Sept. 11, 1956 T. C. HUXLEY III 2,762,200

RESPIRATOR PUMPING APPARATUS

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Fig. 1.

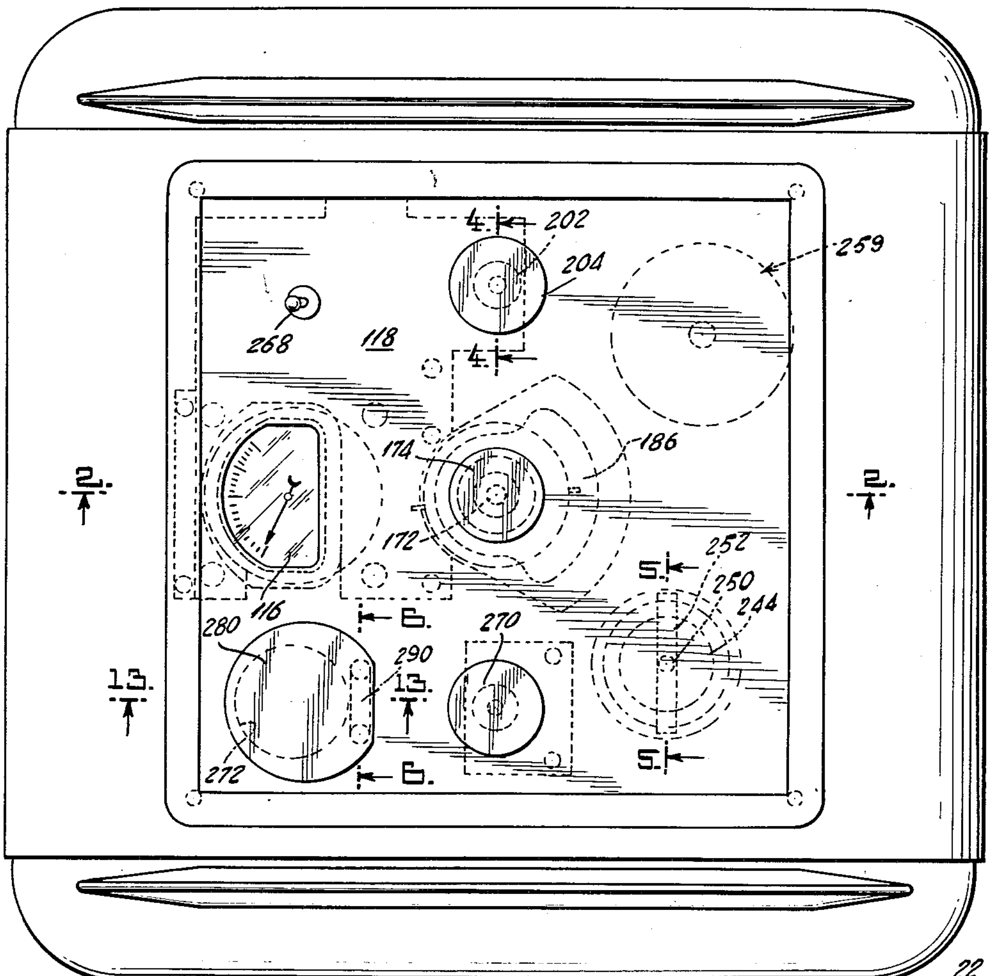


Fig. 4.

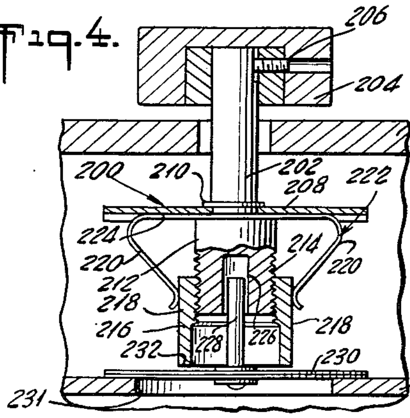


Fig. 5.

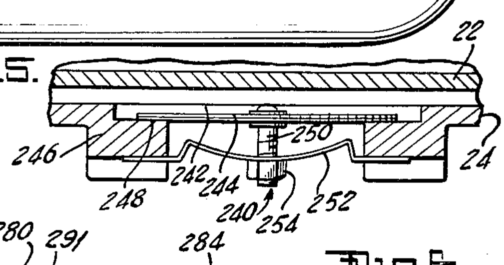
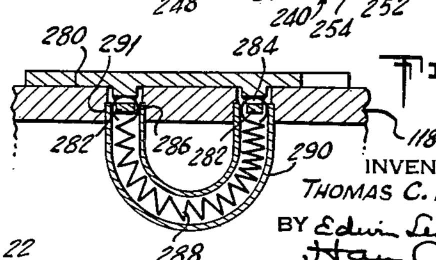


Fig. 6.



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RESPIRATOR PUMPING APPARATUS

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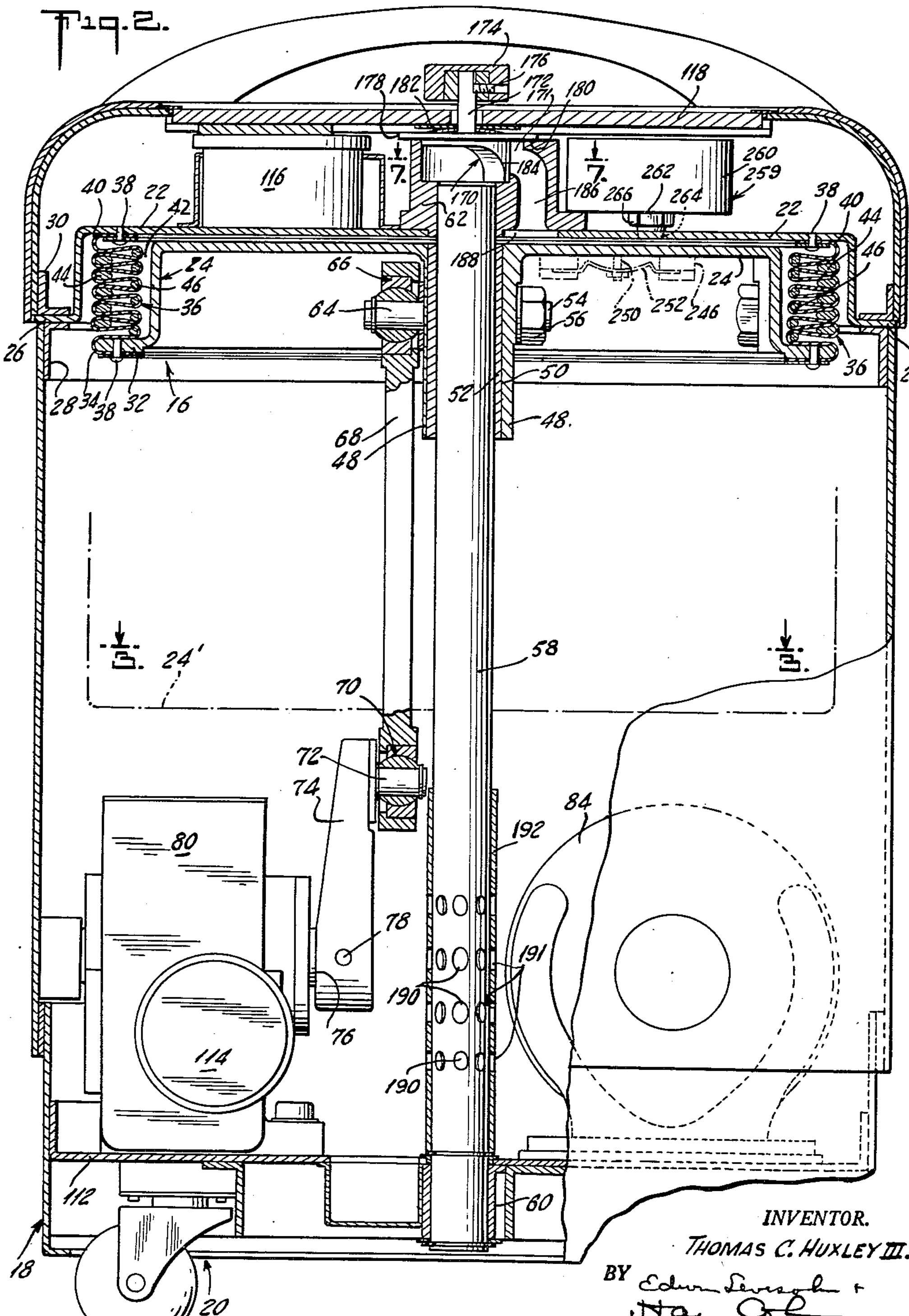
Fig. 2.



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RESPIRATOR PUMPING APPARATUS

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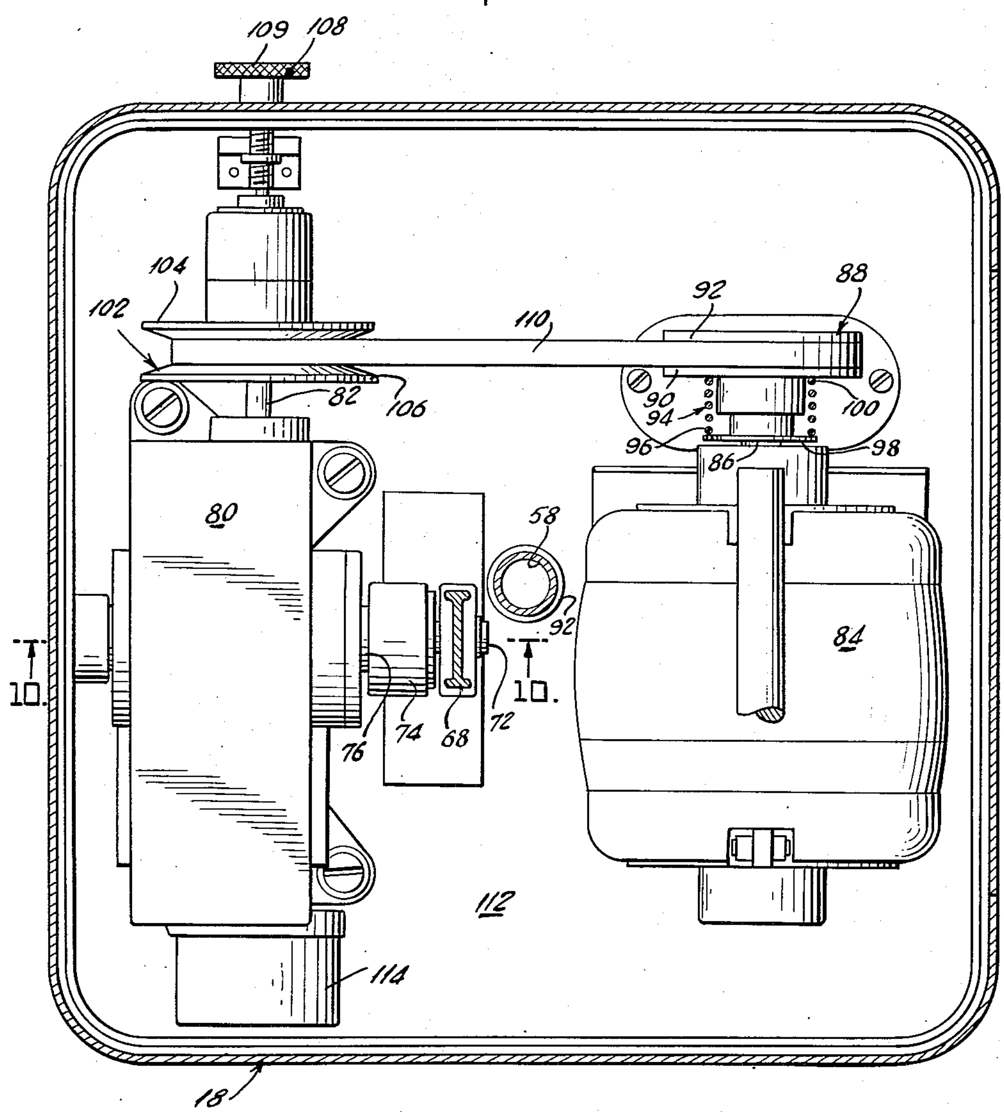
Fig. 3.



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RESPIRATOR PUMPING APPARATUS

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Fig. 9.

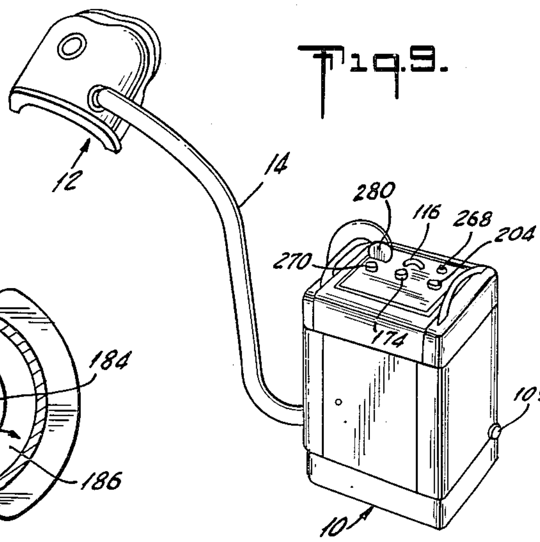


Fig. 7.

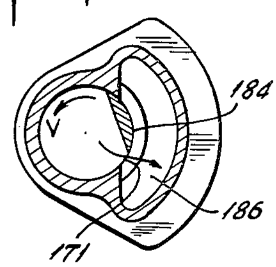


Fig. 8.

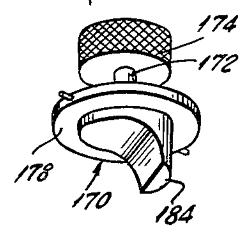
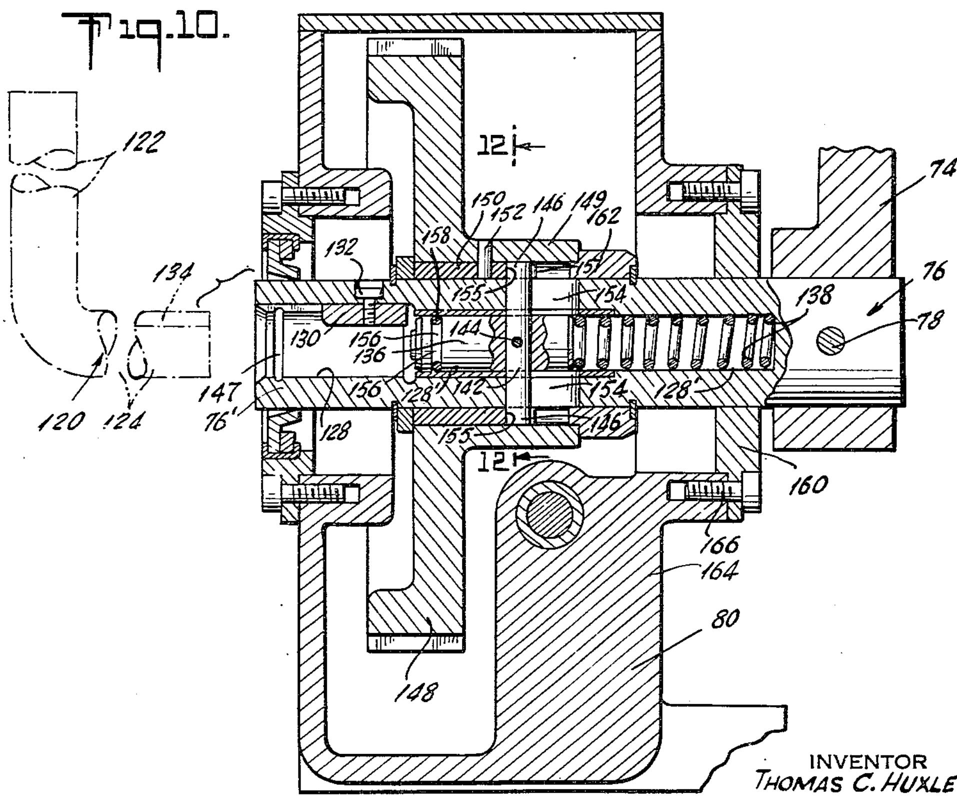


Fig. 10.



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RESPIRATOR PUMPING APPARATUS

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Fig. 13.

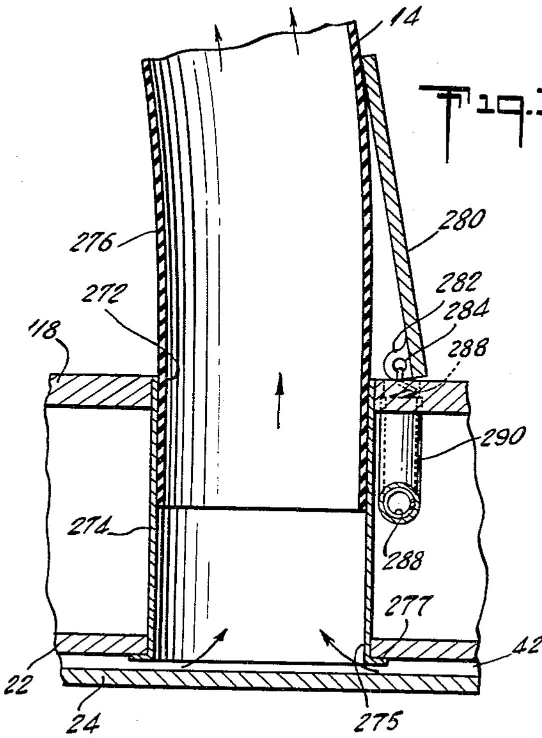


Fig. 12.

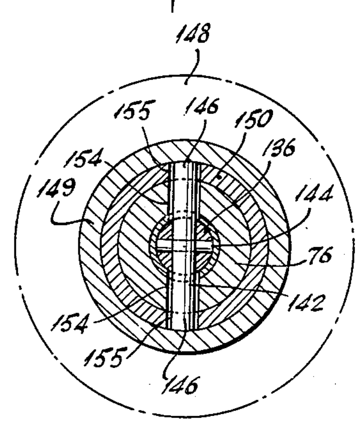
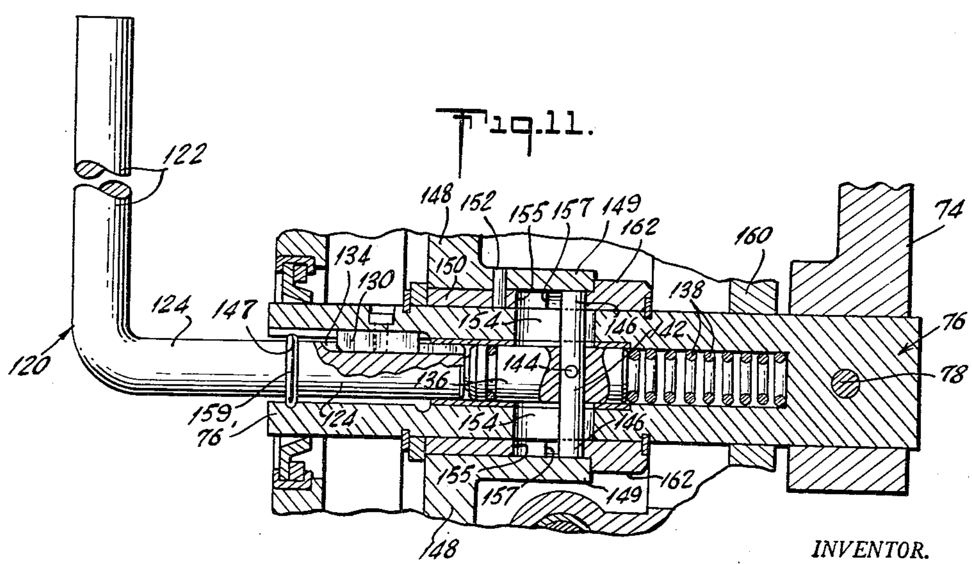


Fig. 11.



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United States Patent Office

2,762,200

Patented Sept. 11, 1956

2,762,200

RESPIRATOR PUMPING APPARATUS

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Application June 24, 1952, Serial No. 295,181

3 Claims. (Cl. 60—62.5)

This invention relates to improvements in respirator pumping apparatus generally and, more particularly, to improvements in the pump and control unit for respirators.

One object of the present invention is the provision of a compact, readily-portable and reliable pump and control unit for artificial respirators.

Another object is to provide a pump and control unit wherein the pump, the actuating means therefor and the controls required for the proper operation of the pump in conjunction with the cuirass of the artificial respirator apparatus are all disposed within the casing of the apparatus.

Another object of the present invention is the provision, in a pump and control unit for respirators, of improved means for manually actuating the pump in the event of power failure, said manual means being effective to automatically disengage the power means from operative association with the pump when the manual means is operatively associated with the pump.

Another object of the present invention is the provision, in a pump and control unit for respirators, of an improved cranking arrangement for actuating the pump in the event of power failure, the power means for actuating the pump being automatically declutched from operative association with the pump in response to the operative association with the pump of a hand crank.

Another object of the present invention is the provision, in a pump and control unit for respirators, of an improved control arrangement for controlling the admission of air to the pumping chamber during the suction phase of the pumping cycle and for independently controlling the discharge of air from the pumping chamber during the positive pressure phase of the pumping cycle.

Another object of the present invention is the provision, in a pump and control unit for respirators, of an improved control arrangement of the above character in which there is provided additional safety means to limit the amount of negative pressure produced by the pump and applied to a cuirass operatively connected to the pump.

Yet another object of the present invention is the provision of a generally improved pump and control unit for respirators which is simple in design and construction, relatively inexpensive to manufacture, and highly effective in the accomplishment of its intended purpose.

The above and other objects, features and advantages of the present invention will be more fully understood from the following description considered in connection with the accompanying illustrative drawings.

In the drawings:

Fig. 1 is a top plan view of the respirator pumping apparatus according to the present invention;

Fig. 2 is a partial sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 2;

Fig. 4 is a sectional view taken on the line 4—4 of Fig. 1;

Fig. 5 is a sectional view taken on the line 5—5 of Fig. 1;

Fig. 6 is a sectional view taken on the line 6—6 of Fig. 1;

Fig. 7 is a sectional view taken on the line 7—7 of Fig. 2;

Fig. 8 is a perspective view of the vacuum control member;

Fig. 9 is a perspective view of the respirator pumping apparatus shown connected to a cuirass;

Fig. 10 is a sectional view taken on the line 10—10 of Fig. 3 with the crank shown disengaged from the apparatus;

Fig. 11 is a fragmentary view similar to Fig. 10 showing the crank engaged in the apparatus;

Fig. 12 is a sectional view taken on the line 12—12 of Fig. 10; and

Fig. 13 is a sectional view on an enlarged scale, taken on the line 13—13 of Fig. 1 with a conduit shown connected to the pumping apparatus.

Referring to the drawings and, more particularly, to Fig. 9 thereof, the respirator pumping apparatus **10** is adapted to periodically supply air to and withdraw air from a cuirass **12**, which is operatively connected to the pumping apparatus **10** by means of the conduit **14**. The cuirass **12** may be any one of the well known types, for example the type shown and described in the patent to Thomas C. Huxley III, No. 2,466,108, issued April 5, 1949, for Artificial Respirator. It will be understood that the cuirass **12** is adapted to be fitted to a patient, and when so fitted, the pumping apparatus **10** is adapted to periodically supply air to and withdraw air from said cuirass to simulate normal respiration. Thus the pumping apparatus **10**, when operatively associated with the cuirass **12**, alternates between partial evacuation and normal pressure of the air within the cuirass at a controlled and variable rate to successfully simulate normal respiration.

The apparatus **10** comprises a bellows-type pump **16** which has means integrated therewith for controlling the amount of negative pressure or suction applied to the cuirass **12** and for controlling the amount of positive pressure applied to said cuirass. The pumping apparatus **10** is housed in a suitable casing **18**, the latter having casters **20** at its lower end to facilitate the movement of the apparatus **10** on a supporting surface. The pump **16**, which is preferably of the bellows-type, comprises a fixed head **22** and a piston **24** relatively movable thereto, said piston being mounted for reciprocation by the means to be described in detail hereinafter. The pump **16** is of generally rectangular outline to conform to the general cross-sectional outline of the casing **18**. The pump head **22** is fixed to the casing **18** in any suitable manner, as by means of the flange **26** secured between the brackets **28** and **30**, the latter being secured to the casing in any desired manner. The piston **24** is formed complementary to the pump head **22** and is provided with a peripheral outwardly extending flange **32**, the latter having secured thereto one end **34** of the bellows **36** in any conventional manner, as by means of the rivets **38**. The opposite end **40** of the bellows **36** is secured to the underside of the head **22** in a similar manner as the securement of the end **34** of said bellows to the piston **24**. It will be understood that the bellows **36** is secured to the pump head **22** and piston **24** in sealing relation therewith whereby there is defined between said head and piston a sealed pumping chamber **42**. The bellows **36** is provided with a series of peripherally extending fold retaining members **44** and **46**, said members conforming to the cross-sectional outline of the pump **16** and being effective to maintain the bellows folds, as shown in Fig. 2. It will also be noted that the fold retaining members **44** are laterally spaced outwardly of the fold retaining members 46 and that the latter are of circular cross-section, whereas the members 44 are of elongated cross-section.

The piston 24 has a depending shaft 48 positioned centrally thereof, said shaft being apertured at 50 for the reception of the bearing sleeve 52, the latter being preferably press-fitted in said shaft. The shaft 48 of the piston 24 is longitudinally split and the bolt and nut 54 and 56, respectively, are adapted to maintain securement of said shaft and bearing sleeve 52 in adjusted position relative to the hollow shaft 58 secured in fixed relation in the housing 18. The piston 24 is adapted to be reciprocated between the broken line position indicated at 24' in Fig. 2 and the solid line position 24, and for guiding said reciprocation of the piston 24 there is provided the hollow shaft 58, the bearing sleeve 52, disposed on the interior of the shaft 48, being slidably mounted on said hollow shaft. The hollow shaft 58 extends vertically of the casing 18 and is secured centrally therein by any suitable means, for example by supporting brackets 60 and 62 at the lower and upper ends of said casing, respectively. Thus the piston 24 is guided for its range of reciprocation by means of the hollow shaft 58, the bearing sleeve 52 of said piston being slidably mounted on said hollow shaft. Laterally projecting from the shaft 48, and in fixed relation therewith, is a pin member 64 which is journaled for relative rotation in the bearing 66 at the upper end of the connecting rod 68. As shown in Fig. 3, the connecting rod 68 is I-shaped in cross-section and has a bearing 70, similar to bearing 66, at its lower end for the reception of the crank pin 72, the latter being journaled for rotation in the connecting rod 68 by means of the bearing 70. The crank pin 72 is secured to the crank arm 74 in any suitable manner whereby it will be seen that the rotation or oscillation of said crank arm will be effective to reciprocate the connecting rod 68 and the latter will impart its reciprocatory motion to the piston 24. Thus the rotation or oscillation of the crank arm 74 will be effective to correspondingly control the pumping action of the piston 24, the down stroke of the latter being the negative pressure or suction stroke and the up stroke being the positive pressure stroke of the apparatus. It will be understood that the volume of the pumping chamber 42 will vary from a maximum to a minimum as the piston 24 is reciprocated through a cycle of operation.

The crank arm 74 is keyed to the shaft 76 by means of the pin 78, said shaft 76 constituting the low speed or output shaft of the speed reducer, indicated generally at 80. It will be understood that the speed reducer 80 is of generally conventional construction and is adapted to reduce the speed of shaft 76 relative to the speed of shaft 82 which constitutes the input shaft of said speed reducer. Shaft 82, during the normal operation of the apparatus 10, is adapted to be power driven by means of motor 84 in a manner now to be described. The output shaft 86 of the motor 84 is provided with a split pulley 88, the movable half 90 of the pulley 88 being spring biased towards the fixed half 92 of said pulley by means of the compression spring 94. More particularly, one end 96 of the spring 94 abuts the bearing plate 98 secured to the shaft 86, and the opposite end 100 of the spring 94 abuts the movable half 90 of the pulley 88 whereby the movable half 90 of said pulley is spring biased toward the fixed half 92 of said pulley. The pulley 102 fixed to the input shaft 82 of the speed reducer 80 is also of the split type, the movable half 104 of which may be adjusted relative to the fixed half 106 by means of the speed adjustment device 108, which is accessible externally of the casing 18. The pulleys 88 and 102 are drivingly connected to each other by means of the V-type drive belt 110 and the manual adjustment of the speed adjustment device 108 is effective to vary the distance between the halves 104 and 106 of the pulley 102 whereby to vary the speed of shaft 82 relative to the speed of shaft 86, as will be readily apparent. Thus to increase the speed of shaft 82 relative to shaft 86, the speed adjustment device 108 will be rotated in a direction to move the half 104 of the pulley 102 away from the fixed half 106 of said pulley whereby the drive belt 110 will be automatically adjusted to a position axially closer to the shaft 82.

It will be understood that as the halves of the pulley 102 are separated, the halves of the pulley 88 come closer together, the position of the halves of the latter pulley being maintained by the spring 94, described above. The speed control device 108, having the control knob 109, thus controls the speed of rotation of the shaft 82 of the speed reducer 80 for the adjustment of the proper pumping rate, said pumping rate being indicated on the instrument panel 118 of the apparatus, as will be more fully described hereinafter. The relative speed of rotation of shafts 82 and 76 of the speed reducer 80 is fixed whereby it will be apparent that the speed adjustment device 108 will be effective to vary the rate of reciprocation of the piston 24 within a predetermined range. The speed reducer 80 is secured in the casing 18 in the bottom region thereof in any suitable manner, as by mounting said speed reducer on the plate 112. A take-off shaft of the speed reducer 80 is operatively connected to the generator 114, the latter being electrically connected to the respiratory rate indicator 116 secured to the instrument panel 118 at the upper end of the casing 18. The respiratory rate indicator 116 is preferably calibrated in respirations per minute and it will be apparent that the number of respirations per minute will be under the control of the speed adjustment device 108.

In the normal operation of the apparatus 10 the motor 84 will be utilized as the power source for reciprocating the piston 24, and in the event of power failure there is provided alternate manually operated means for reciprocating said piston. The alternate manually operated means comprises a crank 120 having a handle 122 and a laterally projecting shaft 124, the latter, when operatively associated with the apparatus 10, being adapted to automatically declutch the speed reducer 80 from the shaft 76. Thus when crank 120 is operatively connected to the apparatus 10, the train of gears disposed in the speed reducer 80 are declutched from output shaft 76 of said speed reducer whereby to permit, and facilitate the ease of manual oscillation of the crank arm 74. With reference to Fig. 10, the shaft 76 of speed reducer 80 has a shaft portion 76' which is apertured at 128, the latter being adapted for the reception of the portion 124 of the crank 120. The shaft portion 76' has a longitudinal key 130 secured therein by means of the screw 132 and the portion 124 of the crank 120 has a keyway 134 formed complementary to the key 130 whereby the portion 124 may be inserted in the aperture 128 in only one position, said position being preselected for optimum ease in manually oscillating the crank 120. The aperture or bore 128', which constitutes an extension of aperture or bore 128, has positioned therein a plunger 136, the latter being spring driven outwardly of said aperture 128' by means of the compression spring 138 seated in the end of said aperture. The plunger 136 has a transversely extending member 142 secured thereto by means of the pin 144, said member having integrally formed therewith diametrically opposed end pin elements 146 which are adapted for a purpose which will be described in detail hereinafter.

When the piston 24 is power driven by means of the motor 84, the gear 148 disposed in reducer 80 is drivingly connected to the shaft 76, the gear 148 having its hub 149 keyed to the intermediate shaft 150 by means of the key or pin 152. With reference to Figs. 10, 11 and 12 it will be noted that shaft 76 has an intermediate portion thereof slotted at diametrically opposite portions as indicated at 154 and that shaft 150 is similarly slotted at diametrically opposite portions as indicated at 155, said slots 154 and 155 being adapted for the reception of pin elements **146** when said slots are aligned as shown in Fig. 12. The plunger **136** is adapted to be axially movable between the power driven position as indicated in Figs. 10 and 12 and the manually driven position as indicated in Fig. 11, the shafts **150** and **76** being fixed against relative rotation in the power driven position of plunger **136** by means of pin elements **146** and being free for relative rotation in the manually driven position of said plunger, as in the latter position pin elements **146** will be retracted from slot **155**. Thus in the manually driven position of plunger **136** the pin elements **146** will clear the end **157** of shaft **150** whereby the latter will be free for rotation relative to shaft **76**. For manually oscillating the shaft **76** for actuating piston **24**, the portion **124** of crank **120** is inserted in the aperture **128**, said portion **124** axially displacing plunger **136** towards the crank arm **74** against the biasing of the spring **138** as shown in Fig. 11, the axial movement of the plunger **136** being effective to disengage the pin elements **146** of the member **142** from the intermediate shaft **150**.

From the above it will be apparent that, when the apparatus is power driven, gear **148** will drive shaft **76** since said gear is keyed to shaft **150** and the latter is keyed to shaft **76** by means of the pin elements **146**, and when the apparatus is manually driven gear **148** and shaft **150** will be disengaged from driving relation with shaft **76** through the retraction of pin elements **146** from the shaft **150**. When the crank **120** is inserted in the aperture **128**, the axial movement of the plunger **136** to the manually driven position will be effective to disengage the pin elements **146** from their associated slots **155** whereby the gear **148** will be disengaged from the shaft **76**. Accordingly, the axial position of the plunger **136** controls the driving engagement of the gear **148** with the shaft **76** and the insertion of the portion **124** of the crank **120** in aperture **128** is automatically effective to displace the plunger **136** from its power driven position to its manually driven position whereby to disengage the gear train in the speed reducer **80** from driving relation with piston **24**. The plunger **136** has an annular groove **156** adjacent its outer end which has seated therein a suitable oil seal **158**. The shaft portion **76'** of shaft **76** has an annular recess **147** adjacent its outer end for the reception of the snap ring **159** of crank **120** when the latter is engaged in aperture **128**. Shaft **76** is journaled for rotation in the bearing plate **160**, the bushing **162**, and shaft **150**, said bearing plate being secured to the housing **164** of the speed reducer **80** in any suitable manner as by means of the screws **166**.

In order to control the amount of vacuum or negative pressure applied to the cuirass **12** by the pump **16**, there is provided a vacuum control for said pump, said vacuum control comprising a control member **170** which is adapted to control the admission of air to the chamber **42** on the down stroke of the piston **24** (see Figs. 2, 7 and 8). More particularly, the vacuum control member **170** is mounted for rotation relative to the panel **118**, said member having an actuating shaft **172** projecting outwardly of said panel. Secured to the upper end of shaft **172**, externally of the housing **18**, is a control knob **174**, said knob being secured to the shaft **172**, in any desired manner, for example by means of the set screw **176**. The member **170** has an annular shoulder **178** which is in abutting relation with the shoulder **180** of the bracket part **62**, said shoulder **178** being biased in said abutting relation with shoulder **180** by means of spring **182**. The bracket part **62** and consequently the shoulder **180** thereof is fixed in the casing **18** and the shoulder **178** of the member **170** is adapted to rotate relative to said part **62**. The valve member **170** has an arcuate face **184** at one side, said face in conjunction with port **171** being adapted to control the admission of air to the conduit **186** which communicates with the interior of the pumping chamber **42**. It will be understood that the conduit **186** is in communication

with the port **188**, the latter communicating with the interior of the pumping chamber **42**. It will be evident from the above that the angular position of the arcuate face **184** of the vacuum control member **170** relative to the inlet port **171** to the conduit **186** will determine the amount of air that may be admitted to the pumping chamber **42** during the negative pressure or vacuum phase of the pumping cycle. With reference to Fig. 7, the vacuum control member **184** is shown in a slightly open condition and the rotation of said control member in the direction of the arrow V, as shown in said figure, will be effective to increase the amount of air admitted to the pumping chamber **42**. Thus the arcuate face **184** of the member **170** cooperates with inlet port **171** to the conduit **186** to control the amount of air admitted to the pumping chamber. As previously noted, the upright shaft **58** is hollow and the lower end portion of said shaft is provided with vertically spaced annular series of vents **190**, the latter communicating with the interior of the casing **18** and consequently with the surrounding atmosphere of the apparatus **10**, it being understood that substantial air leakage through said casing is inherent in the construction thereof. The lower end of the hollow shaft **58** has a reinforcing tube **192** mounted thereon coaxially therewith, said reinforcing tube having vents **191** in registry with the vents **190** above referred to. Thus the control member **170** is effective to control the admission of air to the pumping chamber **42**, the path of air being from the atmosphere through the vents **191** and **190**, past the valve member **170**, through the conduit **186** and port **188**. The opening of the port **171** of the conduit **186** under the control of the valve member **170** increases the amount of air admitted to the pumping chamber **42** and consequently decreases the negative pressure or vacuum applied to the interior of the cuirass **12**. From the above, it will be apparent that the rotation of the vacuum control member **170** will be effective to control the amount of vacuum or negative pressure applied to the cuirass, the amount of vacuum or negative pressure supplied by the pump **16** being independent of the amount of positive pressure, if any, applied to the cuirass **12** by said pump.

In most cases the application of positive pressure to the interior of the cuirass **12** is unnecessary, however when desired, the amount of positive pressure can be controlled through the pressure control valve **200** now to be described in detail. (See Figs. 1 and 4.) The pressure control valve **200** comprises an actuating shaft **202** having a pressure control knob **204** secured thereto at one end by means of the set screw **206**, said actuating shaft **202** being journaled for rotation in the plate **208**. The shaft **202** has a collar **210** formed integral therewith, said collar being adapted to cooperate with adjacent portions of the plate **208** for the positioning of shaft **202**. The shaft **202** has an enlarged portion **212** at its lower end which is externally threaded, as indicated at **214**, said enlarged threaded portion being adapted to cooperate with the short tubular member **216** which is internally threaded at its upper end complementary to the threads **214**. The member **216** is provided with diametrically opposed flattened portions **218** which are adapted to have cooperatively associated therewith the legs **220** of the clip member **222**. The base **224** of the clip member **222** is secured to the underside of plate **208** in any desired manner, the spaced legs **220** of said clip member being adapted to restrain the tubular member **216** against rotation, the latter being free for axial movement relative to the portion **212**. It will be apparent from the above that the rotation of shaft **202** will be effective to axially displace the tubular member **216** a corresponding amount. The shaft portion **212** is centrally apertured at **226** for the reception of the guide shaft **228** which is freely movable in said aperture. The guide shaft **228** has a valve member or diaphragm **230** secured at its lower end, said diaphragm **230** being adapted to control the amount of air bypassed during the positive pressure phase of the pumping cycle. The lower end **232** of the tubular member **216** is adapted to cooperate with adjacent upper face portions of the diaphragm **230** to control the bypass of air for thereby controlling the amount of positive pressure pumped by the bellows pump **16**. Thus the more the tubular member **216** is positioned away from head **22**, the greater will be the amount of air bypassed through said head, and if desired the diaphragm **230** may be retained closed on the head **22** by rotating the shaft **202** the requisite amount. Thus the guide shaft **228** of the diaphragm **230** is freely movable axially and is limited in such axial movement by the head **22** in one direction and by the end **232** of the tubular member **216** in an opposite direction. Thus the amount of air bypassed from the pumping chamber **42** between the diaphragm **230** and the head **22**, through the port **231**, is under the control of the pressure valve **200**, the greater the amount of air so bypassed, the lower will be the positive pressure applied to the cuirass. Thus the amount of air bypassed in this manner is under the control of the actuator shaft **202** and associated mechanism, the latter being effective to axially position the tubular member **216** relative to the diaphragm **230**. During the suction or negative pressure phase of the pumping cycle, the diaphragm **230** will be closed to the head **22** by the atmosphere pressure which will be greater than the pressure in the pumping chamber **42**. From the above, it will be apparent that the positive pressure control valve **200** is independent of the aforedescribed vacuum control **170**. The positive pressure control knob **204** is accessible externally of the apparatus at the panel **118** and is positioned closely adjacent to the vacuum control knob **174** to facilitate the ease of control of the apparatus **10**.

In order to limit the amount of negative pressure or vacuum produced by the pump **16**, there is provided a relief valve **240** which is integrated with the piston **24** in a manner now to be described (see Figs. 2 and 5). The piston **24** is ported at **242**, the latter being open to the interior of the casing **18** in the open condition of valve **240** and said port is normally closed by the valve member or diaphragm **244**. Surrounding the port **242** and depending from the piston **24** is a valve body member **246** having a shoulder **248** forming a platform for adjacent portions of the valve member **244**. The valve member **244** is secured to one end of the shaft **250**, said shaft being adjustably secured to the flexible plate **252**, the latter having peripheral portions secured to the valve body member **246** in any desired manner. The valve member **244** and plate **252** are maintained in a fixed spaced relation by means of the nut **254** which is threaded on the shaft **250**. The plate **252** is formed of a flexible resilient material such as spring metal and is adapted to flexibly yield to permit the valve **244** to open at a predetermined maximum negative pressure condition. Thus the plate **252** controls the valve member **244** and is preset to yield and permit said valve member to open at a predetermined maximum negative pressure condition. It will be apparent that the amount of negative pressure or suction necessary to open the member **244** may be adjusted under the control of the axial position of the nut **254**, the closer said nut is positioned to the valve member **244**, the greater the amount of negative pressure or suction being required for opening said valve member. Thus the primary purpose of the relief valve **240** is to vent excess negative pressures which may inadvertently or accidentally occur in the apparatus and under normal operating conditions the valve member **244** will be seated on the shoulder **248** of the valve body **246**.

In case of power failure, air leakage, or any condition which signifies improper air flow to the patient, an alarm system **259** will be actuated. The safety alarm comprises a casing **260** (see Fig. 2) which has a port **262** in communication with the port **264** in the head **22** by means of the short conduit **266**. In the case of improper air flow to the patient through the medium of cuirass **12**, the safety alarm **259** will be actuated to ring a suitable bell (not shown). The safety alarm **259** is under the control of an alarm switch **268**, the latter being secured in the panel **118** and readily accessible at the top of the apparatus. The instrument panel **118** is further provided with a power switch **270** which is connected to and controls the electrical circuit for the motor **84**. As previously described in detail, in case of power failure the pump **16** may be readily actuated by means of the crank **120**, the latter being effective to automatically disconnect the gear train disposed in gear reducer **80** from driving relation with said pump.

With reference to Figs. 1, 6 and 13, there is provided in the instrument panel **118**, at the top of the apparatus, a port **272** which communicates with the interior of the pumping chamber **42**. The port **272** is defined by the short conduit **274** which is adapted to frictionally receive the end **276** of the conduit **14** to thereby connect the cuirass **12** with the interior of the pumping chamber **42**. The conduit **274** has one end secured to the head **22**, at port **275** in said head, by means of flange **277**, the opposite end of said conduit being secured to the panel **118** in any desired manner. The end **276** of conduit **14** is retained in position relative to the conduit **274** by a friction-fit, the end **276** of the conduit **14** being readily attached to, and removable from, the interior of conduit **274**. The port **272** at panel **118**, defined by conduit **274**, is normally closed to the atmosphere when the conduit **14** is disconnected from the apparatus **10**. For this purpose there is provided a cover member **280** having a pair of spaced lugs **282** which are apertured at **284** for the reception of the end convolutions **286** of the coil spring **288**, the latter being positioned in the U-shaped tube **290** having its ends **291** secured to panel **118**. It will be readily apparent from the above that the cover member **280** will be spring urged by means of the spring **288** in a closing direction and that said cover member may be readily opened against the spring biasing of said spring for the connection of the end **276** of the conduit **14** to the conduit **274**. Thus the spring **288**, which has its end convolution **286** extending through the apertures **284** of the cover member **280**, provides a ready means for spring-hingedly mounting said cover member on the panel **118**.

When the conduit **14** is secured to the apparatus in the manner described above, the cover member **280** will be spring urged against said conduit as shown in Fig. 13.

While I have shown and described the preferred embodiments of my invention, it will be understood that various changes may be made in the present invention without departing from the underlying idea or principles of the invention within the scope of the appended claims.

Having thus described my invention, what I claim and desire to secure by Letters Patent, is:

1. Respirator pumping apparatus adapted to induce a rhythmtic flow of air to and from the cuirass of artificial respirator apparatus, comprising a pump having a fixed head and a movable piston defining an expansible and contractible air chamber having an outlet adapted to be connected to said cuirass in fluid-flow relation thereto, means for actuating said movable piston for cyclically expanding and contracting said chamber for inducing a rhymthic flow of air to and from said chamber through the outlet thereof, a pair of spaced ports in said fixed head in communication with said air chamber, manually adjustable first valve means controlling the venting of one of said ports for controlling the amount of negative pressure applied through said outlet, independent manually adjustable second valve means controlling the venting of the other of said ports for controlling the amount of positive pressure applied through said outlet, and a fixed hollow shaft for guiding the movement of said piston, the interior of said guide shaft communicating with said one port under the control of said first valve means and being vented to the atmosphere whereby said first valve means controls the venting of said one port through said guide shaft.

2 Respirator pumping apparatus adapted to induce a rhymthic flow of air to and from the cuirass of artificial respirator apparatus, comprising a pump having a fixed head and a movable piston defining an expansible and contractible air chamber having an outlet port adapted to be connected to said cuirass in fluid-flow relation thereto, means for actuating said movable piston for cyclically expanding and contracting said chamber for inducing a rhymthic flow of air to and from said chamber through the outlet port thereof, and fluid-control means independent of said outlet port for limiting the maximum and minimum air pressures, respectively, in said chamber in the contracted and expanded conditions, respectively, thereof whereby to control the maximum and minimum cyclic air pressures flowing through said outlet port, said fluid-control means including a second port in communication with the ambient atmosphere, and a manually operable valve for regulating the flow of air into and out of said chamber through said second port during the expansion and contraction of said chamber, and a third port in communication with said chamber and the ambient atmosphere for preventing the generation in said chamber of air pressures above a predetermined maximum, said third port having a manually operable valve for regulating the flow of air therethrough.

3. Rerspirator pumping apparatus adapted to induce a rhymthic flow of air to and from the cuirass of artificial respirator apparatus, comprising a casing having a pump mounted therein, said pump having a fixed head and a movable piston defining an expansible and contractible air chamber having an outlet port adapted to be connected to said cuirass in fluid-flow relation thereto, means for actuating said movable piston for cyclically expanding and contracting said chamber for inducing a rhymthic flow of air to and from said chamber through the outlet port thereof, and fluid-control means independent of said outlet port for limiting the maximum and minimum air pressures, respectively, in said chamber in the contracted and expanded conditions, respectively, thereof whereby to control the maximum and minimum cyclic air pressures flowing through said outlet port, said fluid-control means including a second port in communication with the ambient atmosphere, and a manually operable valve for regulating the flow of air into and out of said chamber through said second port during the expansion and contraction of said chamber, and a third port in communication with said chamber and the ambient atmosphere for preventing the generation in said chamber of air pressures above a predetermined maximum, said third port having a manually operable valve for regulating the flow of air therethrough, an instrument panel disposed at the top of said casing in laterally spaced relation to said fixed head, said instrument panel having negative and positive pressure control knobs accessible thereat for manually controlling said second and third port valves, respectively, at said instrument panel.

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