April 29, 1958 T. C. HUXLEY III ET AL 2,832,335

ARTIFICIAL RESPIRATION APPARATUS

Filed Oct. 2, 1953

FIG. 1

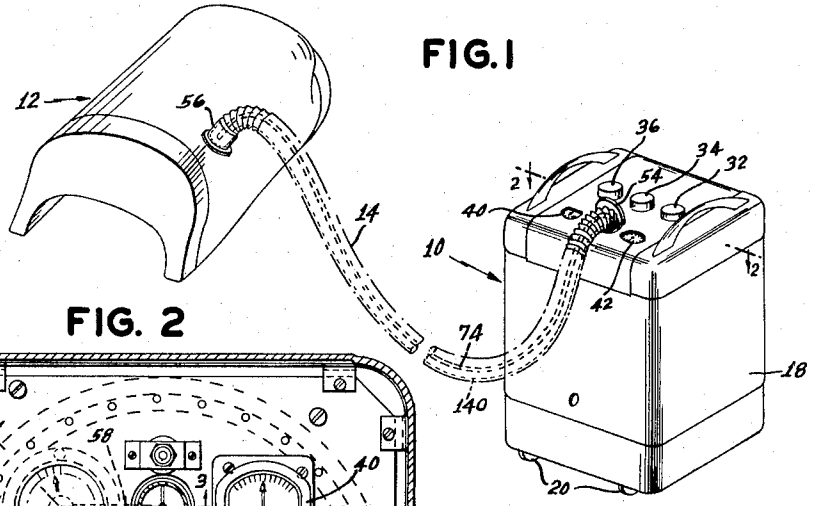


FIG. 2

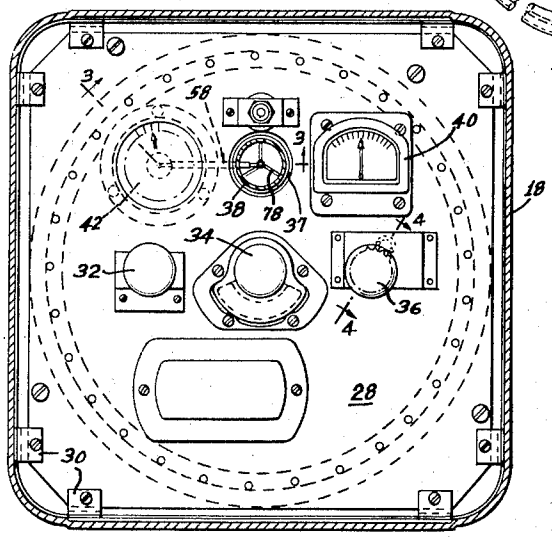


FIG. 4

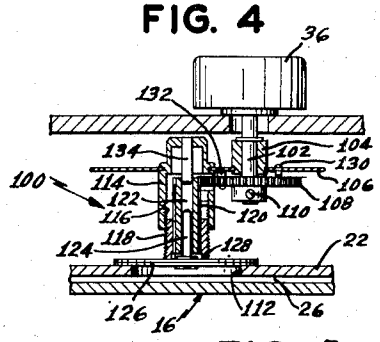


FIG. 3

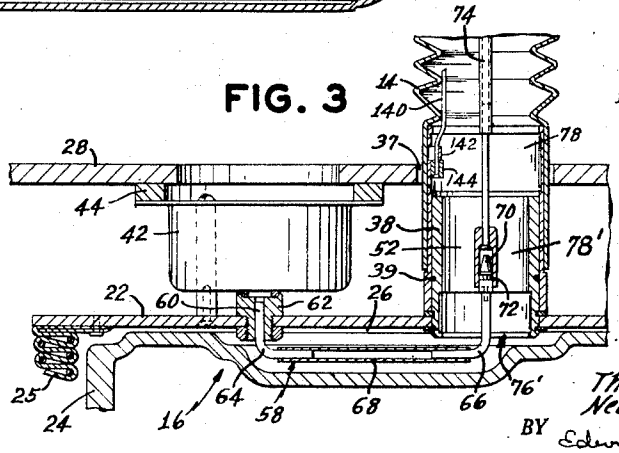
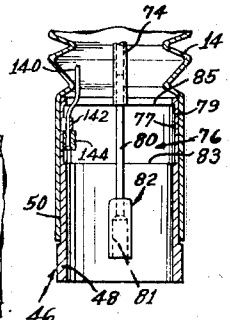


FIG. 5



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ARTIFICIAL RESPIRATION APPARATUS

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6 Claims. (Cl. 128—30)

This invention relates generally to improvements in artificial respiration apparatus and, more particularly, to improvements in artificial respiration apparatus of the portable type.

One object of the present invention is the provision, in artificial respiration apparatus having a pump and control unit adapted for operative association with a cuirass, of pressure-indicating means positioned in close proximity to the control unit with the pressure indicating means measuring pressure directly at the cuirass.

Another object of the present invention is the provision of pressure-indicating means of the aforenoted character having pressure transmitting means disposed in the conduit extending between the pump and cuirass, said pressure transmitting means being adapted for automatic connection with the pressure indicating means on the interconnection of the conduit and pump.

Another object is to provide the flexible tubing which extends between the cuirass and the pump and control unit with means to protect the tubing from the harmful effect of tension to which the tube might otherwise be subjected by careless or indifferent handling of the apparatus.

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 discharge of air from the pumping chamber during the positive pressure phase of the pumping cycle.

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 drawing which illustrates the best mode now contemplated by us for carrying out our invention;

Fig. 1 is a perspective view of the respirator pumping apparatus shown connected to a cuirass;

Fig. 2 is a sectional view, on an enlarged scale, taken on the line 2—2 of Fig. 1;

Fig. 3 is a sectional view, on an enlarged scale, taken on the line 3—3 of Fig. 2;

Fig. 4 is a sectional view, on an enlarged scale, taken on the line 4—4 of Fig. 2; and

Fig. 5 is a fragmentary sectional view of one end portion of the conduit.

The respirator pumping apparatus of the present invention is generally of the type shown and described in the copending application of Thomas C. Huxley III for Pump and Control Unit for Respirators, Serial No. 295,181, filed June 24, 1952, and now Patent No. 2,762,200, and assigned to the assignee of the present invention. Thus the respirator pumping apparatus 10 is adapted to periodically supply air to and withdraw air from the cuirass 12 which is operatively connected to the pumping apparatus 10 by means of the conduit 14. The cuirass 12 may be any 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. Accordingly, 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 is structurally similar to the corresponding apparatus of the afore-referred to copending application and differs therefrom in the respects to be fully described in detail hereinafter.

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. A part of the pump 16, fully described and illustrated in the above mentioned application, is shown by Fig. 3. Briefly described, said pump comprises a fixed head 22 and a piston or relatively movable head 24 connected to a flexible bellows 25 and mounted for reciprocation in the manner fully shown and described in the aforereferred to copending application. The pump head 22 is in fixed relation with the casing 18 and bellows 25 is sealed to said heads 22 and 24, as described in said application, and it will be readily apparent that there is defined between the head 22 and piston 24 a sealed pumping chamber 26. The apparatus 10 is provided with an instrument panel 28 which is supported by the housing 18 through the intermediation of suitable brackets 30. The instrument panel 28 is provided with a power switch 32, a negative pressure control knob 34, a positive pressure control knob 36, an opening 37 leading to a fitting 38 which is adapted for the reception of a companion portion of the conduit 14, and an indicator 40 graduated to indicate respirations per minute.

Pursuant to the present invention there is provided a pressure gage 42 which is mounted on the instrument panel 28 in close proximity to the negative and positive pressure control knobs 34 and 36 aforenoted. The pressure gage 42 is generally of the type shown and described in the aforereferred to copending application and is mounted relative to the instrument panel 28 in any conventional manner, there being preferably interposed between said instrument panel and pressure gage a suitable gasket 44. In accordance with the present invention the pressure gage 42 is positioned in close proximity to the operating controls as aforedescribed with said pressure gage being adapted to measure pressure directly at the cuirass 12 in a manner now to be described in detail. The conduit 14 which is adapted to connect the apparatus 10 to the cuirass 12 in fluid flow relation therewith is preferably of flexible and resilient construction and in the illustrated embodiment said conduit is of the corrugated type. As best shown in Figs. 3 and 5, the terminal ends 46 of the conduit 14, which are structurally identical, are in the form of fittings, the latter comprising a preferably metallic coupling 48 having a portion receivable in end portion 50 of the conduit 14 in fluid sealing relation therewith. As aforenoted, the fittings 46 of the conduit 14 are structurally identical whereby both ends of said conduit may be interchangeably associated with the apparatus 10 and cuirass 12 in a manner to be described in detail hereinafter. It is to be noted that fitting 38 defines a passage 52 which is in fluid communication with the pumping chamber 26. The fittings 46 and 38 are

formed complementary to each other and are adapted for releasable interengagement in fluid sealing relation. The fittings 38 and 46 are adapted for association by a friction fit in fluid sealing relation, said fitting 38 being provided with a sealing ring 39. The opening 37 in the instrument panel 28 may have associated therewith an openable cover 54, and said cover may be of the type fully shown and described in the aforereferred to copending application. The cuirass 12 is provided with the fitting 56 which is structurally similar to fitting 38 and which defines a passage which is in fluid communication with the interior of said cuirass. The fitting 56 is thus formed complementary to the fittings 46 of the conduit 14 aforedescribed and is adapted for frictional interengagement with one of the fittings 46 for establishing fluid communication between the conduit 14 and the cuirass 12. Thus in practice one fitting 46 of the conduit 14 will be operatively associated with the pumping apparatus 10 and an opposite fitting of said conduit will be operatively associated with a cuirass 12 in the aforedescribed manner whereby said conduit is effective to provide fluid communication between the pumping chamber 26 of apparatus 10 and the interior of the cuirass 12.

The pressure gage 42 is provided with a pressure transmitting tube portion 58 which extends in the pumping chamber 26 and to the region of fitting 38, the portion 60 of said tube portion extending into the fitting 62 which is secured to the head 22 in any suitable manner. The tube portion 58 includes the elbow fittings 64 and 66 which are in fluid communication with each other by means of the connecting tube portion 68 which is positioned in the pumping chamber 26. Part of the fitting 66 extends into the passage 52 defined by the fitting 38 and terminates in a free end portion 70 which is constituted by a fitting which is adapted for a purpose which will be fully described hereinafter. Thus the fitting 70 is constituted by a tapered end portion of fitting 66 and is provided with a peripherally extending groove having a sealing ring 72 positioned therein. Thus the tube portion 58 is in fluid flow relation with the pressure indicating gage 42 and terminates in a free end portion constituted by the fitting 70 which is disposed in the region of the fitting 38. The fitting 66 is supported by spider 76' having radially extending arms 78' which are integral with fitting 38 so that fitting 70 is disposed and supported substantially centrally of fitting 38.

Extending longitudinally in the conduit 14 is a pressure transmitting tube 74 which may be formed of any suitable flexible material. In order to support the pressure transmitting tube 74 in the conduit 14 substantially centrally thereof at longitudinally spaced points there are provided supporting spiders 76 having radially extending arms 78. The arms 78 of the spiders fit in a peripheral groove 77 formed by the thinner wall part 79 of fitting 46 and is held by a snug fit in position between peripheral shoulders 83 and 85 at the opposite ends of said groove. In the illustrated embodiment two such spiders 76 are shown for supporting end portions of the pressure transmitting tube 74 relative to the conduit 14. The tube 74 is provided with a tube part 80 at its end portions, each of said tube parts terminating in a fitting 82 which is formed complementary to the fitting 70 of the pressure gage tube portion 58. It is to be noted that both end portions of the pressure transmitting tube 74 are structurally similar whereby either end portion of said pressure transmitting tube may be operatively associated with the fitting 70 of tube portion 58 in a manner to be described hereinafter. The fittings 82 of the tube 74 are formed complementary to the fitting 70 and are adapted to be connected therewith in fluid sealing relation whereby to provide a pressure transmitting passage from the cuirass 12 to the pressure gage 42. The aperture 81 of fitting 82 is dimensioned complementary to fitting 70 and is adapted for interengagement therewith in fluid

sealing relation. Thus one end of the tube 74 is adapted for interconnection with the fitting 70 of the tube portion 58 and the opposite end thereof terminates in a free end portion or fitting in the region of the cuirass fitting 56 whereby the pressure gage 42 indicates the pressure at the cuirass 12.

As aforenoted, the fittings 82 are supported by means of the spiders 76 in a fixed position to the fittings 46 and on the interconnection of the conduit and casing fittings 46 and 38, respectively, one fitting 82 of the tube 74 will be automatically interconnected with its complementary fitting 70 associated with the pressure indicating gage 42 in the aforedescribed manner. From the above it will be apparent that the fittings 70 and 82 aforedescribed constitute means providing for the interconnection of one end of the tube 74 with the free end portion 70 of the tube portion 58 on the interconnection of the conduit 14 with the apparatus 10. It is to be noted that the fittings 70 and 82 provide a releasable fluid sealing interconnection and similarly the connections between the conduit 14 and the apparatus 10 and cuirass 12 are of the releasable fluid sealing type. Thus the conduit fittings 46 at both ends of the conduit 14 are structurally similar and the tube fittings 82 are similarly structurally similar whereby it will be apparent that the conduit fittings may be interchangeably connected to the casing fitting 38 with the tube 74 interconnected with its companion tube portion 58. Thus the pressure gage 42 is positioned on the instrument panel 28 in close proximity to its associate controls with said pressure gage measuring pressure directly at cuirass 12 through the intermediation of the pressure transmitting tube 74 aforedescribed. The connection between the conduit 14 and the apparatus 10 will be effective to automatically connect the pressure transmitting tube 74 with the pressure gage 42 by means of the complementary fittings 70 and 82, aforedescribed.

Pursuant to the present invention there is provided an improved control arrangement for controlling the discharge of air from the pumping chamber 26 during the positive pressure phase of the pumping cycle. 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 100 now to be described in detail.

With reference to Fig. 4, the pressure control valve 100 comprises a rotatably mounted actuating shaft 102 having a control knob 36 secured thereto and accessible at the instrument panel 28. The shaft 102 is mounted for rotation in the bearing part 104 which is secured to the bracket 106 in any desired manner. The inner end of the shaft 102 is provided with a gear 108 which is secured thereto by means of the pin 110. It will be apparent that the rotation of the knob 36 will be effective to concomitantly rotate the gear 108, the latter being adapted to control valve 100 in the manner to be described in detail hereinafter. The fixed head 22 is provided with a port 112 and the valve 100 controls the venting of said port in the manner shown and described in the afore-referred to copending application. Secured to the bracket 106, in any suitable manner, is a guide part 114 which is internally threaded as indicated at 116, said guide part being formed complementary to the externally threaded part 118. The part 114 is in fixed relation with the bracket 106 and the part 118 is rotatably mounted relative to the part 114 and is axially movable on the rotation thereof, it being understood that the parts 114 and 118 are threaded complementary to each other. In fixed relation with the part 118 and extending therein is a gear 120 which is formed complementary to the gear 108 and is in mesh therewith whereby it will be apparent that the rotation of the control knob 36 will be effective to concomitantly rotate part 118 to axially displace the latter relative to the port 112.

Thus the part **118** and the gear **120** are in fixed relation whereby it will be apparent that the rotation of the gear **120** by means of the gear **108** will be effective to rotate part **118** and axially move the latter in a direction corresponding to the direction of rotation of the control knob **36**. The gear **120** is centrally apertured therethrough as indicated at **122** for the reception of the guide shaft **124** which is freely movable in said aperture.

The guide shaft **124** has a valve member or diaphragm **126** secured at its lower end, said diaphragm being adapted to control the amount of air bypassed during the positive pressure phase of the pumping cycle. The lower end **128** of the part **118** is adapted to cooperate with adjacent upper face portions of the diaphragm **126** to control the bypass of air for thereby controlling the amount of positive pressure pumped by the pump **16**. Accordingly, the more the part **118** is positioned away from the head **22**, the greater will be the amount of air bypassed through said head and, if desired, the diaphragm **126** may be retained closed on the head **22** by rotating the control knob **36** the requisite amount. Thus the guide shaft **124** of the diaphragm **126** is freely movable axially and is limited in such axial movement by the head **22** in one direction and by the end **128** of the part **118** in an opposite direction. From the above it will be apparent that the amount of air bypassed from the pumping chamber **26** between the diaphragm **126** and the head **22** through the port **112** is under the control of the pressure valve **100**, the greater the amount of air so bypassed, the lower will be the positive pressure applied to the cuirass **12**. Thus the amount of air bypassed in this manner is under the control of the control knob **36** and associated mechanism, the latter being effective to axially position the part **118** relative to the diaphragm **126**. As fully illustrated and described in the aforereferred to copending application, during the suction or negative pressure phase of the pumping cycle the diaphragm **126** will be closed to the head **22** by the atmospheric pressure which will be greater than the pressure in the pumping chamber **26**. The bracket **106** is provided with a stop member **130** which is adapted to cooperate with the stop member **132** of gear **108** for limiting the rotation of the latter. It will be noted that the part **114** is provided with a depending shaft **134** which is formed complementary to the aperture **122** for guiding the gear **120** during the axial movement thereof. It is to be noted that gear **120** is of substantially smaller diameter than gear **108** whereby one revolution of the latter gear will rotate the former gear a plurality of revolutions to achieve correspondingly rapid axial movement of part **118**. Thus the pressure control valve **100** is positively operated by the gears as aforedescribed and functions to control the amount of positive pressure applied to the interior of the cuirass **12**.

Provision is made to prevent the longitudinally extensible and compressible tube **14** from being impaired by careless handling of the apparatus. For example, it has been found that attempts are sometimes made to move the pump and control unit **10** by pulling on the tube **14**, i. e., by grasping one of the fittings **46** which is remote from the connection of the tube to the unit **10** and pulling on the tube in order to move the said unit to a particular position. Such handling of the apparatus may result in damage to tube **14**, and to obviate this serious disadvantage means are provided in the tube **14** to prevent the pull on the fittings **46** from being transmitted to the compressible and extensible part of the tube. As here shown said means comprises an inextensible flexible wire **140** which is disposed within tube **14** and is secured at its opposite ends to the adjacent fittings **46**, thus constituting a strain-relief member for said tube. More specifically, as shown in Figs. 3 and 5, the fitting **46**, at each end of tube **14** is provided with a struck up portion **142** under which the end portion of the wire is disposed and which constitutes a stop member

for the sleeve **144** which is clamped onto the end of the wire. Wire **140** is not attached to the compressible and expansible part of tube **14**. Accordingly, if the tube **14** is pulled by means of the sleeve **46** at the end of the tube remote from the connection of the tube to the unit **10**, the tension is taken up by the flexible wire **140** instead of being applied to the tube **14** which would be the case in the absence of said strain-relief member **140**. It will be understood that tube **14** has the same construction at each of the opposite ends thereof so that the illustration in Fig. 5 is applicable to either end of said tube.

It will be understood that in respect to certain features of the present invention the tube **14** need not be longitudinally extensible and/or contractible; for example the tube providing the fluid passage between the pump and control unit **10** and the cuirass **12** may be longitudinally inextensible or contractible and in that case the provision of the strain-relief member **140** is not as important as when the tube is corrugated or otherwise longitudinally extensible and/or contractible. Accordingly, it will be understood that in respect to certain features of the invention the tube **14** although preferably flexible need not be longitudinally extensible and/or contractible and in such case it is within the scope of the present invention to omit the strain-relief flexible member **140**.

This application is a continuation in part of our application Serial No. 362,316 filed June 17, 1953 and assigned to the assignee of our present invention, and now Patent No. 2,779,329.

While we have shown and described the preferred embodiments of our 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 our invention, what we claim and desire to secure by Letters Patent, is:

1. In respirator apparatus provided with a chamber within which the air pressure is rhythmically varied and which comprises a pump in fluid-flow communication with said chamber for rhythmically varying the air pressure in the latter, a tube connected between said pump and said chamber and providing the said fluid-flow communication therebetween, said tube being longitudinally extensible and contractible and provided with longitudinally inextensible fittings at its opposite ends, and a strain-relief member extending longitudinally of said tube and secured at its opposite ends to said fittings, respectively, said tube being longitudinally extensible and contractible longitudinally of said strain-relief member.

2. A tube of the character described, comprising a length of tubing having a longitudinally extending part which is longitudinally extensible and contractible and fittings which are inextensible and incontractible connected at the opposite ends of said part of the tubing, a fluid pressure communication tube extending within said tubing, and a strain-relief member disposed within said tubing and extending longitudinally of said longitudinally extensible and contractible part and connected at its opposite ends to said fittings, respectively, said part of the tubing being movable in relation to said strain-relief member longitudinally and laterally of the latter.

3. In respirator apparatus provided with a chamber within which the air pressure is rhythmically varied and which comprises a pump in fluid-flow communication with said chamber for rhythmically varying the air pressure in the latter, a tube connected between said pump and said chamber and providing the said fluid-flow communication therebetween, said tube being longitudinally extensible and contractible and terminating in rigid fittings, and a strain-relief member extending longitudinally of said tube and secured at its opposite ends to said fittings, respectively, said member being substantially longitudinally inextensible whereby to limit the extensi-

bility of said tube to a longitudinal extent corresponding to the length of said member.

4. In respirator apparatus provided with a chamber within which the air pressure is rhythmically varied and which comprises a pump in fluid-flow communication with said chamber for rhythmically varying the air pressure in the latter, a tube connected between said pump and said chamber and providing the said fluid-flow communication therebetween, said tube being longitudinally extensible and contractible and terminating in rigid fittings, and a strain-relief member extending longitudinally of said tube and secured at its opposite ends to said fittings, respectively, said member being substantially longitudinally inextensible whereby to limit the extensibility of said tube to a longitudinal extent corresponding to the length of said member, said strain-relief member being constituted by a length of flexible wire disposed internally of said tube.

5. A tube of the character described, comprising a longitudinally extensible and contractible length of tubing which terminates in rigid fittings, and a strain-relief member extending longitudinally of said tubing and secured at its opposite ends to said fittings, respectively, said member being substantially longitudinally inextensible whereby to limit the extensibility of said tubing to a longitudinal extent corresponding to the length of said member.

6. A tube of the character described, comprising a longitudinally extensible and contractible length of tubing which terminates in rigid fittings, and a strain-relief member extending longitudinally of said tubing and secured at its opposite ends to said fittings, respectively, said member being substantially longitudinally inextensible whereby to limit the extensibility of said tubing to a longitudinal extent corresponding to the length of said member, said strain-relief member being constituted by a length of flexible wire disposed internally of said length of tubing, the latter being movable in relation to said member longitudinally and laterally of said member.

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