July 4, 1933. A. B. DRÄGER 1,917,182

BREATHING APPARATUS

Filed July 23, 1930

Fig. 1.

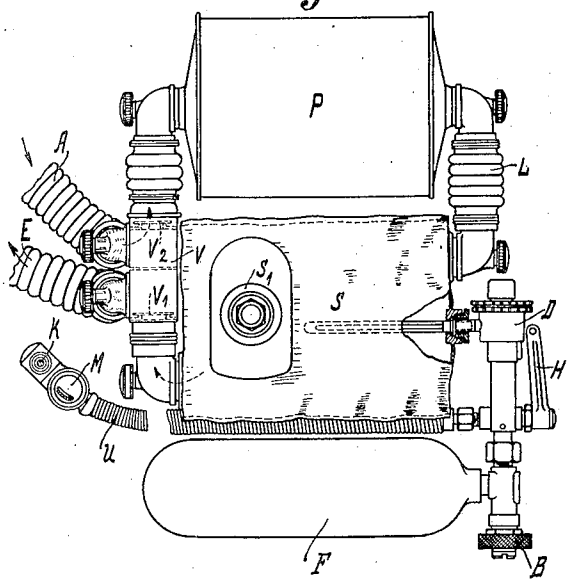


Fig. 4.

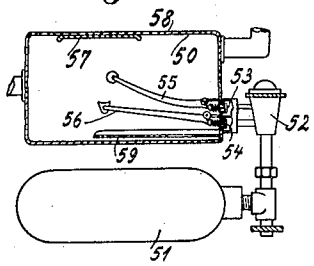


Fig. 5.

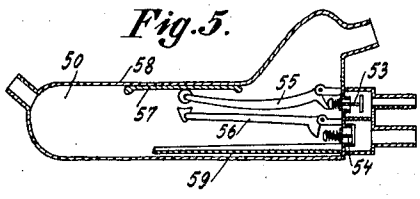
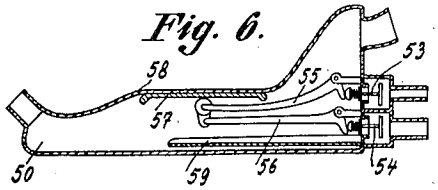


Fig. 6.



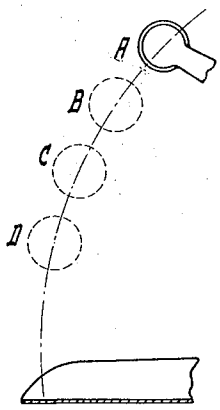


Fig. 2

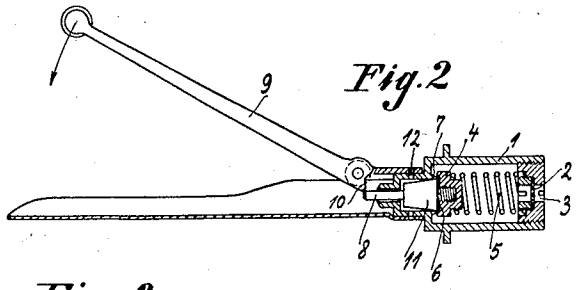
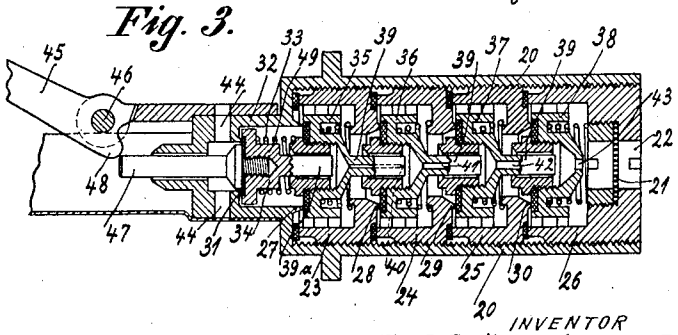


Fig. 3.



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UNITED STATES PATENT OFFICE

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BREATHING APPARATUS

Application filed July 23, 1930, Serial No. 469,979, and in Germany August 28, 1929.

The invention relates to breathing apparatus of the type which is automatically operated through the suction created by inhalation to control the feed of oxygen thereto. It is one of the primary objects of the present invention to provide an apparatus in which the rates at which the oxygen is fed thereto increases with increasing depth of breath, that is, with increasing suction effect produced by inhalation, whereby the danger of an over-accumulation of nitrogen, which is present to a considerable extent in commercial oxygen, is prevented.

Breathing apparatus in which the air is caused to circulate through a closed system which includes a breathing bag and a carbon dioxide absorbing cartridge is well known. In the type of apparatus to which the present invention relates, it has been the practice to utilize the collapsing movement of a wall of the breathing chamber during inhalation by the wearer of the apparatus to effect opening of a valve controlling the communication between an oxygen tank and such breathing bag. These valves have heretofore been so constructed that their whole effective flow area or maximum opening was exposed upon only very slight opening of the valve, so that after the breathing bag had collapsed to the slight extent necessary to produce this slight opening of the valve, an inflow of oxygen at a fixed rate ensued. When heavier breathing occurred, as when more laborious work was being performed by the wearer, the drafts of air were larger, so that the collapse of the breathing bag wall was more pronounced. This greater collapse of the breathing bag wall operated to open the valve to a greater extent and to keep the same open for a longer period of time. The rate at which the oxygen entered the breathing bag remained, however, quite constant, since the full, effective flow area controlled by the valve had already been exposed by the initial opening of the valve. The quantity of oxygen fed to the breathing bag as the depth of breath increased did, indeed, likewise increase, but such increase was due not to an increase in the rate at which the oxygen was fed but to the longer period of time the valve was held open.

It has been found that much greater security against overloading of the breathing circuit with nitrogen, with consequent danger to the wearer of the apparatus, can be gained if the quantity of oxygen fed to the breathing bag is made to increase not only as a result of the longer time interval that the valve is held open when the breathing bag collapses to a greater extent as greater drafts of air are withdrawn therefrom, but also upon increase in the rate of such feed as the depth of breath increases.

In accordance with the present invention the oxygen inlet valve is so constructed that as the valve opens to a greater extent, larger inflow areas are exposed to permit oxygen to enter the bag at increasing rates. This increase in the rate of feed of oxygen may be made to occur in any desired manner; for instance, it may be constant, i. e. follow a straight line, or it may be made to follow any desired geometric curve; it may also be made to take place in stepwise fashion, the rate remaining constant over a limited interval.

While only a single valve has been referred to above, it is clear that similar results may be obtained by the use of a plurality of valves arranged to be operated in sequence, as is shown in copending application Serial No. 143,943, filed October 25, 1926, of which the present application is in part a continuation.

In the accompanying drawing is shown by way of example several embodiments of the present invention; in said drawing, Fig. 1 is a view in elevation, partly in section, showing the general assembly of the parts of a breathing apparatus to which the present invention may be applied; Fig. 2 is a sectional view through a control valve constructed in accordance with the present invention; Fig. 3 is a central longitudinal section through a modified form of the invention; Fig. 4 is a diagrammatic view showing a construction employing a plurality of separate valves adapted to be operated in sequence; and Figs. 5 and 6 are views showing the operation of the valves shown in Fig. 4 upon progressive collapse of the breathing bag.

The letter E in Fig. 1 indicates the inhala-

tion conduit and the letter A the exhalation conduit which are connected to the mask (not shown) fitting over the nose and mouth of the wearer in well-known manner. V is a valve casing in which are located the inlet valve V_1 and the outlet valve V_2. The air purifying cartridge is shown at P and is connected to the breathing bag S by means of the conduit L. The breathing bag is provided with a scavenging valve S_1. F is an oxygen tank controlled by a valve B through which oxygen under pressure is fed to a pressure reducing valve D. There is also provided the usual by-pass conduit U for the reducing valve, such conduit being equipped with a pressure button valve K, a manometer M, and a shut-off lever H.

In the form of the invention shown in Fig. 2, the numeral 1 indicates a valve housing whose inlet opening 3 is protected against foreign matter by a sieve or strainer 2. The opening 3 is adapted to be connected to the oxygen tank by means of any suitable conduit. Located within the housing 1 is a closure member 4 which is urged by a spring 5 to engage an annular crater-like seat 7, the closure member being provided with any suitable packing 6. The member 4 is provided with an extension which passes through the valve seat and at its outer end takes the form of a stem 8 arranged to be engaged by the nose 10 of a lever 9 pivoted within the breathing bag and adapted to be oscillated by a collapsing wall of such bag as drafts of air are withdrawn from the latter. Between the stem 8 and the closure member 4 is a valve head 11 in the form of a truncated cone whose larger end abuts against the said member and is preferably of such size as to contact the inner walls of the annular seat 7 and thus serve to close the valve opening.

Upon oscillation of the lever 9 in the direction of the arrow upon collapse of the breathing bag, the valve head 11 and closure member 4 are forced toward the right against the pressure of the spring 5. Due to the conical construction of the valve head, the effective flow area available for the passage of oxygen through the valve will be gradually increased as the lever 9 is swung to a greater and greater extent. As a result, the rate at which oxygen will pass through the valve will increase in a uniform manner as deeper breaths of air are taken from the breathing bag. The oxygen passes through the space between the valve seat 7 and the conical head 11 and through the openings 12 into the interior of the breathing bag. As the valve is increasingly opened by the lever 9, the time during which the valve remains open is likewise increased so that the quantity of oxygen fed into the breathing bag will be increased. The quantity of oxygen fed to the bag will thus increase with deeper breaths of air (as when heavy work is being performed) as a result not only of the lengthened time interval during which the valve remains open but of the increased rates at which it is fed as the bag collapses to greater extents.

While the lever 9 has been described as being oscillated by collapse of the wall of a breathing bag, it will be understood that any other means may be employed to oscillate the lever in response to the withdrawal of air from the breathing bag.

In the embodiment of the invention shown in Fig. 3, a valve housing 20 is provided with an oxygen inlet opening 22 protected by a sieve or strainer 21. The housing 20 may be provided with an internal thread throughout its length to receive externally threaded bushings 23, 24, 25 and 26. If desired the inner wall of the housing may be threaded only at its right-hand end and only the end box 26 externally threaded so as to be operative upon being screwed into position to clamp the other boxes within the housing. The opening 22, as shown, is located in the bushing 26. The left-hand end 32 of the housing 20 is reduced in diameter to form a shoulder against which the bushing 23 abuts. The inner wall of such reduced end is extended to the right for a short distance to provide an annular and crater-like valve seat 27. The bushings 23, 24, and 25 are similarly provided with annular seats 28, 29 and 30 respectively. An annular seat 31 is located also within the reduced section 32. The seat 31 is engaged by a movable closure member 34 which is urged into closed position by a spring 33. Similarly, closure members 35, 36, 37 and 38 of piston-like form are arranged to cooperate with the annular seats 27, 28, 29 and 30 respectively, and are urged toward closed position by suitable springs. The closure members 35, 36 and 37 are provided with push rods 39 which project into cavities of larger diameters than said rods and located in each case within the next closure member nearer to the inlet 22. The push rods 39 are provided with nozzle openings 40, 41 and 42, which increase in diameter in the order named. The closure member 38 is provided with an opening 43 of larger diameter than the opening 42. The closure member 34 is likewise provided with a push rod 39^a but the latter contains no opening. In the closed position of the closure members shown in Fig. 3, all of the push rods, which may also be termed nozzles, are in constant open communication with each other. Upon opening of the member 34 the oxygen passes into the breathing bag through the ports 44.

The compound valve is adapted to be actuated through the medium of an oscillating lever 45 pivoted at 46 within the breathing bag and arranged to move a stem 47, associated with the member 34, by means of a nose 48. Upon oscillation of the lever 45 from the position of rest indicated at A to the position

B, upon withdrawal of a quantity of air from the breathing bag, the stem 47 is shifted and thereupon the member 34 is moved away from the seat 31. Oxygen thereupon passes through the nozzles 43, 42, and 41 and 40 around the push rod 39[a] and the member 34 through the seat 31 and into the breathing bag through the ports 44. As the nozzles decrease in diameter in the order just named, the rate at which the oxygen will be fed through the ports 44 will be determined by the diameter of the smallest nozzle 40. Upon movement of the lever 45 to the position C, when greater drafts of air are withdrawn from the breathing bag, the shoulder 49 of the closure member 34 strikes against the adjacent end of the closure member 35 and lifts the same from its seat 27. The nozzle 41 thus becomes the last nozzle in the path of the oxygen between the inlet 22 and the outlet ports 44, so that the rate at which the oxygen is fed is increased. The oxygen passing through the nozzle 41 passes around (and also through) the stem 39 of the closure member 35 and through the valve seat 27 (and around the rod 39[a]) to the ports 44, the member 34 remaining, of course, in its open position. When the lever 45 is swung to the position D, the push rod 39 of the closure member 35 strikes against the member 36 and opens the latter. The nozzle 42 thereupon becomes effective to measure and control the rate of inflow of oxygen. Upon further movement of the lever 45 this procedure is continued until all of the nozzles are cut out as measuring elements for the flow of oxygen and the rate of oxygen fed becomes dependent upon the extent to which the last closure member 38 is raised from its seat. In this manner, the rate at which oxygen is fed into the breathing bag is made to increase intermittently with greater oscillations of the lever 45. For example, upon opening of the closure member 34, there will be fed to the breathing bag 0.5 liters of oxygen per minute. This rate of feed increases until the member 38 is fully raised from its seat, when 3 liters of oxygen per minute enter the bag which corresponds approximately to the maximum requirement on heavy work.

In the construction shown in Figs. 4, 5 and 6, there are arranged a plurality of valves which are so positioned and controlled as to be opened in sequence so that the rate at which oxygen is fed into the chamber increases in stepwise fashion as the breathing bag collapses to a greater extent. As shown, this embodiment of the invention comprises a breathing bag 50 which is connected to an oxygen tank 51 provided with a pressure reducing valve 52. Located in a rigid wall of the breathing bag are two oxygen valves 53 and 54 which communicate with the pressure reducing valve 52. The valve 54 is preferably provided with a larger conduit than the valve 53. These valves are held closed by means of springs and are controlled by means of distributing levers 55 and 56 pivoted within the bag 50. The levers are arranged to be operated by the collapsible wall 58 of the breathing bag, the wall being preferably reinforced by a plate 57, while the opposite wall of the breathing bag is held in position by a fixed plate 59.

The operation of the apparatus just described is as follows:

During light breathing, the wall 58 will collapse to only a slight extent and will not reach, or barely reach, the lever 55. When however, comparatively heavy work is done and the breathing is deeper, or when a deep breath follows a period of light breathing, the wall 58 collapses sufficiently to oscillate the lever 55 (Fig. 5), whereupon the valve 53 is opened and oxygen is admitted into the breathing bag. When very heavy work is done and the breathing becomes very deep, the wall 58 oscillates not only the lever 55 but also lever 56, so that both valves 53 and 54 are opened (Fig. 6). Thus, when the wall 58 is collapsed beyond the normal position of the free end of the lever 55, the valve 53 remains open for a period of time which depends upon the extent of such collapse, and the quantity of oxygen entering the bag will depend directly upon the length of such period of time for the rate of flow through the valve is practically constant. When, moreover, the valve 54 is opened, the quantity of oxygen charged by this valve will also depend upon the length of time that it remains open; however, in such event, the total quantity of oxygen fed into the bag by both valves is no longer a simple linear function of the time, because with the opening of valve 54, the rate at which oxygen is fed into the bag increases. Consequently, when very deep drafts of air are drawn from the bag, greater quantities of oxygen are fed thereinto not only because of the longer period of time that the charging mechanism remains open but also because of the increased rate of feed with increased collapse of the bag.

The operation of the two oxygen feed valves 53 and 54 need not be affected by the breathing bag 50. It is sufficient if the apparatus is provided with an actuating element that is movable in response to the sucking action of the lungs, such as a diaphragm or the like which acts on the distributing mechanism.

It will be obvious that more than two valves may be used in the construction shown in Figs. 4, 5 and 6, and when more valves are used, they may each feed oxygen at successively increasing rates, or they may each feed the gas at the same rate.

The feed valves that are operated one after the other may, if desired, be all governed by one distributing lever, with which

the valves are coupled in such a way that they are opened by means of this lever one after the other. If every value has its own distributing lever the arrangement may moreover be such that one single lever or a group of levers are operated by a certain wall of the bag, and the other lever or other group of levers by another wall of the bag. Moreover it is also possible to allow the levers to be operated by surfaces movable by suction which do not belong to the same member, for instance to the same breathing bag. The valve 53 for instance together with its lever 55 may be arranged within the main breathing bag 50, and the valve 54 with its lever 56 within an auxiliary bag-diaphragm or yielding casing or the like arranged between the reservoir 51 and the breathing bag 50. In this case the position of the auxiliary bag or the like within the apparatus alone has the result that the second valve will begin to operate later than the first one. This retarding operation of the two surfaces which operate oxygen feed valves one after the other can be secured instead of by their position by the retarding of the movement of these surfaces by subjecting them to resistances caused by return springs, or by their own weight, or by friction or in any other manner, so that the surfaces having the least resistance act first on the corresponding distributing lever, and the surfaces having the greater resistance later. Even in this case a plurality of valves and corresponding surfaces operated by suction may evidently be used.

Finally instead of two or more of oxygen feed valves a single valve may be used, which does not initially open to its full extent, but the total opening and thus the feed capacity may increase continuously or at intervals for an essential portion of the range of movement of the movable surface at the ratio of such movement, the valve body being adapted to open successively two or more ports. The arrangement moreover may be such that the width of the opening of the valve provided by way of example with a plurailty of ports of increasing widths and the feed pipe increases at a greater ratio than the movement of the movable surfaces causing such feed.

It will be seen from the above that an arrangement had been provided wherein the closure mechanism for the oxygen port or ports is so constructed that it exposes increasing flow areas for oxygen not merely during a slight initial movement thereof but during the greater portion of its movement, and, in fact, until substantially the limit of its opening movement. Expressed differently, the total flow area of the connection or connections between the oxygen tank and the breathing bag is of such magnitude, relatively to the rate at which such area is rendered effective to introduce oxygen as the closure mechanism increasingly opens, that increasing flow areas for oxygen are exposed by said mechanism until substantially the limit of opening movement thereof.

The lung-operated feed valves or the single valve substituted therefor receive their stream of oxygen either directly from a high pressure space of the oxygen reservoir 51 or a chamber connected therewith or from the latter indirectly past the pressure reducing valve 52. The same one valve or a group of valves may be fed with low pressure oxygen, and the other valve or another group of valves with high pressure oxygen. It is advisable to arrange an automatic or hand-operated surplus vent-valve, for instance on the breathing mask or at any other place. In the drawing such a surplus vent-valve is not shown. It may be omitted if one is willing to rely on the timely voluntary venting and washing out or scavenging of the nitrogen by the wearer himself by opening the mouth or lifting up the edge of the mask.

Other variations may be resorted to within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A self-contained breathing device adapted to prevent the breathing air from becoming over-charged with nitrogen, comprising, in combination, an air circuit system, a collapsible breathing bag in said system, an oxygen container, means connecting said container and said bag to conduct oxygen to the latter, movably mounted closure mechanism adapted to control the communication between said connecting means and said bag, the latter having a movable wall which is substantially continuously collapsed upon withdrawal of gas from the interior thereof in proportion to the amount of gas withdrawn, and controlling means adapted to be moved by said collapsing wall and arranged to move said closure mechanism in the opening direction a distance determined by the extent of collapse of said wall, the total flow area of said connecting means being of such magnitude relatively to the rate at which such area is rendered effective to introduce oxygen as the said mechanism increasingly opens, that increasing flow areas for oxygen are exposed by said mechanism until substantially the limit of the opening movement thereof as said bag increasingly collapses, whereby oxygen at progressively increasing rates is fed to the bag as greater drafts of gas are withdrawn therefrom.

2. In an apparatus of the kind described, the combination with a breathing bag, and an oxygen container, of a valve arranged to charge oxygen from said container into said bag, said valve comprising a valve seat member, a valve head member cooperating with said seat and projecting thereinto, and means operative upon withdrawal of air from said

bag to open said valve, at least one of said members being of elongated form and of increasing diameter, whereby greater flow areas are exposed and oxygen at increasing rates is fed as said valve is increasingly opened.

3. In an apparatus of the kind described, the combination with a breathing bag, and an oxygen container, of a valve arranged to charge oxygen from said container into said bag, said valve comprising a valve seat member, a valve head member cooperating with said seat, and projecting thereinto and means operative upon withdrawal of air from said bag to open said valve, at least one of said members being of elongated form and of uniformly increasing diameter, whereby greater flow areas are exposed and oxygen at uniformly increasing rates is fed as said valve is increasingly opened.

4. In an apparatus of the kind described, the combination with a breathing bag, and an oxygen container, of a valve arranged to charge oxygen from said container into said bag, said valve comprising a valve seat, a valve head cooperating with said seat, and means operative upon withdrawal of air from said bag to open said valve, said valve head being of elongated tapered form and passing through said valve seat and engaging the latter at its enlarged end, whereby greater flow areas are exposed and oxygen at increasing rates is fed as said valve is increasingly opened.

5. In an apparatus of the kind described, the combination with a breathing bag, and an oxygen container, of a valve arranged to charge oxygen from said container into said bag, said valve comprising a valve seat, a valve head cooperating with said seat, and means operative upon withdrawal of air from said bag to open said valve, said valve head being arranged to open against the pressure of the oxygen and including a closure member cooperable with the outer periphery of said seat, and a stem attached to said member and engageable by said means, said stem projecting through said valve seat and having an enlarged tapered section within said seat whereby greater flow areas are exposed and oxygen at increasing rates is fed as said valve is increasingly opened.

6. In an apparatus of the kind described, the combination with a breathing bag, and an oxygen container, of a valve arranged to charge oxygen from said container into said bag, said valve comprising a casing, a plurality of movable members arranged in line within said casing, said members controlling ports of successively increasing diameters and arranged to be moved each by the preceding member, and means operative upon withdrawal of air from said bag to move said members in succession to establish communication between said bag and container through increasingly larger openings, whereby oxygen at intermittently increasing rates is fed into said bag as greater drafts of air are withdrawn therefrom.

7. In an apparatus of the kind described, the combination with a breathing bag, and an oxygen container, of a valve arranged to charge oxygen from said container into said bag, said valve comprising a casing having an inlet and an outlet, a plurality of closure members in said casing arranged one behind the other, a nozzle member controlled by each of said closure members, said nozzle members having passageways of increasing diameter from the outlet to the inlet end of the casing, and an operating lever arranged to be oscillated by a collapsing wall of said bag as air is withdrawn therefrom to move said closure members in series to uncover serially nozzles of greater capacity, whereby oxygen at intermittently increasing rates is fed into said bag as greater drafts of air are withdrawn therefrom.

8. The combination as set forth in claim 7, wherein the number of nozzle members is less by one than the number of closure members, said nozzle members being in constant communication, the closure member nearest the outlet opening being operative normally to close the communication between said nozzle members and the outlet of the valve.

9. The combination as set forth in claim 7, wherein said closure members are arranged in axial alignment, and including springs urging said members to closed position, said members being opened in succession by engagement each by the preceding one as the operating lever is oscillated upon collapse of the bag.

10. The combination as set forth in claim 7, wherein each of said closure members except that nearest to the outlet opening has attached thereto one of said nozzles.

11. The combination as set forth in claim 7, wherein each of said closure members except that nearest to the outlet opening has attached thereto one of said nozzles, said nozzles being in the form of hollow stems in axial alignment and terminating in an enlarged cavity in the body of the closure member, into which cavity the stem of the preceding member projects without filling the same.

12. The combination as set forth in claim 7, wherein each of the closure members except that nearest to the outlet opening is in the form of a sliding piston, and including seats with which said members coact, so that each member in its closed position cuts off the nozzles associated with the members nearer to the inlet end of the casing from communication with the outlet end of such casing.

13. A self-contained breathing device adapted to prevent the breathing air from being overcharged with nitrogen, comprising, in combination, an air circuit system, a

collapsible breathing bag in said system, an oxygen container, a plurality of connections between said container and said bag, a plurality of valves, one in each of such connections, and a plurality of valve operating devices within said bag, one associated with each of such valves, the said valve operating devices being so arranged as to be actuated successively by the breathing bag as it collapses when air is withdrawn therefrom during the breathing of the wearer, said successive actuation of the valve operating devices corresponding to increase in the depth of breathing.

14. A self-contained breathing device adapted to prevent the breathing air from being overcharged with nitrogen, comprising, in combination, an air circuit system, a collapsible breathing bag in said system, an oxygen container, a plurality of connections between said container and said bag, a plurality of valves, one in each of such connections, and a plurality of valve operating devices within said bag, one associated with each of such valves, the said valve operating devices being so arranged as to be actuated successively by the breathing bag as it collapses when air is withdrawn therefrom, said connections having varying oxygen feeding capacities which are progressively larger in the order in which their respective valves are operated.

ELFRIEDE DRÄGER,
Executrix of the Estate of Alexander Bernhard Dräger, Deceased.