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APPARATUS FOR DETERMINING THE WATER VAPOR CONTENT OF AVIATION BREATHING OXYGEN

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Fig. 2.

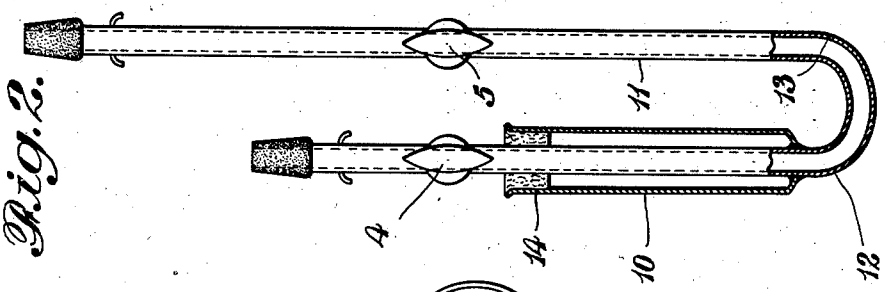
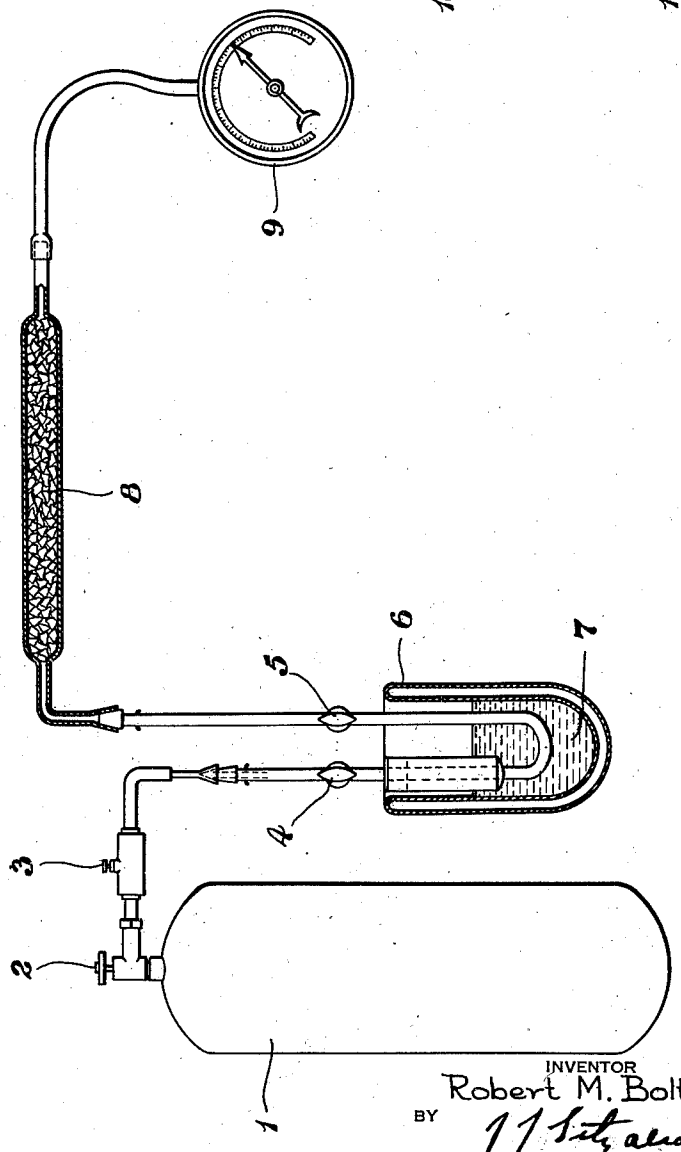


Fig. 1



INVENTOR
Robert M. Bolton,
BY
ATTORNEY

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APPARATUS FOR DETERMINING THE WATER VAPOR CONTENT OF AVIATION BREATHING OXYGEN

Robert M. Bolton, United States Navy

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2 Claims. (Cl. 73—29)

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This invention relates to an apparatus for determining the moisture content of gases, and is particularly adapted for determining the moisture content of gases contained in cylinders.

It is often necessary for aviators to ascend to altitudes where the breathing of oxygen is required. This oxygen is carried in cylinders under high pressure. In order for the oxygen apparatus to properly function at the high altitudes and the low temperatures found at such altitudes; it has been found necessary to limit the moisture content of the gas in the cylinders to such a value that it will not become saturated under operating conditions.

One object of this invention is the developing of an apparatus for carrying out a method of accepting and rejecting cylinders of oxygen according to the moisture content of the gas therein.

Another object of this invention is the construction of an apparatus to determine the maximum allowable moisture content of a gas in a cylinder under pressure.

Another object of the invention is the provision of means for reducing the temperature of a sample of the gas in the cylinder to a value that is lower than that of the temperature experienced under actual operating conditions.

Another object of this invention is the developing of means for readily determining, in the field, quickly, and without the use of large quantities of the gas in the cylinder, whether that cylinder will continue to deliver oxygen at the low temperatures of high altitude flying.

In this disclosure the terms moisture and water vapor are used synonymously.

Fig. 1 is an assembly drawing of the apparatus for practicing my invention.

Fig. 2 is an enlarged view of the constant temperature section of the apparatus of Fig. 1.

Before discussing the apparatus in detail applicant wishes to point out that his invention operates upon the principle that a gas is saturated with varying quantities of moisture depending upon the temperature to which it is exposed.

The following table shows the quantities of moisture found in a saturated gas at the indicated temperatures:

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Temperature in ° C.	Moisture Content in mgm./liter
0	4.870
−20	0.824
−40	0.104
−50	0.032
−60	0.008
−70	0.002

For instance, if a gas contains 0.008 mgm. of moisture per liter and it is exposed to a temperature of −60° C.; it will be at its saturation point for that quantity of moisture and the moisture will remain in suspension. If however, the gas had contained .020 mgm. of moisture per liter it would have contained .012 mgm. of moisture per liter above its saturation point for that temperature, and the excess would have condensed out, as ice particles on the walls of the containing vessel.

It is the condensation of these ice particles at the low temperatures of high altitude flying that clog the apparatus and shut off the aviators supply of oxygen. It is obvious that it is important to determine before the oxygen cylinder is taken aloft whether or not it will operate satisfactorily.

Experiments have shown that when liquid moisture is not present in the cylinder the weight of moisture per liter of expanded oxygen is not independent of the pressure of the oxygen in the cylinder. The weight of the moisture per liter of expanded oxygen increases as the pressure in the cylinder decreases, but at a much less rapid rate than if liquid moisture were present in the cylinder.

Experiments have shown that an oxygen cylinder meeting the following specifications (an over all moisture content of .02 mgm. per liter) will deliver oxygen containing .01 mgm. per liter when the cylinder is substantially at normal pressure.

It is well to note here that oxygen placed in a temperature of −60° C. will be saturated if it contains .008 mgm. of moisture per liter. Any moisture present in excess of that amount will be condensed out in the form of ice particles on the walls of the containing vessel. It must be remembered that minute quantities of moisture are being sought. For instance, if the sample were .005 mgm. per liter over the standard and

25 liters of gas was used, the amount would be only .125 mgm. or slightly more than one-five-hundredth part of a drop of water.

It has been determined experimentally that at least .003 to .005 mgm. per liter of moisture must be condensed out from a sample of 25 liters of oxygen in order to become visible on the walls of the containing vessel.

In Fig. 1 of the drawing element 1 is the aviation breathing oxygen cylinder charged to normal pressure. The cut off valve is shown at 2 and the reducing valve at 3. The constant temperature section of the apparatus is removably fitted to the remaining parts which parts may be more or less fixed. The gas passage consists of a U-shape glass tube 11 containing glass stop cocks 4 and 5, which must be turned to the off position after the run is made in order to prevent any movement of the gas from disturbing the minute crystals of moisture before the condition is noted. The outgoing end of tube 11 is connected to a water absorber 8 to give protection to flow meter 9 in initially conditioning the apparatus for operation. The vacuum vessel 6 for holding the refrigerant 7 is placed in the position shown for cooling the gas.

In Fig. 2 the constant temperature section is shown on an enlarged scale to bring out the features of the glass insulating tube 10, used to prevent condensation in the upper portion of the entrance leg of the tube. A seal is made at 14 with asbestos packing to confine the air therein for better insulating purposes. It is important to the localization of the moisture crystals that the transition in temperature of the oxygen from that of the tank to that of the bath be as abrupt or as localized as possible. This is accomplished by tube 10, as well as preventing the condensation of moisture in the upper part of the tube. When the gas contains sufficient moisture to be condensed out, it collects adjacent or along the bight at points 12 and 13 of tube 11, which points present more or less a baffling effect, where the direction of flow of the gas is changed. Highly polished plates could be inserted in tube 11 at points 12 and 13 in such a manner that the flow of gas would impinge upon them, and they would effectively serve as collectors of the moisture crystals.

The refrigerant 7 used in the vacuum cup 6 is composed of equal parts of chloroform and carbon tetrachloride. It is cooled down to the desired temperature by the addition of solidified carbon dioxide.

Another means of cooling the tube is to utilize the cooling effect of an expanding stream of carbon dioxide gas. The gas could be supplied in a small cylinder included in the apparatus.

In the operation of this device the oxygen cylinder to be tested 1 is connected to the reducing valve 3, the apparatus is as shown in Fig. 1 except that the vacuum cup 6 is removed. The cylinder valve 2 is opened and the oxygen run through the apparatus at a rate of 0.3 to 0.4 liter per minute as indicated by the flow meter 9 until 25 or 30 liters have passed through. The apparatus is at room temperature. In the above manner the apparatus is thoroughly dried to the moisture content of the oxygen in the cylinder under test.

The vacuum cup containing equal parts of chloroform and carbon tetrachloride is cooled down to the desired temperature by the addition of solidified carbon dioxide. The temperature of the refrigerant is kept constant during the test by the expanding carbon dioxide.

The cylinder valve is closed and the vacuum cup containing the refrigerant is placed around the condensing tube. The cylinder valve is now opened until a rate of flow of 0.3 liter per minute is established, and 25 liters of gas is allowed to flow through as determined by meter 9.

When the last of the 25 liters of gas has passed through, the cylinder valve 2 and the stopcocks 4 and 5 are shut off. The refrigerant is removed from the condensing tube by the removal of cup 6.

If the gas contains an amount of moisture in excess of the saturation point at the temperature of the refrigerant, a cloud of moisture will be seen on the inner wall of the condensing tube.

To determine if a given cylinder meets the specifications set forth above, the refrigerant is cooled to −60° C. If on removal of the vacuum cup no condensate of the gas is visible, the gas in the cylinder under test does meet the specifications.

If a condensate is visible at 12 and 13 of tube 11, and the test was run on a cylinder at normal pressure; the gas contains more than .01 mgm. of moisture per liter, and does not meet the specifications.

It is believed that a new and useful apparatus and method has been developed by applicant to insure an adequate supply of oxygen for high altitude flying. The apparatus is easily portable and may be carried to any location where the oxygen cylinders are to be found.

The standard Navy oxygen cylinder carries a pressure of 1800 lbs. per square inch. They are manufactured in four sizes of 96, 205, 295 and 514 cubic inches content respectively.

It is evident that the method and apparatus is operable upon all gases and in particular upon gases that are stored in cylinders under high pressures. While the disclosure is made in connection with the use of oxygen it is to be understood that other gases are included within the scope of applicant's invention.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. In an apparatus for field testing oxygen in a portable oxygen bottle, a U shaped transparent glass oxygen tube open at both ends, one end being adapted to be connected through a pressure reducer to the oxygen bottle, a glass stop cock in each leg of the U tube spaced from the bight thereof, an insulating tube enveloping a part of the oxygen entrance leg of the U tube from below its stop cock to a point somewhat above the bight, the inner surfaces of the U tube adjacent the bight providing visible dew collecting areas if an undesirable amount of moisture is present in the oxygen being tested by exposing the U tube bight as far as the lower end of the insulating tube to a sharp drop in temperature by insertion in a refrigerant and then closing the stop cock when removing from the refrigerant so that any collected dew will be undisturbed by further passage of oxygen and may be visibly observed.

2. Apparatus for field testing oxygen in a portable oxygen bottle comprising a U shaped transparent glass oxygen tube, a glass stop cock in each leg of the U tube spaced from the bight thereof, an insulating tube concentrically en-

veloping a part of one leg of the U tube from below its stop cock to a point somewhat above the bight, said insulated leg forming the oxygen entrance leg to said U tube, conduit and pressure reduction means for connecting the oxygen bottle being tested to said U tube entrance leg, a refrigerant containing vacuum insulated cup into which the U tube bight including the lower end of the insulating tube is inserted for cooling the oxygen passing therethrough, a moisture absorber adapted to be connected to the other leg of said U tube, and an oxygen measuring means connected to said water absorber, whereby oxygen may be passed from the oxygen bottle through the U tube to said measuring means and be exposed to such a temperature drop in passing from the insulated leg to the bight within the refrigerant containing cup that dew will collect along the bight if an undesirable amount of moisture is present in the oxygen being tested, the passage of oxygen being closed by said stop cocks when the

U tube is removed from the refrigerant so that any collected dew will be undisturbed and may be visibly observed.

ROBERT M. BOLTON.

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