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Becker

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[54] **SYSTEM FOR THE DISCHARGING OF A TRANSPORT RECEPTACLE FOR LIQUEFIED GAS**

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[52] **U.S. Cl.** **62/50**
[51] **Int. Cl.** **F17c 7/02**
[58] **Field of Search** 62/50, 51, 55, 45

[56] **References Cited**

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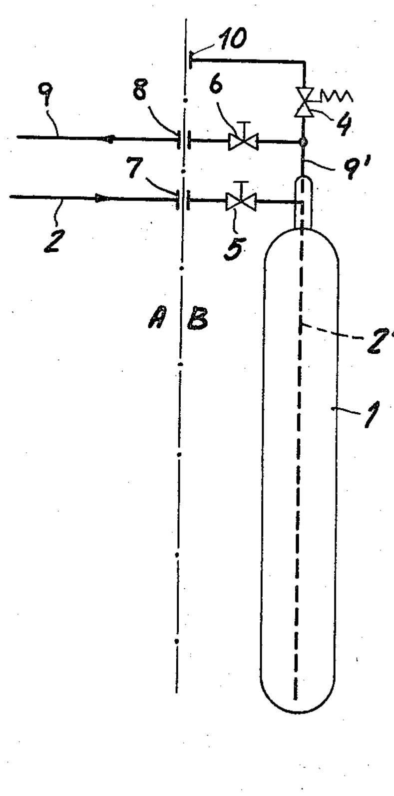
[57] **ABSTRACT**

A system for transporting liquefied gas and for the discharging of the liquefied gas from a container receiving same under pressure comprises a first pressure-relief valve permanently connected to the container and set to relieve pressures above the desired transport-pressure level and a second pressure-relief valve temporarily connected in line with the first pressure-relief valve and adapted to relieve pressures in excess of the sum of the transport pressure and the discharge pressure. The second pressure-relief valve is located at the discharge station and the receptacle for the liquefied gas may form part of a seagoing vessel for the transport of liquid methane.

2 Claims, 4 Drawing Figures



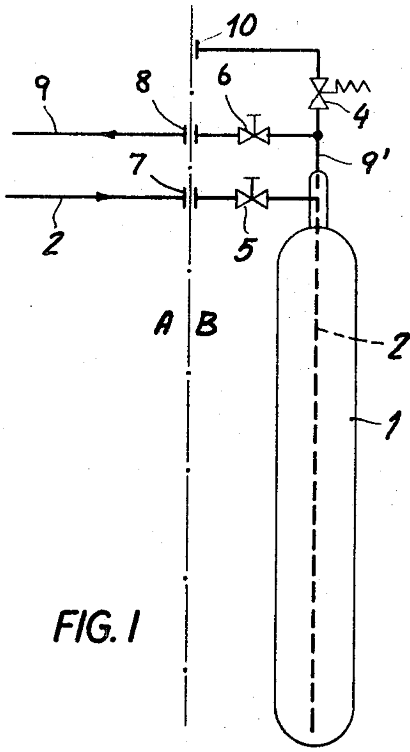


FIG. 1

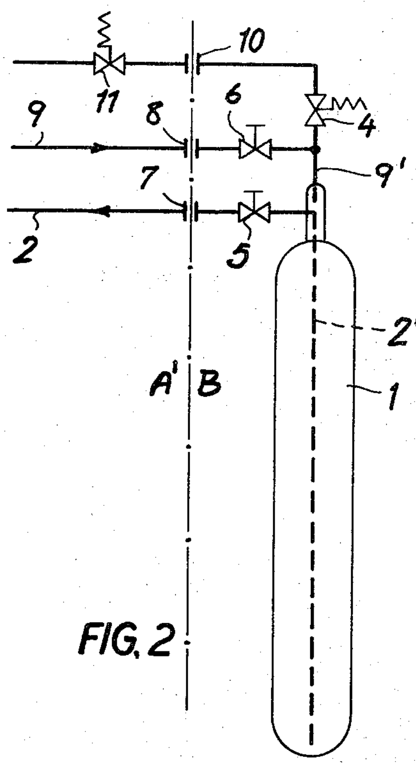


FIG. 2

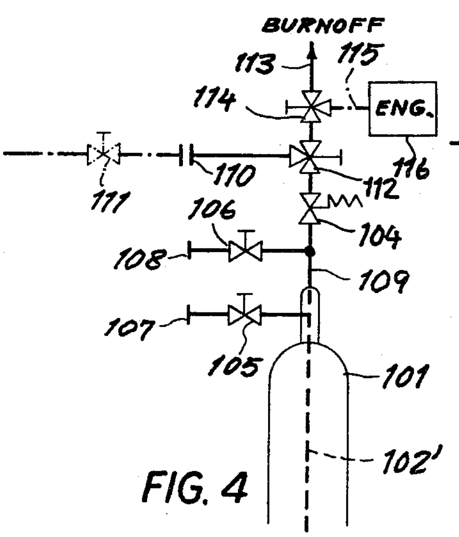


FIG. 4

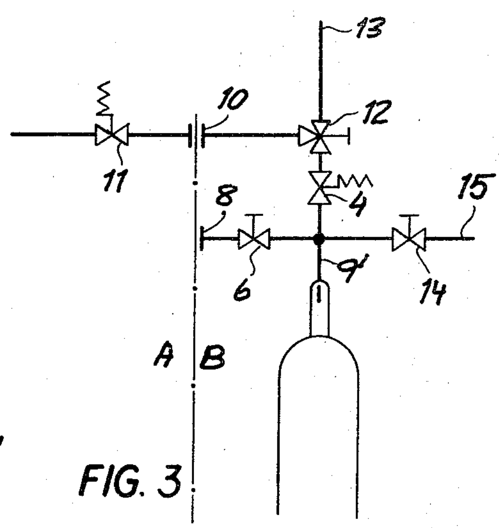


FIG. 3

SYSTEM FOR THE DISCHARGING OF A TRANSPORT RECEPTACLE FOR LIQUEFIED GAS

FIELD OF THE INVENTION

The present invention relates to a system for the discharge of liquefied gases transported under pressure and, more particularly, to a method of and an apparatus for the transportation and discharge of liquefied gases, e.g. liquid methane.

BACKGROUND OF THE INVENTION

In recent years considerable interest has been manifested in the transportation of liquefied gases over relatively long distances. Liquefied gas, generally derived from a gas field removed from an industrial area in which the gas is consumed, e.g. as a fuel, is transformed from the gaseous state to a liquid, charged into tanks of seagoing vessels at the production site, transported in these vessels over relatively large distances, and discharged from the tanks at a discharge station in the consuming region. It has been found to be economical to use such tanks for the delivery of methane or so-called natural gases to fuel-deficient regions. The transport of liquefied gases of this type has been found to be advantageous also because liquefied-gas fuels generate fewer pollutants upon combustion than solid or liquid products currently employed as fuels in many locations.

It is known to provide the tanks of a transport vessel for the purposes described with a pressure-relief valve set to discharge when the pressure within the tank reaches, during transport, an unacceptably high level. It is common practice, moreover, to dishcarge the tanks at a higher pressure than that which may be present during filling and transport at the discharge station. The pressure-relief valve must thus be able to sustain the higher of the discharge pressure and the transport pressure and the receptacle or tank must be dimensioned to sustain this higher pressure in addition to the pressure and forces generated by inertia during the transport process. It will be apparent that the transport process produces movement of the stored mass within the receptacle and consequently imparts to the mass kinetic energy which, by inertial action and impact-like transfer, is converted to force applied to the walls of the receptacle. Thus the walls of the receptacle must be capable of withstanding, not only a force corresponding to the product of the relief-valve pressure threshold and the wall area exposed to the pressure, but the transport forces resulting from mechanical action of the body of liquid upon the walls of the receptacle, in addition. Consequently, the walls of such prior-art receptacles must be made relatively thick or reinforced at considerable expense. The load-carrying capacity of a seagoing vessel, moreover, is sharply limited by the mass of the tanks in which the liquefied gas is carried.

OBJECTS OF THE INVENTION

It is, therefore, the principal object of the present invention to provide a transport receptacle or container for liquefied gas which can have reduced mass and cost for a given carrying capacity or, for a given mass and cost, can have greater load-carrying capacity than has been attainable heretofore.

Another object of the invention is to provide a system of the transport of liquefied gases especially liquid

methane in seagoing vessels, whereby the aforementioned disadvantages are obviated.

It is still another object of the invention to provide a method of transporting liquefied gases which enables the material used for the receptacles to be reduced and the cost of the transport system held lower than with conventional arrangements.

SUMMARY OF THE INVENTION

These objects are attained, in accordance with the present invention, by providing in addition to the pressure-relief valve permanently connected with the pressurizable container or receptacle, a second pressure-relief valve mounted at the discharge station and connectable in line with the first pressure-relief valve during the discharge operation. The first pressure-relief valve has a threshold corresponding to the predetermined permissible transport pressure, i.e. a pressure slightly above atmospheric, while the second pressure-relief valve has a threshold pressure which is equal to the sum of the discharge pressure and the transport pressure. Thus the first pressure-relief valve is operated to vent the tank when the pressure therein during transport or filling exceeds the transport pressure to a slight extent while the second pressure-relief valve is effective to bleed the tank when, during discharge, the pressure within the vessel exceeds, to a slight extent, the sum of the discharge pressure and the transport pressure.

The method aspects of the present invention including process for transporting a liquid, preferably a liquefied gas such as methane which may be stored at a temperature below its boiling point at ambient pressure, in a pressure-retaining receptacle with the liquid at a pressure at most equal to a predetermined transport pressure (established by the safety requirements and equal to the desired maximum pressure within the receptacle during the entire transport); transporting the receptacle to a discharge location while automatically relieving pressure in the receptacle upon the pressure therein exceeding the transport pressure; and displacing the liquid from the receptacle at the discharge location with a discharge pressure in excess of the transport pressure while automatically relieving any pressure in the receptacle upon the pressure therein exceeding the sum of the transport and discharge pressure.

With the present system, the tank walls during transport must be able to take up only the slight superatmospheric transport pressure and the acceleration and inertial forces of the liquid as well as the gravitational forces resulting from the liquid mass. It is no longer necessary to dimension the tank walls to withstand the discharge pressure in addition to the mechanical forces of transport, since the discharge pressure is applied only at the discharge station when the receptacle is no longer in motion. Moreover, this advantage is achieved without detrimentally affecting safety since the transport-pressure maximum is maintained by the first pressure-relief valve and the discharge-pressure maximum is established by the second pressure-relief valve. The difference in the pressure thresholds of the two valves may be several atmospheres. The vessel wall need only be capable of withstanding the larger of the two forces, the mechanical or acceleration forces and the forces associated with the discharge pressure.

DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a flow diagram illustrating an embodiment of the present invention in the tank-filling stage;

FIG. 2 is a view of the system of FIG. 1 in the tank-emptying or discharge stage;

FIG. 3 is a flow diagram illustrating another embodiment of the invention; and

FIG. 4 is a diagram representing still another embodiment of the instant invention.

SPECIFIC DESCRIPTION AND EXAMPLE

In FIG. 1 of the drawing, there is shown a diagrammatic transport tank **1** in the form of an upright siphon which may be mounted in a tankship represented at B shown to be disposed at dockside A for the charging of the tanks with liquid methane. The tank **1** is provided with a siphon tube **2'**, reaching to the bottom of the tank, and formed at its inlet with a valve **5** and a connector **7** which may be of the pressureretaining quick-release type and is adapted to register with another coupling portion at dockside. The tank **1** is also provided with a line **9'** opening into the tank at the top thereof and terminating short of the contents thereof in a full condition of the tank. Line **9'** is fitted with a valve **6** for controlling the discharge of gases from the tank during filling and for admitting a pressurizing gas to the tank during discharge. A quick-release pressure coupling **8** is provided for the branch of the line **9'** carrying the valve **6.** Line **9'** is also provided with a permanently attached pressure-relief valve **4** whose discharge side has a connector **10** normally open to the atmosphere but connectable at dockside to a pressure-relief valve **11** as will be apparent hereinafter.

At the charging dock (FIG. 1) connectors **7** and **8** couple a line **2** with the siphon tube **2'** and a line **9** with the vent line **9'** so that methane may be admitted through the siphon tube to the bottom of the tank while the gases rising in the tank are released via line **9.** At the discharge dock A', FIG. 2, lines **2** and **9** are joined by the connectors **7** and **8** to siphon tube **2'** and vent line **9'**, while the connector **10** is coupled with a pressure-relief valve **11** in line with the pressure-relief valve **4.**

In operation, the seagoing vessel provided with a multiplicity of the tanks **1,** connected in parallel in banks, is brought to dockside (FIG. 1) so that line **2** is connected at **7** to the siphon tube **2'** of the tank **1.** Line **9** is connected at **8** via the valve **6** to line **9'**. The valve **5** is opened and liquefied gas is pumped into the interior of the tank **1** at ambient pressure. The gases within the tank are driven out through the open valve **6** at line **9** for collection, liquefaction or flaring. The pressure-relief valve **4** has a threshold value slightly above atmospheric pressure, e.g. 0.1 atmosphere gauge. Any sudden pressure buildup within the tank during filling is relieved through this valve. Valves **5** and **6** are closed and the vessel transported to its discharge station. During transport the connector **10** is opened to the atmosphere.

During transport, any pressure increase within the tank resulting from, for example, a temperature change, is compensated by venting at the valve **4** so that the container walls need only withstand the acceleration and inertial forces produced by movement of the shift, any elevated fluid pressure within the tank being eliminated by the low-threshold valve **4.**

When the vessel reaches its discharge station (FIG. **2**), the pressure-relief valve **7** is connected at **10** in line with the valve **4** and lines **2** and **9** are connected at **7** and **8** as already described. The valve **11** may have a threshold value of two atmospheres gauge and is fixed at the discharge station. Valve **6** is then opened to admit fluid under pressure (discharge pressure less than two atmospheres) to the line **9'** and above the liquid in the tank **1,** the valve **6** being opened for this purpose. Valve **5,** also open, allows the liquid to be forced out of the tank. Valve **11** prevents the pressure within the tank **1** from exceeding the desired maximum during discharge. Since the discharge pressure is in excess of the transport pressure threshold of relief valve **4,** this valve is readily opened when valve **11** becomes effective. Since the vessel is not in motion, the wall of the tank **1** need only withstand the weight of the liquid and the gas pressure developed in the tank. When the tank is fully emptied, valves **5** and **6** are again closed and the connectors **7, 8** and **10** opened.

FIG. 3 shows a particularly advantageous embodiment which differs from the system of FIGS. **1** and **2** in the sense that a distributing valve **12** is provided between the connector **10,** the line **9'** and the flaring torch **13.** The valve **12** is of the exclusive type, i.e. either the line **13** or the connector **10** are in communication with the relief valve **4** at all times. At no time can both lines **13** and the connector **10** be cut off. In this manner it is possible to shunt gas vented at **4** during transport or filling to a flare or to the atmosphere at **10.** A line **15** may be provided to introduce excess gas to the engine of the vessel as controlled by the valve **14.**

In FIG. **4,** I have shown an arrangement in which the siphon tube **102'** of the tank **101** is provided with a valve **105** and a connector **107** while the vent line **109'** is formed with a valve **106** and a connector **108** as described previously. In this embodiment, however, a distributing valve **112** is provided in series with the first pressure-relief valve **104** and the connector **110** which is designed to place the second pressure-relief valve **111** in line with first pressure-relief valve **104.** In the alternative position of the valve **112,** the pressure-relief valve **104** may vent through still another distribution valve **114** to a flare-off torch **113** or to a line **115** connected to the engine **116.** Both valves **112** and **114** are of the exclusive-position type whereby one of the outlets of each valve is always in communication with its inlet.

I claim:

1. A system for the transport of liquefied gas, comprising a pressurizable receptacle for the liquefied gas; a first pressure-relief valve connected to said receptacle and displaceable therewith between a filling location and a discharge station for relieving the buildup of pressure within said receptacle above a predetermined transport pressure; means for generating a discharge pressure greater than said transport pressure in said receptacle at said discharge station; means communicating with said receptacle for leading liquefied gas therefrom upon development of the discharge pressure; and a second pressure-relief valve located at said discharge station and releasably connectable in line and in series with said first pressure-relief valve for venting said receptacle upon the development of a pressure therein exceeding to a predetermined degree said discharge pressure, said second pressure-relief valve being so constructed and arranged as to vent said receptacle upon the pressure therein exceeding to a predetermined degree the sum of said discharge pressure and said transport pressure, said receptacle being a tank mounted in a seagoing vessel and said liquefied gas being liquid methane, said tank having a siphon tube reaching to the bottom thereof and terminating, externally of said tank, in a first shutoff valve and a first connector, said means for generating said discharge pressure in said receptacle including a vent line communicating with said tank at an upper portion thereof, a second shutoff valve connected to said line and a second connector in line with said second shutoff valve, said first pressure-relief valve communicating with said vent line and being formed with a third connector matingly engageable with a corresponding connector at said discharge station in line with said pressure-relief valve, said discharge station being provided with a gas-pressure line releasably connectable through said second connector with said tank and a liquefied-gas withdrawal line releasably coupled with said first connector.

2. The system defined in claim **1,** further comprising a flaring torch and means between said first and second pressure-relief valve for selectively connecting said first pressure-relief valve to said flaring torch and to said second pressure-relief valve.

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