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[54] **METHOD AND APPARATUS FOR TRANSPORTING LIQUEFIED GAS**
16 Claims, 3 Drawing Figs.

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[50] **Field of Search** 62/239, 45, 55, 54, 51, 52, 53; 141/4, 5, 44, 45, 37; 137/210; 220/14

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ABSTRACT: A movable pressure vessel has an insulated wall portion for limiting the temperature rise of liquefied gas therewithin. A relief valve is provided for limiting the pressure within the vessel to establish a working pressure. The filling means of the vessel includes a relief valve for limiting the maximum pressure of the gas entering the vessel to a pressure of approximately 15 p.s.i.g. less than the working pressure of the vessel. Liquefied gas is loaded into the vessel at a maximum temperature and pressure as determined by the relief valve in the filling means, and temperature rise of the liquefied gas during transport is limited so that the pressure produced by the gas does not exceed the working pressure of the vessel. A vapor return means extends along the bottom of the vessel and opens therewithin at a point remote from the outlet means of the vessel and adjacent the front end of the vessel.

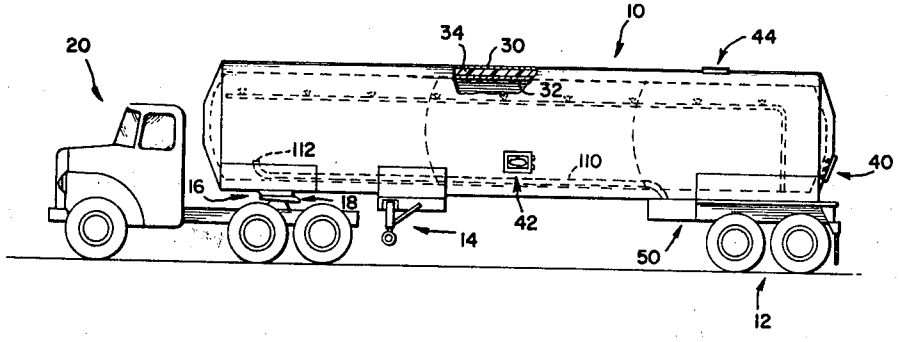


Fig. 2.

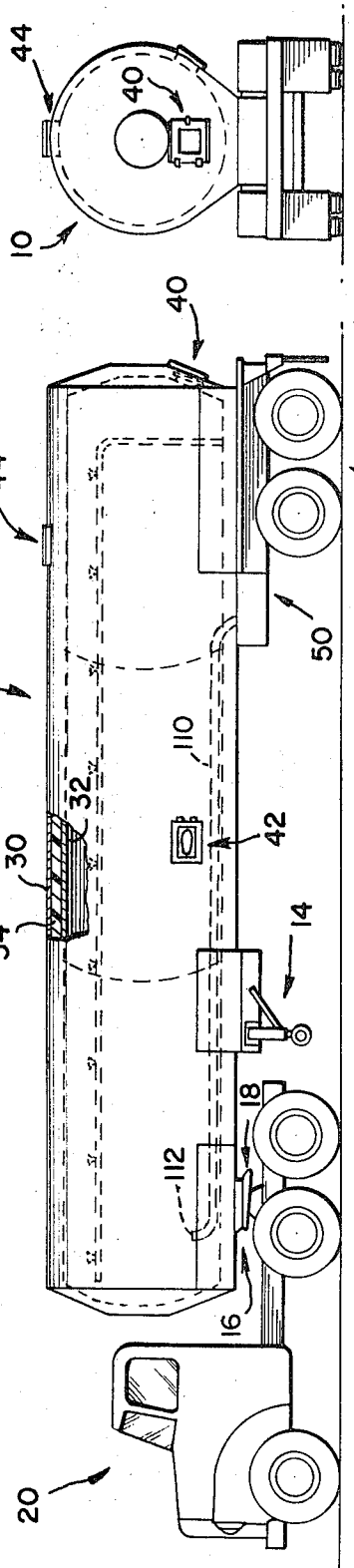


Fig. 3.

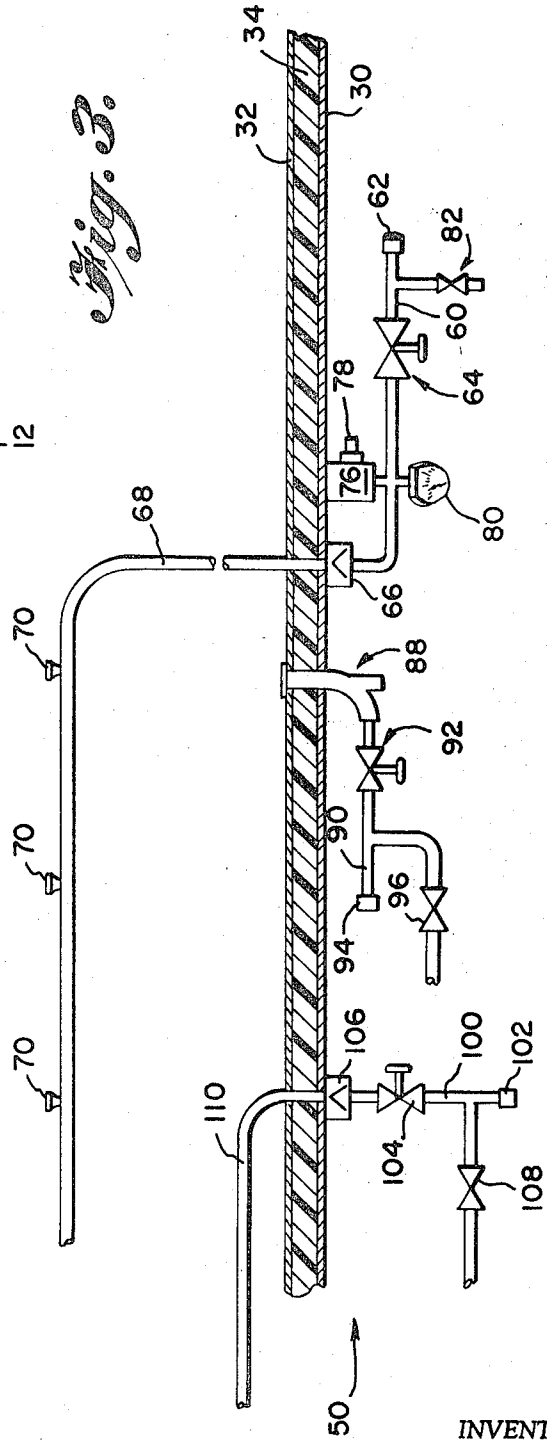


Fig. 1.

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METHOD AND APPARATUS FOR TRANSPORTING LIQUEFIED GAS

BACKGROUND OF THE INVENTION

The present invention relates to the transportation of liquified gas by movable pressure vessels such as trailers now employed by common carriers for transporting liquified gases such as anhydrous ammonia and propane or the like. The economics of the transportation of such products is such that it is necessary to provide a single unit which is suitable for carrying both products.

In the past, liquified gases have been transported either by means of a vessel having a relatively high working pressure, or by one having a relatively low working pressure. A typical high working pressure unit may be designed for working pressures of approximately 265 p.s.i.g. capable of transporting liquified gases at temperatures up to approximately 115° F. On the other hand, the low-pressure units require the transported commodity to be refrigerated. This latter type of arrangement is quite expensive and is very restricted in application and would not be suitable for use with propane since propane is normally loaded at temperatures within the range of about 50° to 70° F. Refrigeration of propane before loading would be so expensive that this type of unit would not be economically feasible.

High working pressure vessels now in use comprise an uninsulated pressure vessel, generally manufactured of T-1 steel which is trailerized and equipped with the necessary loading and unloading valves and fittings.

The problems encountered with stress corrosion cracking due to the transportation of contaminated or uninhibited ammonia has cast increasing doubts as to the longterm economics of such high working pressure vessels now in use.

Recent government regulations require frequent and expensive examination of the vessels to detect stress corrosion cracking. The repair of such damage is quite expensive if extensive damage is discovered.

At present, liquified gas may be received from normal storage facilities at a temperature of approximately 30° F. to 60° F. depending upon the time of the year. After being loaded in a typical high working pressure unit, the vapor space may readily be warmed up to 100° or 115° F. resulting in blowoff from the relief valves of the unit.

It is apparent that presently existing units are disadvantageous since the high working pressure units are of excessively heavy construction thereby substantially increasing the cost and weight of the vessel. On the other hand, low-pressure-type units require an expensive insulating and refrigerating system and are not feasible for use with propane for example.

SUMMARY OF THE INVENTION

The present invention contemplates the provision of a movable pressure vessel having an insulated wall portion defining a closed cavity therewithin for receiving liquefied gas. The wall portion is provided with heat insulation sufficient to limit the heat rise of the liquefied gas during transport to certain predetermined limits. A relief valve is provided in communication with the cavity in the vessel to vent the cavity to atmosphere to establish the working pressure of the vessel.

Filling means is provided for loading the vessel with liquefied gas, a relief valve being provided in the filling means which is set at a pressure approximately 15 p.s.i.g. less than the setting of the relief valve of the vessel. Accordingly, this limits the liquefied gas loaded into the vessel to a maximum pressure at least about 15 p.s.i.g. less than the working pressure of the vessel.

Additionally, the filling means is provided with a thermometer so that the temperature of the liquefied gas loaded into the vessel can be monitored.

The vessel is provided with conventional outlet means, and a vapor return means is provided which is disposed within the vessel and extends along the bottom thereof and opens at a point remote from the outlet means and adjacent the front of the vessel.

The arrangement is such that both anhydrous ammonia and propane can be readily handled in the liquefied state, and the apparatus and method of the present invention provides the greatest total economy.

The ammonia and propane are loaded into the tank up to a maximum temperature and pressure, and the tank is provided with sufficient insulation to ensure that the temperature rise of the gas during transport is within such limits that the pressure within the tank does not exceed the working pressure of the tank so that the gas can be unloaded at a pressure not in excess of the working pressure of the tank. It should be understood that the pressure rise is desirably actually limited to an amount such that it does not exceed a value slightly less than the working pressure to prevent blowoff of gas.

Since the vessel of the present invention has a lower working pressure than conventional uninsulated high-pressure units, the vessel of the present invention can employ a thinner shell and also may eliminate the need for T-1 steel construction so that carbon steel, stainless steel or aluminum may be economically employed in the construction of the vessel. The utilization of such materials will eliminate the stress corrosion problem which is currently causing operational difficulties.

A particular feature of the construction of the present invention is the fact that the insulated vessel of the present invention avoids the excessive pressure requirements which are encountered with normal high-pressure uninsulated vessels when exposed to the sun's energy during hot weather or summer operations.

The vessel of the present invention is equipped for handling ammonia or propane from either a refrigerated or a non-refrigerated storage tank and for discharging to either type of storage or receiving facility. The use of materials such as aluminum or stainless steel in the construction of the vessel along with appropriate accessories makes the vessel economical for transporting other commodities, thus enhancing the overall value of the vessel to a carrier.

The arrangement of the present invention permits the production of a more efficient unit thus reducing the weight and potential total cost of the unit.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is an elevation of a transport unit according to the present invention;

FIG. **2** is an end view of the structure shown in FIG. **1**; and

FIG. **3** is a cross-sectional view schematically illustrating the piping arrangement employed with the pressure vessel of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawing wherein like reference characters designate corresponding parts throughout the several views, a pressure vessel according to the present invention is indicated generally by reference numeral **10**, this vessel being suitably trailerized and provided with a bogie **12** at the rear end thereof having the usual wheels supported thereon. An auxiliary support assembly **14** of conventional construction is provided forwardly of the bogie **12**, and a kingpin arrangement **16** mounted at the forward underside of the vessel is adapted to cooperate with the usual fifth wheel **18** provided on a conventional tractor **20**. It is apparent that the overall arrangement provides a tractor and trailer assembly which is adapted to move over highways to transport liquefied gas from one location to another.

The wall of the vessel includes an outer rigid metallic shell **30** and an inner rigid metallic shell **32** spaced from the outer shell. A suitable heat insulation substance **34** such as foamed polyurethane or the like is provided in the space between the two shells **30** and **32** to provide the necessary heat insulation for the vessel.

Numeral **40** represents a manhole with a pressure gauge and thermometer along with a viewing window in an insulated cover. Numeral **42** designates a rotary liquid level gauge in an insulated cover. A first relief valve assembly **44** is operatively

associated with a spring-loaded insulated cover so that the cover lifts if the relief valve operates.

As seen in FIG. 1, 50 indicates generally the conventional piping system along with safety equipment, control valves and the like which are mounted at the rear end of the vessel.

Referring now to FIG. 3, the details of the piping system may be more fully understood. A 3-inch filling line 60 is provided for loading gas into the vessel. A coupling 62 is provided for connecting this filling line with a suitable filling mechanism. A 3-inch manually operable valve 64 is connected in the line for controlling the flow of liquefied gas therethrough. A one-way check valve 66 is provided in the filling line to enable liquefied gas to be loaded into the vessel and to prevent back flow from the vessel. The filling line includes a portion 68 extending within the vessel and has a plurality of spray nozzles 70 connected therealong, this spray-filling line extending forwardly within the vessel adjacent the top thereof so as to spray the incoming liquefied gas against the top of the vessel in order to cool the vessel as rapidly as possible to reduce the pressure buildup in the vessel during the loading operation.

A relief valve 76 is connected in the filling line 60 and is adapted to vent the filling line to atmosphere through a conduit 78 when the pressure exceeds the setting of the relief valve. A temperature-measuring means such as a thermometer 80 is also connected with the filling line 60 and is employed for monitoring the temperature of the liquefied gas as it is being loaded into the vessel, particularly if any gas is discharged through relief valve 76.

A blow down valve 82 is connected with the filling line intermediate the fitting 62 and valve 64. This blow down valve is employed for exhausting gas from the inlet side of the valve 64 prior to removing the filling means connected with fitting 62.

The outlet means includes a conventional fail-safe emergency valve 88 connected with an outlet line 90. A manually operable 3-inch valve 92 is connected in this outlet line, and a fitting 94 is adapted to be connected with a suitable outlet conduit or conventional pumping system if so desired. A blow down valve 96 is employed for exhausting product from the outlet line on the discharge side of the shutoff valve 92 prior to removing any unloading hoses or piping connected with the outlet means.

A vapor return line 100 is provided with a fitting 102 for connection with a suitable conduit means to provide a vapor return line from a tank being filled to the vessel. A manually operable control valve 104 is provided, and a one-way check valve 106 is connected in the vapor return line to permit flow of vapor into the interior of the vessel and to prevent backflow therefrom. A blow down valve 108 is connected between fitting 102 and valve 104 to permit gas to be vented from the vapor return line prior to disconnecting fitting 102 from associated conduit means.

The vapor return line includes a portion 110 disposed within the interior of the vessel and which extends forwardly within the vessel adjacent the bottom thereof so as to be immersed within the liquefied gas disposed within the vessel. The forward end 112 of portion 110 of the vapor return line as seen in FIG. 1 opens into the interior of the vessel at a point remote from the outlet means and adjacent the front of the vessel. This arrangement ensures that warm vapor returning from a tank being filled is cooled as it passes through portion 110 of the vapor return line whereupon the vapor is discharged within the forward end of the vessel.

The relief valve means 44 of the vessel determines the working pressure of the vessel. The highest working pressure of a vessel according to the present invention is about 175 p.s.i.g. Relief valve 44 is therefore set to open at such pressure. The relief valve 76 is accordingly set to open at a pressure of approximately 160 p.s.i.g. which is about 15 p.s.i.g. less than the pressure at which relief valve 44 is set to open.

With a vessel having the relief valve settings as described, propane may be loaded at any temperature up to about 95° F. which corresponds to a pressure of 160 p.s.i.g., and may be unloaded at any temperature up to 101° F. which corresponds to a pressure of 175 p.s.i.g. Similarly, anhydrous ammonia may be loaded at any temperature up to about 88° F. which corresponds to a pressure of 160 p.s.i.g. and may be unloaded at any temperature up to about 93° F. which corresponds to a pressure of 175 p.s.i.g.

A pressure vessel according to the present invention may have an intermediate working pressure of about 125 p.s.i.g., and in such instance relief valve 44 is set to open at 125 p.s.i.g. and relief valve 76 is set to open at approximately 110 p.s.i.g.

With a vessel having an intermediate working pressure of approximately 125 p.s.i.g., propane may be loaded at a temperature of up to about 70° F. which corresponds to a pressure of 109.3 p.s.i.g. and may be unloaded at a temperature up to about 78° F. which corresponds to a pressure of 125 p.s.i.g. Similarly, anhydrous ammonia may be loaded into such a vessel at any temperature up to about 68° F. which corresponds to a pressure of 110 p.s.i.g., and may be unloaded at any temperature up to about 75° F. which corresponds to a pressure of 125 p.s.i.g.

A vessel according to the present invention may also be designed to operate at a minimum working pressure of about 100 p.s.i.g. In such a case, relief valve 44 is set to open at about 100 p.s.i.g. and relief valve 76 is set to open at about 85 p.s.i.g.

In a vessel designed for operation at this minimum working pressure, propane may be loaded at any temperature up to about 55° F. which corresponds to a pressure of 84.6 p.s.i.g., and may be unloaded at any temperature up to about 64.5° F. which corresponds to a temperature of 100 p.s.i.g. Similarly, anhydrous ammonia may be loaded at any temperature up to about 56° F. which corresponds to a pressure of 85.2 p.s.i.g. and may be unloaded at any temperature up to about 63.9° F. which corresponds to a pressure of 100 p.s.i.g.

The time of transport of the liquefied gas is in the range of about 12 to 48 hours.

It will be noted that the pressure rise during the transport time between the maximum loading and unloading pressures in each case is approximately 15 p.s.i.g. Accordingly, an important feature of the present invention is the fact that the pressure rise is limited to no more than about 15 p.s.i.g. during the transport time of the gas in the vessel.

It will be noted that the temperature rise varies between the maximum loading and unloading temperatures in the different cases from about 5° F. to about 10° F. Accordingly, the insulation of the vessel is such as to limit the pressure rise from the maximum loading temperatures to no more than about 10° F. which will cause the pressure rise to fall within the aforedescribed limits.

It will be understood that the loading and unloading temperatures and pressures given above are the maximum values practical for loading the liquefied gas for a given working pressure of the pressure vessel. The liquefied gas can be loaded at any temperature and pressure lower than those set forth hereinabove. For example, propane and ammonia gas are generally loaded at a pipeline terminal at a maximum temperature of about 65° F. Propane is generally loaded from underground storage facilities such as caverns and the like at temperatures of about 45° to 60° F. On the other hand, refrigerated anhydrous ammonia is presently loaded from storage systems at new plants at temperatures of about −28° F. to −20° F.

Ammonia may be loaded from refrigerated storage at its boiling point of −28° F. and its temperature may be increased in route to approximately +20° F. to +32° F. so that it can be unloaded into normal nonrefrigerated storage without causing handling problems due to the formation of rust on piping, valves and instrumentation.

It is apparent that the vessel of the present invention permits both propane and anhydrous ammonia to be handled in both a refrigerated and warmed condition, and the vessel is adapted to receive these high-tonnage commodities at temperatures and pressures commonly encountered at points where trailer tanks are loaded.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive, and since the scope of the invention is defined by the appended claims, all changes that fall within the metes and bounds of the claims or that form their functional as well as conjointly cooperative equivalents are therefore intended to be embraced by those claims.

I claim:

1. The method of transporting liquefied gas comprising providing a movable insulated pressure vessel, limiting the maximum pressure within said vessel by providing a relief valve connected to said vessel to establish a working pressure, loading liquefied gas into said vessel, limiting the maximum pressure at which gas is loaded into the vessel by providing a relief valve in a fill line connected to said vessel and venting at a pressure lower than said working pressure so that the maximum pressure of the loaded gas is less than said working pressure, retaining said gas in the vessel and moving the vessel to transport the gas to a remote location, allowing the pressure produced by the gas in said vessel to rise during transport to a pressure no more than said working pressure of the vessel, and then unloading the gas at a remote location at a pressure no more than the maximum limit pressure of the vessel.

2. The method as defined in claim 1 wherein during transport the gas is allowed to increase in temperature to produce a pressure increase of no more than about 15 p.s.i.g. more than the maximum loading pressure.

3. The method as defined in claim 1 wherein during transport the liquefied gas is allowed to rise in temperature no more than about 10° above the maximum loading temperature.

4. The method as defined in claim 1 wherein the gas is retained in the vessel for a transport time of no more than about 48 hours.

5. The method as defined in claim 1 wherein the liquefied gas in the vessel is allowed to increase in temperature no more than about 10° above the maximum loading temperature and is allowed to increase in pressure no more than about 15 p.s.i.g. more than the maximum loading pressure.

6. The method as defined in claim 1 wherein the maximum loading pressure of the gas is at least 15 p.s.i.g. less than the working pressure of the vessel.

7. The method as defined in claim 1 wherein said liquefied gas comprises propane, the propane being loaded into the tank at a maximum temperature of about 95° F. and a maximum pressure of about 160 p.s.i.g.

8. The method as defined in claim 7 wherein the propane is unloaded from the vessel at a maximum temperature of about 101° F. and at a maximum of about 175 p.s.i.g.

9. The method as defined in claim 1 wherein the liquefied gas comprises anhydrous ammonia, the ammonia being loaded into the vessel at a maximum temperature of about 88° F. and a maximum pressure of about 160 p.s.i.g.

10. The method as defined in claim 9 wherein the ammonia is unloaded from the vessel at a maximum temperature of about 93° F. and a maximum pressure of about 175 p.s.i.g.

11. A movable insulated pressure vessel for transporting liquefied gas comprising a wall portion defining a closed cavity therewithin for receiving liquefied gas, said wall portion including heat-insulating means sufficient to limit the heat rise to certain limits during transport of liquefied gas, a first relief valve in communication with said cavity to vent said cavity at a predetermined pressure to establish the working pressure of the vessel, filling means for loading the vessel, outlet means for discharging gas from the vessel, vapor return means in communication with said cavity and in communication with a fitting disposed externally of said vessel for connection to a container being filled from said vessel, said filling means including a filling line having a second relief valve connected therein for determining the maximum loading pressure, said second relief valve being set to open at a lower pressure than said first-mentioned relief valve.

12. Apparatus as defined in claim 11 wherein said second relief valve is set to open at approximately 15 p.s.i.g. less than said first-mentioned relief valve.

13. Apparatus as defined in claim 11 including temperature-measuring means connected in said filling means for measuring the temperature of the liquefied gas entering said vessel.

14. Apparatus as defined in claim 11, wherein said vapor return means includes an open end portion opening within the cavity in the vessel at a point remote from said outlet means in a direction extending longitudinally of said vessel.

15. Apparatus as defined in claim 14 wherein the open end of said vapor return means opens adjacent the front end of said vessel.

16. A movable insulated pressure vessel for transporting liquefied gas comprising a wall portion defining a closed cavity therewithin for receiving liquefied gas, said wall portion including heat insulation means sufficient to limit the heat rise to certain limits during transport of liquefied gas, a first relief valve in communication with said cavity to vent said cavity at a predetermined pressure to establish the working pressure of the vessel, filling means for loading the vessel, outlet means for discharging gas from the vessel, vapor return means in communication with said cavity and in communication with a fitting disposed externally of said vessel for connection to a container being filled from said vessel, said filling means including a filling line having a second relief valve connected therein for determining the maximum loading pressure, said second relief valve being set to open at a lower pressure than said first-mentioned relief valve, said vapor return means including an open end portion opening within the cavity in the vessel at a point remote from said outlet means in a direction extending longitudinally of said vessel, said vapor return means extending along the interior of the vessel closely adjacent the bottom thereof.