Oct. 11, 1927. 1,645,312

R. VON DER HEIDE

BREATHING APPARATUS

Filed Dec. 27, 1920 3 Sheets-Sheet 1

Fig. 1.

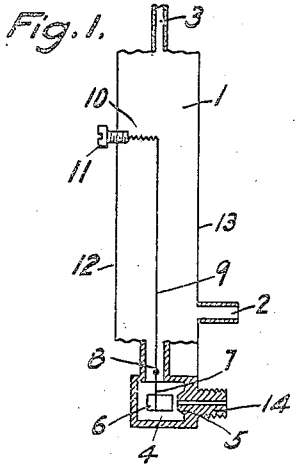


Fig. 2.

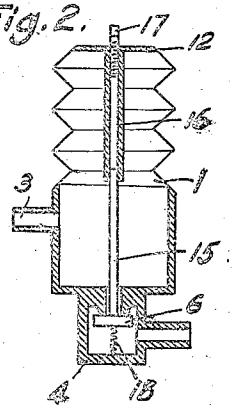


Fig. 5.

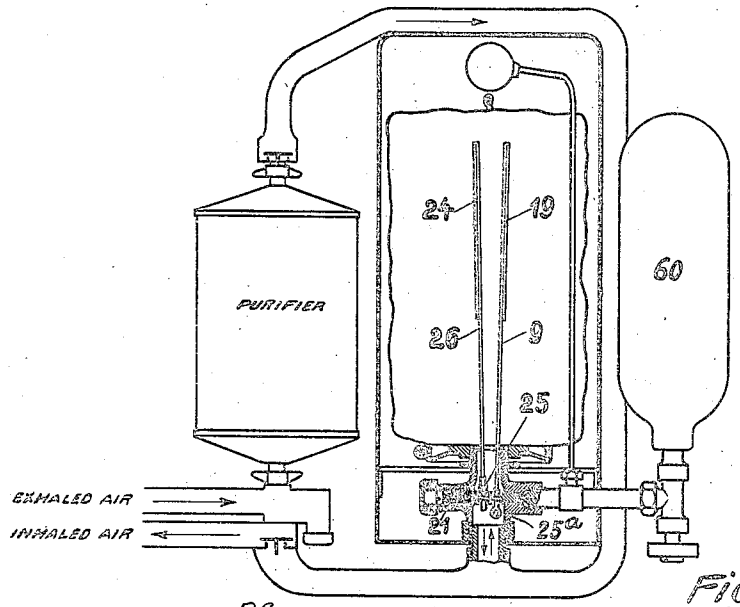


Fig. 5a

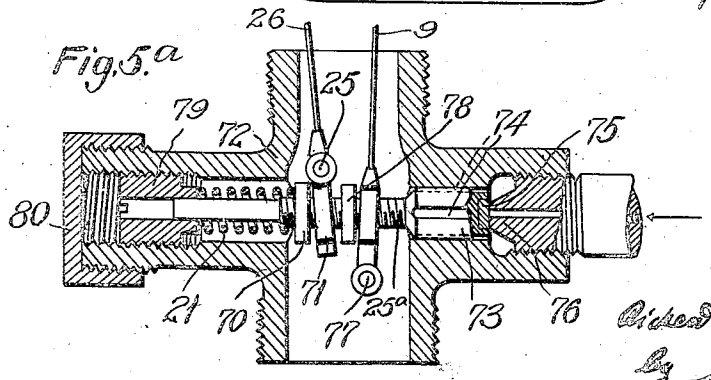
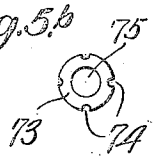


Fig. 5b



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Their Attys.

Oct. 11, 1927.

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Fig. 3.

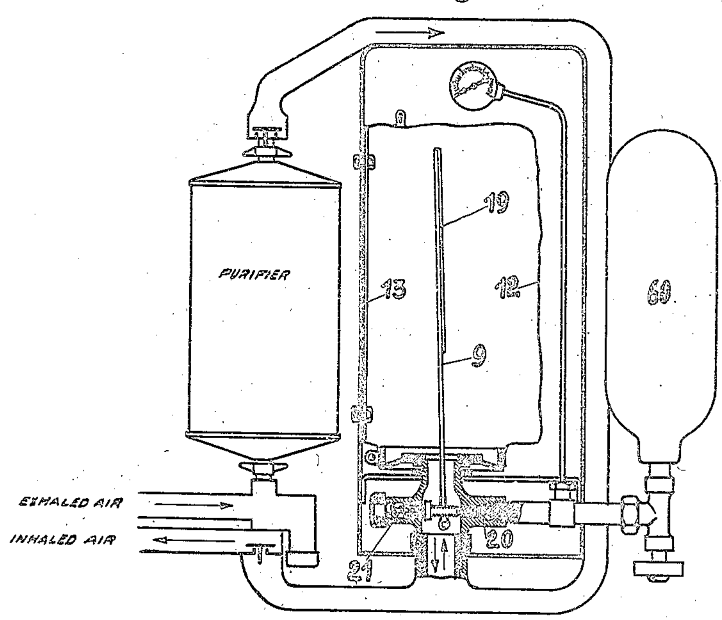
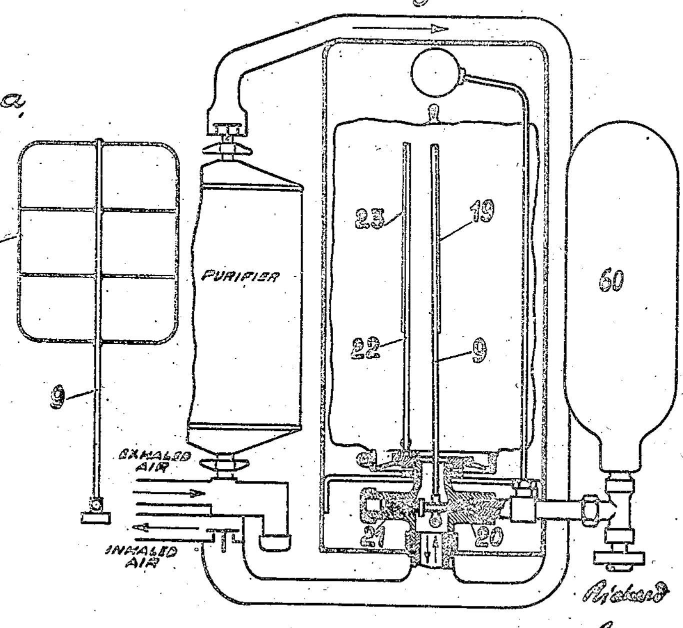


Fig. 4.

Fig. 4a.



Inventor
Richard von der Heide
By [signature]
His atty.

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BREATHING APPARATUS

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Fig. 6.

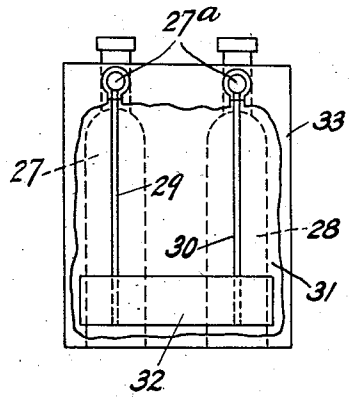


Fig. 7.

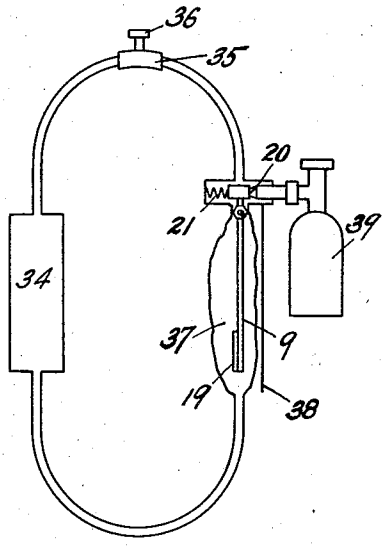


Fig. 8.

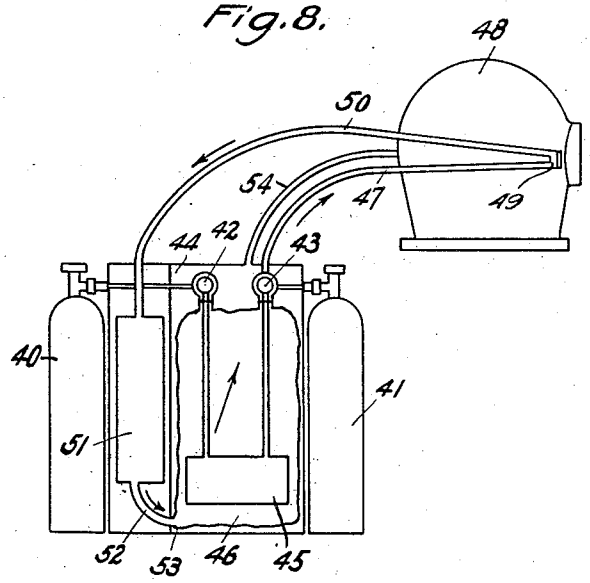
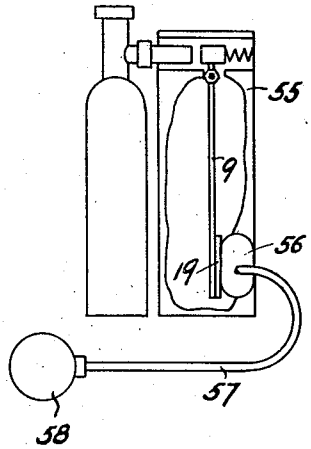


Fig. 9.



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his ATTORNEYS

Patented Oct. 11, 1927. 1,645,312

UNITED STATES PATENT OFFICE.

RICHARD VON DER HEIDE, OF BERLIN, GERMANY.

BREATHING APPARATUS.

Application filed December 27, 1920, Serial No. 433,547, and in Germany December 27, 1919.

This invention relates to breathing apparatus comprising a supply of nutritive gas, a breathing bag and a pressure reducing valve, or in other words to a breathing apparatus in which nutritive gas under high pressure, contained in a gas storage vessel, in flowing out through an expansion nozzle, is reduced to the pressure required for the purposes of respiration. Such pressure reducing valves have hitherto been invariably constructed in the form of a special or separate part of the breathing apparatus. Besides, it has so far not been possible to regulate these valves in accordance with the amount of respiratory gas required at each moment. The valve was simply opened to a certain extent so as to permit the gas to permanently flow out at a certain rate, this rate of discharge either being sufficient to satisfy the greatest demand that might occur at any time or being only sufficient to supply enough gas for a small demand, the surplus of nutritive gas required in cases of an increased demand being supplied through a special valve manipulated by hand. The former mode of operation necessarily involves a waste of gas, and a drawback in connection with the latter mode of operation is that just at moments of more strenuous effort or intense action both hands of the bearer of the apparatus are generally occupied. thus rendering the turning on of an additional gas supply impossible.

In distinction from these known methods the invention embodies an entirely new principle which resides in using the movable wall of the breathing bag itself as a diaphragm for controlling the pressure reducing or regulating valve. In this way the volume of respiratory gas supplied is regulated automatically in a faultless manner in accordance with the quantity consumed. Another advantage over the known methods is that the tensioned diaphragm of the ordinary pressure reducing valve with all its disadvantages and the spring action in connection with this diaphragm is done away with.

The conditions of operation of the novel apparatus are rendered particularly advantageous by an arrangement in which the movable wall of the breathing bag is caused to act on the longer arm of a double armed lever whose shorter arm is made to open the closing member of an inlet nozzle in opposition to a spring power. The distribution of the forces acting in the apparatus is then such that on the one hand a high specific pressure acts at the inlet nozzle upon a small surface and a short arm of the lever, and on the other hand a small pressure acts in the breathing bag upon a large surface and a long lever arm. The said spring power required for closing the nozzle can then be made small so that the forces needed for counter-balancing the effect of this spring may be small also. Since, in addition to this, the movement by which the spring is caused to cease acting is executed by the long arm of the lever the play of the forces controlled by the breathing bag is an exceedingly delicate one and capable of exerting an effect on the slightest sinking or rising of the pressure in the bag.

A substitute for the said lever arrangement that may be used in certain cases consists in the ratio of the active surface of the bag to the cross section of the nozzle being made large enough.

By arranging the various parts in the manner described particularly favorable conditions for the practical construction of the apparatus are obtained and above all things a sure and easy response of the valve is secured.

A particularly important advantage obtained by certain forms of my improved constructions, is that contents of the breathing bag can be reduced to an exceedingly small quantity, that is, the bag can be almost entirely deflated so that, in comparison with certain other forms, the space in the breathing bag that remains unused by the process of respiration is reduced.

In apparatus in which the respiration gas is produced from chemicals, which only become effective gradually the device constructed in accordance with the invention may be utilized for the purpose of supplying the oxygen required immediately the equipment is used. When the development of gas from the chemical commences the supply from the supplementary device is gradually and automatically cut off.

A breathing apparatus operating in accordance with the invention may also be used in connection with self-contained diving apparatus for the purpose of regulating the contents of air in the diving dress in such a way as to avoid or lessen the danger arising through sudden drops to greater depths. This is accomplished by the pressing together of the breathing bag (which

results when the pressure rises) being caused to effect the turning-on of a supply of supplementary respiration gas. The fluctuations of pressure in the diving dress are caused to act upon the breathing bag through the medium of a pipe whose one end leads into the interior of the diving dress and whose other end issues in a casing in which the breathing bag is contained.

In order to meet all the requirements of practice, the invention provides still another device which enables the user of the breathing apparatus to turn on a supplementary gas supply at will. This device consists of a pneumatic member, such as a hollow rubber ball, from which, on the ball being squeezed, air is expelled which exerts pressure on a controlling lever (or levers) which turn on the supplementary supply of respiration gas.

Some constructional forms of the invention are illustrated more or less diagrammatically in the drawing in which

Fig. 1 shows in more or less diagrammatical form a section of a breathing bag with a gas supply valve controlled by a lever actuated by a movable wall of the bag,

Fig. 2 shows diagrammatically a section of an extensible breathing bag in the form of a bellows whose movable wall controls the gas supply valve with the aid of a straight rod,

Fig. 3 represents in longitudinal vertical section a practical breathing apparatus having a bag with one fixed side or wall and a valve control lever suspended in the bag and having a plate attached to its lower end,

Fig. 4 illustrates in similar section a breathing apparatus having a bag with two movable or flexible sides, a fixed rod with a plate extending into the bag, and a lever pivoted at one end and having a plate arranged opposite to the plate attached to the fixed rod,

Fig. 4[a] shows the plate 19 of Fig. 4 in front elevation,

Fig. 5 shows a bag with plates similar to those of Fig. 4 except that both plates are attached to levers with pivots at their top ends,

Fig. 5[a] shows in longitudinal vertical section in larger scale the detail of the double arm valve control,

Fig. 5[b] shows in detail the end view of the high pressure gas supply valve.

Fig. 6 illustrates diagrammatical fashion a bag in which a suspended plate and its attached levers control the valves of two individual gas supplies,

Fig. 7 shows in similar fashion an equipment comprising a breathing bag with a vertical suspended lever controlling a gas supply, and a means for developing oxygen from a chemical or chemicals,

Fig. 8 represents the head piece of a diving dress or armor connected to gas supplies controlled by levers actuated by the movements of the sides of an alternately inflated and deflated bag, and

Fig. 9 shows an apparatus in which the valve of the supplementary gas supply is controlled at will by squeezing a hollow ball.

The breathing bag 1 shown in Fig. 1 has two short pipes 2 and 3 through the former of which the exhaled air that has been purified by an air purifying means (such as is indicated in Fig. 3) is conducted into the bag out of which it passes through the pipe 3. Connected to the lower end of the breathing bag is a terminal piece 4 which contains a nozzle 5 and an opening and closing member 6. The closing member 6 is attached to the short arm 7 of a two-armed lever which is pivoted at 8 and whose longer arm extends into the interior of the breathing bag. A pull is exerted on the end of the long arm by a spring 10 attached to a screw 11 in the movable side or wall 12 of the breathing bag whose other wall 13 is assumed to be immovably fixed.

The short pipe 14 with which the nozzle 5 is associated is connected to a supply of nutritive gas (not shown). The nozzle or valve 5 is kept closed by the spring 10 until the deflation of the bag due to the consumption of nutritive respiration gas has proceeded to a certain point and the tension of the spring 10 is relaxed by the motion of the wall 12. The closing member 6 then recedes from the nozzle and allows respiration gas to flow in until the inflation of the bag which now takes place results in the spring 10 being tensioned again so that the closing member is again pressed against its seat and closes the nozzle. This alternate opening and closing of the nozzle or valve takes place continuously and automatically in accordance with the amount of gas consumed.

In the apparatus shown in Fig. 2 the one wall 12 of the breathing bag 1, which is constructed in the form of a cylindrical bellows, is arranged to act on the closing member 6 through a straight rod 15 extending from the said member into the interior of the bellows or bag. A sleeve 16 attached to the wall 12 is adapted to slide up and down on the rod 15 and a spindle 17 is arranged to be screwed in or out of the top end of the sleeve.

The closing member 6 arranged in the terminal piece or cap 4, when moved downward in opposition to a spring 18, opens the gas inlet. The air is inhaled from the bag through the pipe connection 3.

When the bag collapses its wall 12 together with the sleeve 16 and the spindle 17 move downwards. The lower end of

the spindle then presses down the rod 15 and causes the gas inlet valve to open. The ratio of the cross sectional area of the gas inlet passage to the surface area of the wall 12 may be made such that the conditions of operation are practically the same as in the case of Fig. 1.

In the complete apparatus shown in Fig. 3 the upper end of a lever 9 carries a plate 19, which may be of any suitable shape. The movable wall 12 bears against the plate 19 when the bag collapses and by deflecting the lever causes the valve 20 to open in opposition to the action of the spring 21 to permit nutritious gas supply from storage reservoir 60. Hence the wall 12 may consist of the ordinary material used for making breathing bags. The reliable action of the valve control device is ensured by the provision of the plate 19 which assumes the functions of the afore-described rigid or stiff bag wall. In other respects the operation is the same as in the case of Fig. 1.

In the case of Fig. 4 there is provided, in addition to the lever 9 which is provided with a plate 19, an arm 22 rigidly fixed to the base of the apparatus and extending upward in the bag in a direction parallel to the lever 9. The arm 22 carries a plate 23 arranged opposite to the plate 19 and having the same outline as the latter. The plate 23 fulfils the functions of the fixed wall 13 which, in the above-described modifications, had to be used as a member whose position in space relative to the valve control lever is fixed. Thus in Fig. 4 the plate 19 is movable relative to the plate 23, and the valve 20 is made to respond as soon as the bag—which in this case is quite similar to an ordinary breathing bag—collapses to such an extent that its one wall bears against the plate 23 while its other wall bears against the plate 19.

By this arrangement the inner space of the breathing bag may be much more fully utilized because the deleterious or unused space which exists between the fixed wall 13 and the plate 19 of Fig. 3 is obviated.

The effect of a gas bag consisting entirely of flexible fabric, collapsing on two plates extending freely into the bag can be further enhanced for the purpose of controlling the gas admission in the manner shown in the modification Figures 5, 5a and 5b. It will be noted that in Fig. 5 in addition to plate 19 which as previously described with reference to Figs. 3 and 4 controls the gas admission valve, a second plate 24 is arranged which plate, however, contrary to the illustration in Fig. 4 is not stationary but also connected with the valve control similar to the manner arranged with respect to plate 19. In Fig. 5, and as shown in detail in Fig. 5a, plate 19 is carried by the arm 9 which extends freely into the bag and which is pivoted in the valve casing at 77 and which engages near its pivot point the stem 25a of gas supply valve 73. The engagement occurs by way of an adjustable shoulder 78 which is threaded on the valve stem. Plate 24 which is arranged opposite plate 19 in the bag is carried by a long lever arm 26 pivoted at 25, a short end 71 of this lever extending downward beyond pivot 25, this short arm engaging a shoulder 70 also threaded on valve stem 25a so that it can be properly adjusted. The free end of valve stem 25a is guided in a bushing 79 threaded into the rear extension of the valve casing 72, and a spring 21 is disposed between bushing 79 and shoulder 70, which when properly tensioned by the adjustment of bushing 79 will hold valve 73 on its seat 76 against the high gas pressure which exists in flask 60. Thus when the bag collapses during the inhalation its sides engage both plates 19 and 24 moving them towards each other. Thereby the arm portion of the levers operatively connect with the respective shoulders 78 and 70 as hereinbefore described engage these shoulders simultaneously and jointly move the valve stem 25a to the left against the tension of spring 21 so that valve 73 is lifted from its seat. Breathing gas will now escape from the flask 60 and will pass into the valve casing by way of the small grooves 74 longitudinally arranged on the surface of the valves 73 as shown in Fig. 5b. After the amount of nutritious gas consumed at the previous respiration period has been restored so that the bag is again slightly inflated, levers 9 and 26 return to their normal position thru the action of spring 21 and at the same time valve 73 is again seated. As will be noted from Figs. 5a and 5b the end of valve 73 carries a small bolster 75 of suitable material and properly polished so that tight closing of the valve is insured.

The great advantage of this double lever action is that a comparatively light bag can be used and that the atmospheric pressure thru which the bag is collapsed is used to the fullest extent in operating the valve control levers.

The apparatus shown diagrammatically in Fig. 6 comprises a flask 27 filled with compressed air and a flask 28 containing oxygen. The outlet valves of these two flasks indicated at 27a are each controlled by a lever 29 and 30 respectively which extend downwards into a breathing bag 31 and are interconnected at their lower ends by a plate 32. All the parts are enclosed in a box 33 to the rear wall of which the breathing bag is fixed. When the bag collapses its movable wall presses against the plate 32 and causes the outlet valves of the flasks 27 and 28 to be opened for the purpose of refilling the bag. When this has been done the plate is relieved of the pressure of the movable

wall of the bag and the parts are restored to their normal positions.

Fig. 7 is a diagrammatical illustration of an apparatus in which a chemical that develops oxygen is used.

34 represents a removable box containing the chemical, 35 is a casing enclosing the inhalation and exhalation valves, 36 is the mouth-piece, 37 the common breathing bag whose one wall bears against a fixed plate 38 and whose other wall moves against the plate 19 in the manner described with reference to Fig. 3 when the bag is deflated and thus causes the valve 20 of the supply flask 39 to be opened more or less in opposition to the spring 21.

When breathing with the aid of the bag is commenced the latter contains no air. Hence when the first breath is drawn the valve of the flask will be immediately opened by the lever 9 and oxygen will flow in automatically until the chemical in 34 gives off sufficient respiration gas to the bag to cause it to release the valve control lever and stop the outflow of gas from the supply flask. If in consequence of a sudden increase in physical exertion on the part of the user of the apparatus, an increased demand for respiration gas ensues which the chemical cannot immediately completely supply, a delivery of gas from the supply flask 39 will immediately and automatically commence.

Fig. 8 shows the breathing apparatus applied in an independent or self-contained diving apparatus which is arranged for operation with oxygen and compressed air.

The oxygen is contained in the flask 40 and the compressed air in the flask 41. The discharge pipes from these flasks terminate in valves 42 and 43 respectively arranged in a receptacle 44 which is closed to the exterior. The valves are controlled in the above-described manner by levers connected at their lower ends by a common plate 45 and extending into a breathing bag 46 arranged in the interior of the receptacle 44.

A pipe 47 leads from the breathing bag into a diver's helmet 48 and issues in a mouth-pipe 49. The exhaled air passes through the pipe 50 into an air-purifying device 51 and returns thence in a purified state through the pipe 52 into the breathing bag. The breathing bag is arranged in the receptacle 44 in a compartment which is connected by a passage 53 to another compartment that contains an air-purifying device 51. Communication between the interior of the receptacle 44 and the interior of the diver's dress or armor is established by a pipe 54 that leads from the receptacle 44 to the helmet 48.

The supply of air required for beathing is regulated as described by the wall of the bag pressing against the plate 45 when the bag is deflated and thus causing the respiration gas contained in the flasks to be turned on until the breathing bag is sufficiently filled. If the diver suddenly falls to a lower depth the air in his diving dress will be compressed and this rise of pressure will be communicated through the pipe 54 to the receptacle 44 and squeeze the bag together so that it will produce the same effect as in the case of a deficiency of air, i. e. it will cause the supply of respiration gas from the flasks to be turned on and thus cause air to flow into the diving dress.

In the equipment shown in Fig. 9 the general arrangement is the same as that in Fig. 3 except that the parts are enveloped in a box or receptacle 55. A pouch 56 is provided in the box and is connected by a flexible tube 57 with a hollow ball 58. When this ball is squeezed the pouch 56 is inflated so that it presses against the plate 19 arranged at the lower end of the valve control lever 9. It is seen that by this means the breathing bag can be filled at will.

It will be obvious that many changes and modifications can be made without departing from the scope of my invention.

I claim:—

1. A breathing apparatus comprising a source of high pressure gas for respiration, a breathing bag having a movable side, a pressure reducing valve directly connecting the bag with said source, a spring tending to close the valve, a lever having a short and a long arm said long arm extending freely into said bag, the short arm being associated with the valve, two oppositely arranged plates, one of said plates being attached to the long lever arm and adapted to be moved with it toward the other plate by the said movable side, whereby the short arm of the lever relieves the spring pressure upon said valve, permitting the gas pressure to open it.

2. A breathing apparatus comprising a source of high pressure gas for respiration, a breathing bag consisting entirely of flexible fabric, a pressure reducing valve directly connecting the bag with said source, a spring tending to close the valve, a lever having a short and a long arm, said long arm extending freely into said bag, the short arm being associated with the valve, two oppositely arranged plates disposed within said bag, one of said plates being attached to the long lever arm and adapted to be moved with it toward the other plate when the bag collapses, whereby the short arm relieves the spring pressure upon said valve, permitting the gas mixture to open it.

3. A breathing apparatus comprising a source of high pressure gas for respiration, a breathing bag consisting entirely of flexible fabric, a pressure reducing valve directly connecting the bag to said source, a spring tending to close the valve, two levers each having long and short arms, both of

said long arms extending freely into said bag, the pivotal points of said levers being so disposed that the short arms simultaneously relieve the spring pressure upon said valve thereby permitting the gas pressure to open it when the long arms move toward each other, and plates attached to the long lever arms and being engaged by the sides of the bag when it collapses, thereby actuating the levers to move towards each other.

In testimony whereof I have signed this specification.

PROF. DR. RICHARD VON DER HEIDE.