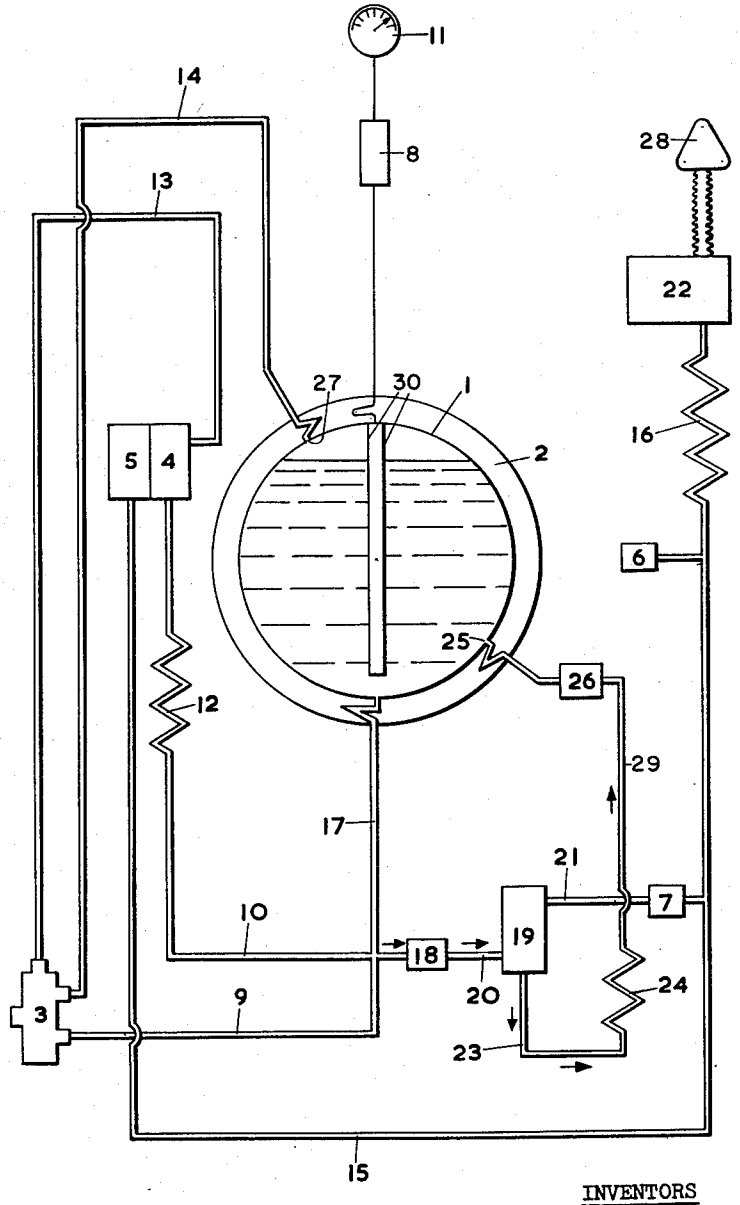
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BREATHING APPARATUS

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BREATHING APPARATUS

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This invention relates to breathing apparatus used in conjunction with liquid oxygen converters.

In liquid oxygen systems used in aircraft, a considerable drop in pressure takes place in the converter when the aircraft is in the inverted flight position and more especially if such an attitude is assumed during the early part of flight. Further, considerable shaking of the converter during the early stages of a flight may result in an undesirable reduction in pressure. In a typical installation this pressure might drop almost immediately to substantially half of the normal operating pressure and during the next few minutes the pressure may even drop to substantially one third of the initial value.

It is an object of the invention therefore to provide a breathing apparatus in communication with a liquid oxygen converter wherein means are provided to permit substantially all or a relatively large percentage of gaseous pressure present in a charged oxygen converter to be available when said converter is inverted or severely shaken, although this may take place soon after commencement of a flight.

It is a further object of the invention to provide a breathing apparatus according to the preceding paragraph wherein said converter may be inverted or shaken for several minutes without considerable reduction in gaseous pressure.

The invention consists in a breathing apparatus comprising a liquid oxygen converter in conduit communication with a breathing system, said breathing system in conduit communication with a regulator of the demand type and an associated breathing mask, a recirculating system for returning to the converter any excess oxygen from the breathing system, said oxygen thus returned being at a higher temperature than the oxygen stored therein.

The invention also consists in breathing apparatus according to the preceding paragraph wherein upon inhalation, liquid oxygen flows from the base of the converter to the breathing system where it is converted into gaseous oxygen and from whence it flows to the breathing mask according to the demands of the user.

The invention also consists in breathing apparatus according to the preceding paragraph wherein upon exhalation, oxygen from the breathing system is returned to the converter at a higher temperature than the oxygen stored therein.

The invention also consists in breathing apparatus according to the third preceding paragraph, wherein said breathing system comprises a first flow control and pressure control means, a liquid oxygen trap, outlet means provided in top and bottom of said liquid oxygen trap, a second flow control and pressure control means, pressure relief means, vaporization means, each in conduit communication and respectively disposed upstream of each other.

The invention also consists in breathing apparatus according to the preceding and fourth preceding paragraphs wherein said recirculating system comprises vaporization means and non-return flow control means in conduit communication with said bottom outlet means of said liquid oxygen trap, both respectively disposed upstream of said liquid oxygen trap and communicating with said converter.

The invention also consists in breathing apparatus according to the preceding and second preceding paragraphs, wherein each flow control and pressure control means comprise a differential check valve.

The invention also consists in a breathing apparatus according to the third preceding paragraph wherein pressure relief means comprise a relief valve.

The invention also consists in a breathing apparatus according to the third and fourth preceding paragraphs, wherein each vaporization means comprises a heater coil vaporizing liquid oxygen into gaseous oxygen.

The invention also consists in a breathing apparatus according to the preceding, fourth preceding and eighth preceding paragraphs wherein said vaporization means provided within said recirculating system warms oxygen being returned to said converter causing this oxygen to mix with the liquid oxygen already contained therein, thus avoiding the presence of a warm layer usually confined only to the top of the converter.

The invention also consists in breathing apparatus comprising a liquid oxygen converter in conduit communication with a breathing system, said breathing system in conduit communication with a regulator of the demand type and an associated breathing mask, a recirculating system for returning to the converter any excess oxygen from the breathing system, during inhalation oxygen flows from converter to the breathing system and is converted into gaseous oxygen by a heater coil provided in said breathing system, said gaseous oxygen is supplied to the mask according to the demands of the user, excess oxygen contained with a liquid oxygen trap provided in said breathing system is vaporized by way of a heater coil provided in said recirculation system and returned to said converter at a higher temperature than the oxygen stored therein thus warming as well as mixing with the main volume of liquid oxygen stored therein.

The invention also consists in breathing apparatus substantially as hereinafter described and as shown in the accompanying drawing which is a diagrammatic drawing of the breathing apparatus.

In carrying the invention into effect according to one convenient form by way of example only, referring to the accompanying drawing, a liquid oxygen converter generally indicated at **1** has an evacuated space **2** disposed between the inner and outer walls of said converter. The converter is provided at its base with a liquid connection **17** and at its top with a vent connection **27**; connection **17** and vent connection **27** are in communication to form a circulating system having provided therein a build-up coil **12** downstream of said connection **17** and in communication thereto by way of conduit **10**. Downstream of build-up coil **12** is provided a pressure closing valve **4** in communication by way of conduit **13** with a combined filler, buildup and vent valve generally indicated at **3** disposed downstream of vent connection **27** and in communication thereto by way of conduit **14**. The filler build-up and vent valve **3** is also in communication with connection **17** by way of conduit **9**.

A further inlet **25** is provided near the base of converter **1**, disposed to one side of connection **17**; connection **17** and inlet **25** are in communication to form a circuit by way of differential check valve **18** provided downstream of connection **17** and in communication by way of conduit **20** with a liquid trap **19** provided downstream of check valve **18**. A heater coil **24** is provided downstream of said liquid trap **19**, and communicates thereto by way of conduit **23**. A differential check valve **26** is provided upstream of inlet **25** and communicates with heater coil **24** by way of conduit **29**.

Conduit **21** provides communication between the top of liquid trap **19** and a demand regulator **22** and asso-

ciated breathing mask 28. Between liquid trap 19 and demand regulator 22, an evaporator coil 16 is provided upstream of said demand regulator 22 in conduit communication with a differential check valve 7 provided downstream of said liquid trap 19. A relief valve 6 is disposed between said check valve 7 and said evaporator coil 16. Conduit 15 provides communication between pressure opening valve 5 and conduit 21 at a point situated between check valve 7 and relief valve 6; pressure opening valve 5 is in conduit communication with pressure closing valve 4.

Means are associated with the converter 1 for measuring the contents therein comprising a pair of electrodes indicated at 30, said electrodes are connected to an electrical instrument 8 which indicates by way of gauge 11, the quantity within the converters.

In operation of the invention, the liquid oxygen converter 1 is filled with liquid oxygen by any convenient means by way of filler, build-up and vent valve generally indicated at 3. The liquid oxygen passes to the converter via conduit 9 and enters therein at connection 17, at the base of the converter. During the filling operation, the design of the filler, build-up and vent valve 3 is such that the top of the converter 1 is connected via conduit 14 through the filler, build-up and vent valve 3 to atmosphere. Thus the quantity of liquid oxygen in the converter 1 is indicated on the gauge 11 and any excess liquid oxygen may exude from the system by way of a vent provided in the filler, build-up and vent valve 3 (not shown).

Upon disconnecting the filling means, the vent automatically closes and communication is provided between conduit 13 and conduit 14. Liquid oxygen tends to flow from connection 17 into conduit 10 and build-up coil 12 where it absorbs heat, expands and by way of conduits 13, 14 and vent connection 27 exerts pressure on top of the liquid oxygen contained within the converter. More liquid is therefore forced into build-up coil 12 forming a continuous build-up of pressure until a predetermined pressure is reached whence the pressure closing valve 4 automatically closes thus preventing any further build-up of pressure.

When it is desired to commence breathing operations, the breathing mask 28 is attached to the face of the user and each inhalation from the demand regulator 22 causes liquid to flow from the converter by way of the connection 17 through the differential check valve 18 into the lower part of the liquid trap 19. Some liquid will also flow generally along conduit 21 from the upper side of the liquid trap 19 towards evaporator coil 16 where it will vaporize into gaseous oxygen and pass to the breathing mask.

Upon each exhalation, the pressure build-up in the conduit 21 forces liquid from the base of the liquid trap 19 into the outlet conduit 23 where it quickly vaporizes in the heater coil 24 from whence it is returned to the converter at inlet 25 by way of differential check valve 26 and passes into the liquid oxygen already stored therein. The check valve 26 closes upon each inspiratory breath thus preventing any back flow into the system from inlet 25. By conversion of some of the liquid oxygen to gaseous oxygen and the subsequent return of gaseous oxygen to the converter at inlet 25, this gaseous oxygen warms as well as mixes with the main volume of liquid oxygen stored in the converter, thus avoiding the presence of a warm layer which is usually confined only to the top of a converter.

If pressure has built-up due to standing, as hereinbefore described, to the pressure of the pressure relief valve 6, and it is desired to commence breathing operations, the initial inhalation demands of the user will be met by gaseous oxygen contained at the top of the converter 1, by way of conduit 15, pressure opening valve 5, pressure closing valve 4, conduit 13 and conduit 14. This pressure is quickly breathed down until the pressure

opening valve 5 again closes, and further inhalation will draw liquid oxygen from the converter 1 in a manner as hereinbefore described.

It is not convenient to include the combined filler, build-up and vent valve generally indicated at 3 as a part of the converter 1, in that it is desirable to provide the filler on the skin of the aircraft for the purposes of liquid oxygen replenishment.

It is to be appreciated and understood by those skilled in the art that variations and modifications may be made to the example hereinbefore described without departing from the scope of the invention, for instance, a single connection may be provided near the base of the converter with combined purpose of withdrawing liquid and for returning to the converter some of the liquid which has been changed to gaseous oxygen.

We claim as our invention:

1. A liquid gas converter for use with breathing apparatus comprising: an insulated container having inlet means and outlet means; trap means having an inlet in communication with said outlet means of said container, said trap means having a first outlet and a second outlet disposed respectively in the upper and lower portions of said trap means; a supply circuit leading from said first outlet to a point of use; a recirculating circuit leading from said second outlet of said trap means to the interior of said container so as to communicate with liquid gas in said container; vaporizing means for vaporizing liquid passing through said recirculating circuit to the interior of said insulated container so as to maintain delivery pressure in said container.

2. Apparatus as recited in claim 1 further comprising flow control means and pressure control means located between the outlet of said container and the inlet of said trap means.

3. Apparatus as recited in claim 1 wherein said supply circuit comprises flow control and pressure control means downstream of said trap means, pressure relief means downstream of said flow control and pressure control means, and vaporizing means downstream of said pressure relief means.

4. Apparatus as recited in claim 1 further comprising means in said recirculating circuit for preventing reverse flow from said container toward said trap means.

5. Breathing apparatus characterized by a liquid gas converter comprising: an insulated container provided with inlet means and outlet means; a liquid trap having an inlet in communication with said outlet means of said container, and having a first outlet and a second outlet disposed respectively at the upper and at the lower portions of said liquid trap; a supply circuit in communication with said first outlet of said liquid trap; a recirculating circuit connecting said second outlet of said liquid trap to said inlet means of said container and including vaporizing means such that liquid contained within said liquid trap is vaporized by said vaporizing means of said recirculating circuit and returned to said container by way of said inlet means thereof, the gas thus returned being at a higher temperature than gas stored therein, thereby warming as well as mixing with the main volume of liquid gas to disturb said main volume and prevent the formation of warm layers, thereby maintaining sufficient delivery pressure within said container although said container may be inverted or severely shaken.

6. Breathing apparatus characterized by a liquid gas converter comprising: an insulated container provided with inlet means and outlet means; a liquid trap having an inlet in communication with said outlet means of said container and a first outlet and a second outlet disposed respectively at the top and at the bottom of said liquid trap; a supply circuit, including vaporization means and a regulator of the demand type and associated breathing mask, in communication with said first outlet of said liquid trap; a recirculating circuit, including vaporizing means, connecting said second outlet of said liquid trap

to said inlet means of said container such that liquid contained within said liquid trap is vaporized by way of said vaporizing means of said recirculating circuit and returned to said container by way of said inlet means thereof, the gas thus returned being at a higher temperature than gas stored therein, thus warming as well as mixing with the main volume of liquid gas to disturb said main volume and prevent the formation of warm layers, thereby maintaining sufficient delivery pressure within said container although said container may be inverted or severely shaken, and further whereby upon inhalation liquid gas flows from said outlet means of said container to the vaporization means of said supply circuit wherein it is vaporized and flows to said breathing mask according to the demands of the user.

7. Breathing apparatus characterized by a liquid oxygen converter comprising: an insulated container provided with inlet means and outlet means; means for maintaining pressure therein; a liquid trap having an inlet in communication with said outlet means of said container and a first outlet and a second outlet disposed respectively at the top and at the bottom of said liquid trap; a supply circuit, including vaporization means and a regulator of the demand type and associated breathing mask, in communication with said first outlet of said liquid trap; a recirculating circuit, including vaporizing means, connecting sad second outlet of said liquid trap to said inlet means of said container; whereby, upon inhalation, liquid oxygen flows to said breathing mask by way of the outlet

means of said container, said liquid trap, said vaporization means where it is vaporized and said regulator of said supply circuit; liquid oxygen being trapped within said liquid trap, the oxygen so trapped being returned to the inlet means of said container by way of said vaporizing means of said recirculating circuit, the gaseous oxygen thus returned being at a higher temperature than oxygen stored therein, thus warming as well as mixing with the main volume of liquid oxygen to disturb said main volume and prevent the formation of warm layers so as to maintain sufficient delivery pressure within said container although said container may be inverted or severely shaken.

8. Breathing apparatus as claimed in claim 7 wherein oxygen trapped in said liquid trap is vaporized by said vaporizing means of said recirculating circuit and is returned to said container as gaseous oxygen being bubbled through the liquid oxygen within the container, thereby disturbing the surface thereof and transferring heat thereto.

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