

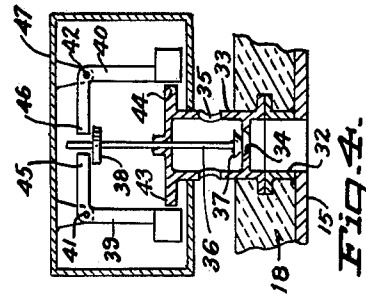
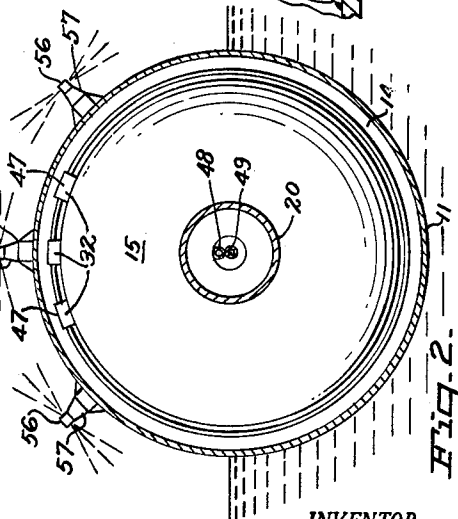
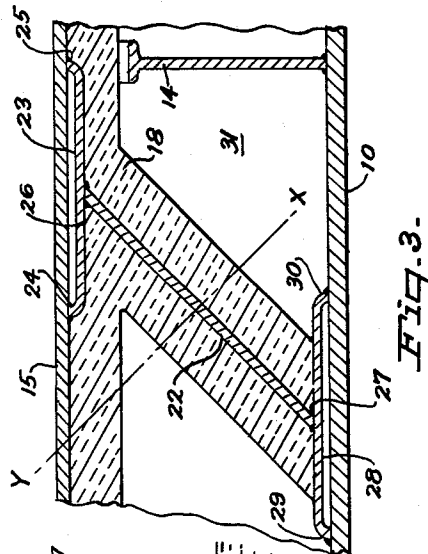
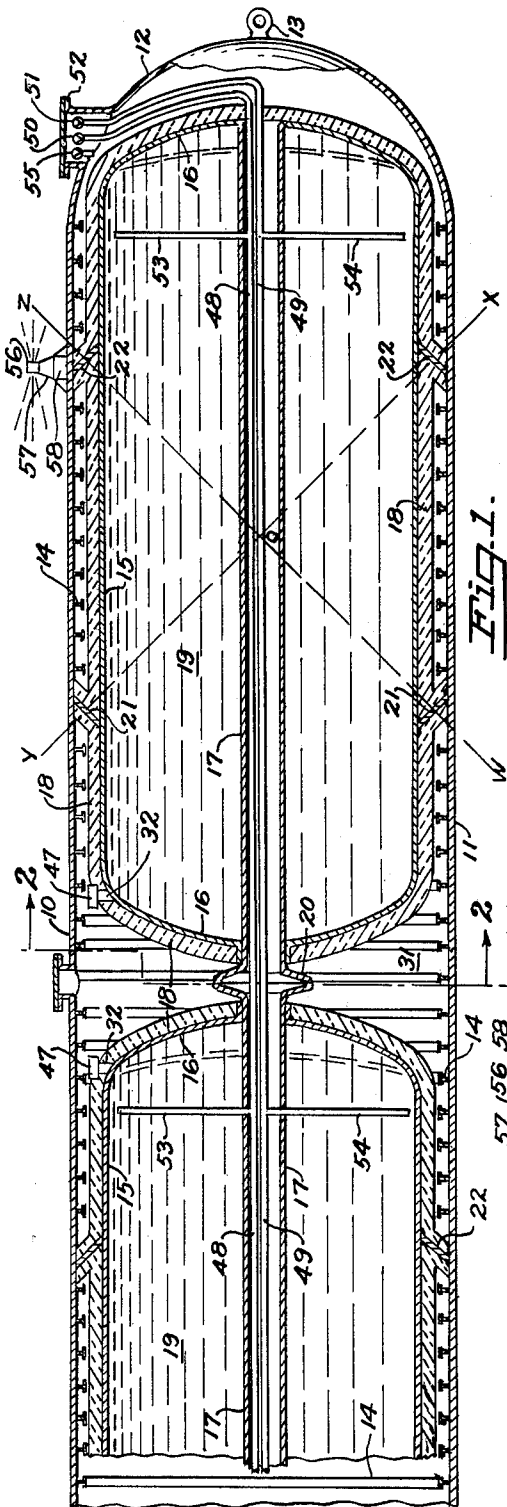
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3,157,147

VESSEL FOR LIQUEFIED GAS

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3,157,147

VESSEL FOR LIQUEFIED GAS

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9 Claims. (Cl. 114-74)

This invention relates to ocean-going vessels which are towed or which may have a powered section at their stern portion, and particularly refers to an improved arrangement of a cylindrical pressure hull section with a plurality of insulated cylindrical chambers concentrically supported therein and adapted to convey liquefied gas under pressure with little or no evaporation loss.

Among the objects of this invention are included:

(1) To provide an improved cylindrical pressure hull construction for a tank ship or a tank vessel, and particularly a novel arrangement of frusto-conical skirts to support internal chambers, these supports being located at specifically designated points to minimize stresses due to the large temperature changes involved in the handling of liquefied petroleum gases at temperatures ranging downwardly from atmospheric to about minus 260°-300° F.

(2) To provide an improved cylindrical pressure hull and internal liquid-containing chamber arrangement with means for venting only vaporized material into the pressure hull under conditions of rolling or oscillation of the vessel about its longitudinal axis.

(3) To provide an improved cylindrical pressure hull and internal liquid-containing chamber arrangement per se with means for filling and emptying the latter without the use of pumps or other mechanical equipment.

(4) To provide an improved attitude-controlled vent valve construction which will prevent release of liquid phase material to the pressurized hull of a vessel of this type.

(5) To provide an arrangement of hull framing, internal chamber supports, and insulation that will prevent moisture accumulation in the latter that would reduce its effectiveness in preventing heat transmission to the chambers and the liquefied gas therein.

(6) To provide an arrangement of a tank vessel in which the outer hull is of adequate strength to withstand wave action and at the same time is adequate to contain internal pressure due to temperature rise of the liquefied gas cargo, thereby enabling voyages of long duration to be made without the loss of any vaporized product.

(7) To provide a tank structure for liquefied gas, such as natural gas, wherein the external shell contains the gas pressures involved, permitting the inner chambers to be of a thinner construction, to conserve the expensive alloys of which they are constructed.

(8) To provide a form of cylindrical hull for a tank vessel that will be least affected by wave action that would cause rolling, and hence will give the least agitation to refrigerated liquefied gas cargo, thereby to reduce the heating and consequent vapor release from the latter.

These and other objects and advantages will be further apparent from the following description of a preferred embodiment of the invention, taken in connection with the attached drawing, which forms a part of this specification.

In the drawing, FIG. 1 is a side elevation view, partially cut-away, of the bow portion of a tank barge or tank ship embodying the invention.

FIG. 2 is a transverse vertical sectional view taken on line 2-2 of FIG. 1.

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FIG. 3 is an enlarged vertical sectional view showing a preferred detail of an attachment skirt connecting the inner tank or chamber to the pressure hull.

FIG. 4 is a schematic view of a type of attitude-responsive vent valve suitable for the arrangement of FIGS. 1 and 2.

Referring to the drawing, reference numeral 10 designates a cylindrical pressure hull, preferably without any external longitudinal keel or other appendages that would tend to destroy its symmetry and cause it to roll or oscillate about its longitudinal axis in a heavy sea. Desirably, but not necessarily, the bottom plates 11 of the hull may be somewhat thicker than the others, to add to the stability and to give the structure a relatively long natural period of roll, say of the order of a minute or more.

The forward or bow end 12 of hull 10 in the example shown is generally hemispherical in shape and provided with a towing attachment 13. The stern (not shown) may also be hemispherical, if the vessel is to be towed, or could contain propulsion and navigation equipment, if this invention is to be applied to a tank ship.

Hull 10 is designed as a cylindrical pressure vessel, for example to retain safely an internal pressure of 50 pounds per square inch gauge (p.s.i.g.) if liquefied natural gas or methane is to be transported, and is provided with a plurality of circumferential inner reinforcing frames 14 spaced as required throughout the cylindrical portion. Under some conditions longitudinals may also be needed.

Within frames 14 but out of contact therewith there are supported a plurality of axially aligned cylindrical chambers 15, desirably of aluminum or an alloy of iron and nickel that will not be embrittled or weakened by repeated temperature cycles, ranging from atmospheric down to minus 260°-300° F. which may be imposed by successive loading and unloading cycles, periodic overhauls and other factors. The ends 16 of each chamber 15 are desirably ellipsoidal and are connected by an internal axial tube 17, also of alloy steel, which serves to provide an access passage and a support for fluid conveying piping to be described below. A suitable insulation layer 18 surrounds each chamber and is also spaced to be free from contact with the inner faces of hull frames 14, to reduce the transmission of heat to chambers 15 and the liquefied gas 19 contained therein. A radially extending lip 20 is formed in the axial tube 17 between the ends of adjacent chambers 15, to equalize the expansion and contraction stresses along the tube 17.

Referring now to FIGS. 1 and 3, the sole support for each chamber 15 and its contents comprises an opposed pair of frusto-conical skirts 21 and 22, secured between the inner face of hull 10 and the outer face of chamber 15 and extending entirely around the latter. To provide for the unavoidable changes of length of chamber 15 during the temperature changes in its operating cycles, skirts 21 and 22 are so located and shaped as to flex slightly and uniformly between their inner and outer edges, without exceeding the elastic limit of the alloy steel of which they are constructed. To this end they are so located with respect to the center O of chamber 15 that lines X, Y and W, Z, which are normal to the inner conical surfaces of 21 and 22, will pass, respectively, substantially through point O. In this example the skirts are so placed that their inner faces are at an angle of 45° with respect to chamber 15. If they were desired to be further apart, this angle would be increased to maintain the required relationship of the center O of the chamber and the lines X, Y and W, Z just given. As an example, for a chamber 15 about 55 feet in diameter and 100 feet long, containing between 30,000 and 40,000 barrels of liquefied methane and with an annular spacing between

the wall of chamber 15 and hull 10 of 30 inches, the thickness of each skirt 21 and 22 need be only about ½ inch of 9% nickel alloy steel.

FIG. 3 illustrates a desirable modification of the direct attachment between the skirt edges and the walls of chamber 15 and hull 10 shown in FIG. 1. To add flexibility and distribute weld stresses more effectively, a shallow channel ring 23 is welded along its edges 24 and 25 to the wall of chamber 15, and the edge 26 of skirt 22 is welded to the median line of the channel. Similarly, a channel ring 28 is secured to hull 10 along its edges 29 and 30, and the edge 27 of skirt 22 is welded to its median line. A similar construction can be applied to the opposed skirt 21. Insulation 18 is desirably extended to cover both sides of skirts 21 and 22 to reduce the transmission of heat thereto from the gas-filled space 31 inside of hull 10. It is not necessary to make the outer surface of insulation 18 impervious, in fact it is desirable that the vaporized gaseous product should permeate it to avoid possible accumulations of moisture which would freeze and reduce its insulating properties.

It is contemplated that the pressure of the vaporized product gas which fills space 31 should be between that in chambers 15 and atmospheric pressure, for example at about 50 p.s.i.g., and this requires some form of pressure release valve means in the top of chamber 15. To insure that this valve will pass only vapor and not liquid phase material 19 into space 31 when the vessel is rolling, it is desirable that some form of attitude control should be superimposed on the pressure responsive means. The arrangement shown schematically in FIG. 4 provides this feature and will now be described.

At one or more points at the top of chamber 15 and on each side of its center line are placed flanged pipe nipples 32 each communicating with a valve body 33 having a seat 34 and outlet ports 35. An axially movable stem 36 carries valve member 37, which will rest on and close seat 34 unless the pressure inside chamber 15 rises to a predetermined value. To prevent the latter from happening when the vessel is rolling so that the lower end of nipple 32 is momentarily below the liquid level in chamber 15, a gravity-responsive attitude control is provided for stem 36. In this example it consists of a disc 38 on the stem and a pair of opposed weighted levers 39 and 40. Levers 39 and 40 are pivoted at 41 and 42, respectively, and their lower weighted ends are normally in contact with fixed abutments 43 and 44, with their upper ends 45 and 46 each spaced somewhat above disc 38 so that stem 36 and valve member 37 are free to move upwardly to open the passage through the valve body 34 and release gas from chamber 15 to space 31. The levers 39 and 40 lie in a vertical plane which is transverse to the longitudinal axis of tank 15. Thus, if the tank rolls either way from the vertical, one of the two weights will swing out and depress end 45 or 46, holding the valve 37 shut regardless of the pressure below its seat. A light metal housing 47 may be provided for this arrangement.

Means for filling tanks or chambers 15 are included in the form of an inlet piping system generally designated 48 and outlet piping system 49, leading respectively, from valves 50 and 51 at access hatch 52 in hull 10. These systems traverse axial tubes 17 and extend throughout all the chambers 15. Risers 53 lead upwardly from 48 and open into the vapor space above the liquid level of the liquefied product 19 being carried in chambers 15. Product outlet or drawoff lines 54 lead downwardly from system 49 to the bottoms of the chambers 15. A third valve 55 at hatch 52 communicates only with the gas space 31 inside of hull 10. To fill the tanks, valve 50 is connected to a source of liquefied gaseous product, for example methane, which is forced into system 48 under suitable high pressure until the tanks 15 are filled to the desired level. To empty the tanks at their destination, outlet valve 51 is connected to suitable insulated storage containers (not shown) whereupon the expanding vapor

in the tops of tanks 15 will displace the liquid phase material through outlet system 49. Under certain conditions it may be necessary to introduce displacing gas through system 48 to completely empty the tanks of liquefied product, or to refrigerate them before loading.

Maritime regulations usually require signal means, such as lights 56 for vessels being towed, under way, or at anchor, and these may be provided on external mounts 57, and desirably each with its independent power supply and control means 58 external to the pressure hull 10.

In conclusion, it will be apparent that numerous changes, for example, that of surrounding pressure hull 10 with an additional shell to meet governmental regulations, could be made in certain of the features and arrangements shown and described without departing from the invention herein, and all such modifications that come within the scope of the appended claims are intended to be embraced thereby.

I claim:

1. A rigid cylindrical vessel for conveying a liquefied gas under pressure, comprising a cylindrical outer pressure hull having a plurality of inner circumferential frames, a plurality of insulated cylindrical liquefied gas chambers concentrically supported in said hull to be free of said frames, vent means for said chambers communicating with said hull to release vaporized material thereio and support means connecting each of said chambers to said hull, said support means comprising a pair of opposed frusto-conical skirts secured to said hull and to said chamber in such a position that a line extending inwardly normal to the surfaces of each of said skirts passes substantially through the midpoint of said chamber, to equalize expansion and contraction stresses in said chamber.

2. A vessel according to claim 1, in which each of said cylindrical chambers is provided with means forming an axial access and piping passage connecting the ends of said chambers.

3. A vessel according to claim 1, with the addition of a plurality of navigation lights at the ends of said vessel and spaced around a part of its circumference so that at least one will be visible at any normal attitude of said vessel, and a power source for said lights isolated from vapors within said hull.

4. A pair of opposed frusto-conical connectors for supporting a horizontal cylindrical chamber concentrically positioned in a cylindrical vessel, the wall of said chamber being subjected to larger temperature changes than that of said vessel, each connector comprising a frusto-conical skirt and means securing said skirt at its smaller end to said chamber wall and at its larger end to said vessel wall and in such a position in said vessel that a line extending inwardly normal to the surfaces of each of said skirts passes substantially through the midpoint of said chamber.

5. A pair of connectors according to claim 4 in which the securing means for the edges of said skirts comprise shallow circular channel members secured, respectively, to said chamber and to said vessel, said skirts being secured between the median portions of said channels.

6. A vessel according to claim 1, in which said vent means for each of said chambers to said hull comprises at least one pressure-responsive valve, said valve being provided with a gravity-responsive element to keep said valve in closed condition when the attitude of said vessel places said valve below the liquid level in said chamber to prevent the release of liquid to said hull.

7. An attitude-responsive valve for releasing vapor from a partially liquid-filled tank undergoing periodic oscillation about its longitudinal axis, comprising a body having means forming a passage, a valve seat in said passage, a valve member movable from said seat to an open position when the pressure in said passage below said seat exceeds a predetermined value, attitude-responsive means for said valve member for holding it in closed position independently of pressure so long as the attitude of said tank and said body departs from the vertical by an amount

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which would permit liquid to be released from said tank by said valve.

8. An attitude-responsive valve for releasing vapor from a partially liquid-filled tank undergoing periodic oscillation about its longitudinal axis, comprising a valve seat, a valve member having a stem and movable from said seat to an open position when the pressure in said tank reaches a predetermined value, and gravity-responsive means associated with said stem for keeping said valve against said seat when the angle between said stem and the vertical exceeds a predetermined value independently of the pressure in said tank.

9. A valve according to claim 7 in which said attitude-responsive means comprises a pair of opposed weighted levers pivoted in a plane at right angles to the longitudinal

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axis of said tank, said valve body provided with opposed vertical abutments for said levers, so constructed and arranged that when said passage is vertical said valve is free to be opened by said predetermined pressure beneath said seat, and when said passage is inclined in said plane one of said levers will move to prevent motion of said valve from said seat.

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