

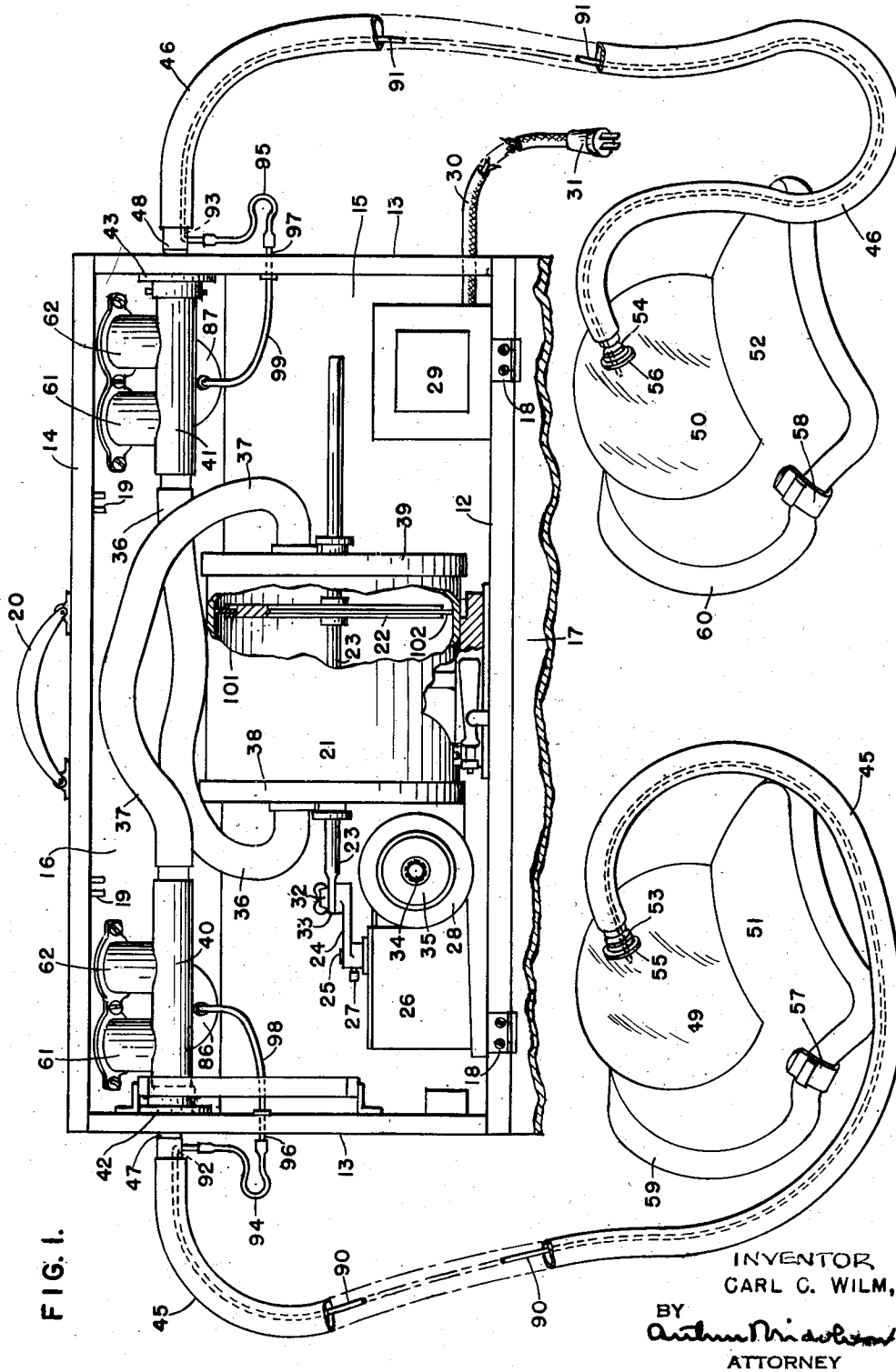
Jan. 8, 1952

C. C. WILM
RESPIRATOR

2,581,893

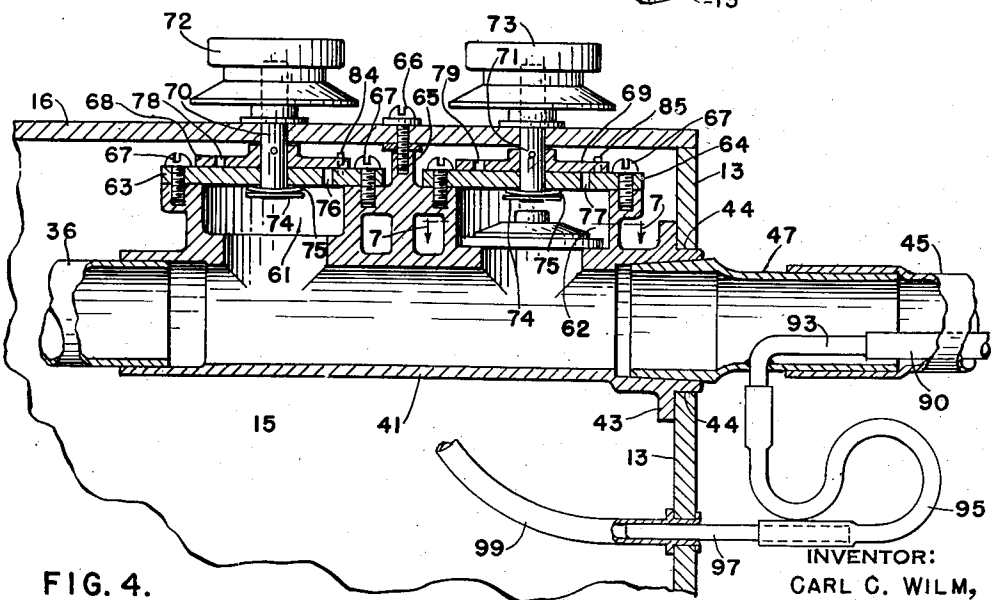
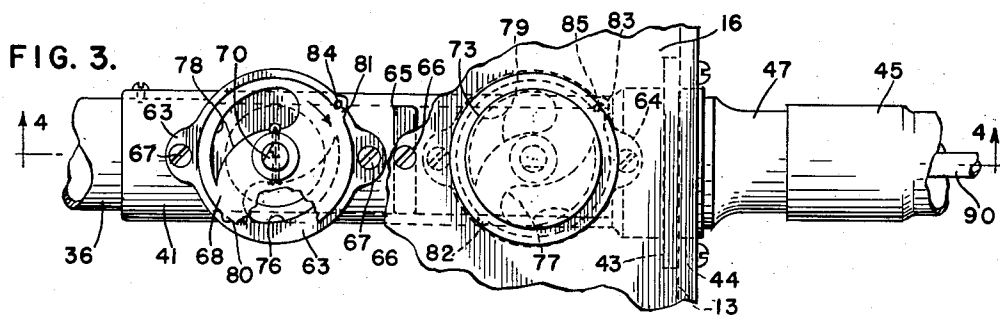
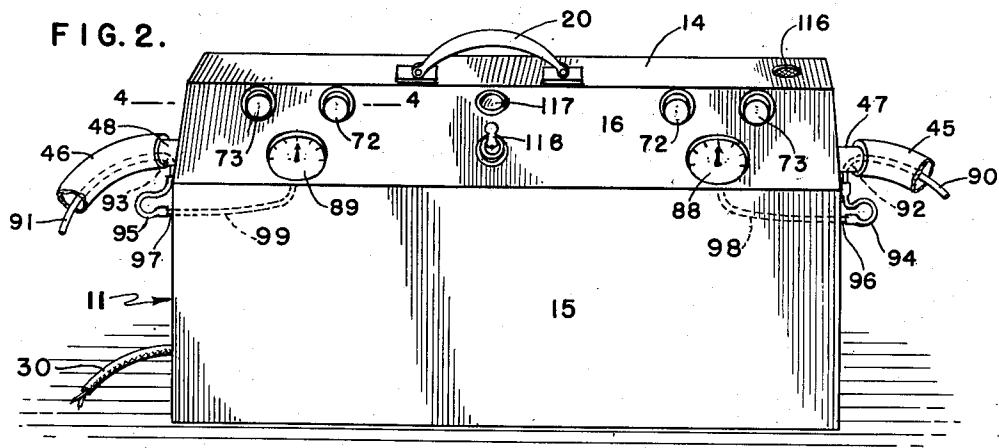
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2,581,893

3 Sheets-Sheet 2



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3 Sheets-Sheet 3

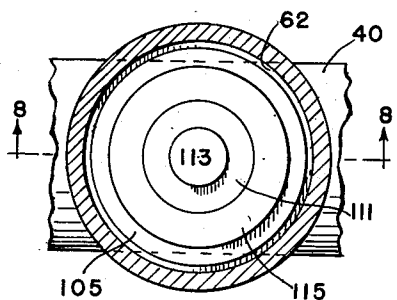
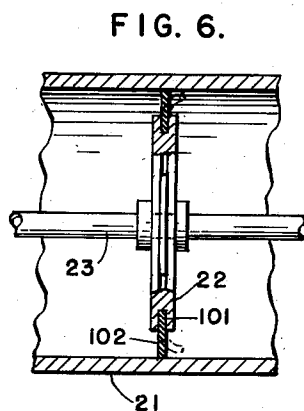
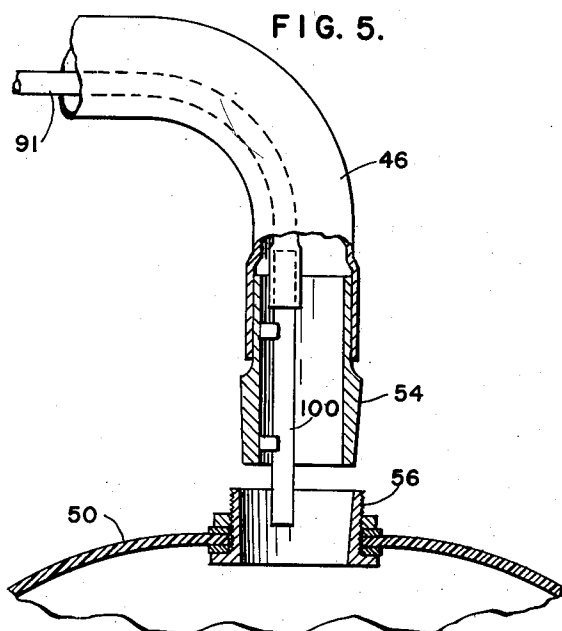


FIG. 7.

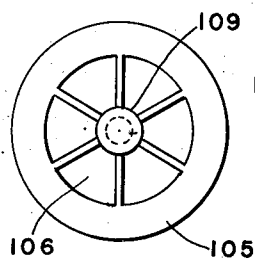


FIG. 9.

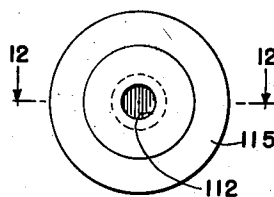


FIG. 11.

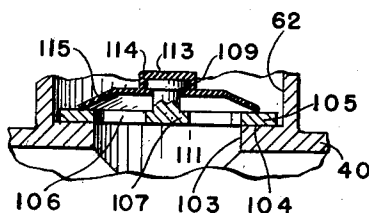


FIG. 8.

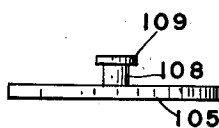


FIG. 10.

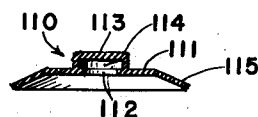


FIG. 12.

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UNITED STATES PATENT OFFICE

2,581,893

RESPIRATOR

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Application August 2, 1949, Serial No. 108,139

6 Claims. (Cl. 128—30)

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This invention relates to respirators and comprises an improvement over that shown in my patent application Serial No. 735,162, filed March 17, 1947, now Patent No. 2,490,395. That application discloses a power-driven respirator for patients whose lung-motivating muscles have been rendered deficient by paralysis, such as in cases of polio sufferers. The inhaling and exhaling of air by the lungs is facilitated by mechanical means applying cyclically compression and expansion through the medium of alternate positive and negative pressured air-flows set up within a torso-engaging plastic convex rigid shell or breast-plate fitting tightly over the thorax of the patient. A flexible conduit leads from the shell on the patient to an instrument casing containing a device adapted to apply air-flows to the conduit alternately under compression and suction. The suction stroke or negative pressure causes the patient's lungs to expand (and inhale) breath while the compression stroke or positive pressure causes the patient's lungs to compress (and exhale) breath. The rhythm of the cycle is controlled to approximate or simulate the patient's normal breathing. The degree of positive and negative pressure of the air-flows is controllable by valves because the negative pressure usually is made more intense than the positive pressure. For instance, the negative pressure may go to between 12 to 15 millimeters of mercury while the positive pressure may go to between 2 to 4 millimeters. The reason for this low positive pressure is that gravity and automatic contraction of chest muscles help in the exhaling action.

So one of the objects of this invention is to devise devices associated with the conduit going to the shell on the patient from the compressor or its equivalent, which can be adjusted to control these positive and negative pressured air-flows to the degree best suited to the patient. A corollary to this is that since it is important to know very accurately the degree of these pressures being applied to the patient's thorax, another object of this invention is to devise apparatus by which such pressures can be measured directly at their place of application, rather than merely at some place in the conduit more or less remote from the patient, with the consequent possibility of false indication of pressure. In this conduit, the areas or waves of plus and minus pressure are created by a flow of air through the conduit in opposite directions. I have found that it is undependable to measure the degree of pressure in these flows of air because of friction be-

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tween air-flow and conduit-surface, so it is another object of this invention to devise means for measuring these pressures by a gauge on the power unit casing and thus closely adjacent to the pressure controls and yet measuring them directly at the patient's thorax through the medium of a pressure conveying or transmitting device through which these oppositely-directed flows of air do not pass. The conduit, for convenience in transportation, is usually made detachable both from the shell and from the power unit or instrument casing. When so detached, an operator is apt to start the compressor in the casing and then put his hand over the outlet aperture in the casing to which the conduit is connectible with the result that the back pressure so placed on the compressor will break some part in it or its operating mechanism—which, after all, is only devised to compress up to about $\frac{3}{4}$ of a pound. So it is a further object of this invention to devise and arrange a safety mechanism to relieve such abnormal pressures without damage to the operating parts yet which allow the parts to go back to normal operation as soon as the cause of such high pressure is removed.

The environment of this invention is a shell tightly fitted to the patient's torso with a flexible air-flow conducting conduit leading from that shell to an instrument casing wherein there is mechanism for producing cyclically in the conduit a flow of compressed air in a direction toward the shell followed by a flow of reduced pressure air in the reverse direction, namely, away from the shell and toward the casing. In the casing is a gauge indicating and measuring plus and minus pressures. In this environment, it is one of the features of this invention to provide in the conduit a small diameter tube projecting from the shell-end of the conduit and leading through the conduit to be connected to the pressure gauge in the casing while functionally remote from the air-flows and the atmosphere.

In this environment, it is another feature of this invention to associate with the conduit closely adjacent to the pressure gauge a valve mechanism of special construction which permits the operator to control adjustably the degree of positive pressure and the degree of negative pressure passing through the conduit to the shell on the patient. Included in this special construction are the particular control features of the valves characterized by the peculiar shape of the opening in a turnable gate as correlated with a coating opening in a plate abutting the gate.

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The co-operating openings or apertures are generally in the shape of a comet with a curved tail or perhaps more nearly the shape of an apostrophe but with the apostrophes oppositely directed for giving unusually accurate control. One valve is provided for letting air into the conduit while another valve is for emitting air from the conduit. The latter valve is pressure closed, preferably by a flexible domed closure that, however, is inflexible enough to prevent emission of air until the pressure of air within the conduit thereagainst is great enough to flex the closure.

In this environment, it is another feature of this invention to use for creating the plus and minus pressure, a compressor of the reciprocating piston type characterized by a special peripheral gasket which collapses or bends over when dangerously abnormal pressure backs up against the piston, thus letting the pressure escape to the opposite or back of the piston to establish a lessened or normal pressure within the system, whereby the abnormal pressure is dissipated, and whereupon the gasket returns to normal cylinder-contacting and air-compressing position.

A feature of advantage of the small tube within the larger flexible conduit is that since the wall of the small tube is acted upon by the alternating pressures inside of the larger conduit, the final effect is for the elimination of variation of volume inside the tube with the resultant increase in accuracy of measurement of the pressures acting upon the patient within the shell of the respirator. When pressure is increased inside of the conduit, pressure is simultaneously increased in the tube. When pressure is decreased in the conduit, pressure is simultaneously decreased in the tube. The result is that the tube's diameter does not vary whereas the diameter of the larger flexible conduit does. This measurement of pressure through the tube avoids errors of indication if the measurement is of the pressures within the larger conduit because the conduit is being subjected constantly to oscillating pressures and vacuums so that its volume changes accordingly and seriously affects accuracy of measurement. These inaccuracies are avoided by the use of the small tube especially since its non-shell end terminates within the pressure gauge and thus is not open to the atmosphere or to the variable pressure-producing compressor.

The best embodiment of this invention now known to me has been chosen for the purpose of illustration but it is described hereinafter as an example of the invention used for illustrative purposes so it is to be recalled that equivalents of certain parts and functions can be used. The example has been illustrated in the accompanying drawings, in which:

Figure 1 is an elevational open rear view of the apparatus showing the mechanism within the casing and includes a pair of torso-engaging rigid shells or breast plates, parts being broken away to better illustrate same.

Figure 2 is a perspective front view of the case without the connected torso-engaging shells.

Fig. 3 is an enlarged fragmentary detail of a valve assembly forming a part of the apparatus.

Fig. 4 is a sectional elevational view of same taken along a plane indicated by the line 4—4 of Figs. 2 and 3.

Fig. 5 is a fragmentary detail, partly in section, showing a connection between the end of a

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flexible conduit and a torso-engaging shell, a portion only of the shell being shown.

Fig. 6 is a fragmentary section of a cylinder which forms a part of this apparatus and shows, partly in section therein, a piston having a special resilient peripheral gasket.

Fig. 7 is an enlarged fragmentary detail of a part of a valve assembly and is taken approximately along line 7—7 of Fig. 4, looking in the direction indicated by the arrows.

Fig. 8 is a sectional elevational view taken in a plane along the line 8—8 of Fig. 7.

Fig. 9 is a plan view of a part removed from Fig. 7.

Fig. 10 is a side elevational view of same.

Fig. 11 is a bottom plan view of a part removed from Figure 7; and

Fig. 12 is a sectional elevation of same taken along the line 12—12 of Fig. 11.

Referring to the parts in detail, 11 designates a casing or housing having a bottom 12, side walls 13, top 14, lower front wall 15, a beveled front-top 16, and a rear panel 17 which is hinged to the bottom 12 by hinges 18 and is provided with locking tongues (not shown) which engage spring clips 19 when the rear panel 17 is closed. A carrying handle 20 may be provided as shown.

Within the casing 11, there is mounted a pump cylinder 21 having a piston 22, reciprocally movable therein. A shaft 23 is attached to the piston 22 and is given reciprocal movement by its connection to a crank arm 24 which is secured upon a shaft 25 extending through the casing of gear-reduction unit 26. A set screw 27 secures the crank arm 24 upon the shaft 25. An electric motor 28 is geared to and drives the gear-reducing unit to rotate the crank arm 24 and impart reciprocal movement to the shaft 23 and its connected piston 22. Electrical energy is transmitted to the motor 28 through an electrically-connected voltage-reducing transformer 29 which is, in turn, supplied with current from its source by a conventional conductor 30 and its attached plug 31. The outer end of the crank arm 24 is detachably connected to the piston shaft 23 by means of a wing-headed pin 32 which is threaded upon the outer end of the crank arm 24 and engages a slotted cross-head 33 formed upon the end of the piston shaft 23. A speed control knob 34, connecting with a governor in a governor casing 35, supplies a means to regulate the revolutions of the motor 28.

Conduits 36 and 37 connect with the compartments of the cylinder 21 through orifices in the cylinder heads 38 and 39, respectively. From the cylinder heads, the conduits 36 and 37 lead to and are attached to the inner ends of tubular valve units 40 and 41, respectively. These valve units 40 and 41 are secured at their outer ends 42 and 43, to the side walls 13 of the casing 11 and project through orifices 44 (Figs. 3 and 4), in the side walls 13.

Flexible and resilient conduits 45 and 46 (which may be corrugated transversely) having tapered connection thimbles 47 and 48, are attached, at one end, to the tubular valve units 40 and 41, respectively (Figs. 1, 3 and 4), and at their other ends are attached to the transparent plastic domes 49 and 50 of torso-engaging shells or breast plates 51 and 52, respectively. Upon the dome attachment ends of the flexible conduits 45 and 46 are tapered connecting thimbles 53 and 54, which fit snugly into bevel-walled tubes or rings 55 and 56, respectively. These

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rings are securely attached in orifices to the domes 49 and 50 (Fig. 5). The torso-engaging shells 51 and 52 are each provided with a suitable strap and clasp 57 and 58, respectively, as a means for tightly attaching the torso-engaging shells over the thorax of a patient. When a single patient is to be treated, one of the torso-engaging shells and its connecting conduit may be disconnected from the apparatus. Inflatable, resilient and flexible gaskets 59 and 60 are attached along the edges of the torso-engaging shells 51 and 52, respectively, and provide the means for effecting a tight juncture with the body of the patient.

As the piston 22 is given reciprocal motion in its cylinder 21, air-flows are created in the conduits 45 and 46, between their attached torso-engaging shells 51 and 52, and the compartments in the cylinder 21 formed by the piston 22 and the cylinder head 39 and between the piston 22 and the cylinder head 33, which are alternately under compression and suction. The suction stroke or negative pressure causes the patient's lungs to expand (inhale) breath while the compression stroke or positive pressure causes the patient's lungs to compress (exhale) breath. The degree of positive and negative pressure of the air-flows is controllable by valves, the negative pressure usually being made more intense than the positive pressure. The negative pressure may go to between 12 to 15 millimeters of mercury reading while the positive pressure may go to between 2 to 4 millimeters.

Controlling means for regulating the positive and negative air-flows are provided and consist of the arrangement of parts in connection with the tubular valve units 40 and 41, heretofore mentioned. For the purpose of simplicity of description, a single tubular valve unit 41 will be described, the other tubular valve unit 40 being identical in parts, arrangement and action. Extending from and integrally formed upon the tubular valve unit 41 (Figs. 3 and 5), are dual cylindrical valve pockets 61 and 62, which are capped with cover plates 63 and 64, respectively. An attachment stud 65 upon the tubular valve unit between the cylindrical pockets provides a means for attachment to the bevel front 16 of the casing 11 and is held thereto by a screw 66. The cover plates 63 and 64 are secured upon the cylindrical valve pockets 61 and 62, respectively, by screws 67.

Abutting turntable valve-plates 68 and 69 are concentrically mounted upon the cover plates 63 and 64, respectively, and are given partial rotation thereon by means of a shaft 70 to which the turntable valve plate 68 is pinned and a shaft 71 to which the turntable valve plate 69 is pinned. The shafts 70 and 71 extend upwardly through the beveled top 16 of the casing 11 and have, removably keyed thereto, turnable knobs 72 and 73, respectively. Washers 74 are secured upon the lower ends of the shafts 70 and 71 and have, disposed between them and the lower surface of the cover plates 63 and 64, flat spring washers 75 which act to hold the turntable valve-plates 68 and 69 snugly against the cover plates 63 and 64, respectively.

The cover plates 63 and 64 are formed with apostrophe-shaped apertures 76 and 77, respectively, while the abutting turntable valve plates 68 and 69 are similarly formed with apostrophe-shaped apertures 78 and 79. The apostrophe-shaped apertures in the turntable valve plates are brought into perfect alignment with the apostrophe-shaped apertures in the cover plates when

the turntable valve plates are turned clockwise or in the direction indicated by the arrow X shown in Fig. 3, thereby fully opening the air passages to the valve pockets 61 and 62. By rotating the turntable valve plates in an opposite direction or counter-clockwise, the apostrophe-shaped apertures thereon may be turned out of alignment with their co-operating apostrophe-shaped apertures in the abutting cover plates to close the air passage to the valve pockets. Various degrees or sizes of air passages through the apostrophe-shaped openings may be attained from minimum pin-head-sized openings to the full-sized openings attained when the coinciding apostrophe-shaped apertures are aligned. Lugs 80-81 and 82-83 are formed upon the periphery of the turntable valve-plates 68 and 69, respectively, and engage stop pins 84 and 85 upon the respective cover-plates 63 and 64 to limit the turning movement in either direction of the turntable valve-plates.

To visually indicate the pressure, either positive or negative, in the torso-engaging shells 51 and 52, there are provided gauges 86 and 87 (the casings of which are shown in Fig. 1), having dial plates 88 and 89, respectively, shown in Fig. 2, upon the outer surface of the bevel top 16 of the casing 11. The gauges 86 and 87 are connected by means of small-diameter flexible tubes 90 and 91 carried inside of the flexible conduits 45 and 46, respectively. The small-diameter tubes 90 and 91 terminate in connecting elbows 92 and 93 (Figs. 1, 2 and 4), which extend through the connecting thimbles 47 and 48 upon the ends of the conduits 45 and 46, respectively, and have attached thereto short flexible connecting tubes 94 and 95, upon the free ends of which there are secured nipples 96 and 97 (Figs. 1 and 4), respectively. The nipples 96 and 97 are detachably connected to the outer ends of rigid tubes 98 and 99, respectively, and are easily disconnected when the conduits are disconnected from their corresponding tubular valve units. The rigid tubes 98 and 99 are connected to the gauge casings 86 and 87, respectively. The gauges are of conventional bellows type and have air-pressure chambers into which the rigid tubes 98 and 99 terminate.

In Figure 5 there is shown a means to prevent damage to the operating parts in the casing when, inadvertently, an operator covers the conduit opening with a hand, or otherwise, while the motor is operating. While this damage-prevention means is provided upon both conduits, a single conduit 46 is shown. The conduit 46 terminates, as already stated, upon a thimble 54 which carries upon it a section of rigid tubing 100 which extends outwardly beyond the end of the thimble 54. The small diameter tube 91 is attached to the inner end of the tube 100. When the conduits are detached from the torso-engaging shells, the projecting end of the tube 100 prevents any coverage of the open end of the conduits by the operator's hand, or otherwise.

A further damage prevention-means is provided upon the piston 22 and consists of supplying, in a groove 101, upon the periphery of the piston 22, a flexible gasket 102 which collapses, or bends over, as shown by broken lines in Fig. 6, when dangerously abnormal pressure backs up against the piston, thereby letting the pressure escape to the opposite or back side of the piston to establish a lessened or normal pressure within the system, dissipating the abnormal pressure and

allowing the gasket to return to normal cylinder-contacting and air-compressing position.

With the varying pressure of the air-flow through the large flexible conduit, the wall of the enclosed small diameter tube is acted upon by the alternating pressure inside of the larger conduit, and the final effect is for the elimination of variation of volume inside the small diameter tube with the resultant increase in accuracy of measurement of the pressures acting upon the patient within the shell of the apparatus.

When pressure is increased inside the conduit, pressure is simultaneously increased in the tube, with negligible air-flow. When pressure is decreased in the conduit, pressure is simultaneously decreased in the tube likewise with negligible air-flow. The result is that the tube's diameter does not vary, whereas the diameter of the larger flexible conduit does. Inaccuracies are avoided by the use of the small diameter tube, especially since its non-shell end terminates within the pressure gauge and therefore is not open to the atmosphere or to the variable pressure-producing compressor.

Referring back to the tubular valve units, it will be noted that each unit includes two valve pockets, namely, 61 and 62. Through the valve pocket 61 air is admitted to the flexible conduit 45 or 46, while through the valve pocket 62 air is emitted from the conduit. The latter valve is pressure-closed, preferably by a flexible domed closure member that, however, is inflexible enough to prevent emission of air until the pressure of air within the conduit thereagainst is great enough to flex the closure member. Such a member is illustrated in Figs. 7 to 12, inclusive.

The valve pockets 62 are formed with an opening 103, which connects the pocket with the tubular portion of the tubular valve unit 40 and provides a ledge 104 upon which is fixed, by cementing or other suitable means, a wheel-shaped disk 105 having openings 106 and a central hub portion 107. From the hub portion there extends upwardly a pedestal 108, having a flanged cap 109 over which is fitted a flexible closure member 110. This closure member is formed with an annular table portion 111 and has a central opening 112 and a covering dome portion 113 forming a pocket 114 into which the flanged cap 109 fits to hold the closure member in place. A tapered or beveled annular flange 115 extends downwardly from the table 111 and forms a closure at the point of contact between its lower annular edge and the upper surface rim of the ring 105.

A screened air-vent 116 is formed in the top 14 of the casing 11 (Fig. 2) and similar screened openings may be provided in other parts of the casing. A pilot light 117 and switch are located upon the bevel front portion 16 of the casing 11.

I claim:

1. Respirator apparatus having a shell adapted to be fitted tightly to a patient's thorax, an instrument casing having a source of positive and negative pressured air-flows together with valve mechanism for controlling the degree of such air-flows as well as a pressure-indicating gauge and a conduit associated with the valve mechanism and the gauge for connecting the shell with said source; characterized by a con-

nection between the interior of the shell and the gauge comprising a pressure-transmitting device from which such air-flows are significantly excluded so that any tendency of its interior volume to change is minimized, said device comprising a non-expansible tube passing through the conduit lengthwise thereof and projecting into the shell a distance greater than does the conduit.

2. Apparatus according to claim 1, with the addition that the pressure-transmitting tube has one of its ends entering the shell and one of its ends connected to the gauge while being functionally remote from the air-flow and the atmosphere.

3. Respirator apparatus having a shell adapted to be fitted tightly to a patient's thorax, an instrument casing having a source of positive and negative pressured air-flows together with a pressure-indicating gauge as well as a conduit for connecting the shell with said source; characterized by a valve mechanism for independently controlling the degree of each type of such air-flows comprising valves interposed in the conduit adjacent the gauge and of which one valve is adapted for letting air into the conduit while another is adapted for emitting air from the conduit wherein at least one of the valves has an apertured plate and an abutting apertured turnable gate aligned therewith, with the aperture in at least one of these being in the shape of an apostrophe.

4. Respirator apparatus having a shell adapted to be fitted tightly to a patient's thorax, an instrument casing having a source of positive and negative pressured air-flows including a motor-driven reciprocating piston in a cylinder together with a pressure-indicating gauge as well as a conduit for connecting the shell with said source; characterized by means for avoiding damage to the motor drive for the piston if abnormal pressures are developed thereon comprising a gasket between the periphery of the piston and its cylinder that is normally inflexible enough to produce the desired air-flows but flexible enough to bend automatically to permit abnormal pressures to escape past the piston.

5. Apparatus according to claim 4, wherein the gasket is annular and is retained seated in a peripheral groove in the piston by resilience of the gasket material.

6. Apparatus according to claim 4, wherein the conduit is detachable from the instrument casing thus exposing a place where abnormal pressure may be created by the inadvertent placing there in closing position of the operator's hand.

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