This invention relates to a portable pack for converting liquid air or oxygen into gaseous form for breathing use and particularly for use in work, such as emergency or rescue work or in mines, where in use the pack is shifted and held in various positions with reference to its normal vertical position, such as when carried on the back of a miner crawling up a slope in the mine.

One of the principal objects of the present invention is to permit the liquid air or oxygen in the supply container by gas developed from the contained liquid. To achieve this object a part of the liquid is withdrawn, heated and returned as a gas to the gas head above the liquid. By this means advantage is taken of the high ratio of expansion of the liquid to gas which in the case of liquid air is 630 to 1.

Another important object is to prevent such returned gas from being recon densed in the liquid thereby to destroy its pressurizing effect and impair the expulsion of the liquid for breathing purposes. This object is effected by moving the open outlet end of a pressurized gas return tube by gravity to the highest part of the container in angular positions of the latter with reference to its normal upright position so that the returned gas is discharged into the gas head in such angular positions and not into the body of liquid to condense therein.

Another object is to expel a large total amount of the liquid regardless of such angular positions of the container so as to render available for breathing purposes the largest practicable amount of the liquid. This object is effected by moving the open inlet end of a liquid outlet tube by gravity to the lowest part of the container in angular positions of the latter with reference to its normal upright position.

Another object is to combine such gravity positioning of the outlet end of the pressurized gas tube and inlet end of the liquid outlet tube by a simple interconnection between the two. This object is effected by mounting these tubes to project radially from swivels journaled on the upper and lower ends heads of the liquid container, connecting the swivels by a concentric rod or tube fixed thereto, and weighting the outlet end of the liquid discharge tube.

Another object is to provide such a pack which is simple and extremely reliable in operation and not subject to breakdown or malfunction. Other objects and advantages of the invention will be apparent from the following description and drawings in which:

FIG. 1 is a schematic representation of a breathing pack embodying the present invention.

FIG. 2 is an enlarged central longitudinal section through a container for the liquid air or oxygen included in the breathing pack.

The invention is essentially concerned with the mechanism contained within a double walled container or bottle indicated generally at 5 and containing a body 6 of liquid air or oxygen for breathing purposes. This container is included in a portable pack designated generally by the dot dash line 8 and which can be strapped to the back of the miner or other user. A gas head 9, derived from the liquid 6 as hereinafter described, is used to pressurize the bottle 5.

The liquid air or oxygen 6 is withdrawn from the container or bottle 5 through a liquid outlet conduit 12 which has a branch 13 containing a fill valve 14 and having a filling connection indicated generally at 15. The liquid air or oxygen from the liquid outlet conduit 12 is converted into gas for breathing purposes by passage through a heat exchanger or heater 16 and the outlet line 18 which connects with a fitting 19 forming part of a quick disconnect indicated generally at 20. The other part 21 of this quick disconnect has a flexible line 22 leading to the face mask (not shown) of the miner or other user.

In the practice of the present invention a part of the liquid air or oxygen from the liquid outlet conduit 12 is converted into gas and this gas is used to pressurize the double walled container or bottle 5 by being admitted into the gas head 9 above the body 6 of liquid in the double walled container or bottle 5. To this end a branch line or pipe 25 from the liquid outlet conduit 12 connects with the inlet of a build up heating coil 26, the outlet line 28 of which contains a valve 29 and connects with the inlet of a pressure regulating valve indicated at 30. This pressure regulating valve has a relief valve 31 discharging into the atmosphere and its outlet line 32 connects with a gas pressurizing conduit 33 having a vent valve 34 and leading to the gas head 9 in the top of the double walled container or bottle 5. Desirably the breathing pack also includes a restrictor 35 in the liquid conduit 12 between the branch outlet conduit 12 and the heat exchanger 16; an accumulator tank 36 followed by a supply valve 37 in the line 18; a check valve 38 in the branch line 25 in advance of the build up coil 26 and a relief valve 39 in the line 28 following this build up coil 26.

This double walled container or bottle 5 is preferably of cylindrical form with its axis normally arranged upright and includes an inner cylindrical shell 40 having an upper end head 41 and a lower end head 42 and a concentric outer cylindrical shell 43 having an upper end head 44 and a lower end head 45. The space 46 between these shells can contain insulation (not shown). This insulation is preferably a pure vacuum or in the form of superinsulation, that is, alternative layers or porous paper and reflective foil.

To withdraw the liquid air or oxygen from the bottom of the double walled container or bottle 5, the liquid outlet conduit 12 connects with a fitting 48 extending through and secured, as by welding, to the lower end head 45 of the outer shell 43 and connected by a pipe 49 in the space 46 with a fitting 50 extending concentrically through the lower end head 42 of the inner shell 40. This fitting 50 has a bore 51 extending downward from the top of the fitting concentric with the axis of the inner container 40 and communicating at its lower end with the outlet pipe 49 leading to the liquid outlet conduit 12. An important feature of the invention resides in the bore 51 of the fitting 50 serving as bearing for a swivel 52. This swivel 52 has a depending stem 53 journaled in the bearing bore 51 and has a vertical bore 54 extending upwardly from its bottom. The upper end of this bore 54 communicates with a liquid outlet tube 55 secured to and extending laterally outwardly from the swivel 52 and having its outlet open end 56 arranged close to the inner wall of the outer shell 40 and its upper end is secured, as by a pin 61, to the depending neck 62 of a swivel 63. This swivel 63 has an upwardly extending neck 64 which is journaled in the open lower end of a bore 65 of a fitting 66 extending concentrically through
and secured, as by welding, to the upper end head 41 of the inner shell 40. The swivel 63 has a bore 68 which is open at its upper end and at its lower end communicates with the gas pressurizing tube 69 fixed to and extending laterally outwardly from the swivel 63. The outer end 70 of the gas pressurizing tube 69 is arranged to swing close to the line of juncture of the side wall of the inner shell 40 and its upper end head 41 and an important feature of the invention resides in the opened end gas pressurizing tube 69 projecting in the opposite direction with relation to the open ended liquid outlet tube 55, that is, these two tubes being 180° out of phase with reference to each other.

The upper end of the bore 65 is connected with the space 46 to a fitting 72 extending through and secured to the upper end head 44 of the outer shell 43. This fitting 72 connects with the gas pressurizing conduit 33.

In use, in response to the inhalation demand of the user as applied at the quick disconnect 20, liquid air or oxygen is supplied to this humidifier and the body 6 contained within the inner shell 40 of the double walled container and flowing out the inlet end 56 of the liquid outlet tube 55 into the bore 65 of the swivel 52. From this bore the required liquid air or oxygen flows through the fitting 51 of the fitting 51 and thence through the pipe 49 and fitting 48 into the liquid outlet conduit 12 of the breathing pack. In the heat exchanger or heater 16 this liquid air or oxygen is converted into gaseous form before being supplied to the quick disconnect and to the breathing mask (not shown) of the user.

A part of this liquid air or oxygen from the liquid outlet conduit 12 enters the buildup heating control and is converted into gas, the pressure of this gas being under control of the pressure regulating valve 30 and its relief valve 31. From the outlet 32 of this pressure regulating valve 30 this gas enters the gas pressurizing conduit 33 and through the fitting 72, pipe 71 and fitting 66 enter the bore 65 of this last fitting and entering the bore 68 of the swivel 63 journalled in this bore 65. From the swivel 63, the gas enters the gas pressurizing tube 69 and its pressure is impressed against the gas head 9 in the inner shell 40 above the body 6 of liquid air or oxygen contained therein.

Since the swivels 63 and 52 are connected together by the gas pressurizing tube 69, as the outboard weighted end 56 of the liquid outlet tube 55 seeks the highest position through the tube 60, it swings the outer end 70 of the gas pressurizing tube 69 to the highest position within the inner shell 40. As a result, the incoming gas from the gas pressurizing tube 69 employs to pressurize the gas head 9 of the liquid outlet tube 55 seeks the highest position through the tube 60, which is also sought, of course, by the gas head 9. This is an important feature of the invention since if the incoming gas were introduced into the body 6 of liquid air or oxygen, it could recondense into the necessary pressure within the inner shell 40. There is a 630 to 1 expansion of liquid air into gas form, this being the basis for pressurizing the liquid body 6 to provide a uniform and steady pressure to expel the liquid air or oxygen.

As a further advantageous feature of the invention, the seeking of the lowest level within the inner shell 40 of the outboard weighted end 56 of the liquid outlet tube 55 also insures the discharge of a large amount of liquid air or oxygen regardless of the position of the tank.

It will be seen that the invention is particularly applicable for air packs to be used by miners or other workers who are required to work in other than upright body positions, as when a miner is required to crawl along a slope in the mine. Thus, when this occurs, the axis of the double walled container 5 is brought to an angular position with reference to the vertical. When this occurs, the weight 57 at the outboard end 56 of the liquid outlet tube 55 swings this outboard end to the lowest position within the inner shell 40 so that even if only a small amount of liquid air or oxygen 6 is left within this inner shell, it will be supplied to the miner in response to his demands. More important, if the inner shell 40 at this time contains the maximum amount of liquid air or oxygen 6 with a minimum gas head 9 thereof, this swing of the weighted liquid outlet tube 55, through the tube 60, causes the two levels 57 and 63, swings the outer end 70 of the gas pressurizing tube 69 to the highest position within the inner container 40 so that it discharges directly into the gas head 9 and not into the body 6 of liquid air or oxygen to recondense therein and fall in its function of pressurizing this body 6 of liquid air or oxygen for use by the miner.

I claim:

1. In a portable pack for converting liquid air or oxygen into gaseous form for breathing use in work where the pack is subject to being held in various positions, the component comprising a container for a body of said liquid and for a head of gas evolved from said liquid and having a side wall enclosing by upper and lower end heads, an open-ended liquid outlet tube movably mounted in the bottom of said container, an open-ended gas pressurizing tube movably mounted in said container, a swivel jointed between said container, a liquid outlet conduit communicating with said liquid outlet tube, means converting the liquid in said liquid outlet conduit into gas for breathing purposes, a gas pressurizing conduit communicating with said gas pressurizing tube, means converting a part of the liquid in said liquid outlet conduit into gas and conducting such gas to said gas pressurizing conduit, and means actuated by gravity to move the open end of said liquid outlet tube to its lowest position and the open end of said gas pressurizing tube to its highest position within said container, whereby in angular position of said container with reference to the vertical, the gas pressurizing tube will discharge gas into said gas head and thereby avoid recondensing said gas into said body of liquid and whereby in all such angular positions of said container said liquid outlet tube will expel a large total quantity of said liquid.

2. The combination set forth in claim 1 wherein said liquid outlet tube projects radially from a swivel journalled on said lower end head to permit movement of its open end along the line of juncture of said side wall shell and lower end head, wherein said gas pressurizing tube projects radially from a swivel journalled on said lower end head to permit movement of its open end along the line of juncture of said side wall shell and upper end head, and wherein means connect said swivels and compel them to rotate in unison.

3. The combination set forth in claim 2 wherein said gravity actuated means includes a weight fixed to said open end of said liquid outlet tube to cause it to seek the lowest level in all such angular positions of said container.

4. The combination set forth in claim 3 wherein said swivels are concentric and a rod is fixed at its opposite ends to said swivels to compel them to rotate in unison.

5. The combination set forth in claim 4 wherein opposing necks are provided on said swivels concentric with their axis of rotation and wherein said rod is in the form of a thin-walled hollow tube with its opposite ends embracing and fixed to said necks.

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