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TRANSPORTATION OF LIQUEFIED GASES

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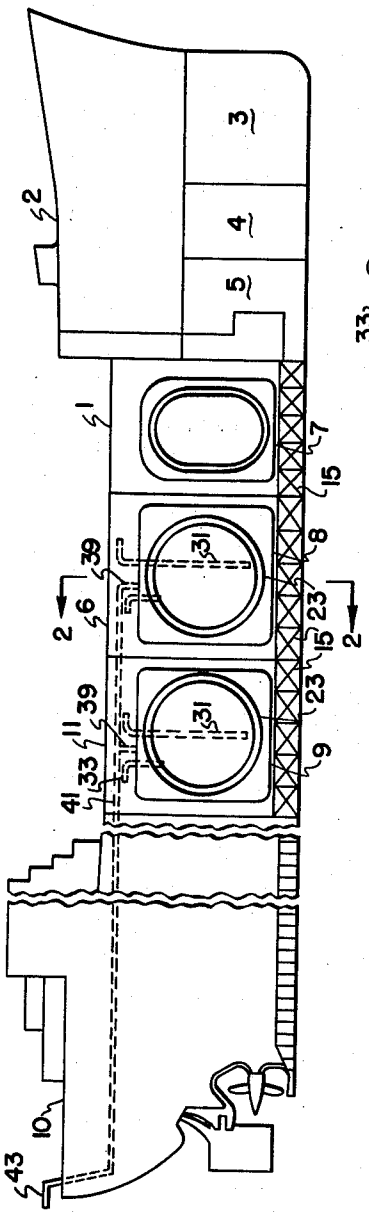

Fig. 1

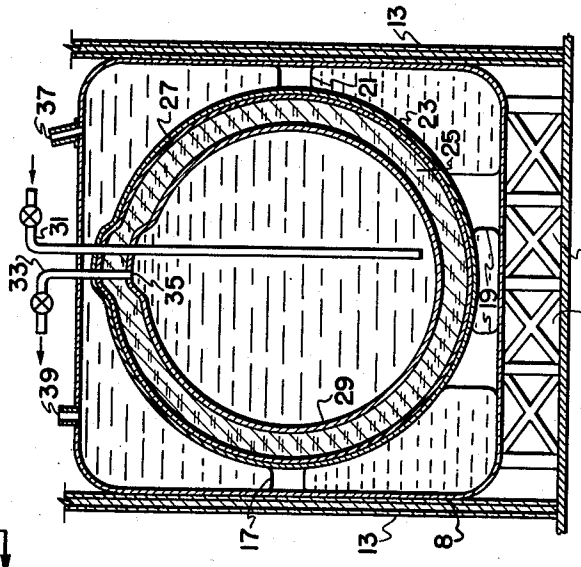

Fig. 3

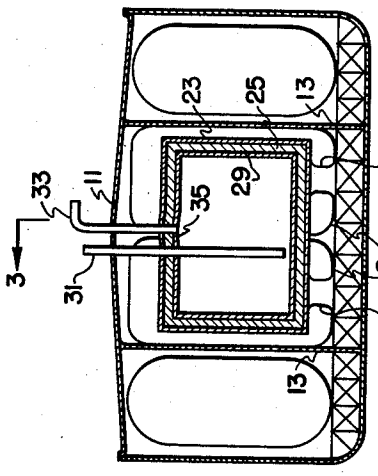

Fig. 2

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TRANSPORTATION OF LIQUEFIED GASES

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6 Claims. (Cl. 62—45)

The present invention relates to improvements in transportation of liquefied gases. More particularly, it pertains to an improved process and apparatus for handling normally gaseous hydrocarbons such as natural gas, ethylene, and other substances of very low boiling points or boiling ranges.

It has previously been proposed to liquefy low boiling products of the general character referred to above and to transport them in liquid condition. Substances such as methane, natural gas which is largely methane, ethane, ethylene and the like, have enormously high vapor pressures at ordinary atmospheric temperatures. In fact, some of these cannot be liquefied at any pressure at ordinary temperatures. It is obvious that the shipment of such low boiling materials in pressure vessels is not commercially feasible, particularly where large quantities are to be shipped and their economic value is relatively low.

It has also been proposed in the prior art to liquefy normally gaseous materials of the type mentioned and to transport them in vessels maintained merely at atmospheric pressure. Obviously, even with the best of thermal insulation, part of the products are bound to evaporate during transportation to any substantial distance. The free evaporation of these materials involves considerable hazard although they obviously may be used for refrigeration, as engine fuel, or they may be recompressed and reliquefied and returned to storage. Even when the gases are so disposed of, there are still substantial hazards involved in transporting liquefied gas in equipment and by processes known to the prior art.

According to the present invention, the difficulties mentioned are largely overcome by transporting the liquefied gas in thermally insulated tanks or vessels which are submerged, or at least partially submerged, in liquids of much higher boiling range. For example, natural gas may be liquified and stored in a well-insulated tank which in turn is kept submerged in a tanker or vessel filled with a material, e.g. crude oil or gasoline, which will absorb large quantities of the gas. Under these conditions, any incidental leakage of the liquefied gas or of the products evaporating therefrom is caused to pass into the liquid medium surrounding the insulated tank. Natural gas, i.e. the lower hydrocarbons, can be absorbed to a substantial extent in a large body of heavier hydrocarbons. The surrounding liquid preferably is one which does not have a flash specification; otherwise if gas leaks into it, it may have to be reprocessed. Moreover, according to another feature of the invention, the gases which may escape into the heavier oil in excess of its capacity to absorb them, can be readily controlled and, if necessary, they may be bled off at a safe point from the vessel or carrier so as to minimize fire and other hazards.

The invention will be more clearly understood by referring to presently preferred specific embodiments thereof. It will be understood, however, that the invention is not necessarily limited thereto.

Referring to the accompanying drawings,

Figure 1 shows a typical longitudinal sectional view of a vessel or tanker adapted to carry liquefied normally gaseous material such as liquefied natural gas, certain parts being broken away.

Figure 2 shows a transverse section of the vessel of Fig. 1, taken substantially along the line 2—2 of Fig. 1.

Figure 3 shows an enlarged cross-section of a liquefied gas tank immersed in a liquid filled tank of common type, this view being taken substantially along line 3—3 of Fig. 2.

Referring first to Fig. 1, an outer vessel such as an oil tanker is indicated at 1. It has a bow portion 2, containing tanks 3, 4, 5, and a middle section 6 containing further tanks 7, 8, 9. The stern section 10 contains the engine and crew compartments, etc. The vessel itself is constructed so as to be substantially liquid-tight and it preferably has a deck 11 which also is more or less liquid-tight. Suitable vents and means of access into the inner parts of the vessel may be provided as will be obvious to those skilled in the art. Suitable structural elements 13, 15 are provided for supporting tanks 7, 8, 9, from the vessel walls.

Suitably mounted in the lower part of one or more of the tanks, 8, 9, etc. and at the sides thereof are saddles or supporting members 17, 19 and 21, best shown in Fig. 3. These are so arranged as to provide adequate support for an inner vessel 23. The latter is lined with an effective heat-insulating material such as cork, balsa wood or the like, applied in a layer which may be from two or three inches to a foot or more in thickness. This insulating material is indicated at 25 and is suitably bonded to the vessel 23 by means of an adhesive or bonding layer 27. The vessel 23 is impervious to gas and is preferably made of steel or other suitable material. The insulating material 25 may be impregnated to make it impermeable to gas or liquid contained therein, and it is preferably coated on its inner face with a lining or layer 29 of liquid-proof and gas-tight material. The adhesive or bonding layer 27 also is preferably gas and liquid-proof.

Inlet means for supplying liquefied gases to the tank 23 are indicated at 31 and an outlet 33 is provided for gases which evaporate and collect in the upper part of the tank at 35.

A feed line 37 is provided for supplying oil to, and removing it from the outer tank 8. Although inner tanks are shown placed only in two tanks 8, 9, of the tanker vessel, Fig. 1, it will be obvious that all of the cargo tanks of the vessel may be provided with such if desired.

In use, the inner tank 23 is filled with the liquefied gas to be transported. Since it is well insulated thermally, the amount of evaporation taking place therein is kept low. The outer vessel 11 is filled with a heavier material such as crude oil, gasoline, etc., as previously mentioned, or some other material boiling well above normal atmospheric pressures.

It will be understood, of course, that normally there are no gases escaping from the inner tank into the outer compartment. The normally evaporating gases are carried off through outlet 33. From this outlet, they may be taken to the engine room to supply fuel to the power

plant or they may be first used for refrigeration and then burned as fuel. Alternatively, they may be recompressed and liquefied and returned to the vessel through the line 31. In general, the inner tank will have its own independent inlet and outlet connections which pass through the cover or top wall of the outer tank in which the inner container is located.

The shape of the inner tank may be varied and it need not be built to withstand substantial pressure. As indicated in Fig. 3, a horizontal cylindrical tank for liquefied methane, etc. can be carried in smooth saddles which conform on their bottom to the bottom of the ordinary cargo tank. In all cases, it is desirable to have the inner tank supported at some distance above the bottom of the outer tank. This permits inspection and cleaning of all of the opposed surfaces of both the inner tank and the outer tank.

In order to provide for escape of gas from the outer tanks such as 8, Fig. 3, in case of a large volume leakage of gas from the inner tank which the oil cannot fully absorb, a vent 39 is provided. This connects to a vent line 41 which preferably extends to the rear of the vessel where it will direct escaping gas away from the vessel as indicated at 43. Obviously, a flare may be provided here, if needed, to burn escaping gas, especially when the vessel is not in motion so as to diffuse escaping gas rapidly enough for safety.

While the above description has suggested the storage and transportation at atmospheric pressure, it will be understood that the same principles may be applied to transportation of gases which are kept liquid under pressure. Thus, propane, butane and mixtures thereof, even containing some proportions of ethane, may be kept liquid without venting them to the surface. As indicated above, such materials may be stored in the inner tank. If a leak develops in the inner tank, no harm is done since the escaping materials are soluble in the oil which surrounds it.

The arrangement described has several advantages. Since it makes full use of the cargo space available, capital costs are low per unit of total liquid cargo capacity. Where gases are to be maintained at very low temperature to keep them liquid, the use of the internal insulation such as balsa wood reduces the heat transfer rate to such a low figure that it makes little or no difference whether the external wall of the inner tank is exposed to air or to a liquid oil or oil product. In either case, the submersion of the inner tank in oil, or gasoline, etc., increases safety. The pressure of the outer body of oil helps resist internal pressure within the inner tank. In addition, the oil is available to absorb substantial quantities of escaping gases, as previously pointed out. For this reason, the production of explosive mixtures in empty confined spaces within the vessel, is eliminated. When the outer or hull tank is not used for oil, it may be filled with water to maintain this same safety against explosion.

It will be noted that the total volumetric capacity of the moulded hull of a bulk oil carrier remains almost unaffected by fitting it with the internal tanks. Hence, capacity for total shipment is kept high. A carrier of this type is highly flexible as to the service to which it can be put. Thus, instead of carrying only liquefied gases or in combination with oil products, the vessel can be used for a full load of almost any form of liquid product. When demand for the liquefied gas is low, the inner tank may be filled with crude oil, gasoline or other oil products. Hence, the full capacity of the vessel may be utilized regardless of the products to be carried. The invention is applicable to railroad tank cars, truck-mounted tanks, barges, etc. as well as to large oil tankers.

It will be obvious that numerous variations may be made in the equipment and process without departing from the spirit of the invention. It is intended to cover these in the following claims so far as the state of the prior art permits.

What is claimed is:

1. A container for liquefied materials which are gaseous at atmospheric temperatures and pressures, comprising an outer substantially liquid-tight container shell which in turn comprises at least a portion of the structure of a bulk transport container, an inner substantially gas-tight container shell supported within said outer shell and disposed therein with the outer surface portions of said inner shell in spaced relation to the inner surface portions of said outer shell, whereby to define a first storage compartment substantially surrounding said inner shell, a liner of substantial thickness and of a solid, thermal insulation material secured to the inner surface portions of said inner shell in gas-tight relation thereto, said liner defining a second storage compartment within itself and including an inner surface portion of a material substantially impervious to said liquefied materials, a body of liquid disposed in said first storage compartment submerging said inner shell, said liquid having a boiling point at atmospheric pressures which is substantially above the normal range of atmospheric temperatures, means for introducing said liquid into said first storage compartment, means for introducing said liquefied materials into said second storage compartment, means for venting vapors from said first storage compartment including leakage from said second storage compartment, means for venting vapors from said second storage compartment, and means for disposal at a distance from each of said first and second storage compartments of vapors vented from said first storage compartment.

2. A container according to claim 1 wherein said second storage compartment is adapted to contain a liquefied gaseous hydrocarbon material, and wherein said body of liquid in said first storage compartment comprises a hydrocarbon liquid having the capacity to absorb at least a portion of said liquefied gaseous hydrocarbon material.

3. A container according to claim 2 wherein said liquefied gaseous hydrocarbon material is liquefied natural gas, and said body of hydrocarbon liquid in said first storage compartment comprises a hydrocarbon liquid boiling at atmospheric pressure in the boiling temperature range of gasoline and higher.

4. A container according to claim 1 wherein said bulk transport container comprises a marine vessel.

5. A container for liquefied materials which are gaseous at atmospheric temperatures and pressures, comprising an outer substantially liquid-tight container shell which in turn comprises at least a portion of the structure of a bulk transport container, an inner substantially gas-tight container shell supported within said outer shell and disposed therein with the outer surface portions of said inner shell in spaced relation to the inner surface portions of said outer shell, whereby to define a first storage compartment substantially surrounding said inner shell, a liner of substantial thickness and of a solid, thermal insulation material secured to the inner surface portions of said inner shell in substantially continuous contact therewith, said liner defining a second storage compartment within itself, a body of liquid disposed in said first storage compartment submerging said inner shell, said liquid comprising a hydrocarbon liquid having at least some capacity to absorb liquefied natural gases and having a boiling point at atmospheric pressures which is substantially above the normal range of atmospheric temperatures being at least in the boiling temperature range of gasoline and higher, means for introducing said liquid into said first storage compartment, means for introducing said liquefied materials into said second storage compartment, means for venting vapors from said first storage compartment including leakage from said second storage compartment, means for venting vapors from said second storage compartment, and means for disposal at a distance from each

of said first and second storage compartments of vapors vented from said first storage compartment.

6. A container according to claim 5 wherein said bulk transport container comprises a marine vessel.

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