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ARRANGEMENT IN BREATHING APPARATUS

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Fig. 1.

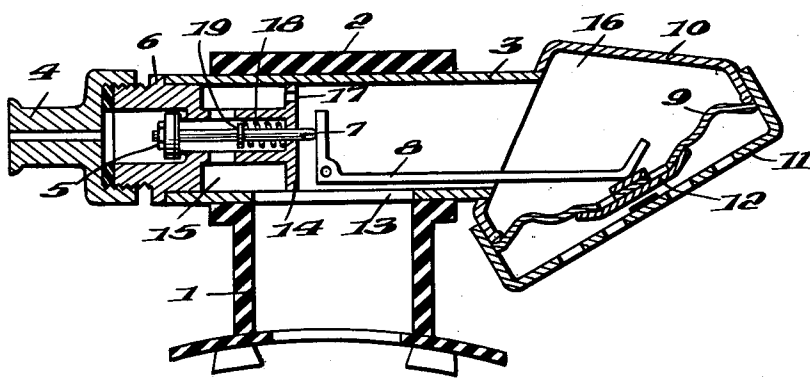
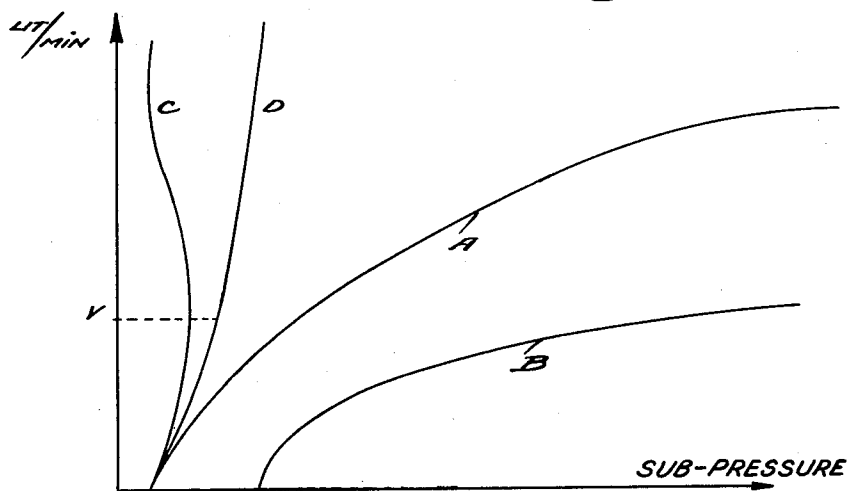


Fig. 2.



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ARRANGEMENT IN BREATHING APPARATUS

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3 Claims. (Cl. 128-142)

The present invention relates to a breathing apparatus which is suitable for use under water or in an unbreathable atmosphere, such as smoke-infested air. In breathing apparatus of this kind there is a general requirement of easy breathability. That is to say, the sub-pressure that has to be created by the wearer of the apparatus when breathing in should be low and the overpressure that has to be produced in a similar manner in breathing out should also be low. If a breathing apparatus does not meet these requirements, there will result an unnecessarily large amount of work for the mere breathing process, so that the useful work that can be performed by the wearer is correspondingly reduced.

In a breathing apparatus which is to be used under water down to depths of the order of 50 or 60 meters there is the further requirement that the sub-pressure which is necessary for breathing in should stay within reasonable limits, even at the large air quantities that have to be supplied at such depths. Obviously, the apparatus must also be constructed so as to be able to deliver such quantities.

In breathing apparatus for use in an unbreathable atmosphere, such as smoke-infested air, the same requirement for delivering very large quantities of air is not present, but on the other hand it is very desirable to keep the breathing resistancies at low values so that breathing through the apparatus will not be inconvenience and tiresome.

It has generally been held, that in breathing apparatus of good quality which meets the above requirements, the sub-pressure required for inhaling may be of the order of 10 mm. water column, whereas the over pressure required for exhaling may have reached a value of a few mm. water column.

In earlier forms of breathing apparatus having a membrane which is movable in response to the difference in pressure between the surrounding medium and the breathing passages of the wearer to control the inhalation valve, it was necessary, in order to meet these requirements, to provide a membrane of a relatively large area to obtain the necessary force for controlling the inhalation valve. This in turn lead to comparatively large dimensions of the valve unit comprising the inhalation valve and the exhalation valve, as well as the membrane and other details, so that a unit of this type could hardly be used in combination with a mouth piece.

Furthermore, various constructions of breathing apparatus have been proposed having a substantially smaller membrane for controlling the inhalation valve. In this way the dimensions of the valve unit could be made small enough to make it usable in connection with a mouth piece. However, these known apparatus types did not work satisfactorily, since the sub-pressure required in inhalation was excessively large, of the order of 40 to 50 mm. water column, and further, these types were unable

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to supply the large air quantities required at the larger depths of the order of ten meters or more.

On the accompanying drawing, FIG. 1 shows an embodiment of the present invention and FIG. 2 shows some curves representing for various breathing apparatus types the sub-pressure required in inhalation for the supply of a certain air quantity per unit of time.

The curve A of FIG. 2 illustrates in principle the relationship between sub-pressure and supplied air quantity in liters per minute which is valid for the earlier types of breathing apparatus. As is apparent from the curve, a certain relatively low sub-pressure is required to open the inhalation valve and let in the air for breathing. The required sub-pressure then increases relatively slowly with an increase in the air quantity supplied. For larger quantities of air, however, the required sub-pressure increases rapidly and there is a limit to the air quantity supplied per unit of time, the apparatus being unable to deliver quantities in excess of this value in spite of a very large increase in the sub-pressure.

As was mentioned above, the curve A is representative of earlier types of breathing apparatus. It should be noted, however, that the initial value at which the inhalation valve normally opens is different for different types, as is the maximum air quantity delivered per unit of time.

It is apparent from the introductory discussion of the requirements on breathing apparatus that an apparatus according to curve A is not entirely convenient, primarily in view of the large sub-pressure that is required for the apparatus to deliver sufficient quantities of air.

The application of the present invention results in a breathing apparatus which is able to deliver very large air quantities per unit of time without any appreciable increase in the sub-pressure that is required. Further, the apparatus can be arranged to have the inhalation valve open already at a very low inhalation sub pressure in spite of the fact that the membrane actuating the valve has a small area. Owing to these favorable characteristics, the apparatus can be used with advantage under water down to very large depths as well as for work in a non-breathable atmosphere.

The invention is predicated on a valve unit comprising an inhalation valve, a membrane for actuating the same, and an exhalation valve and containing a wall separating space containing the inhalation valve from a space bordered by the membrane. Valve units of such construction are previously known but the partition provided in the valve unit was then differently located and served another purpose than according to the present invention.

According to the invention, the said partition is arranged so as to make the breathing gas flowing in from the inhalation valve create an injector effect tending to set up a sub-pressure in the space bordered by the membrane, a predetermined degree of compensation of the said effect being provided simultaneously through a direct connection arranged between the space containing the inhalation valve and the space bordered by the membrane, through which connection a limited gas flow is possible into the space bordered by the membrane. The said connection may preferably consist of a hole provided in the partition between the two spaces and should be dimensioned in such a way that the sub-pressure required for opening the inhalation valve is substantially constant in

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dependently of the gas quantity per unit of time that enters through the inhalation valve.

The invention will be described in more detail with reference to the accompanying drawing, in which FIG. 1 shows an embodiment of the invention.

In the embodiment described, the apparatus is provided with a mouth-piece 1, but the invention may also be applied to a breathing apparatus of the face mask type. The mouth-piece 1 is provided with a tube 2 of elastic material, such as rubber, into which the valve unit 3 is inserted. Breathing gas is supplied from a tube, not shown in the drawing, which is connected with a connecting stud 4 at the end of the valve unit 3. An inhalation valve 5 is provided in an insert 6 of the unit and is controlled via a valve stem 7 and a crank lever 8 by a membrane 9 mounted in a membrane housing 10. The housing has a perforated cover 11 allowing the surrounding medium to act on the outside of the membrane 9. Preferably, an exhalation valve 12 is placed on the membrane 9. Finally, a hole 13 is provided in the partition of the unit 3 to allow passage of inhaled or exhaled air.

The details of the breathing apparatus so far described are of known and conventional construction. However, a known apparatus of this type is very unsatisfactory in operation in that a very large sub-pressure is required to open the inhalation valve and also for the reason that the apparatus can supply only an insignificant amount of air per unit of time even for a very large increase in the inhalation sub-pressure. The operating characteristic of such known apparatus is therefore largely of the type illustrated by curve B of FIG. 2, from which is apparent, firstly, that the inhalation valve opens only at a relatively large subpressure and, secondly, that the apparatus is able to supply only a small amount of air per unit time. The investigations on which the present invention is based have shown that the latter feature is largely due to the fact that the air entering through the inhalation valve is blown towards the inside of the membrane, thereby preventing it from moving inwardly to the extent that is required in response to a larger inhalation sub-pressure. A known apparatus of such construction is therefore not suitable for use at large depths under water or in a non-breathable atmosphere.

As is apparent from the drawing, there is provided in the valve unit 3 a partition 14, which separates a space 15 of the valve unit containing the inhalation valve from a space 16, which is bordered by the membrane 9. The partition 14, according to the invention, is located and constructed so as to deviate the gas entering through the inhalation valve 5 towards the mouth-piece 1, thereby preventing the gas from exerting a pressure on the inside of the membrane 9. There is created instead through the injector effect caused by the gas flowing from the space 15 to the mouth-piece 1 a certain sub-pressure in the space 16, which would increase with an increase in the amount of gas supplied, unless steps are taken to counteract this effect. The operation of a breathing apparatus of this construction would be in accordance with the curve C of FIG. 2. It is characteristic for the curve C that the required sub-pressure is at first substantially constant for an increase in air quantity but decreases when the quantity of air supplied per unit of time exceeds a predetermined value, which is designated v on the drawing. Such an operation does render the apparatus easily breathable but it is nevertheless not desirable, since the inhalation of large quantities may create the impression of air being blown into the lungs. It is therefore desirable that the sub-pressure required at larger air quantities should not diminish but remain substantially constant. However, a small increase in sub-pressure may be of value, since such a relationship resembles more closely the physical conditions in ordinary breathing.

It is apparent from this discussion that the operation of a breathing apparatus should be in accordance with curve D of FIG. 2, which means that the sub-pressure

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required for opening the inhalation valve should be low and that with an increase in the gas supply the required sub-pressure is substantially constant or rises slowly. This type of operation is obtained according to the invention by the provision of a direct connection between the space 15 containing the inhalation valve and the space 16 bordered by the membrane. This connection enables a limited flow of gas to the last mentioned space. In the embodiment shown in the drawing, this connection is in the form of a hole 17 of suitable dimensions, which is provided in the partition 14. In a breathing apparatus of such construction the gas entering through the inhalation valve 5 will then be directed chiefly towards the mouth-piece 1 and thus be supplied directly to the wearer. This air flow has an injector effect tending to create a sub-pressure in the space 16. This effect is compensated for to a desired extent by the air passing directly through the hole 17 into the space 16, the result being that the operation of the apparatus is in accordance with the preferable type of curve D.

The pressure of the breathing gas supplied through the connecting stud 4 is normally of the order of 5 kg./cm.² above that of the ambient medium, whereas the pressure in the spaces 15 and 16 and in the mouth-piece 1 should be approximately the same as that of the ambient medium. For the purpose of providing a small actuating pressure for the opening of the inhalation valve 5, which means that only a small force has to be exerted by the membrane 9, the inhalation valve 5 is acted on by a spring 18 which is inserted under pressure between a flanged portion 19 provided on the valve stem 7 and the partition 14. The spring is of such dimensions that the difference between the closing pressure exerted on the inhalation valve 5 and the force of the spring tending to unseat the inhalation valve 5 results in the desired small pressure for opening the inhalation valve. The spring 18 should furthermore have a relatively small active interval, so that its influence on the valve stem 7 ceases as soon as the inhalation valve 5 has opened.

The construction of the breathing apparatus in accordance with the embodiment shown on the drawing causes the air entering through the inhalation valve 5 to be subjected to several changes in direction before it reaches the mouth-piece 1. The air first enters the space surrounding the valve stem 7, where it is deflected to the space 15. There are then two changes of direction before the air reaches the mouth-piece 1. This has the advantage that the inhalation air does not reach the wearer in the form of a concentrated stream, which might be disagreeable.

What is claimed is:

1. In a breathing apparatus, the combination comprising: a cylindrical casing defining a valve chamber and including an opening at one end thereof for operatively communicating the chamber with a source of breathable air to permit flow of the air into the chamber; a movable flexible diaphragm mounted at and closing the other end of the casing and having one side thereof subjected to the ambient medium and responsive to the difference between the pressure of the ambient medium and the pressure within the chamber; an inhalation valve co-operating with said opening to control the flow of air into the chamber; means for controlling the inhalation valve in response to movement of the membrane; a partition within the casing disposed laterally of the casing axis and having a diameter equal to the inner diameter of the casing, the partition dividing the casing valve chamber into a first space including the said opening and a second space including the membrane; an exhalation valve in the second space operatively communicating with the ambient medium; a tube permitting passage of inhaled air to and exhaled air from a wearer; a communication port connecting the chamber with the tube, the partition being situated at the communication port and dividing the port into a first opening communicating with the said

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first space and a second opening communicating with the second space, the partition forming with the first opening an injector means causing a sub-pressure in the second space upon passage of inhaled air through the first opening, and the partition further defining a hole enabling a limited flow of air directly from the first space to the second space to counteract the decrease in pressure in the second space caused by the injected means.

2. The combination according to claim 1 wherein a portion of the means for controlling the inhalation valve passes through the said partition.

3. The combination according to claim 1 wherein the inhalation valve is mounted outside the casing and is held

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against the opening by the pressure of the breathable air source, and the means for controlling the inhalation valve includes a lever within the casing and operable to move the inhalation valve away from the opening and permit flow of air on inward deflection of the flexible membrane.

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