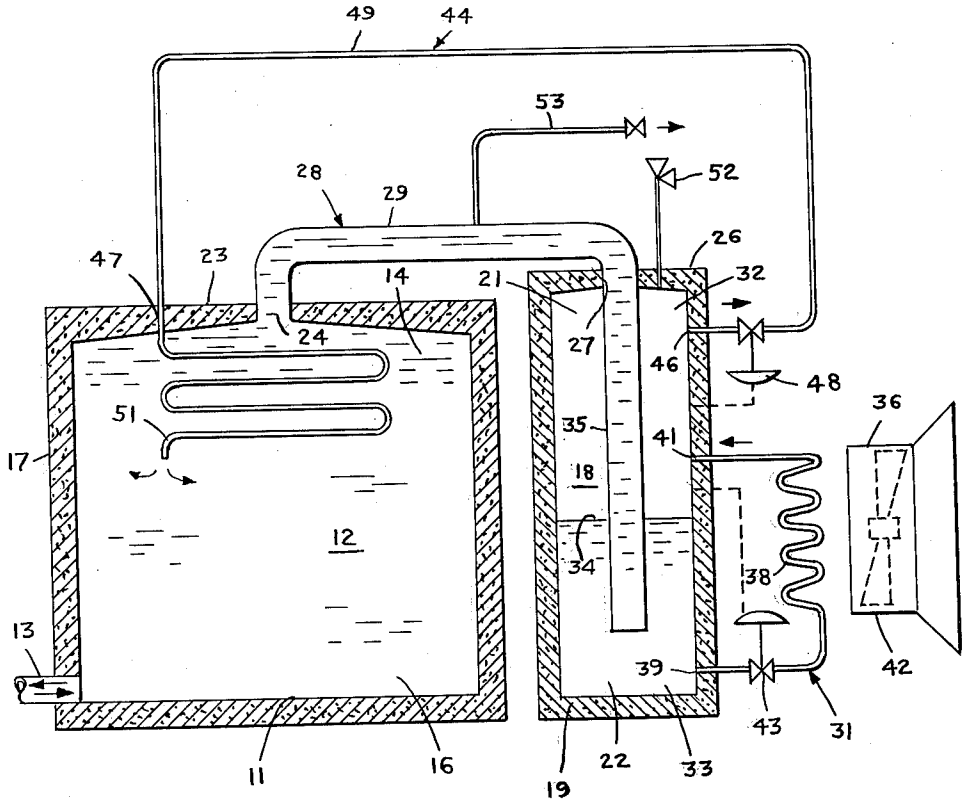
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VESSEL FOR SUBCOOLED LIQUID

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# VESSEL FOR SUBCOOLED LIQUID

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This invention relates to the handling of subcooled liquids. More particularly it is a means for transporting substances in their subcooled liquid state.

An inert gas such as nitrogen is often used above a subcooled cargo liquid to provide a cushion for the expansion of the liquid. In situations, for example the shipment of subcooled liquified methane, contamination of the cargo by an inert gas would be undesirable. In such instances, a gas phase of the cargo liquid would usually be a very suitable material to serve as the cushion. The use of the gas phase of the cargo liquid to provide this cushion is prevented because a subcooled liquid in motion will condense its gas phase creating an inleakage pressure gradient. Accordingly, the problem is, how to maintain a gas phase cushion of the cargo liquid in the face of the condensing influence of the jostled subcooled liquid.

Motion is an important aspect of the condensation problem here addressed. In a stationary vessel it is possible to sustain a gas phase of a stored liquid on the liquid without having the entire body of liquid reach saturation temperature. In this stationary system only the upper surface of the liquid need be in equilibrium with the gas phase. Greater liquid density with lower temperature makes it possible to maintain a temperature gradient in the liquid. When the vessel is set into motion, mixing generally occurs so the entire vessel comes to a uniform temperature.

With jostling, the cooler lower subcooled liquid is brought into contact with the gas phase increasing the overall condensing influence of the liquid on that gas phase. Condensation continues until the internal pressure of the gas reduces to that value corresponding to equilibrium with the vapor pressure of the liquid at uniform temperature which naturally would be below atmospheric pressure.

The present invention provides a means for transporting substances in their subcooled liquid state which permits the maintenance of a cushion of the gas phase of the subcooled cargo liquid. More particularly, this invention comprises a closed vessel defining a liquid reservoir. Liquid inflow and outflow means are operatively connected to the vessel to introduce and remove cargo liquid to and from the reservoir. An expansion tank defining a pocket is provided. The pocket communicates with the reservoir. Vaporizer means produce gas from the cargo liquid thereby introducing the gas into the pocket so that it cushions the cargo liquid.

Basically this embodiment of the invention offers a safe inexpensive means for transporting highly volatile liquified gases in their subcooled states. Contamination and explosive air gas mixing are avoided. By operation of the vessel below ambient pressure an additional safety precaution against the escape of noxious cargoes may be included. The use of relatively inexpensive low pressure vessel designs in this application is made possible and inleakage is reduced. Because the reservoir is completely full, the capacity of the vessel is a maximum. The sensitivity of control means is magnified. A pressurized gas phase provides net positive suction head for emptying the tank by means of a pump.

These and other advantages will be seen more fully from the specification and claims viewed in conjunction



with the accompanying drawing of a shipping receptacle embodying the present invention.

In the drawing of the receptacle, closed vessel 11 defines reservoir 12 for containing subcooled cargo liquid. Liquid is introduced into and removed from reservoir 12 via means passage 13 which penetrates vessel 11. Reservoir 12 has upper reservoir portion 14 and lower reservoir portion 16.

Closed vessel 11 is jacketed by suitable insulating means 17. In this embodiment of the invention the substance to be transported must already be in the subcooled liquid state when it is introduced into reservoir 12. Of course, the substance could be brought to its subcooled state while it is in the receptacle by refrigeration means but the bringing of the substance to that state is no part of this invention so the more simple insulated receptacle version was selected for presentation.

Means defining pocket or space 18 are shown as expansion tank 19. Pocket 18 has upper pocket portion 21 and lower pocket portion 22. Vessel 11 and tank 19 may be of unitary construction with pocket 18 situated inside vessel 11.

Upper reservoir portion 14 is bounded by vessel crown 23 with vessel port 24 formed therein. Upper pocket portion 21 is bounded by tank crown 26 with tank port 27 formed therein. Vessel port 24 communicates with reservoir 12. Fluid communication means generally designated 28 are shown as overflow conduit 29 which communicates with vessel port 24 and passes through tank port 27 to communicate with lower pocket portion 22. Overflow conduit 29 also provides a means to initially fill pocket 18 with cargo liquid.

Gasifying means generally described 31 maintains a gas phase 32 of the cargo liquid in pocket 18 so that gas phase 32 cushions the cargo liquid in pocket 18. Only the liquid 33 in pocket 18 need be in equilibrium with gas phase 32. Thus, it is feasible to transport many substances in the subcooled liquid state rather than shipping them in highly pressurized vessels. Gas phase 32 is situated in upper pocket portion 21 and is confined against liquid surface 4 by tank 19 and outside 35 of overflow conduit 29 so that gas phase 32 maintains an energy balance with the liquid. Gasifying means 31 could be any known technique for generating a gas phase from a liquid.

The form of gasifying means 31 in this embodiment has a heat supply means 36 shown as atmosphere air to supply heat for non-contacting heat exchange relationship with the cargo liquid. Cargo liquid is brought into heat exchange association with the heat supply means 36 by means of vaporizer conduit 38 communicating with pocket 18 via liquid hole 39 and gas hole 41. Blower 42 is operatively disposed to circulate atmosphere air past vaporizer conduit 38. By eliminating blower 42 and using a vaporizer conduit 38 of suitable size the means for transporting substances in their subcooled liquid state as set forth in this teaching need have no moving parts.

A wide variety of control techniques is possible for maintaining the pressure of gas phase 32 within a desired range. For example, attemperator means could dissipate the energy of the gas phase 32. In the embodiment shown and described the approach to pressure regulation is to control the rate of both the generation and the condensation of gas phase 32. Obviously either generation or condensation control techniques could be employed alone.

The control for the generation of gas phase 32 is vaporizer flow regulator 43 connected in series with vaporizer conduit 38 and operative in response to a variation in a signal which indicates the need for gas generation. The signal shown is a pressure signal emitted by gas phase 32 in pocket 18.

Liquid in lower pocket portion 22 communicates with upper reservoir portion 14 and is in contact with gas phase 32. Accordingly, the liquid in pocket 18 will be warmer than that in reservoir 12. This situation is analogous to the temperature gradient often maintainable in stationary tanks. The warmer temperature in pocket 18 facilitates the maintenance of equilibrium between the liquid and its gas phase 32.

To deenergize gas phase 32, the condensing effect of the subcooled liquid in reservoir 12 is employed. Gas is returned to reservoir 12 via return means generally designated 44 which communicates first return tap 46 and second return tap 47.

Return flow regulator 48 is connected in series with return conduit 49 to control flow therethrough. Regulator 48 is operative in response to a signal which indicates the desirability of reducing the pressure of the gas phase 32 cushion. In the drawing, regulator 48 is shown responsive to variations of the pressure exerted by gas phase 32.

A subcooled liquid acts as a condenser, but additional condenser means shown as condenser coil 51 disposed in reservoir 12 and in flow series with return conduit 49 is also provided.

In operation, the reservoir is filled through passage 13 so that the entire reservoir is filled. Subcooled liquid is passed via overflow conduit 29, to fill pocket 18. Ports 52 and 53 permit the exhausting of entrapped gases. When both reservoir 12 and pocket 18 are filled a valve (not shown) closes passage 13. Vaporizer flow regulator 43 is opened permitting vaporizer coil 38 to build up gas phase 32 to a desired pressure. Gas phase 32 then acts as a cushion maintaining a head on level 4 of the liquid. In the event the pressure of gas phase 32 becomes excessive, return flow regulator 48 opens to permit the return of a portion of gas phase 32 to reservoir 12 where it will be condensed by subcooled liquid.

Transportation of liquified gases is only one application of the present invention. An example of other applications of this invention is in fuel tank designs for volatile liquids. Within the context of this specification any receptacle designed for jostling and to contain a subcooled liquid may be considered a receptacle for transporting substances in their subcooled state. It will be understood by those skilled in thermodynamics that wide changes may be made in the details of construction and in the correlation of the various elements of this invention without departing from the scope of this invention as defined by the claims.

What is claimed is:

1. The means for transporting substances in their subcooled liquid state comprising:

(*a*) a closed vessel defining a reservoir for the liquid,

(*b*) an expansion tank having an upper portion and a lower portion,

(*c*) means connected to said reservoir for commmunicating the liquid in said reservoir with said lower portion of said expansion tank whereby liquid from said reservoir is deposited in said lower portion,

(*d*) gasifying means operatively associated between said lower portion of said expansion tank and said upper portion of said expansion tank to generate the gas phase from the liquid in said lower portion and discharge said gas phase in said upper portion whereby a gas phase cushion will be formed in said upper portion,

(*e*) return means communicating said upper portion of said expansion tank with said reservoir and adapted to return a portion of said gas phase to said reservoir on the pressure of said gas phase exceeding a predetermined value.

2. A receptacle for transporting substances in their subcooled liquid state comprising, a closed vessel defining a reservoir for the liquid, said vessel forming an upper portion of said reservoir, an expansion tank defining a pocket, said expansion tank defining an upper portion of said pocket and a lower portion of said pocket, an overflow conduit in said reservoir for communicating said upper portion of said reservoir with said lower portion of said pocket and for permitting a portion of said liquid to be delivered to said pocket, said expansion tank defining a liquid hole and a gas hole, said liquid hole disposed below said gas hole, gasifying means including a vaporizer conduit disposed externally of said tank and communicating said liquid hole and said gas hole, said vaporizer conduit receiving cargo liquid from said pocket through said liquid hole and exhausting gas phase of said cargo liquid to said pocket through said gas hole, heat supply means in non-contacting heat exchange relationship with said vaporizer circuit, return means communicating said upper portion of said pocket with said reservoir to return a portion of said gas phase to said reservoir.

3. The means for transporting substances in their subcooled liquid state as claimed in claim 2 with atmosphere air as said heat supply means, a blower operatively disposed to circulate said air past said vaporizer circuit.

4. The means for transporting substances in their subcooled liquid state as claimed in claim 3 with a return flow regulator operatively associated with said return means to control flow therethrough, said return flow regulator operative in response to variations of the pressure exerted by said gas phase.

5. The means for transporting substances in their subcooled liquid state as claimed in claim 4 with a condenser tube connected in series with said return means, said condenser tube disposed in said reservoir.

6. The receptacle claimed in claim 2 with a vaporizer flow regulator operatively associated with said vaporizer conduit to control flow therethrough, said vaporizer flow regulator operative to throttle the flow of liquid from said pocket to said vaporizer conduit, said vaporizer flow regulator operative in response to variations of the pressure exerted by said gas phase in said upper portion of said pocket.

7. The receptacle for transporting substances in their subcooled liquid state as claimed in claim 6 with said vaporizer conduit of sufficient size to permit the vaporization of liquid by non-contacting heat exchange with atmosphere air.

8. The receptacle for transporting substances in their subcooled liquid state as claimed in claim 7 with a blower operatively disposed to circulate air past said vaporizer conduit.

9. The receptacle for transporting substances in their subcooled liquid state as claimed in claim 8 with said tank including a tank crown, said tank crown defining a first return tap, said vessel including a vessel crown, said vessel crown defining a second return tap, said return means comprising a return conduit communicating said first and second return taps, a return flow regulator operatively associated with said return conduit to control flow therethrough, said return flow regulator operative in response to variations of the pressure exerted by said gas phase in said upper portion of said pocket.

10. The receptacle for transporting substances in their subcooled liquid state as claimed in claim 9 with a condenser tube connected in series with said return conduit, said condenser tube disposed in said reservoir.


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