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Becker et al.

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[54] **CONTAINER SYSTEM FOR THE STORAGE AND/OR TRANSPORTATION OF LIQUEFIED GAS**

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[52] **U.S. Cl.** .... **114/74 A; 220/9 LG**

[51] **Int. Cl.** **B63b 25/12**

[58] **Field of Search** .... 114/74 A, 74 R; 220/9 LG

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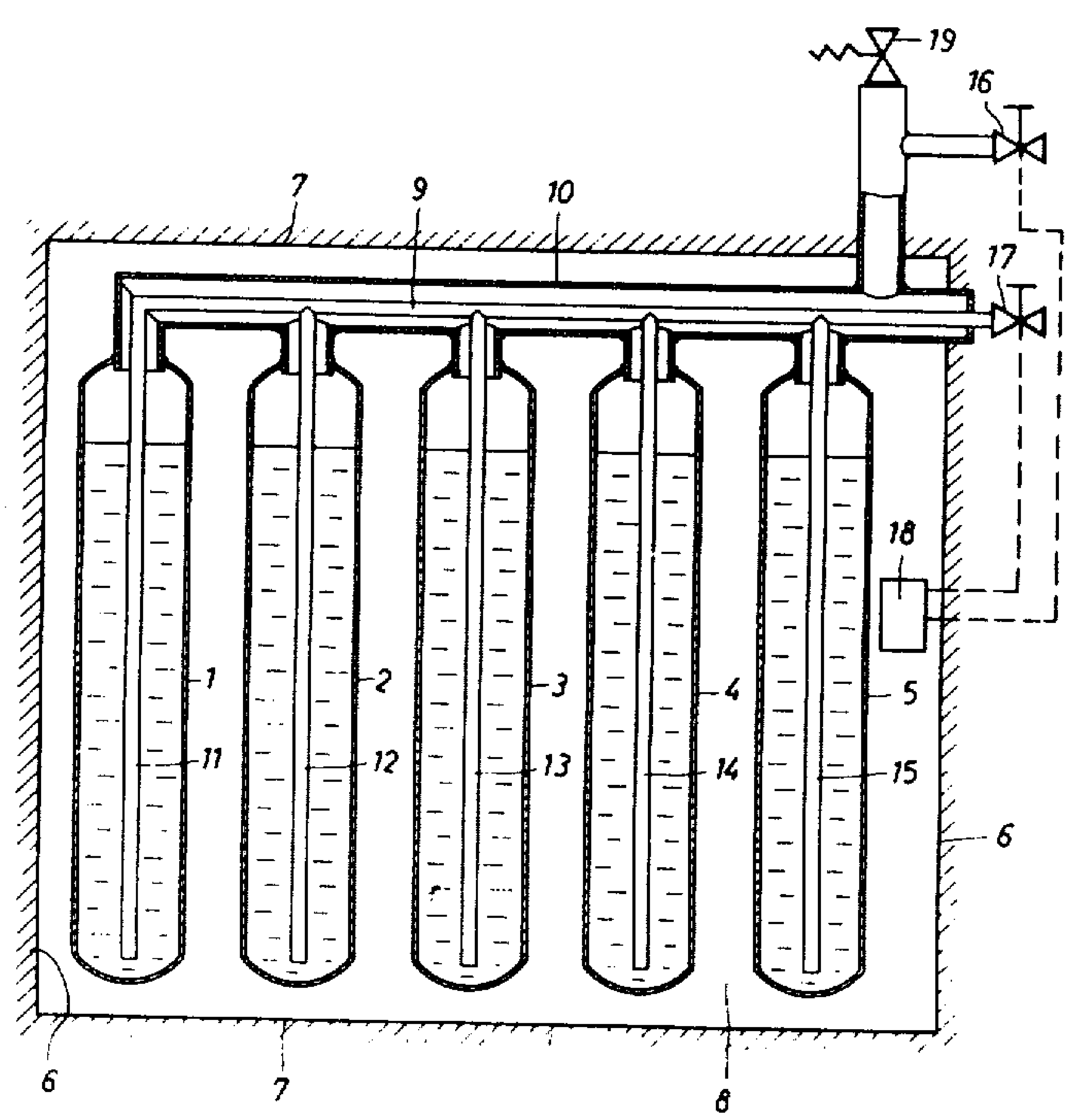
[57] **ABSTRACT**

A system for the storage and/or transportation of liquefied gases, especially liquefied natural gas, oxygen or nitrogen, comprises a thermally insulated enclosure having a battery of upright individual vessels (bottles, flasks or cylinders) containing the liquefied gas at least in a bottom portion of each vessel while a top portion thereof serves as a vapor space. A conduit network leads from each vapor space and communicates, externally of the chamber with a source of pressurizing gas for discharging the liquid or with a receptacle, reliquefaction apparatus or the like when liquid is pumped into the vessels. A second conduit network opens into the bottom portion of each vessel for introducing the liquefied gas or removing same. The safety of the system is improved by providing the conduit communicating with the liquid space wholly within the conduit communicating with the vapor space at least in regions in which the networks lie in the spaces between receptacles of the enclosure, thereby eliminating the need for a separate safety valve at each vessel for liquid conduits.

1 Claim, 2 Drawing Figures



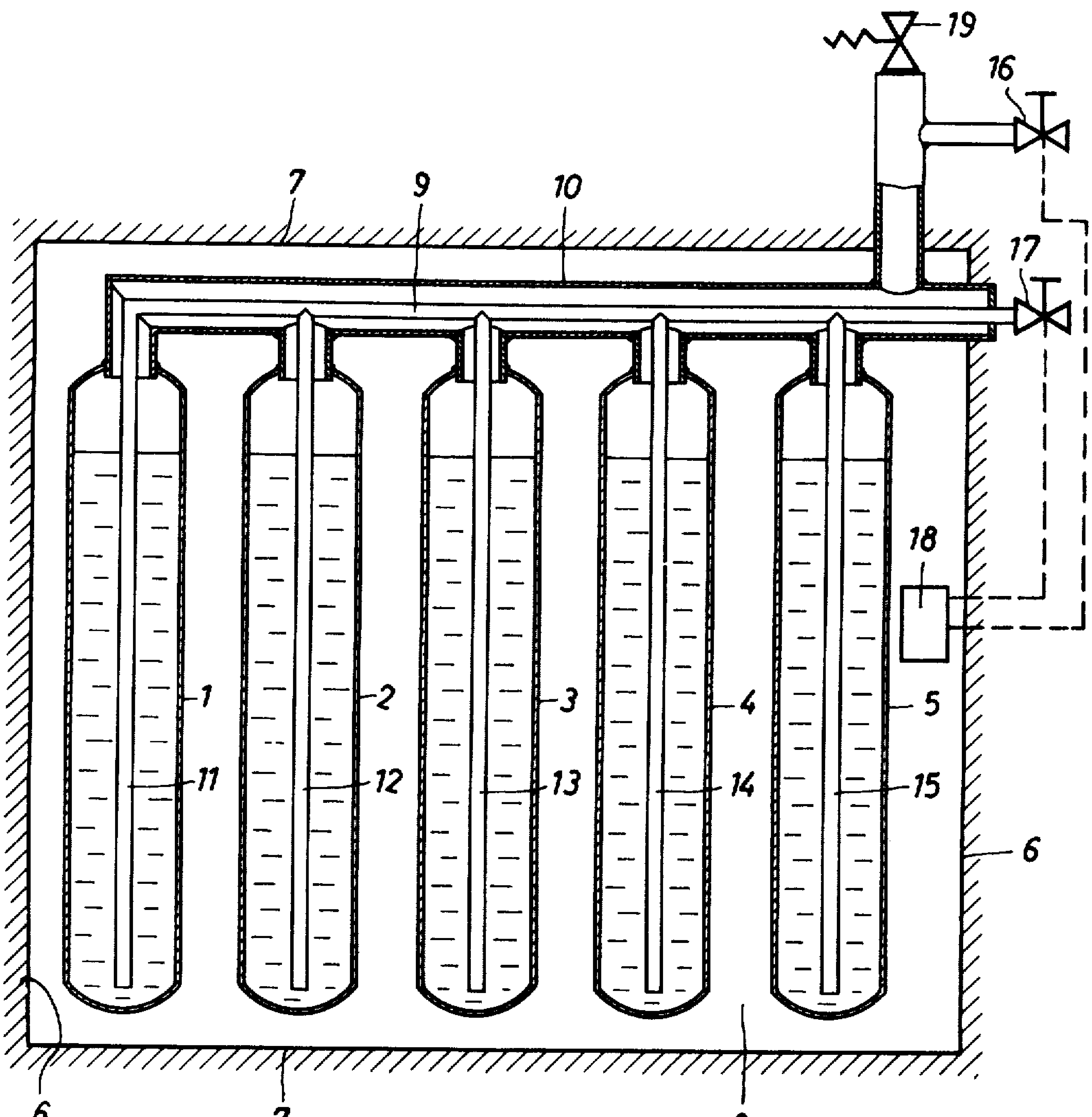


Fig.1

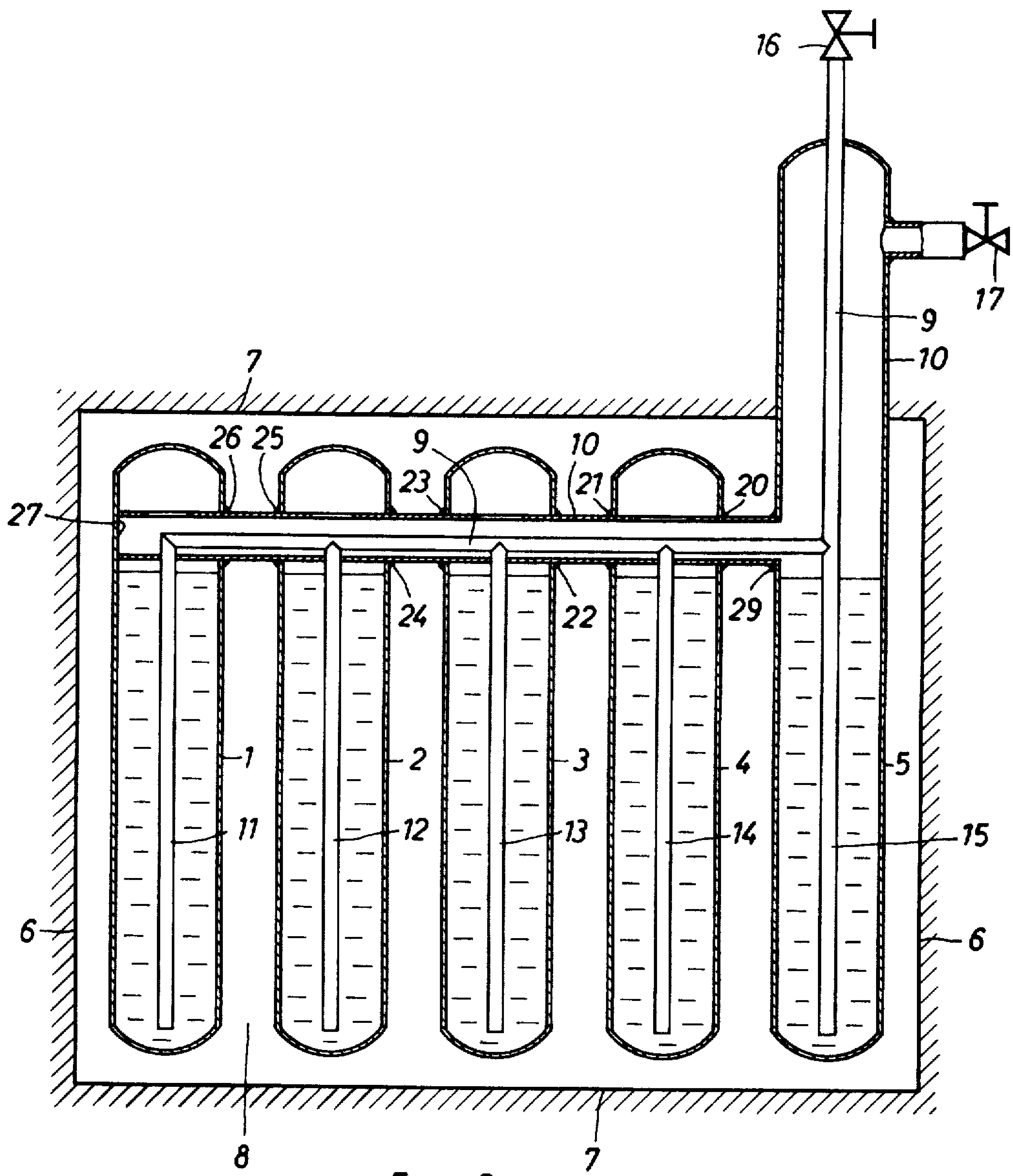


Fig. 2

CONTAINER SYSTEM FOR THE STORAGE AND/OR TRANSPORTATION OF LIQUEFIED GAS

CROSS-REFERENCE TO RELATED APPLICATION

The present application is related to the commonly assigned application Ser. No. 318,161 filed Dec. 26, 1972 by Rudolf Becker, one of the present applicants.

FIELD OF THE INVENTION

Our present invention relates to a container system for the storage and transportation of volatile liquids and especially liquefied gases which are in a gaseous state at ambient temperature and pressure. More particularly, the invention relates to a system for the safe and economical transport of liquefied gases such as liquefied natural gas, liquid oxygen and liquid nitrogen.

BACKGROUND OF THE INVENTION

In recent years the transportation of low-temperature liquefied gases from a source to an ultimate consumer has become of increasing importance especially for so-called "energy" gases and industrial gases. For example, a practical solution to energy crises or insufficiency in urban areas and in low-fuel areas has been the liquefaction of natural gas (methane) at a source thereof, the delivery of the liquefied gas from a storage tank at a site convenient to the source of a tankship (tanker) or other transport vehicle, the discharge of the liquefied gas at a site convenient to consumption and distribution, the storage of the liquefied gas at this latter site, and the regasification of the stored liquid prior to delivery to the ultimate consumer. The economy of the process is based not only upon the low cost of the natural gas, but also upon the convenience of transporting it in a liquid state so that the transportation volume is relatively small but the gas volume at the consumer end is considerably greater. The same advantages may be gained by the transportation of other liquefied gases, especiallly the industrial gases oxygen and nitrogen, from a station convenient to an air-rectification apparatus to a station convenient to the ultimate consumer, e.g., a steel plant using oxygen to blow a steel melt. Thus the term "liquefied gas" is used herein to describe liquids which are gaseous at ambient temperature and pressure and which must be stored, if a liquid state is to be maintained, at low temperatures, high pressures or both. It has been found to be desirable to minimize the pressure under which such liquefied gases are stored and transported and hence most installations for the storage and transport of large quantities of liquefied gas have made use of insulating techniques, controlled evaporation and the like to maintain a sufficiently low temperature in the storage compartments.

It has been proposed previously to provide, within the thermally insulated storage compartments of a tankship for liquefied gas, liquid oxygen or liquid nitrogen, batteries of cylinders, flasks or bottles (hereinafter simply denominated "receptacles"), e.g., of steel each holding a quantity of the liquefied gas. For convenience in filling these receptacles and in discharging the liquid therefrom, a first conduit network is provided with individual branches leading to the vapor space above the liquid level in the receptacle. In addition, each receptacle is provided with a branch of a second conduit network communicating with the interior of the receptacle below the level of the liquid therein (e.g., a syphon tube). During filling of the receptacles, the second con-

duit network is connected to a pump and a source of the liquefied gas so that the liquid is charged into the receptacles and the liquid level rises therein, displacing gas from the vapor space through the first conduit network which may be connected to a reservoir collecting the displaced gas. During emptying of the receptacles, a displacement gas is forced into the receptacles via a first network to assist in driving the liquid through the second network to a storage tank, gasifier or consumer line. The displacement gas may either be the gasified displaced liquid or some inert gas. During transportation of the gas, the second (liquid) network is cut off while the first (vapor) network remains effective to permit controlled evaporation of the liquefied gas and maintain the desired transport or storage temperature.

The networks generally lie entirely within the thermally insulated compartment or space in which the battery of receptacles is received, only a single line connected to the networks emerging from this insulated space.

It will be apparent that rupture of any branch of the liquid conduit network within the insulated space will pose a substantial danger to the transport vehicle or vessel because the liquefied gas will pass into the space around the individual receptacles and, because of its low temperature, cause thermal contraction and rupture of the walls of the chamber. In addition, the small quantity of discharged liquefied gas, upon attaining a temperature above its boiling point, spontaneously undergoes a manifold increase in volume, providing the danger of mechanical rupture and explosion.

To reduce these dangers, it has been the common practice to provide each branch, at least, of the liquid conduit network with a safety valve at the point at which this branch is connected to the receptacle. The valves are located within the insulated compartment and are designed to cut off the receptacles from the network should a break occur in any of the liquid conduit lines. This prevents large quantities of liquefied gas from flowing into the hold of the ship upon rupture of one of the lines of the network.

However, the use of such vales is disadvantageous because the valves are costly and the unit cost must be multiplied by the number of receptacles which are provided. It is not uncommon, for a tankship to have more than 600 liquefied gas bottles or flasks, each with a respective safety valve. Maintenance of the large number of valves, of course, is also a problem in such systems, especially since all of the valves lie within the cold thermally insulated chamber described earlier.

OBJECT OF THE INVENTION

It is the principal object of the present invention to provide a container system for the storage and/or transport of low-temperature liquefied gases in separate receptacles, especially of a tankship, in which the cost of the installation can be reduced and the safety increased.

Another object of the invention is to provide a system for the filling, emptying and storage of liquefied gases in individual receptacles, e.g., a battery of flasks, bottles, cylinders and the like constituting a storage assembly.

Still another object of this invention is to increase the safety of storage and transportation of low temperature liquefied gases, especially liquefied natural gas, oxygen and nitrogen whereby the aforementioned disadvantages are obviated.

SUMMARY OF THE INVENTION

We have now discovered that the aforedescribed objects can be attained conveniently and simply by providing the liquid conduit network wholly within the passages of the vapor conduit network at least over the portions of these networks which are within the thermally insulated chamber receiving the battery of receptacles.

More specifically, the aforementioned objects are achieved by providing, in a system for the storage and/or transportation of liquefied gases, especially liquefied natural gas, liquefied oxygen, liquefied nitrogen and any low-temperature liquid which is gaseous at ambient pressure and temperature, thermally insulated wall means defining an insulated chamber a plurality of upright receptacles (preferably in the form of gas cylinders, bottles or flasks) in the insulated space and having lower liquid-receiving spaces and vapor spaces above the liquid receiving spaces, and a first or vapor conduit network within the chamber and communicating with these vapor spaces for venting gas therefrom and enabling gas-pressurization of the receptacles. In addition, a liquid conduit network is provided with branches opening into the liquid space of each receptacle and, in accordance with the present invention, the two networks are provided one within the other, especially with the liquid-conduit network being disposed within the vapor-conduit network. Hence the inner network communicates with the liquid spaces while the outer network communicates with the vapor spaces of the receptacles of the battery.

This system is inexpensive, at least by comparison with systems providing a safety valve at each receptacle, is substantially maintenance free since it does not require any valving within the insulated compartment and reduces the risk of danger and even precludes endangerment of the vessel by pipe breakage during the three operating periods or phases (filling, transport and emptying). The advantage of the system is that any break in the liquid conduit network will simply discharge liquid into the surrounding vapor conduit network and will be contained thereby.

During the filling of the receptacles of, for example, a tankship with liquefied gas, e.g., from a tank on shore, the liquefied gas is pumped through the inner network to the bottom portion of the receptacle while gas is displaced from the receptacles by the rising liquid level therein. The displaced gas, delivered by the outer network to a collector in which the gas is condensed and returned to the liquid compartments or is stored at the shore installation. During filling in this manner, any break in the liquid conduit network within the insulated chamber will simply deliver a portion of the supplied liquefied gas directly to the outer gas conduit network and then into the reliquefaction cycle listed earlier or into the receptacles inasmuch as the vapor therein is generally displaced without significant counterpressure. In either case, the break in the liquid conduit network does not discharage liquid into the thermally insulated hold of the tankship. Should, during filling, rupture of the outer or gas conduit network occur, gas may be released into the hold where it is detected, according to the present invention, by a gas analyzer or sensor. The sensor, upon detection of the gas in the hold generates a signal which closes a valve leading to the inner or liquid conduit network and disposed externally of the hold. Filling can then be stopped and the gas releasesd into the hold vented through the outer conduit network.

For the highly improbably case in which both networks rupture during filling, gas is admitted to the hold space as noted earlier while liquid must flow through the outer network until it finds an escape opening. The liquid is thereby distributed and only in the region of the leak in relatively small quantities emerges into the hold. The greater part of the liquid will normally find its way into the receptacles in spite of the defect in the outer conduit network. In this case as well the gas analyzer automatically and immediately cuts off the inner conduit network while the gases, leaking from the networks are vented into the atmosphere by a chimney or stack communicating with the hold.

During emptying of the receptacles under pressurized gas, the outer gas conduit system is connected to a source of compressed gas (e.g., vaporized stores liquid), or an inert gas, thereby increasing the pressure in the vapor spaces of each receptacle and driving the liquid through the inner or liquid conduit network. The liquid conduit network may be connected by a valve externally of the thermally insulated hold to a gasifier or storage tank as described.

Should a break occur under these conditions in the inner conduit network, additional gas enters the liquid line and, with a small break, the result is only a reduction in the efficiency with which the liquid is discharged from the tank. With large leakages, a pressure equalization occurs between the inner and outer conduit networks and ultimately displacement of the liquid by the gas terminates.

In the event of a break in the outer network or any rupture in both networks, the result is the same as that obtained during filling with exception that the gas analyzer closes off the source of pressurized gas leading to the outer network. The gas collected in the thermally insulated hold is then vented through a stack as described previously.

Should rupture occur during the transport phase, the inner conduit network is blocked while the outer or vapor conduit is open to the atmosphere and the gas is vented. The break in either the inner or the outer conduit network, therefore, does not affect the liquid within the receptacles.

According to a particularly advantageous construction of the system according to the present invention, which finds its greatest significance when the latter is used in a tankship, the networks are disposed at upper portions of the receptacles and the outer and inner networks pass through these upper portions of the receptacles. Where the outer network transverses the walls of the receptacles, they are sealed to the outer network, e.g., by welding. In this case, the branches of the inner network can pass into the outer network directly within the respective receptacle. Thus greater utilization of the space within the insulated chamber is ensured. Since the walls of the receptacle are thus rigid at least with the conduits of the outer network, the conduit system functions to strengthen the assembly of receptacles and the latter provide effective structural support for the outer network. Thus additional means for fastening the receptacles in place within the insulated chamber are eliminated. Instead of connecting all of the receptacles to common conduits, it is advantageous to subdivide the receptacles into batteries of several receptacles which are provided with respective networks. In this case, the rupture of one of the ducts will only affect a group of receptacles rather than the entire collection of them.

While the invention as described is particularly applicable to a tankship and the subsequent description will deal with the application of the invention to such vessels, the principle is similarly applicable to other storage and transport systems. Whenever (e.g., upon land in a storage installation or upon railroad cars or automotive vehicles), it is desired to charge and discharage a number of receptacles with liquefied gas, the system of conduits one inside the other may be used to advantage.

DESCRIPTION OF THE DRAWING

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

FIG. 1 is a vertical section, partly in diagrammatic form, of the system of the present invention as applied to a tankship; and

FIG. 2 is a view similar to FIG. 1 illustrating another embodiment.

SPECIFIC DESCRIPTION

FIG. 1 shows a group of five liquefied gas storage receptacles **1, 2, 3, 4, 5,** in the form of cylinders, bottles or flasks of conventional construction, received in the open space of an insulated chamber **8** defined between thermally insulated walls **6** and **7** and constituting a hold of a ship. Each receptacle **1 – 5** is provided with a syphon tube **11, 12, 13, 14, 15,** extending dwonwardly to a location just above the bottom of the receptacle and within the liquid-storage region thereof. Above the receptacles **1 – 5,** each of the syphon tubes **11 – 15,** which constitute branches of a liquid conduit network, is connected to a common conduit **9** which serves to deliver the liquid phase or withdraw it from the receptacles. The network **9,** etc., in the regions thereof external of the receptacles **1 – 5,** lies wholly within the outer conduit network **10** which communicates via downwardly extending branches with the vapor space above the liquid in each receptacle. Where the syphon tubes reach above the receptacle, therefore, they are coaxial with these downwardly extending portions of network **10.**

The outer conduit network **10** serves to discharge gas from the receptacle or to admit pressurized gas thereto when, during the emptying phase, the pressurized gas drives liquid upwardly through the syphon tubes **11 – 15** and through conduit **9.** Externally of the insulated chamber, cut off valves **16** and **17** are provided for manual operation and for automatic control by a gas analyzesr **18** located within the insulated chamber **8** and responsive to the leakage of gas into the latter. A vent valve **19** is of teh pressure-relief type and may open into the atmosphere at the top of a stack rising from and forming part of the outer network **10.**

During filling of the receptacles **1 – 5,** the valve **17** is connected to a tank or liquefaction apparatus of conventional design. As the pump displaces liquefied gas into the receptacles **1 – 5,** the rising liquid drives gas upwardly through the network **10** and out of the system. During discharge of the liquefied gas, however, valve **16** is connected to a compressor which displaces an inert gas (nitrogen) or a gas of the same type as is stored in the receptacles while valve **17** is connected to a discharge line leading to a storage tank, a pump and/or a gas as, for example, described in connection with the aforementioned copending application. The pressure applied at network **10** forces the liquid downwardly in each receptacle **1 – 5** and displaces the same upwardly through the respective riser tubes **11 – 15** and into the conduit **9.** During transport, valves **16** and **17** are closed and any pressure developed within the network **10** is vented via valve **19** when this pressure attains a predetermined level. With rupture of either of the conduits within the chamber **8,** the gas analyzer operates to close the valves **16** and **17** during filling and discharge as previously described.

The system in FIG. **2** differs from that of FIG. **1** in that the outer duct **10** passes through the upper portions of each receptacle **11 – 14** and is sealed to the walls thereof by welding at **20 – 26,** thereby constituting of the receptacles and the conduit **10** a rigid structure. The end of pipe **10** abuts the wall of the last receptacle **1** at **27** as noted. In the embodiment of FIG. **2,** moreover, the gas analyzer may be provided as described in connection with FIG. **1** and the venting stack may be an extension of the first receptacle **5.** The system of FIG. **2,** of course, operates in a manner similar to that of FIG. **1.**

We claim:

1. A system for the storage and/or transport of a low-temperature liquefied gas, said system comprising:

a plurality of thermally insulated walls defining an open-space storage chamber;

a plurality of generally upright vertically elongated liquified-gas storage receptacles disposed in said chamber in spaced relationship in a row, each of said receptacles having a bottom portion adapted to receive a liquefied gas and an upper portion forming a vapor space above the liquefied gas in said receptacle;

a first conduit network communicating with said vapor spaces of all of said receptacles of said row within said chamber, said first conduit network comprising:

a horizontal large-cross-section dust spaced directly above said receptacles and extending along said row over all of the receptacles thereof;

a respective large diameter pipe fixed centrally to each of said receptacles and extending vertically therefrom to terminate at said duct while communicating between the respective vapor space and said duct, and

a vertical riser extending upwardly from said duct through one of said walls, said duct having an end extending into another of said walls;

a second conduit network communicating with said bottom portions of said receptacles and entirely received in said receptacles and said first network within said chamber, said second network including a first-horizontal tube of relatively small cross-section extending through said duct and emerging therefrom at said one end outside said chamber, and respective small-cross-section second tubes extending vertically from said first tube through said pipes and reaching downwardly into said receptacles substantially to the bottoms thereof;

a pressure relief valve communicating with said riser for venting said first network; and

respective controllable valves connected to said first network and to the end of said first tube emerging from said duct and selectively operable for charging said receptacles with liquefied gas and discharging liquefied gas from said receptacles.

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