fluid in the other cylinder, or a discharge of a predetermined quantity of the other fluid from the other cylinder, or a mixing of the other fluid with the driving fluid in a predetermined ratio, for example.

Practical applications of the apparatus include: mixing and pressurizing fluids for delivery through various respirators or valves to humans and animals of any age for anesthesia, therapy, resuscitation, respiration assistance, or any breathing function; pressurizing of air or other non-pressurized gases or fluids for the first mentioned purposes; pumping and/or mixing of fluids by gases, such as water by chlorine for drinking or swimming systems, oil by gases from oil wells, blood by CO_2 in surgery, or any fluid when powered by pressure from internal combustion engine manifolds; mixing and/or pumping explosive or inflammable liquids or gases when conventional pumps and motors may present a spark hazard; pumping of gases by liquids in many small household applications such as tire and air mattress pumps using a garden hose and water pressure; and the inflation of children's toys with air while watering the lawn, for example. These are a few of the many practical applications to which the apparatus of this invention can be applied.

Referring now to the drawings, in FIG. 1 a housing indicated generally at **10** is adapted to contain an embodiment of this invention is illustrated. Illustrated on the housing **10** is a fluid delivery flow rate selector dial **11**, and a dial **12** the setting of which controls the operation of the apparatus as either a patient-triggered assistor for a respirator, for example, or as a controller for actuating a respirator to supply a fluid at a fixed rate of delivery.

A pressure gauge **13** is provided on the face of the housing **10** for indicating at all times the pressure of the fluid for each delivery cycle thereof, and a safety valve **14** of a pop-off type is also provided on the housing face for enabling the operator to instantly adjust the maximum delivery pressure and to maintain it in working condition. In addition to a main on-off switch **15**, a manually operable trigger **16** is provided to trigger the apparatus as described more in detail hereinafter. The mixed fluid for delivery to a patient is emitted through a coupling **17**, and another coupling **18** is provided for a control fluid line to the patient's mask.

A sensitivity control device **19**, which is operable to adjust the operation of a trigger switch as seen hereinafter is provided on the housing face. On the rear (not shown) of the housing **10**, a coupling is provided for receiving into the housing **10** a first fluid, the purpose of which will be seen hereinafter. On the top of the housing **10**, another coupling **20** is provided for receiving a

second fluid, the purpose of which will be seen hereinafter.

Referring particularly to FIG. 2, a generic embodiment of the fluid mixing apparatus of this invention is shown comprising a first cylindrical container 21 having a pair of closed ends 22 and 23, with a pair of ports 24 and 26 formed in the end 22, and with a port 27 formed in the end 23. A first piston 28 is mounted within the container 21 for reciprocal sliding movement therein in a fluid tight manner, and thereby forming a pair of expansible chambers 31 and 31*a*, on either side of the piston 28 within the container 21. The piston 28 has a pair of opposed faces 29 and 30 which are responsive to the pressure of a fluid through port 24, for example, to move in a direction away from the port 24 and force a fluid on the other side of the piston 28 outwardly through the opposite port 27.

The fluid mixing apparatus includes also a second container 32 (FIG. 2) having one end 33 closed and with the opposite end 34 open. A pair of passages 36 and 37 are formed in the closed end 33 of the second container 32; and a second piston 38 is reciprocally mounted in the second container 32, having a sliding, fluid tight fit therein. The second piston 38 forms an expansible second chamber 39 within the second container 32.

The pistons 28 and 38 are interconnected, as illustrated, by a rod 40, whereby movement of either piston is transmitted in direct ratio to the other piston. It will also be noted that the pistons 28 and 38 are located at comparable positions relative to their respective containers 21 and 32. It should be noted herein that the pistons could be connected by a lever and fulcrum arrangement interposed therebetween, whereby the movement of one piston relative to the other could be varied.

To alternately fill and discharge a pair of different fluids into and from both containers 21 and 32, simultaneously, the following system of fluid transmitting conduits or lines and valves is provided. A fluid supply line 41, for supplying, for example, 50 lb/in^2 of oxygen to the chamber 31*a* is fluidly connected to the port 24 and has a two-way valve 42 interposed therein. The valve 42 in one position permits the fluid to flow toward the container 21, and in the opposite position prevents the flow. A discharge line 43 is fluidly connected to the port 26 for discharging fluid from the chamber 31*a*, and also has a two-way valve 44 interposed therein, the valve 44 being identical to the valve 42.

At the other end of the container 21, a discharge line 46 is fluidly connected to the port 27, and has a one-way valve 47 mounted therein on the other side of a junction 48 of the discharge line 46 with the other discharge line 43. The valve 47 will permit fluid to flow therethrough away from the port 27; however, should a vacuum or suction pressure be effected in the chamber 31 by movement of the piston 28 to the left as illustrated in FIG. 2, whereby fluid would be transmitted through the discharge line 43, the valve 44 and into the line 46, the valve 47 would not permit fluid to flow thereby. The purpose of this will be seen hereinafter.

Referring to the second container 32, this container is supplied by a second fluid transmitted through a supply line 49 fluidly connected to the passage 36, the supply line 49 having a one-way valve 51 mounted therein. The valve permits fluid to flow through the line 49 into the chamber 39, but not opposite thereof. A discharge line 52 is fluidly connected to the passage 37, and also has a one-way valve 53 therein for permitting the flow of fluid outwardly only of the chamber 39 and through the discharge line 52 to a junction 54 with the first container discharge line 46. Thus, at the junction 54, the second fluid discharge in a predetermined quantity from the container 32 is mixed with the first fluid discharged in a predetermined quantity from the container 21, with the mixture being then discharged through a line 56 for appropriate use.

In the operation of the FIG. 2 embodiment, assume the pistons 28 and 38 to be in their illustrated positions, with valve 42 open and valve 44 closed. Assume also the chamber 31 filled with a first fluid and the chamber 39 filled with a second fluid. Upon a supply of the first fluid, oxygen in this case, unde pressure through the line 41, the impinging of this fluid upon the adjacent face 29 fo the first piston 28 will result in the piston 28 moving to the right of its container 21 as viewed in FIG. 2. As the piston 28, then, moves to the right, the first fluid in the chamber 31 is forced outwardly through the opposite port 27 and the discharge line 46 through the one-way valve 47.

Due to the direct connection of the rod 40 between the piston 28 and the second piston 38 in the second container 32, the movement of the piston 28 is transmitted directly to cause a like movement of the piston 38. Thus, the second fluid in the chamber 39 is forced outwardly through the passage 37 and the discharge line 52 to open the one-way valve 53, thereby flowing toward the junction 54. At the junction 54, the predetermined quantity of the first fluid in chamber 31 an the predetermined quantity of the second fluid in chamber 39 is thereby mixed for full discharge through the line 56.

Prior to both pistons 28 and 38 reaching their rightmost positions as viewed in FIG. 2, one of the pistons, 28 for example, engages a rod or electrical switch (not shown). Upon engagement of the piston 28 with said rod or switch, valve 42 is progressively closed at the piston 28 continues to move toward its end of travel. The progressive closing of the valve 42 relative to the movement of the piston 28 reduces the flow rate of the incoming first fluid, thereby causing the piston's velocity to be gradually reduced to zero just prior to engagement of the piston 28 with the closed end of container 21. The pistons 28 and 38 are then returned to their original positions, illustrated by full lines in FIG. 2, by means of one or more springs (not shown) acting upon the interconnected pistons as a unit.

Prior to the return movement, it will have been noted that due to the two-way valve 44 for the first container 21 being closed, the first fluid transmitted through line 41 for the purpose of driving the piston 28 will have remained in the now expanded chamber 31*a*. Thus, prior to a return of the piston unit, the valve 44 will be changed to an open position with a simultaneous change of the valve 42 to a closed position. Thus, as the pistons return and move to the left, wherein a suction or vacuum is effected, within the now expanding chambers 31 and 39, the first fluid in the chamber 31*a* will be by-passed through the line 43, valve 44, the junction 48 and line 46 into the chamber 31. Simultaneously, and due again to the vacuum caused within the chamber 39, another quantity of the second fluid will be sucked through the line 49 and the valve 51 opened thereby. During this return movement of the pistons,

valves 47 and 53 will be held closed. Thus, upon a full reciprocation by both pistons 28 and 38, both chambers 31 and 39 are again charged with a predetermined quantity of the different fluids prior to another mixing stroke of the pistons. It is important to note that the power stroke of the piston 28, and thus the piston 38, is effected by the same fluid from the first container 21 which is subsequently mixed with the second fluid.

It can be readily appreciated from the schematic in FIG. 2 that the specific embodiment of the invention illustrated therein permits variation, for example, of the size of the containers 21 and 32 to vary the ratio of the mixed first and second fluids. Furthermore, either piston 28 and 38 could be adjusted lengthwise on the rod 40 and within a respective chamber to also adjust the amount of fluid discharged from either chamber, without varying the container dimensions. And as mentioned hereinbefore, rather than having a direct proportion rod 40 interconnecting the pistons 28 and 38, other interconnecting means could be used to vary the rate of movement of one piston relative to the other. Naturally, the type of fluid may always be changed.

Another embodiment of the apparatus of this invention is illustrated in FIGS. 3–5 inclusive, with the FIG. 3 illustration being of a schematic nature. A first container 57 is provided, having closed ends 58 and 59, with a quartet of ports 61, 62, 63, and 64 being formed in pairs, as illustrated in the two ends 58 and 59.

A first piston 66 is reciprocally mounted in the container 57 for a fluid-tight sliding movement therein. The piston 66 is provided with opposed faces 67 and 68, and in turn divides the container into a pair of expansible chambers 69 and 69*a*.

A second container 71 also has a pair of closed ends 72 and 73, with a pair of passages 74 and 76 formed in one closed end 72, and another pair of separate passages 77 and 78 formed in the other closed end 73. A second piston 79 is reciprocally mounted in the container 71 for a sliding, fluid-tight fit therein.

The second piston 79 is also provided with a pair of opposed faces 81 and 82, and divides the container 71 into a pair of expansible chambers 83 and 83*a*. The first and second pistons 66 and 79 are interconnected by a straight rod 84 whereby movement of one piston, 66 for example, results in movement of the second piston 79 in direct relationship to the movement of the first piston 66. Again, means different from the rod 84 can be envisioned for varying the relative rate of movement between the two pistons 66 and 79. One example would be a lever and fulcrum arrangement.

A fluid transmission system for supplying and discharging fluid to and from the first container 57 includes a main fluid supply line 86 within which is interposed a main valve 85 which branches into a pair of fluid supply branches 87 and 88, and with the respective branches each having a two-way valve 89 and 91 interposed therein. The supply branch 87 is fluidly connected to the port 61, and the supply branch 88 is fluidly connected to the port 63. For discharge purposes, a pair of discharge lines 92 and 93 are fluidly connected, respectively, to the ports 62 and 64. A pair of two-way valves 94 and 96 are interposed in the lines 92 and 93, respectively, with the discharge lines joining at 97 to form a main discharge line 98.

The fluid supply and discharge system for the second container 71 includes a second fluid supply line 99 fluidly connected to the passage 74 and another second fluid supply line 101 fluidly connected to the passage 77. A pair of one-way valves 102 and 103 are interposed in the supply lines 99 and 101, respectively. The valves 102 and 103 permit fluid to flow into the container 71 but not outwardly therefrom through the supply lines 99 and 101.

For discharge purposes, another pair of lines 104 and 106 are fluidly connected to the passages 76 and 78, respectively. Antoher pair of one-way valve 107 and 108 are interposed in the lines 104 and 106, and permit the flow of fluid outwardly of the container 71 but not inwardly thereof through the lines 104 and 106. The lines 104 and 106 converge at 109 and by means of line 111 form a main discharge conduit 112 with the discharge line 98 of the first container 57.

With respect to the operation of the specific embodiment of the apparatus of this invention shown in FIG. 3, it may be assumed that a first fluid fills te chamber 69 and a second fluid fills the chamber 83. Furthermore, the two-way valves 89 and 96 are open to the first container 57, but the valves 91 and 94 are closed.

Upon the supply of a first fluid, such as 50 lb/in^2 of oxygen through the line 86, due to the valve 85 being opened the first fluid will then pass through the line 87 and the port 61 to impinge against the face 67 of the first piston 66. The fluid under pressure will thus force the piston 66 to the right as illustrated, and in so doing will force a predetermined volume or charge of the first fluid into the chamber 69 outwardly through the open port 64, line 93, and valve 96 to the discharge line 98 for the first container 57.

In the second container 71, due to the first direct connection of the piston 79 with the piston 66, movement of the piston 79 causes a predetermined volume or charge of the second fluid in the chamber 83 to pass outwardly through the open passage 78, and the line 106 and valve 108 to the discharge line 111 for the second container 71. Thus, in the main discharge line 112, a predetermined amount of fluid from the container 57 will be mixed with a predetermined amount of fluid from the container 71, for discharge as a mixture for an appropriate use.

At the end of the stroke of the pistons 66 and 79, the expansible chamber 69*a* contains a like predetermined charge of the first fluid, and the expansible chamber 83*a* a like predetermined charge of the second fluid due to the flow of the same through the line 99. This latter flow can be induced by the vacuum created in the chamber 83a as the piston 79 is moved from left to right (FIG. 3), or by the second fluid being under its own pressure as the case may be. Due to an automatic mechanism as explained hereinafter in detail, or due to other envisionable devices, prior to both pistons reaching their rightmost positions as viewed in FIG. 2 the piston 66, for example, engages a rod or electric switch. Upon engagement of the piston 66 with said rod or switch, valve 85 is progressively closed as the piston 66 continues to move toward its end of travel. The progressive closing of the valve 85 relative to the movement of the piston 66 reduces the flow rate of the incoming first fluid, thereby causing the piston's velocity to be gradually reduced to zero just prior to engagement of the piston 66 with the closed end 59 of container 57. At the end of travel, the valves 89 and 96 are closed, and valves 91 and 94 are open by conventional linkage actuated by the rod or switch mentioned hereinbefore.

Then, upon an opening of the main valve **85**, a supply of the first fluid through lines **86** and **88** forces the fluid to impinge against the face **68** of the piston **66**, resulting in the piston moving to the left as illustrated. The first fluid is thus forced out of the chamber **69***a* and through the lines **92** and **98** toward line **111**. Within the second container **71**, movement of the piston **79** to the left discharges the second fluid through the line **104**, valve **107**, junction **109**, and line **111** to the main discharge line **112** where it is combined with the first fluid, the resulting fluid mixture discharged then as a single fluid.

At the end of the stroke of the pistons **66** and **79** to the left and into the positions illustrated, the expansible chambers **69** and **83** are again filled each with a predetermined volume of its respective fluid. After the main valve **85** has been gradually closed and the pistons **66** and **79** have come to a complete stop in their left-most positions (FIG. **3**) as previously described, the valves **89** and **96** are caused to be opened and the valves **91** and **94** are caused to be closed, as illustrated, The embodiment of FIG. **3** is then ready for another full cycle.

In FIGS. **4** and **5**, the apparatus is illustrated as it would be adapted for use as a respirator for the delivery of a predetermined volume of a predetermined mixture of a pair of fluids. The apparatus would be interposed in an inhalation line to the patient, with the apparatus made operable by the beginning inhalation of the patient. After the inhalation, the patient would exhale through a separate exhalation line, suitable valves being provided for this purpose. Then, when the patient again inhaled, the apparatus would once more be set into operation for a complete inhalation supply.

Specifically, a cylindrical container **116** is provided with a closed end **117** within which is provided a port **119**, and an open end **118**. The end **118** is sealed closed by a longitudinally adjustable end panel **120** within which is formed a port **121**. The panel **120** is made adjustable by being attached to a tube **122** movable axially of the container **116**, and which is fluidly communicable with the interior of the container **116** by the port **121**. An aperture **123** is formed in the outer end of the tube **122** for a purpose hereinafter described. Within the container **116** is mounted a first piston **124** having opposed faces **125** and **126** formed thereon, and whereby the container **116** is divided into a pair of expansible chambers **127** and **127**a.

A second container **128** is also provided, which is of a cylindrical nature and which has a closed end **129** thereof provided with a passage **131** formed therein. The other end **132** of the second container **128** is open, but has fluid-tight panel **133** adjustably movalbe therein. A passage **134** is formed centrally in the panel **133**, and the latter is secured at one end of an axially movable tube **136**, the interior of which is in fluid communication with the interior of the container **128** by means of the passage **134**. An aperture **137** is formed at the outer end of the tube **136** for purposes hereinafter described.

A second piston **138** is mounted within the container **128**, having a pair of faces **139** and **141** formed thereon, and whereby the container **128** is divided into a pair of expansible chambers **142** and **142***a*.

To connect the two pistons **124** and **138**, a wire **143** is provided. Although not shown as continuous due to the connections thereof with the pistons, the wire **143** functions as being continuous. The wire is trained about a pair of adjustable pulleys **144** and **146**, whereby upon movement of the wire, both pistons **124** and **138** are movable simultaneously and in direct proportion. It will be noted that as the piston **124** moves from right to left in FIG. **4**, the piston **138** moves equally, but from left to right. As illustrated, therefore, both pistons are relatively located in their respective containers.

The wire **143** passes through an aperture **147** formed in the closed end **117** of the first container, through the port **121** formed in the adjustable end panel **120**, and then through an otherwise closed end **148** of the tube **122**. The wire **143** then is trained through an aperture **149** formed in the closed end **129** of the second container, through the passage **134** in the end panel **133**, and then through an otherwise closed end **151** of the second tube **136** to complete the continuous nature thereof.

The fluid transmission system for the embodiment of FIGS. **4** and **5** comprises a main valve **150** interposed in a driving fluid supply line **152** which branches off at **153** and **154** to a pair of stub lines **156** and **157**. The latter two lines are fluidly connected, respectively, to the port **119** in the closed end **117** of the first container **116**, and to the aperture **123** formed in the tube **122**.

Discharge lines for the first container **116** are a pair of lines **161** and **163** leading away from the stub lines **156** and **157**, and within which two-way valves **162** and **164** are interposed. It will be seen that two-way valves **158** and **159** are placed in the lines **153** and **154** between th main valve **150** and the fluid communication with the container **116**.

For the second container **128**, a second fluid input line **166** is provided for fluid communication with the chamber **142** via the passage **131**, and within which a two-way valve **167** is mounted. Discharge for the chamber **142** is provided by a line **168** also in fluid communication with the passage **131**, and within which a two-way valve **169** is mounted. The line **168** joins the discharge line **163** of the first container **116** at junction **171**.

At the other end of the container **128**, another second fluid input line **172** is provided, having a two-way valve **173** provided therein and which is fluidly communicable with the interior chamber **142***a* of the container **128** via the aperture **137** in the tube **136**. A discharge line **174** is also in fluid communication with the aperture **137**, and has a two-way valve **176** mounted therein, the line **174** being joined to the discharge line **161** of the first container **116** at junction **177**. From the junctions **171** and **177**, lines **178** and **179** join to form a mixed fluid delivery line **181** for delivering the mixed fluid as appropriately determined.

It will be noted in FIG. **4**, that a flow rate selector valve **182** is interposed, along with the pressure gauge **13** and pop-off safety valve **14**, in the mixed fluid delivery line **181**. It has been seen as it will again hereinafer during further discussion of the FIGS. **4** and **5** embodiment, that the apparatus of this invention will perform as an assistor or as a controller for a conventional respirator, wherein a fixed volume charge of a fluid mixture is discharged or delivered to the patient for each single stroke of the interconnected pistons. The rate of the delivery is determined either by the patient or by an automatic setting.

To vary the rate of delivery, but not the amount delivered for each charge - so to speak, the flow rate se-

lector valve **182** is provided. This valve may be of a needle valve type, for example, whereby to control the diameter of the line **181** at that point. Thus, whereas an amount of 100 cc of fluid mixture is normally delivered per second, manipulation of the dial **11** (FIG. 1) to set the valve **182** can change the rate to 100 cc per half second, or to an actual per second delivery of 200 cc of fluid mixture. The pressure gauge **13** is a valuable indicator enabling the operator at all times to see the pressure of the fluid being delivered to the patient, from zero at the beginning of the inhalation, to a maximum at the end of the inhalation.

Referring now particularly to FIG. **5**, the electric circuit for operating the valves and otherwise controlling operation of the apparatus of FIG. 4 is illustrated.

At the closed end **117** of the first container **116**, for example, a spring limit switch **186** is mounted, which is adapted to be actuated by engagement with the piston **124**. The switch **186** is connected by leads **187** and **187a** to an Eccles-Jordan flip-flop circuit **188**. At the other end **120** of the container **116**, another spring limit switch **192** is mounted, and which is also connected to leads **193** and **193*a*** to the circuit **188**.

From the circuit **188**, a pair of solenoids **199** and **201** are connected, which solenoids control the respective positions of the valves. Thus, for example, solenoid **199** controls valves **158, 164, 167,** and **176,** which valves are spring biased to a normally closed position. Upon energization of solenoid **199,** all four specificed valves are then opened simultaneously. De-energized solenoid **201** is shown holding normally closed, spring biased valves **159, 162, 173,** and **169** closed; energization of the solenoid **201** resulting in opening these valves. Both solenoids **199** and **201** are electrically connected to a suitable electrical potential as shown at **204** in FIG. **5.**

From terminals **202** and **203** in the lines **187** and **193,** lines **202*a*** and **203*a*** join at junction **195** for entry at one side of another Eccles-Jordan flip-flop circuit **208.** The other side of the circuit **208** is connected b/ lead **209,** grounded rectifier **211,** series-connected rectifier **212** and condenser **213** to either a normally open, patient operated switch device **214,** or to the manually operated switch **16,** the other sides of both of which are grounded. The circuit **208** side of the switch **214** is also held at a suitable electrical potential througb a resistor **216.**

On the other side of the second Eccles-Jordan circuit **208,** leads **217** and **218** connect that circuit to a pair of solenoids **219** and **221,** both solenoids electrically connected to a suitable electrical potential at **222** on their other side. Solenoid **219** is operably connected to the main valve **150** (FIG. 4) and solenoid **221** is operably connected to reset switch **214.** The latter switch **214** can, for example, be a negative pressure type mechanism, operable to close at the beginning of inhalation by the patient, to whom the oxygen from the container **116** and the fluid, such as room air from container **128** is being supplied in the proper mixture. The provision of the solenoid **221** is a safety feature to ensure the proper function of the patient triggered switch **214.** The control device **19** (FIG. 1) is provided to vary the pressure at which the switch **214** functions so as to vary and control the response of the apparatus to the patient.

Operation of the embodiment as illustrated in FIGS. **4** and **5** is as follows. Assuming a first fluid such as oxygen to be in the chamber **127a** of the first container **116,** and a second fluid such as room air in the chamber **142** of container **128,** and with the valves in their positions as illustrated, the apparatus is shown in one position ready for operation, except the piston **124** would normally be against the panel **120** and the piston **138** would normally be against the panel **133.**

As the patient begins an inhalation function of his body, the trigger switch **214** would close. The resulting electrical pulse would cause solenoid **219** to open valve **150,** when the solenoid was energized by operation of the flip-flop circuit **208.** Driving fluid would then begin to flow through line **152,** valve **159,** branch **154** and stub branch **157,** and then through the interior of the tube **122** to chamber **127** in the container **116.**

This would result in the piston **124** being forced from right to left as illustrated in FIG. **4,** forcing the fluid in chamber **127*a*** outwardly through the port **119,** and the lines **156** and **161,** also passing through the open valve **162** to the junction **177** of a second container line.

In the second container **128,** as the piston **124** effects a like movement of the piston **138** due to the interconnecting wire **143,** the piston **138** moves from left to right as illustrated in FIG. **4,** thus forcing the second fluid out of the chamber **142** and through the line **168** and open valve **169** to the junction **171.** Thus, in line **178** a predetermined amount of the first fluid from the first container **116** flows, whereas in line **179** a predetermined amount of the second fluid from the second container **128** flows toward the first fluid. These fluids are then combined in main discharge line **181** for appropriate transmission.

Prior to the piston **124** reaching the end of its travel in the container **116,** it contacts the spring limit switch **186** which causes the flip-flop circuit **208** to switch, thus energizing for example solenoid **221** while de-energizing solenoid **219.** Actuation of the solenoid **221** resets the trigger switch **214** to its normally open position, and de-actuation of the solenoid **219** effects a closing of the main valve **150.** Simultaneously a time delay circuit **224** in the other circuit **188** is energized by the engagement of the piston with the spring limit switch **186.**

After a suitable time delay, a time delay circuit **224** causes the flip-flop circuit **188** to switch, thus energizing for example solenoid **199** while de-energizing solenoid **201.** Identical time delays **224** and **225** are interposed in both lines **187*a*** and **193*a***. The actuation of these solenoids **199** and **201** results, respectively, in valves **158, 164, 167,** and **176** opening, with the other quartet of valves **159, 162, 173,** and **169** closing. During the time delay and after the progressive closing of valve **150,** the piston **124** continues its travel toward the end of the cylinder **116** being driven by pressure of the driving fluid trapped in the conduit between closed valve **150** and the piston **124.** The velocity of the piston **124** is gradually reduced to zero just prior to the piston's engagement with the closed end **117** of container **116.** The patient can now exhale through a separate exhalation line and suitable one-way valves (not shown).

When the patient again inhales, the main valve **150** is again opened and the cycle is repeated, except that at this time the driving piston **124** moves from left to right, as illustrated, and the driven piston **138** moves from right to left. At the end of the travel of the piston **124,** the limit switch **192** is operated to again cause a progressive closing of the main valve **150** as the piston continues to move, with an opening, after a suitable

time delay, of the valves **159, 162, 173,** and **169** along with a closing of valves **158, 164, 167,** and **176.** Furthermore, the patient triggered switch **214** is again reset to its normally open position. Thus, during the completion of one mechanical cycle of the apparatus of FIGS. **4** and **5,** the patient has been supplied two separate volumes of fluid for inhalation purposes.

It can of course be visualized that the flip-flop circuit **108** could be so arranged, electrically, to effect more than one patient-inhalation supply of fluid at a time, as compared to the single supply just described, prior to a resetting of the patient triggered switch **214.** This would thereby inject a "sigh" into the respiration cycles for the patient. And furthermore, although the embodiments are fluid powered by the driving fluid, it is quite conceivable that the patient triggered switch could actuate means for effecting reciprocal movement of the pistons without the need of a pressurizing fluid. Thus, two unpressurized fluids can be mixed in a predetermined ratio, and delivered at a controllable rate. It can further be visualized that the valves in the system may be caused to operate through suitable linkage by the piston **124** engaging a push rod prior to the piston reaching its end of travel.

Another embodiment of the apparatus of the invention is illustrated in FIGS. **6** and **7** inclusive, with the Figures being of a schematic nature. The apparatus as illustrated is adapted for use as a respirator for the delivery of a predetermined volume of a predetermined mixture of a pair of fluids. The apparatus is interposed in an inhalation line to the patient, with the apparatus made operable by the beginning inhalation of the patient. After the inhalation, the patient would exhale through a separate exhalation line, suitable valves being provided for this purpose. Then, when the patient again inhaled, the apparatus would once more be set into operation for a complete inhalation supply.

The embodiment of FIGS. **6–8** is contained in a housing identical to housing **10** of FIG. **1,** and like reference numerals indicate like parts. Specifically, a cylindrical container **316** is provided with a closed end **317,** within which is provided a port **319,** and an open end **318.** The end **318** is sealed closed by a longitudinally adjustable end panel **320** within which is formed a port **321.** The panel **320** is made adjustable by being attached to a tube **322** movable axially of the container **316,** and which is fluidly communicable with the interior of the container **316** by the port **321.** An aperture **323** is formed in the outer end of the tube **322** for a purpose hereinafter described. Within the container **316** is mounted a first piston **324** having opposed faces **325** and **326** formed thereon and whereby the container **316** is divided into a pair of expansible chambers **327** and **327***a*.

A second container **328** is also provided which is of a cylindrical nature and which has a closed end **329** thereof provided with a passage **331** formed therein. The other end **332** of the second container **328** is open, but has a fluid-tight panel **333** adjustably movable therein. A passage **334** is formed centrally in the panel **333,** and the latter is secured at one end of an axially movable tube **336,** the interior of which is in fluid communication with the interior of the container **328** by means of the passage **334.** An aperture **337** is formed at the outer end of the tube **336** for purposes hereinafter described. A second piston **338** is mounted within the container **328,** having a pair of faces **339** and **341** formed thereon, and whereby the container **328** is divided into a pair of expansible chambers **342** and **342***a*.

The pistons **324** and **338** are connected by means of a rod **343.** Both pistons **324** and **338** are movable simultaneously and in direct proportion and are relatively located in their respective containers. From the piston **324,** the rod **343** passes through a rod seal **347** formed in the closed end **317** of the first container, through an otherwise closed rod seal **351** of the second tube **336,** and then through the passage **334** of the end panel **333,** and is finally connected to the second piston **338.**

The fluid transmission system for the embodiment of FIGS. **6** and **7** comprises a driving fluid supply line **352** which branches into lines **353** and **354.** Lines **353** and **354** are connected to a pair of stub lines **356** and **357,** respectively. The latter two lines are fluidly connected respectively to the ports **1P** of valve **1** and **2P** of valve **2.** Port **1C** of valve **1** is fluidly connected to port **3E** of valve **3** and to line **358.**

Referring to FIG. **8,** valve No. **1** is schematically illustrated, valve No. **1** being identical to the other valves No. **2,** No. **3** and No. **4.** The valve **1** is a three-way valve having port **1P** connected to a high pressure line, such as stub line **356** (FIG. **6**); port **1C** connected to a hydraulic cylinder line, such as tube **322;** and port **1E** open to the atmosphere and thus being at the ambient pressure. When the valve **1** is energized, so to speak, the valve seat **1S** is moved to the dotted line position wherein the high pressure fluid flows from the stube line **356** through ports **1P** and **1C** toward the cylinder **316.** The valve **1** can then be shut down by moving the seat **1S** to the full line position as illustrated in FIG. **8,** wherein the high pressure flow is stopped and fluid can flow from the port **1C** outwardly through the exhaust port **1E.**

Port **2C** (FIG. **6**) of valve **2** is fluidly connected to port **4E** of valve **4** and to line **359.** Line **362** fluidly connects lines **358** and **359** to a patient exhaust valve in the nasal mask **468.** Port **3C** of valve **3** is fluidly connected to aperture **323.** Port **4C** is fluidly connected to port **319.** Ports **3P** of valve **3** and **4P** of valve **4** are fluidly connected, respectively, to lines **363** and **364** which are in turn fluidly connected through line **367** to the patient.

For the second container **328,** a second fluid input line **466** is provided for fluid communication with the chamber **342** via the passage **331,** and within which a one-way valve **467** is mounted. Discharge for the chamber **342** is provided by the line **368** also in fluid communication with the passage **331,** and within which a one-way valve **369** is mounted. The line **368** joins the main discharge line **367.**

At the other end of the container **328,** another second fluid input line **372** is provided, having a one-way valve **373** provided therein and which is fluidly communicable with the interior chamber **342***a* of the container **328** via the aperture **337** in the tube **336.** A discharge line **374** is also in fluid communication with the aperture **337,** and has a one-way valve **376** mounted therein, the line **374** being joined to the main delivery line **367.**

The valves **467** and **373** permit fluid to flow into the container **328,** but not outwardly therefrom throught the supply lines **466** and **372.** The valves **369** and **376** permit the flow of fluid outwardly of the container **328** but not inwardly thereof through the lines **368** and **374.**

Line 367 delivers the mixture of the first and second fluids to the patient. It will be noted in FIG. 6, that a flow rate selector valve 382 is interposed, along with the pressure gauge 13, pop-off safety valve 14, and trigger switch 522 in the mixed fluid delivery line 367.

It has been seen as it will again hereinafter during further discussion of the FIGS. 6 and 7 embodiment, that the apparatus of this invention will perform as an assistor or as a controller for a conventional respirator, wherein a fixed volume charge of a fluid mixture is discharged or delivered to the patient for each single stroke of the interconnected pistons. The frequency of delivery is determined either by the patient or by an automatic setting.

To vary the flow rate of delivery, but not the amount delivered, for each charge — so to speak — the flow rate selector valve 382 is provided. This valve may be of a needle type valve, for example, whereby to control the diameter of the line 367 at that point. Thus, whereas an amount of 100 cc of fluid mixture is normally delivered per second, manipulation of the dial 11 (FIG. 1) to set the valve 382 can change the rate to 100 cc per half-second, or to an actual per second delivery of 200 cc of fluid mixture. The pressure gauge 13 is a valuable indicator enabling the operator at all times to see the pressure of the fluid being delivered to the patient.

Referring now particularly to FIG. 7, the electric circuit for operating the valves and otherwise controlling the apparatus of FIG. 6 is illustrated.

At the closed end 329 of the second container 328, for example, a spring limit switch 692 is mounted, which is adapted to be actuated by engagement with the piston 324. One side of switch 692 is connected by a lead 385 to an Eccles-Jordan flip-flop circuit 388. At the other end 332 of the container 328, another limit switch 386 is mounted, one side of which is also connected by lead 693 to a second Eccles-Jordan flip-flop circuit 389.

Flip-flop circuits 388 and 389 are connected by leads 390 and 391 to amplifiers 392 and 393, respectively. Amplifier 392 is operably connected to valves 2 and 3 by lines 394 and 395. Amplifier 393 is operably connected to valves 1 and 4 by lines 396 and 397. Amplifier 392 and 393 are connected to an "or" gate 398 by lines 394 and 500, and lines 396 and 501, respectively. The "or" gate 398 is operably connected by line 502 to a relay 503.

Amplifiers 392 and 393 are also connected by lines 394 and 505, and by lines 396 and 504, respectively, to an "and" gate 506. The "and" gate 506 is connected to a "grounding" gate 508 by line 507, and the "grounding" gate 508 is connected to line 387 by lines 509. Timing circuit 523 is connected to flip-flop circuits 388 and 389 by lines 520, 519, 516, 514, 513, 512, and 511. Automatic sigh timer 524 is connected to flip-flop circuits 388 and 389 by lines 518, 516, 514, 513, 512, and 511.

One side of the manual trigger switch 16 is connected to flip-flop circuits 388 and 389 by lines 517, 516, 514, 513, 512, and 511. One side of negative pressure switch 522 is connected to flip-flop circuits 388 and 389 by lines 515, 514, 513, 512, and 511. The second sides of switches 521 and 522 are connected to a suitable electrical potential. The second sides of limit switches 386 and 392 are alternately connected to suitable electrical potential by engagement with piston 338.

Operation of the embodiment as illustrated in FIGS. 6 and 7 is as follows. Assuming a first fluid such as oxygen to be in the chamber 327*a* of the first container 316, and a second fluid such as room air in the chamber 342 of container 328, and with the valves in their normally closed positions, the apparatus is shown in one position ready for operation, except the piston 324 would normally be against the panel 320 and the piston 338 would normally be against the panel 333.

As the patient begins an inhalation function of his body, the trigger switch 522 closes. The resulting electrical pulse causes flip-flop 389 and amplifier 393 to operate valves 1 and 4, allowing the first fluid to flow from port 1P to port 1C, from port 1C to port 3E, from port 3E to port 3C, and from port 3C through aperture 323, the tube 322, the port 321 and into the chamber 327 of container 316. This would result in the piston 324 being forced from right to left as illustrated in FIG. 6, forcing the fluid in chamber 327*a* outwardly through the port 319, through port 4C to port 4P, from port 4P through lines 364, 365 and 367 outwardly to the patient.

Simultaneously with the operation of valve 1, the first fluid flows from port 1P to port 1C, through lines 358, 361, and 362 to a patient exhaust valve, via the coupling 18, in the patient's nasal mask 468, causing the patient exhaust valve to close.

The nasal mask 468 is shown in FIG. 9 as placed over a patient's nose. The mask 468 comprises a semicircularly formed shell 469 of plastic or the like, which has a fluid fitting 471 on one side thereof, and a port 472 formed in its upper portion. An open-type, light metal strap 473 of an inverted U-shape is secured to the shell 469 as illustrated. The shell 469, when placed on a doughnut-like mass of material 474, of soft denture liner for example, formed completely about the nose, forms an airtight cavity 476 thereover, which cavity is fluidly communicable with line 367 attached to fitting 471, and with the atmosphere via the port 472 which functions as an exhaust port.

The exhaust port 472 is open or closed depending upon the condition of an inflatable bladder 477 positioned over the port 472 by a circular, flat, washer-like disc 478 to which the bladder is bonded. The bladder 477 rests lightly over the port 472 and normally closes it. The disc 478 is secured to an upright fitting 479 inserted through an aperture therefor in the strap 473 and secured to the strap by a nut 481 and washer 482. The exposed end of the exhaust fitting 479 is fluidly connected to line 362, and opens through a port in the bladder formed therefor in the interior of the bladder 477 to the line 362.

Positive pressure in both lines 367 and 362 simultaneously effects transmission of the fluid in line 367 to the patient via the mask cavity 476 and his nasal passages, and effects a sealing of the port 472 by inflation of the bladder 477. Negative or lack of pressure in line 362 permits deflation of the bladder 477, and normal exhalation of the patient through the open exhaust port 472 and to the atmosphere about the legs of the strap 473. Subsequent to the exhalation, the bladder 477 assumes its normal position resting lightly over and closing the exhaust port 472, preventing inhalation through the port 472. Lines 362 and 367 may connect to a valve adaptor (not shown) instead of the mask 468, which adaptor permits the respirator to be attached to the patient through an endotracheal tube.

In the second container **328**, as the movement of piston **324** effects a like movement of the piston **338** due to the interconnecting rod **343**, the piston **338** moves from right to left as illustrated in FIG. **6**, thus forcing the second fluid out of the chamber **342**, via passage **331**, through the line **368** and through one-way valve **369** to the main delivery line **367**. Thus a predetermined volume of the second fluid is mixed in line **367** with a predetermined volume of the first fluid from the first container **316**.

As piston **338** moves from right to left, it causes a vacuum in chamber **342***a* which results in a flow of the second fluid inwardly through second fluid input line **372**, through one-way valve **373**, aperture **337**, tube **336**, passage **334** and into chamber **342***a*. As the piston **338** approaches the closed end **329** of container **328** it contacts the spring limit switch **392** causing the flip-flop **389** to switch. Flip-flop **389**, operating through amplifier **393**, de-energizes valves **1** and **4** causing valves **1** and **4** to return to their original positions. The normal position of all valves **1–4** inclusive is closed.

Thus port **1P** of valve **1** is closed, assuming its full line position of FIG. **8**, and port **4P** of valve **4** is closed. Ports **1E**, **1C**, **3E** and **3C** are open providing an exhaust passage to chamber **327** via aperture **323**, tube **322**, and port **321**, allowing the pressure of the first fluid within chamber **327** to equalize with that of the surrounding atmosphere. Ports **4C**, **4E**, **2C** and **2E** are open providing an exhaust passage to chamber **327***a* via port **319**, allowing the pressure of the first fluid within chamber **327***a* to equalize with that of the surrounding atmosphere. Valves **1** and **4** operate at the same time, causing chamber **327** and chamber **327***a* to be exhausted simultaneously.

By this arrangement, wherein both chambers are open to the atmosphere, for what amounts to a short period of time, the pressure of the respective fluids therein become the same, thus being equal to the ambient pressure. Thus both fluids are therefore delivered at the same pressure, providing therefore for a precise metering of exact volumes to the patient.

When port **4P** of valve **4** closes, the pressure of the fluids in lines **363**, **364**, **365**, **367**, **368**, **374** and chamber **342** is increased due to the continued inertial movement from right to left of the piston **338**, the rod **343**, and the piston **324**. The piston **338**, the rod **343**, and the piston **324** continue to move after the operation of valves **1** and **4** due to the force of inertia.

The movement of this piston and rod assembly is gradually slowed by friction and the pressure of the second fluid in chamber **342** until the assembly comes to a complete stop. Spring limit switch **392** is adjustably positioned so that piston face **341** of piston **338** does not contact the inner surface of the closed end **329** of container **328**.

When valve **1** operates, closing port **1P**, and opening port **1C** and **1E** it allows lines **358**, line **361**, and line **362** to begin to exhaust. As the pressure in line **362** reduces, the patient exhaust port **472** opens, allowing main delivery line **367**, all associated fluidly connected lines, and chamber **342** to be exhausted to atmospheric pressure. The patient can now exhale through the nasal mask **468** to the atmosphere.

When the patient again inhales, valves **2** and **3** are caused to operate and the cycle is repeated, except that at this time the pistons **324** and **338** move from left to right, as illustrated. Near the end of travel of the pistons **324** and **338**, the limit switch **386** is operated to cause the operation of valves **2** and **3**, and the gradual shutdown and exhaust cycle is repeated. Thus, during the completion of one mechanical cycle of the apparatus of FIG. **6**, the patient has been supplied two separate volumes of fluid for the purpose of inhalation.

Referring specifically to FIG. **7**, the action of the automatic sigh timer **524** is such that at predetermined times a double cycle of the mechanical apparatus is caused to deliver to the patient a double inhalation volume or sigh. Referring to FIG. **1**, a selector knob **501** is illustrated which, upon rotation, causes the panels **320** and **333** (FIG. **6**) to be moved a predetermined and equal distance longitudinally within their respective cylinders. Such movement changes the effective length of the respective chambers within the cylinders, thus controlling the volume of fluid delivered to the patient by the respirator. Also illustrated is a scale **502** having an indicator **503** to display the volume being delivered by the respirator. The indicator **503** is attached to the end panels **320** and **333** and thus visibly illustrates their exact movement.

The operation of the device hereinbefore described is that of a respiratory-assistor wherein the patient initiates the operation of the delivery of fluid mixture. In the event that the patient has not the power to initiate operation, timing circuit **523** is provided, which causes the triggering of fluid delivery at regular intervals, operating the machine as a respiratory controller.

In the event of the simultaneous operation of valves **1**, **2**, **3**, and **4**, resulting in a stalling of the machine, amplifiers **392** and **393** both deliver a signal to "and" gate **506** through lines **504** and **505**. "And" gate **506**, upon receiving two signals at once, sends a signal through line **507** to grounding gate **508**. The output from grounding gate **508** through lines **509** and **510** causes flip-flop **388** to switch. The flip-flop **388** causes valves **2** and **3** to return to their former positions. The machine then resumes normal operation.

Although the embodiments hereinbefore described are fluid powered, it is quite conceivable that other means for effecting reciprocal movement of the pistons, such as an electric motor, could be embodied. Thus two unpressurized fluids can be mixed in a predetermined ratio, and delivered at a controllable volume, flow, and pressure.

Although a preferred embodiment of this invention has been described and disclosed hereinbefore, it is to be remembered that various modifications and alternate constructions may be made thereto without departing from the true spirit and scope of the invention as defined in the appended claims.

We claim:

1. Respirator means comprising:

patient means including a member having a chamber formed therein fluidly communicable with a patient's lungs, an inhalation conduit fluidly communicating with said chamber, said member having a port formed therein open to the atmosphere, a valve controlling said port, and a control line fluidly connected to said valve, said valve responsive to said control line to close said port during inhalation of the patient and operable to open said port during exhalation of the patient;

a pair of cylinders each having a piston reciprocally mounted therein, said pistons interconnected;

one of said cylinders operably connected to a fluid source and fluidly connected to said control line, the other of said cylinders operably connected to a fluid source and fluidly connected to said inhalation conduit; and

valve means regulating the flow of fluid to said control line and to said inhalation conduit, said valve means operable in one position to transmit fluid simultaneously to said control line and to said inhalation conduit, and operable in another position to cease said fluid transmissions during exhalation of the patient.

2. Respirator apparatus as defined in claim **1,** and wherein said valve is responsive to the flow of fluid thereto from said one cylinder through said control line to close said port during inhalation of the patient, and said valve is responsive upon withdrawal of said fluid flow therefrom by action of said valve means to open said port upon exhalation of the patient.

3. Respirator apparatus as defined in claim **2,** and wherein said valve comprises a resilient bag normally engaging said member and covering over said port, said bag movable away from said port due to exhalation of the patient, said bag rendered immovable from said port upon receipt of said fluid flow thereto during inhalation of the patient.

4. Respirator apparatus as defined in claim **3** and wherein said bag is expandable to an expanded condition upon receipt of said fluid transmitted thereto, and is retractable to a normal, non-expanded condition upon withdrawal of said fluid therefrom, a strap element holding said bag loosely against said port in said normal condition and holding said bag tightly against said port in said expanded condition, said bag movable away from so as to open said port to the atmosphere in response to impingement thereon of said exhalation fluid of the patient in said chamber when said bag is in said normal condition, said bag immovable by fluid pressure in said chamber during inhalation of the patient.

5. Respirator means comprising:

patient means including a member having a chamber formed therein fluidly communicable with a patient's lungs, an inhalation conduit fluidly communicating with said chamber, said member having a port formed therein open to the atmosphere, a valve controlling said port, and a control line fluidly connected to said valve, said valve responsive to the flow of fluid thereto from said control line to close said port during inhalation of the patient, and said valve responsive upon cessation of said fluid from said control line to open said port upon exhalation of the patient;

a pair of cylinders each having a piston reciprocally mounted therein, said pistons interconnected;

one of said cylinders operably connected to a fluid source and fluidly connected to said control line, the piston of said one cylinder operably responsive to receipt in said one cylinder of the fluid from said source to transmit said fluid to said control line;

the other of said cylinders connected to another fluid source and fluidly connected to said inhalation conduit, the piston of said other cylinder responsive to operation of said one cylinder piston to transmit said other fluid to said inhalation conduit; and

valve means regulating the flow of fluid to said control line and to said inhalation conduit, said valve means cooperable in one position with said cylinders to transmit fluid to said control line from said one cylinder and to said inhalation conduit from said other cylinder, and cooperable in another position with said cylinders to cease the transmission of said fluids during exhalation of the patient.

6. Respirator apparatus as defined in claim **5,** and wherein said valve comprises a resilient bag normally engaging said member and covering over said port, said bag movable away from said port due to exhalation of the patient, said bag rendered immovable from said port upon receipt of said fluid flow thereto during inhalation of the patient.

7. Respirator apparatus as defined in claim **6** and wherein said bag is expandable to an expanded condition upon receipt of said fluid transmitted thereto, and is retractable to a normal, non-expanded condition upon withdrawal of said fluid therefrom, a strap element holding said bag loosely against said port in said normal condition and holding said bag tightly against said port in said expanded condition, said bag movable away from so as to open said port to the atmosphere in response to impingement thereon of said exhalation fluid of the patient in said chamber when said bag is in said normal condition, said bag immovable by fluid pressure in said chamber during inhalation of the patient.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,788,313 Dated January 29, 1974

Inventor(s) Leon J. Arp and James M. Varnum

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 17, line 15, cancel "from said one cylinder". Column 18, line 12, cancel "said fluid to said control line" and insert therefor --motion to the other piston--; lines 22, 23 cancel "from said one cylinder".

Signed and sealed this 14th day of January 1975.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

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