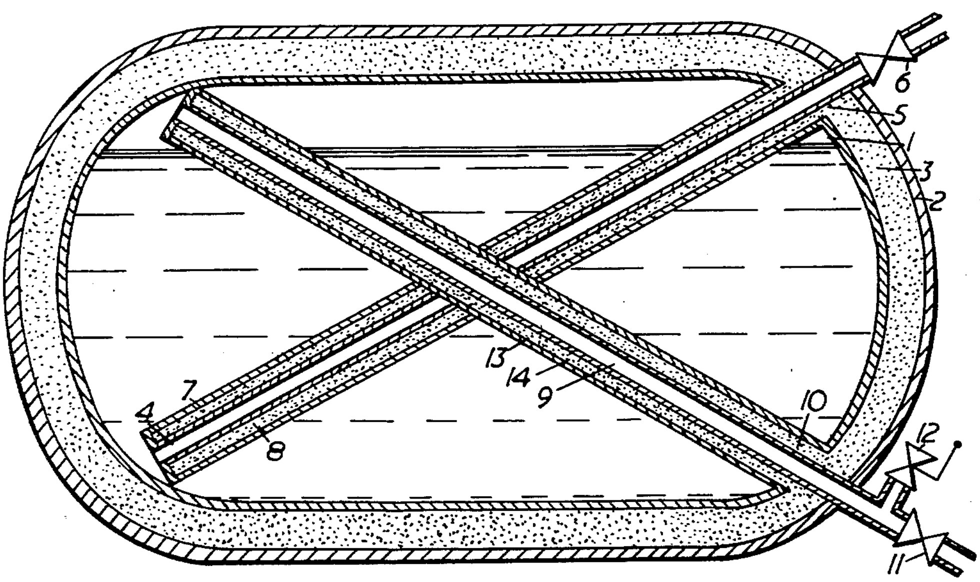
June 14, 1960 W. O. KEEPING 2,940,631

STORAGE VESSELS FOR LIQUEFIED GASES

Filed June 17, 1957



Inventor
William O. Keeping
By
Aaron R. Townshend
Attorney

United States Patent Office

2,940,631

Patented June 14, 1960

2,940,631

STORAGE VESSELS FOR LIQUEFIED GASES

William O. Keeping, Surrey, England, assignor to The British Oxygen Company Limited, a British company

Filed June 17, 1957, Ser. No. 665,968

Claims priority, application Great Britain July 3, 1956

3 Claims. (Cl. 220—14)

This invention relates to the design and construction of storage vessels for liquefied gases.

Liquefied gases, the boiling points of which are substantially below ambient temperature at atmospheric pressure, for example liquid oxygen or liquid nitrogen, are normally stored in such a manner that the influx of heat into the storage vessel from the surrounding atomsphere is kept to a minimum. Under such conditions the evaporation losses of the stored liquefied gases would be small, thus making the storage efficient and economical.

Storage losses are caused by the heat inleak in the first instance through the container walls and secondly through the filling and emptying connections. The losses through the walls can be very substantially reduced by the choice of the right method of insulation. An efficient method is to use a doublewall vessel, the interspace of which is filled with powder of a very small grain size and evacuated. The absolute pressure inside the evacuated space can vary between 10^{-1} and 10^{-6} mm. Hg. In cases where the insulating layer is relatively thin, a significant amount of heat can be transmitted through the walls by radiation. In such cases "opacised" powders or anti-radiation shields may be used. These prove to be very effective if a high degree of insulating efficiency is required.

All these remedies, however, cannot reduce the second category of cold losses mentioned above, caused by straightforward thermal conduction along the filling or emptying lines. In order to decrease these evaporation losses the filling and delivery pipes are usually made of a poorly conducting metal, such as stainless steel or German silver, their wall thickness and diameter are kept to a practical minimum and their length increased as much as conveniently possible. In one method of minimising the heat inleak along the supply and withdrawal lines, the liquid filling line can be accommodated inside the vapour venting line. Alternatively, these lines can be located in the insulating space between the inner and the outer shell and run inside it for a considerable distance, parallel to the inner vessel. This results however in an increased thickness of the insulating space in order to accommodate the filling and emptying connections and still maintain the required thickness of insulation.

It is an object of the present invention to provide a storage vessel for liquefied gases in which heat inleak along the filling and venting lines is minimised without increasing the thickness of the insulation of the vessel.

According to the present invention, an insulated storage vessel for liquefied gases of low boiling point is provided with long insulated liquid withdrawal and vapour venting lines, located for the greater part of their length within the liquid contents space of the vessel.

Conveniently, the filling and withdrawal line may open at a point near to the bottom of the vessel and leave the vessel through or near the top. The vapour venting line similarly will open at a point within the vapour space at the top of the vessel and leave the vessel through or near the bottom. Preferably, the liquid withdrawal and vapour venting lines are straight and are arranged at an equal angle on either side of the vertical so as to cross within the vessel, thus ensuring the maximum length for both lines.

With such an arrangement, there is no need to provide long filling and emptying connections protruding from the storage vessel since the necessary length of line is provided within the vessel itself. The liquid and vapour delivery valves may therefore be positioned close to the outer shell of the vessel.

The insulation of the vessel may be of any conventional type; the space between the vessel and its outer shell may be filled with powder or fibre, it may be filled with powder and evacuated or it may simply be evacuated. The insulation of the filling and vapour venting lines preferably forms part of the insulation system of the vessel. Thus, the filling line may be joined to and pass through the outer shell of the vessel at one end and be joined to its own shell at the other. This shell is itself joined at its other end to the inner wall of the vessel, so that the space between the line and its shell communicates with the space between the vessel and its shell. The distance between line and shell may be maintained if necessary by spacers made of a material of low thermal conductivity. With such an arrangement, the outer shell of the filling line is maintained at a low temperature by the liquefied gas surrounding it and is separated from the inner line by the selected insulation.

When the tank is filled with liquid and the filling valve is closed, vapour will gradually accumulate within the filling line owing to the heat inleak along the line from outside the vessel. Ultimately the whole length of the line will be filled with vapour, the temperature of which will vary from that of the boiling liquid under storage pressure up to the ambient temperature. Such a temperature gradient along tthe vapour in the line reduces very substantially the heat inleak along the line. Some of the vapour may be recondensed but any surplus vapour which cannot be accommodated within the filling line will pass through the opening of the line and will leave the tank through the venting line. This latter line is constructed in a similar manner to the filling line.

It will be appreciated that provision will have to be made to allow for differential thermal contraction or expansion of the filling and venting lines and their respective outer shells as the vessel is filled or emptied. This may be effected by using materials of construction which have a low thermal contraction coefficient, such as "Invar" (registered trademark), or if conventional materials of construction are used, stress-relieving elements, such as bellows or membranes, may be incorporated in the inner line or the outer shell.

An important application of this inventon is to vessels where the interspace between the inner and outer vessels, and the respective interspaces between the filling line and its outer jacket, and the vapour line and its outer jacket, are filled with a powder of low thermal conductivity, the interstices between the particles of powder being maintained at a gas pressure of less than 5×10^{-3} mm. of mercury absolute, but greater than the pressure normally employed when a vacuum space only is relied upon for insulating effect.

When powders are employed under such conditions in a narrow layer (that is, of less than about 2 inches' thickness) an important mechanism of heat transfer between the surroundings and the contents of the vessel is radiation. The heat transferred by this mechanism can be reduced by including with the insulating powder, and intimately mixed with it, a proportion of small reflecting bodies such as finely divided aluminium powder, finely divided copper or bronze powder and the like.

One embodiment of the invention will now be more particularly described with reference to the accompanying drawing which shows in longitudinal section a storage vessel according to the invention.

The storage vessel **1** is of cylindrical shape and is provided with an outer shell **2** surrounding and spaced from the vessel to define an insulating space **3**. The liquid filling and withdrawal line **4** opens at a point near to the bottom of the vessel at one end and leads diagonally in a straight line to emerge through an orifice **5** of diameter greater than that of the line in the wall of the vessel **1** at its opposite top corner, and then in gas-tight manner through the shell **2**. Flow of liquid through the line **4** is controlled by a valve **6** located close to the outside of the shell **2**. The line **4** is surrounded by a shell **7** spaced therefrom to form an insulation space **8**. This shell is joined in gas-tight manner to the line **4** at its open end, and at its other end is joined in gas-tight manner to the periphery of the orifice **5** so that the insulation spaces **3** and **8** are in communication.

In a similar manner, the vapour withdrawal line **9** opens into the gas space above the liquid in the vessel **1** at the same end as that at which the line **4** opens, and leads diagonally downwards in a straight line to pass through the orifice **10** in the opposite bottom corner of the vessel **1**, and thence in gas tight manner through the outer shell **2**. Flow of vapour through the line **9** is controlled by a valve **11** located close to the outside of the shell **2**. A safety valve **12** is provided between the valve **11** and the outside of the shell **2**. The line **9** is provided with a shell **13** surrounding and spaced therefrom to define an insulation space **14**, the shell **13** being joined in gas tight manner to the open end of the line **9** and to the periphery of the orifice **10**, so that the insulation spaces **3** and **14** communicate.

Provision (not shown) is made for filling the combined insulation space **3**, **8** and **14** with an insulating powder and for evacuating the space.

In operation, the liquefied gas is supplied and withdrawn through the line **4** whilst the vapour is vented through the line **9**. During storage, the unavoidable heat inleak into the vessel **1** along the withdrawal line **4** will cause evaporation of the liquefied gas. When the valve **6** is closed, the line **4** will be filled with vapour which will maintain a temperature gradient along the line thus further reducing the evaporation process.

I claim:

1. A thermally insulated storage vessel for liquefied gases of low boiling point comprising an inner container for the liquid, a first outer shell surrounding and spaced from said inner container, a liquid withdrawal line opening within said container at a point close to the bottom thereof and passing through a first aperture formed in the wall of said container at the top thereof, the diameter of said first aperture being greater than the outer diameter of said liquid withdrawal line and said liquid withdrawal line passing through said first aperture without touching the wall of said container, a second outer shell surrounding and spaced from the part of said liquid withdrawal line within said container, said second outer shell being joined at one end to said liquid withdrawal line at the open end thereof and at the other end to said container at the periphery of said first aperture, a vapour venting line opening within said container at a point close to the top thereof and passing through a second aperture formed in the wall of said container at the bottom thereof, the diameter of said second aperture being greater than the outer diameter of said vapour venting line and said vapour venting line passing through said second aperture without touching the wall of said container, a third outer shell surrounding and spaced from the part of said vapour venting line within said container, said third outer shell being joined at one end to said vapour venting line and at the other end to said container at the periphery of said second aperture, the space formed between each of said liquid withdrawal and vapour venting lines and said second and third outer shell respectively being in communication with the space formed between said inner container and said first outer shell to form a single insulation space, and means for evacuating said insulation space.

2. A thermally insulated storage vessel according to claim 1 wherein said single insulating space is filled with a powder of low thermal conductivity.

3. A thermally insulated storage vessel for liquefied gases of low boiling point according to claim 1 wherein said single insulating space is filled with a powder of low thermal conductivity in admixture with small reflecting bodies.

References Cited in the file of this patent

UNITED STATES PATENTS

673,073	Bobrick	Apr. 30, 1901
1,813,612	Du Pont	July 7, 1931
2,000,882	Comstock	May 7, 1935
2,579,035	Edelman	Dec. 18, 1951
2,725,722	Ashlstrand et al.	Dec. 6, 1955

FOREIGN PATENTS

701,137	Germany	Jan. 9, 1941