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METHOD OF AND APPARATUS FOR STORING LIQUEFIED GAS MIXTURES

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Fig. 1.

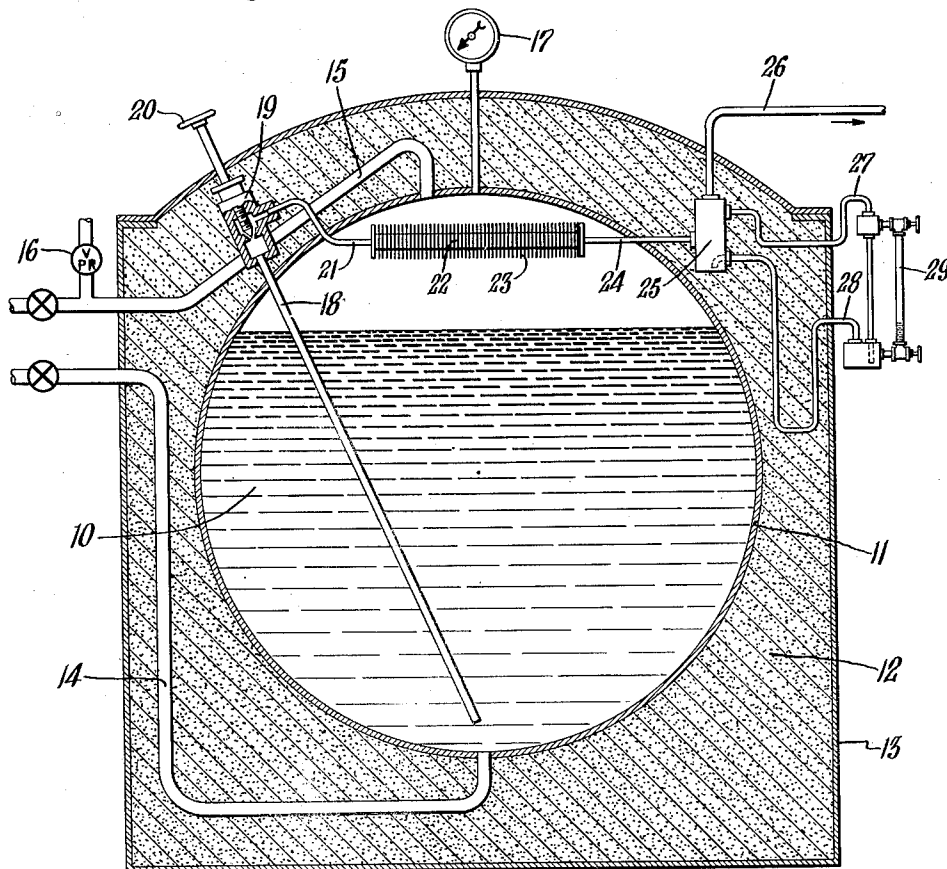
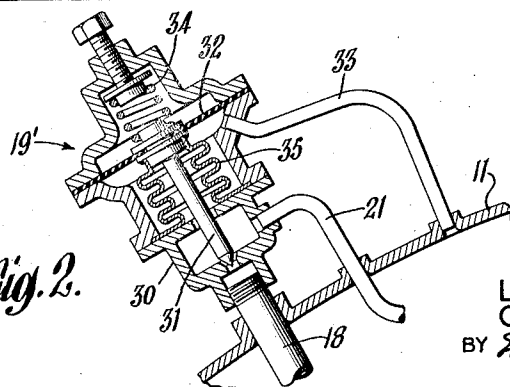


Fig. 2.



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METHOD OF AND APPARATUS FOR STORING
LIQUEFIED GAS MIXTURESLeo I. Dana, Buffalo, and George H. Zenner, Ken-
more, N. Y., assignors to The Linde Air Prod-
ucts Company, a corporation of Ohio

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4 Claims. (Cl. 62-1)

This invention relates to a method of and apparatus for storing liquefied gas mixtures at relatively low temperatures and more particularly to a method of and apparatus for maintaining substantially constant, the proportions of the constituents of a mixture of gases, when gas is discharged from an insulated container holding a body of the gas mixture at low temperature in the liquid state.

When liquefied gases are stored in insulated containers at relatively low temperatures, below atmospheric temperature, some leakage of heat into the stored liquid inevitably occurs because the commercially available insulating means employed in such containers does not exclude all heat tending to enter the liquid from the environment. Thus a small amount of liquid will constantly tend to evaporate and build a pressure in the gas space above the liquid in the container and unless the container is strong enough to withstand any pressure that may develop, it is necessary to vent gas from the container to prevent an excessive rise in pressure.

When a mixture of liquefied gases having different boiling points, such for example, as a liquefied gas having mixed therein a small proportion of another liquefied gas of different boiling point is stored, the evaporation due to heat leak causes the gas produced to have a relatively different composition than that of the liquid because the component having the lower boiling point will tend to evaporate preferentially so that the composition of the vapor as well as the composition of the remaining liquid will change, the vapor produced and vented being initially richer in the component having the lower boiling point and the liquid remaining in storage becoming richer in the component having the higher boiling point. Such variation of composition is in general quite undesirable in commercial practice.

According to the invention such changes of composition or purity of both gas withdrawn and liquid stored are prevented and the effects of heat leaks into a container having a body of liquefied gas are counteracted by withdrawing a small quantity of liquid from the main body of liquid, and evaporating completely such withdrawn liquid in a manner that prevents an excessive rise in pressure. The vapor so evolved by complete evaporation of the small quantity of liquid will be of the same composition as the liquid and there will be no undesirable difference of composition or purity.

It is a principal object of the present invention

to provide an improved method of and apparatus for storing mixtures of liquefied gases at relatively low temperatures. Other objects of the invention are: to provide a method of and apparatus for maintaining substantially constant the proportions of the constituents of a mixture of gases when stored in the liquefied state; for maintaining the proportions of the constituent gases relatively constant when evaporating a mixture of liquefied gases; to provide a method of and apparatus for counteracting the effects of heat leak into a stored body of liquefied gas of commercial purity by causing such heat to completely vaporize a portion of liquid separated from the stored body of liquid in a manner such that an excessive rise of pressure is prevented and the composition and purity of the vapor produced and the stored body of liquid remains substantially constant; and for maintaining substantially constant the purity of commercial oxygen supplied in both gaseous and liquid states from an insulated container in which is stored a body of liquid oxygen at low temperature. These and other objects and novel features of this invention will become apparent from the following description and the accompanying drawing, in which:

Fig. 1 is a sectional view of an exemplary container for holding a body of liquid oxygen including means for maintaining the purity of gas discharged therefrom substantially constant according to the principles of the present invention; and

Fig. 2 is a fragmentary sectional view on an enlarged scale of an alternative form of expansion valve.

The principles of the invention will be set forth in connection with means for storing commercial liquid oxygen, as an example of a mixture of liquefied gases which by customary storage arrangements would have a gas phase above the liquid of different composition than the liquid. Commercial liquid oxygen generally and preferably contains 99.6% pure oxygen; the remainder consisting of mainly liquid argon and nitrogen. The boiling points of oxygen, argon and nitrogen at normal atmospheric pressure are -183°C. , -186°C. and -196°C. , respectively. Commercial liquid oxygen thus constitutes a liquefied gas mixture in which the constituents have substantially different boiling points and when commercial liquid oxygen is stored in the customary insulated container, the slow inflow of heat through the insulation to the liquid causes a slow but constant evaporation of liquid to oc-

cur. The vapor that accumulates in the gas space above the liquid in the container is richer in argon and nitrogen than the liquid. Thus, when it is desired or necessary to draw vapor from the gas space of such a container to prevent excessive rise of pressure, the gas withdrawn will not comprise 99.6% oxygen but will be of lower purity. It is desirable that all the gas material in both liquid or gas phases withdrawn from the storage container for commercial use should be of a constant purity.

According to the present invention, the heat leak that normally occurs into a body of stored liquid oxygen is compensated for or removed from the container by withdrawing portions of liquid of constant composition from below the surface of the stored body of liquid and evaporating the entire amount, the amount so withdrawn and evaporated being sufficient to remove, due to the heat of vaporization, the heat entering the container. The vaporization may be effected while the portion being evaporated is in heat exchanging contact with the vapor in the gas space above the liquid whereby such vapor is cooled and partially condensed and the pressure reduced.

Referring now to the drawing, and particularly to Fig. 1, a body of liquefied gas, for example, commercial liquid oxygen is indicated at 10, stored within a metal vessel 11 which may of any suitable shape, for example, cylindrical or spherical. The vessel 11 is surrounded by a relatively thick layer of heat insulating material 12 which may be of any customary type such as a vacuum insulation or a dry powdered material. The insulation is held within an outer casing 13. Suitable means for adding and withdrawing liquid oxygen are provided in the form of a liquid line 14 connecting with the bottom of the vessel 11 and leading to a point outside of the casing 13. A gas phase withdrawal line 15 connecting with the top of the vessel 11 is also provided. A branch of the line 15 is preferably provided with a safety or pressure relief valve 16. It is also desirable to provide a pressure gauge 17 connecting with the vessel 11 to indicate the pressure therein. The means for maintaining the purity constant comprises an eduction tube 18 leading from a point within the body of liquid 10 to an expansion valve 19 having an operating handle 20. From the discharge side of the expansion valve 19, a connection 21 conducts liquid to an evaporating coil or condenser 22. The condenser 22 may be of any suitable form providing sufficient heat transfer area such as a tubular section having external heat transfer fins 23. The condenser 22 is preferably disposed within the gas space above the body of liquid 10. From the other end of the condenser 22, a connection 24 passes through the wall of the vessel 11 to a trap 25. The trap 25 comprises a small chamber from the top of which the evaporated gas is withdrawn or discharged through a pipe 26. The trap 25 is provided with upper and lower connections 27 and 28 leading to a liquid level gauge 29 which is provided to indicate the presence of liquid in the trap 25. The gas withdrawn through pipe 26 may, if desired, be conducted to a gas holder or to a compressor for charging the gas into storage cylinders or, gas withdrawn through connection 26 may be delivered to oxygen consuming apparatus that requires the oxygen to be of the standard purity because the purity of such evaporated liquid will be substantially constant

and the same as the purity of the main body of the liquid 10.

In operation a body of liquid 10 is introduced into the storage container 11 which preferably is constructed to withstand only a relatively low internal pressure above atmospheric pressure. As heat leaks through the insulation 12 and reaches the liquid 10, some of the liquid will evaporate and tend to build a pressure in the space above the liquid. Such pressure will be indicated on the pressure gauge 17. When the desired safe upper limit of pressure is reached, a pressure is maintained in the pipe 26 of a value that is lower than the pressure in the vessel 11, such as by connecting the pipe 26 to a low-pressure gas holder or to the suction side of a pump. The expansion valve 19 is opened by the operation of the handle 20 to a degree sufficient to allow liquid to pass up through the eduction tube 18, become expanded in passing through the valve 19 and flow into the condenser 22. Under the effect of the reduction of pressure, which lowers the boiling point of the liquid, the liquid passing into the condenser 22 will boil at the expense of heat absorbed from the vapors in the space above the liquid 10. Due to such heat exchange, a portion of the vapors which arise from the surface of the liquid 10 will become recondensed and fall back to the body of liquid. In this manner the heat that enters the liquid 10 after the predetermined pressure has developed is removed by the condenser 22. The vapors produced in the condenser 22 pass through the connection 24 and the line 26. If the valve 19 is opened too much so as to pass liquid at too great a rate, some liquid will pass out through the connection 24 and begin to accumulate in the trap 25. Such accumulation will be indicated by the liquid level gauge 29 and the operator will then reduce the flow by closing the valve 19 slightly.

If desired, the valve 19 may be replaced by an automatically operated valve 19' as shown in Fig. 2, which valve is caused to open by a rise of pressure in the vessel 11. Such automatic valve 19' may be of any suitable construction and may comprise a valve body 30 having a port therein controlled by a needle valve 31. The needle valve 31 is connected for operation to a diaphragm 32, the underside of which is exposed to the pressure of the vessel 11 by connection with the vessel through a conduit 33. The valve is urged to the closed position against the action of the diaphragm by an adjustable spring 34 and the valve stem 31 may be sealed by a bellows 35 having one end secured to the body 30 and the other end secured to the stem of the valve 31. It will be evident that when the pressure in the vessel 11 rises, the diaphragm 32 will be moved upwardly against the force of the spring 34 and the valve 31 will be lifted from its seat. When sufficient liquid has passed through the valve casing 30 from the inlet 18 to the outlet connection 21, the pressure in the gas space above the liquid 10 will be reduced due to condensation of gas. This will cause the pressure in the vessel to drop and allow the valve 31 to close and thus automatically maintain the pressure in the vessel substantially constant.

The embodiments described herein and illustrated in the drawing are disclosed to indicate how the invention may be applied. Certain features of the invention may be used independently of others and changes may be made in the details of the apparatus without departing from the principles of the invention. Due to the difference

of pressure, the portions of liquid that are passed into the vaporizer 22 will boil at a lower temperature than the main body of liquid, thus a pressure rise can be prevented by permitting a flow of liquid into the vaporizer at a rate sufficient to balance the heat leak into the storage vessel. It is also contemplated that the vaporizer may have the form of a pipe coil arranged in heat conducting relation to the outside surface of the liquid holding vessel 11, and in any embodiment of the invention the refrigeration still contained in the gas discharged through the conduit 26 may be usefully applied to cool the insulation 12 by passing the gas through a tube disposed in the insulation 12 in a manner similar to that proposed in U. S. Patent No. 1,866,514 of C. W. P. Heylandt.

We claim:

1. Apparatus for storing a mixture of liquefied gases at low temperature which comprises a container for holding a body of such liquefied gases; heat insulating means surrounding said container; means for withdrawing portions of said body of liquid; means for expanding such withdrawn portions of liquid; a condenser disposed entirely in the vapor space of said container for vaporizing said expanded withdrawn portions of liquid in heat exchanging relation with vapor above the liquid stored in said container; and a conduit connected to said condenser for conducting away the vapors of said vaporization for use.

2. Apparatus according to claim 1 in which said expansion means comprises a valve operable in response to a pressure increase in said container.

3. Apparatus according to claim 1 including means interposed in said conduit for indicating the outflow of unvaporized liquid with gas discharged through said conduit.

4. Method of maintaining substantially constant the composition and purity of a valuable gas mixture when stored in the liquid state in an insulated container at a relatively low temperature and below a predetermined pressure which comprises, withdrawing regulated portions of said liquid; completely vaporizing such withdrawn portions of liquid by heat exchange with vapors above the surface of the stored liquid; withdrawing for use the vapors of such vaporization; and regulating said liquid withdrawal and said vaporization at a rate sufficient to maintain the pressure of said vapors above the stored liquid below said predetermined pressure, whereby the temperature and composition of the stored liquid is maintained substantially constant and the composition of the vapor withdrawn is maintained the same as the composition of said stored liquid.

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