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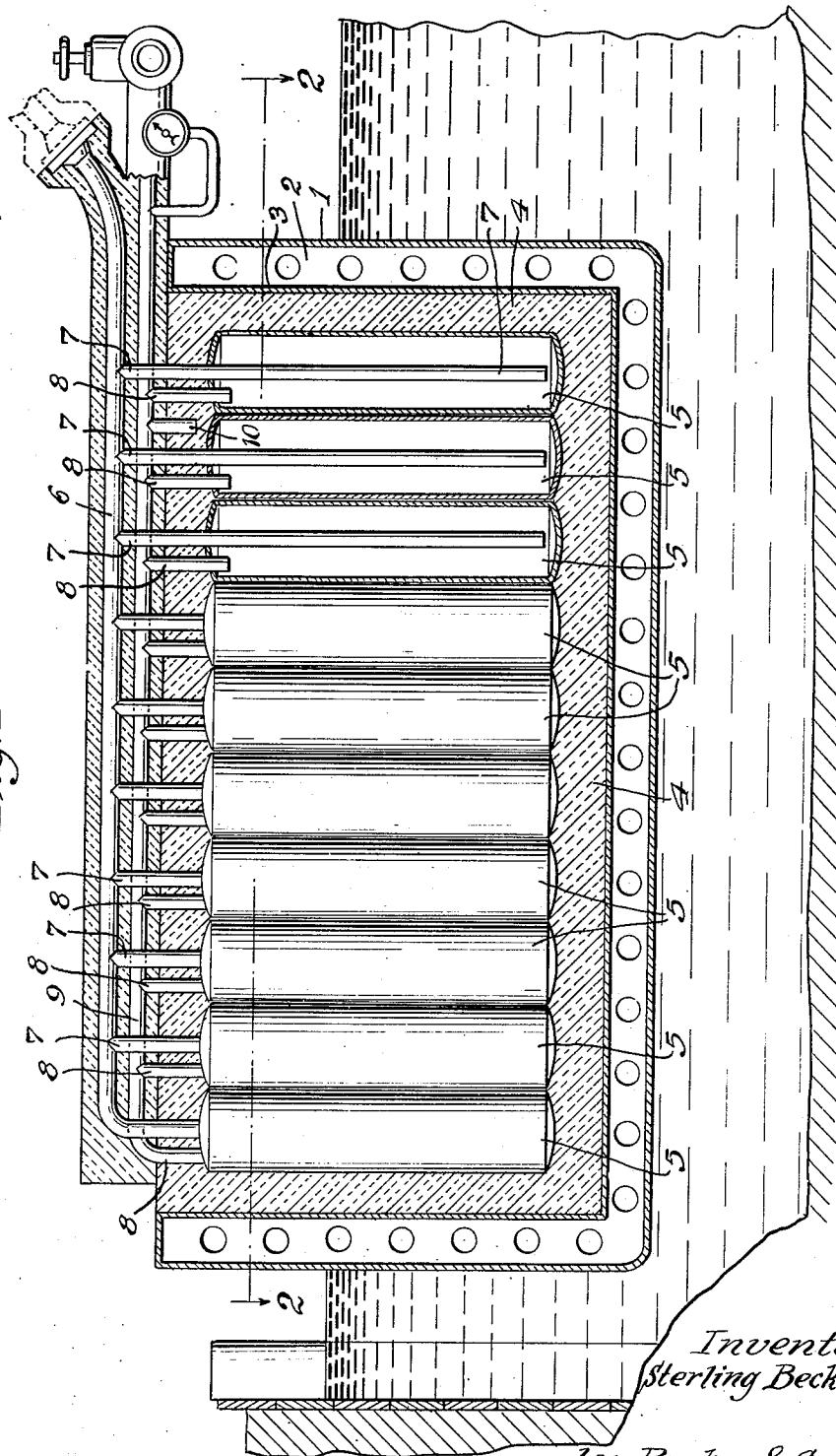
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MEANS FOR STORING AND TRANSPORTING COLD LOW BOILING LIQUIDS

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2 Sheets-Sheet 1

Fig. 1



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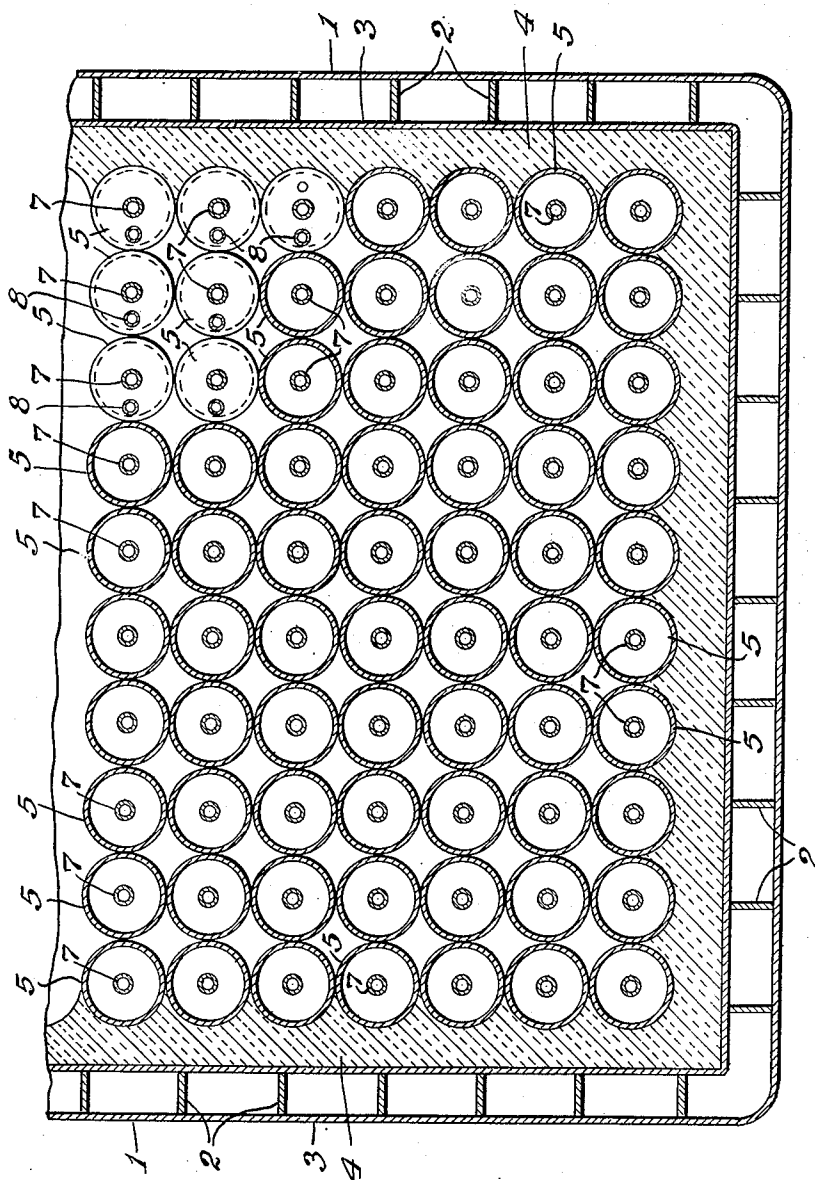
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Fig. 2



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MEANS FOR STORING AND TRANSPORTING COLD LOW BOILING LIQUIDS

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5 Claims. (Cl. 62—1)

My invention relates to improvements in storage and shipment means for cold low boiling point liquids and is especially well adapted to the storage and shipment of liquefied methane which boils at approximately -258° F. at atmospheric pressure though my apparatus is equally well adapted for the storage of other liquids.

One object of my invention is to provide transportable storage means for such cold liquids which will insulate the liquid from the ambient heat of the surrounding air and so control the rate at which ambient heat causes boiling and gasification of the liquid.

Another object of my invention is to provide a storage means which while insulating the liquid will prevent excessive swashing or washing of the liquid when in transit as for example on a barge or ocean-going vessel.

Another object of my invention is to so insulate the structure supporting the tank or tanks containing the cold boiling liquid that the structural elements on the strength of which reliance is placed will be protected from temperature reduction which might otherwise result in deterioration of the structural material.

Other objects will appear from time to time throughout the specification and claims.

It is well known that the larger the mass of liquid being stored or transported as a unit, the less proportional is the effect of ambient heat causing boiling or gasification because if the liquid is in a large body, the surface or boundary of the body will be smaller in proportion to the mass as the mass increases.

Experience has taught that when such cold liquids which I propose to store and transport are in contact with the metal walls of a tank containing the liquid, the structural material soon reaches the exceedingly low temperature of the liquid and may be deleteriously affected. Moreover, the temperature of the wall becomes so low that unless it is completely insulated from contact with the ambient air, moisture condenses on the wall and must be removed or taken care of.

It has been proposed therefore to place the insulation on the inside of the tank, allowing the insulation to come in contact with the cold liquid and allowing the heat as it penetrates the insulation from the outer tank wall to vaporize some of the liquid and generate a pressure which would resist penetration of the liquid through the insulation toward the tank wall. But when this is done in large quantities in large tanks, if those tanks are to be shipped in a barge or ocean-going vessel, then swash plates of substantial size and strength and complication must be inserted in the tank in contact with the lining, thus adding greatly to the expense and complication of the structure because large volumes of liquid when violently agitated, generate in the tank very high pressures of impact so that very strong swash plates must be installed, thus structurally overloading the insulation sometimes.

I propose to solve this problem by lining the hold of the vessel with an effective insulation to define an insulating chamber in which a multiplicity of smaller tanks of non-ferrous or austenitic material may be enclosed. Alumi-

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num, copper, bronze, brass or the like may be formed into tanks and these tanks can be nested in the insulating chamber. The insulating chamber may comprise the entire hold of the ship or barge or there may be one or more insulating chambers within the hold or carried on the barge. The small tanks will each contain a relatively small amount of the cold boiling liquid but the aggregate of all the tanks in the cold chamber will give a very large amount of cold boiling liquid so that the mass of liquid will be great enough in proportion to the area exposed to ambient heat to give, when properly insulated, a suitable evaporation rate.

Each tank will be separately mounted within the insulating chamber and each tank will be of such size that it can be safely supported by and positioned by the insulating means. A suitable insulation is a built-up layer of balsa wood which has adequate structural strength under compression at the low temperatures involved to support the nest of tanks, preferably of aluminum and each tank is small enough so that movement of the vessel supporting the insulating chamber will not set up dangerous wave action in the individual tanks.

The insulating chamber will be gas-tight with any suitable piping necessary to conduct the cold boiling liquid to the tanks for filling and to discharge it either as a liquid or as a gas from the tanks when desired. Each tank will preferably be open to the insulating chamber at the top so that gas boiled off from the liquid in the tank may enter the insulating chamber and be withdrawn therefrom as desired. The result is that the space around each tank between it and the insulation in the chamber will be filled with the liquid in gaseous phase so condensation of water from air and the like will not present a problem.

When dealing with liquids such as methane which is combustible and explosive when mixed with air, it is essential that no combustible or explosive mixture be formed within the tanks or within the insulating chamber or hold of the vessel. This can be insured by placing in each tank and in the insulating chamber outside of the tanks, a body of such an inert gas as carbon dioxide which being heavier than air can expel or purge from the tanks and from the chamber all air.

A convenient way to do this is to place Dry Ice or solidified carbon dioxide separately in each tank and in the insulating chamber outside of the tank. The ambient heat or heat of the tank or chamber will cause vaporization of this Dry Ice, the carbon dioxide will spread through the system and being heavier than air will purge the tank and reservoir of air. When the cold boiling liquid is introduced into the tanks, its temperature will be lower than the freezing temperature of carbon dioxide and the carbon dioxide will return to its Dry Ice condition with substantial reduction in volume and will remain in the tank and in the insulating chamber occupying but a very small part of the space in the tank and chamber so that this carbon dioxide will always be there available to vaporize and again fill the tank if the liquefied gas or low boiling liquid is ever removed from the tank. As a matter of actual practice, once the tank is filled with the cold boiling liquid it will always contain some of that liquid under most circumstances of operation so that never again except when repair is necessary will the tanks or the insulating chamber be allowed to contain anything except the inert gas, for example carbon dioxide, and the cold boiling liquid or its gas.

My invention is illustrated more or less diagrammatically in the accompanying drawing wherein—

Figure 1 is a transverse section through the hull of a vessel;

Figure 2 is a section along the line 2—2 of Figure 1.

Like parts are indicated by like characters throughout the specification and drawings.

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1 is the outer skin of the hull of a waterborne vessel. 2 are the reinforcing structural frame members of the vessel. 3 is the inner skin supported by the frame members 2. 4 is an insulating lining in the skin 3 and defining an insulated cold storage chamber which is in effect the hold of a ship. The hull may be coextensive with the vessel or there may be a plurality of such chambers or a single chamber of much less size than the hold of the vessel. The insulation 4 is preferably of balsa wood though other porous insulating material may be used.

Nested within the insulating chamber is a multiplicity of relatively small vertically disposed tanks 5. If they are cylindrical, there will be considerable clearance between the tanks in the chamber. If they are rectangular the clearance space between the tanks will be reduced. They will preferably be in contact with one another so that the metal of the tanks being a good heat conductor will permit heat flow and thus maintain a substantially uniform temperature throughout the entire insulating chamber. Each tank is separately supported within the insulating chamber. I have shown the tanks with convex top and bottom to interlock with the insulating chamber walls though any other suitable arrangement may be used to long as each tank is held in place in the insulating chamber by contact direct or indirect, as the case may be, with the insulating wall of the chamber so that relative movement between the tanks will not take place. The tanks may be tied together as a unit within the insulating chamber and out of contact with the outer skin or wall 3 of the insulating tank.

6 is an insulated feed manifold having branches 7 extending down toward the bottom of each tank 5. The cold boiling liquid may be introduced into the tanks through the manifold 6 and branches 7, the flow into individual tanks being controlled by any suitable flow control means not here illustrated since it forms no part of the present invention. 8 is a discharge pipe associated with each tank 5, communicating with a gas discharge manifold 9 so that the gas boiled off from the liquid may be discharged from the tanks and from the cold storage chamber. The gas manifold 9 communicates also with the interior of the insulating chamber through branches 10. Any suitable control means for these branches may be provided but under ordinary conditions, these control means will maintain the pressure of gas in the insulation and insulating chamber substantially equal, pressure of gas in each of the tanks thus preventing the development of differential pressures between the tanks and the insulating chamber.

Since the tanks will individually be of relatively small capacity and since the tanks are nested in the insulating chamber and supported by one another and by the chamber walls and since those tanks will be made of material which is not substantially weakened as a result of the cold, the cold boiling liquid will be kept out of contact with the insulating wall of the chamber. However, should there be any leakage or breakage of any of these tank walls, the worst that could happen would be a spreading of the liquid throughout the insulated area. The liquid would be at the same temperature in all the tanks so no change in that situation would prevail and since the insulation is continuous throughout the inner wall of the insulating chamber, the liquid will be kept away from the metal structural wall of the insulating chamber. If the liquid penetrates by hydrostatic pressure any capillary attraction into the pores of the insulation, such penetration will be in capillary filaments and these capillary filaments will meet the ambient heat penetrating the insulation from the outer structural wall of the cold storage chamber, will vaporize the liquid to generate a gas pressure in the insulation sufficient to, if not expel the liquid from the insulation, at least prevent penetration as far as the metal of the cold storage wall or hold of the ship. Therefore, since the gas will usually be above the temperature of the liquid and since its specific heat is much less than that of

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the liquid, the temperature of the outer structural wall of the cold storage chamber or hold of the ship will remain above the safety point.

Since each of the tanks is in communication with the interior of the chamber outside the tank, the chamber will always be filled with the gas boiled off from the liquid.

I have referred to the use of non-ferrous or austenitic material within the insulating cold chamber which contains the cold boiling liquid. It will be obvious that any material which can be relied upon at the very low temperatures in question to maintain its structural strength sufficient to support the hydrostatic pressure and any pressure of the liquid in the tank will be suitable. The illustrations given above are perhaps the best but any other material may be used.

Preferably the outer wall or shell of the vessel or tank which encloses the insulation will be of steel against which the insulation abuts. Preferably the insulation will be of balsa wood or a similar light, porous, self-sustaining material of sufficient strength which is not harmfully affected by the low temperatures involved. Preferably, the individual tanks contained in the insulated chamber would be of metal such as aluminum which is not deleteriously affected by contact with cold gas or cold liquid involved. However, any suitable structural material which will have the desired characteristics may be used in place of these preferred elements, it being essential that the wall of the tank enclosing the individual liquid bodies of whatever it is made, be impervious to the liquid and not dangerously adversely affected by the low temperature involved. It is essential that the insulation be light and retain its structural strength when in contact with the gas or even the liquid and it is essential that the shell or wall surrounding the insulation be of sufficient strength to support the insulation even against any distortion resulting from hydrostatic pressure in the tanks or in the insulated chamber.

Preferably, in order to promote uniform temperature throughout the entire insulated area, the tanks would be in contact with one another. They may be circular or of other shape in horizontal cross section. They will all be nested within the insulating chamber. If they are in contact, the tank walls will be of such character that they may distort under change in temperature without ruptural danger. If they are out of contact, they will be free to expand and contract and distort under change in temperature and pressure.

The assembly proposed divides the liquid up into a multiplicity of relatively small, generally vertically disposed bodies which are separated from one another as units, are not separately insulated and the assembly of such bodies is insulated by the insulating lining walls of the tank, hold or vessel.

While it is desirable to divide the liquid mass into a large number of separate portions to prevent too great liquid flow or agitation, it is equally desirable to get as much room as possible in the insulated hold or tank or chamber. Therefore, the tanks will be closely nested. Preferably they will be directly or indirectly in contact with one another for heat flow and they will be so supported and so shaped that expansion and contraction of the tanks as a result of introduction or withdrawal of the cold boiling liquid will not deleteriously affect the relationship between the tanks and the relationship of the tanks with the insulated chamber.

An arrangement such as that above disclosed provides for a control of the rate of evaporation as a result of ambient heat, such control being in the first instance in the design of the insulation. All that is necessary is to provide an insulation of such thickness in the light of the volume and temperature of the cold boiling liquid and in the light of the warmest ambient temperature to be encountered which will prevent excessive boiling of the cold liquid because if excessive boiling takes place, the gas must be flared or otherwise wasted but if under any particular circumstance, evaporation is not as rapid as desired, it

is easy to provide additional means to increase the evaporation rate. Therefore the thickness of the insulation in an arrangement such as this depends on the circumstances of use.

However, since in the interest of safety, the apparatus must be designed in such wise that no harm can come from the escape of cold boiling liquid from the individual container tanks, the insulation must also be designed so that under the coolest ambient temperature conditions, the thickness of the insulation, the rate at which heat flows through it and the rate at which the liquid can be forced through it by hydrostatic pressure and capillary attraction will be such that under no circumstances in the absence of leaks which can be otherwise taken care of, the liquid will penetrate the lining at a rate high enough to reach the outer wall of the insulating chamber without expansion. In other words, the design must be such that no matter what the conditions, any liquid in the pores of the lining will be vaporized before that liquid as liquid is able to contact the outer shell of the insulating chamber.

I claim:

1. A storage means for liquefied low boiling gas comprising the combination of a rigid shell of large dimension, a plurality of gas-tight tanks of smaller dimension arranged substantially in side by side relation out of contact one with the other within said shell and with the outer tanks spaced from the inner walls thereof, a liquefied natural gas at about atmospheric pressure and a temperature of about -258° F. contained within said gas-tight tanks, a solid porous thermal insulating material having sufficient structural strength to support the load of the tanks between the outer walls of the outer tanks and the inner wall of the shell whereby the tanks mutually insulate one another within the shell and the insulation minimizes heat transfer from the shell to the tank, inlet means for the passage of liquid methane into each of the tanks, and outlet means for removing vapors released from the liquid methane within the tanks a header common to all of the inlet means, and another header common to all of the outlet means.

2. A storage means for liquefied low boiling gas comprising the combination of a rigid shell of large dimension, a plurality of gas-tight tanks formed of aluminum metal arranged in side by side relation out of contact one with the other in a cluster within said shell and spaced from the inner walls thereof, a liquefied natural gas at about atmospheric pressure and a temperature of about -258° F. contained within said tanks, a solid porous thermal insulating material having sufficient structural strength to support the load of the tanks lining the inner wall of the shell and directly supporting the smaller tanks within the shell, means extending into the bottom end portion of each of said tanks and a header interconnecting each of said means outside of the tank for use in the passage of liquid into and out of each of the tanks, and outlet means communicating with the upper portion of each of said tanks for bleeding off vapors released by the liquid methane within said tanks.

3. A storage means for liquefied low boiling gas comprising the combination of a rigid shell of large dimension, a plurality of gas-tight tanks formed of aluminum metal within said shell and spaced from the inner walls

thereof, a liquefied natural gas at about atmospheric pressure and a temperature of about -258° F. contained within said tanks, a solid porous thermal insulating material lining the inner wall of the shell and directly supporting the smaller tanks within the shell, means extending into the bottom end portion of each of said tanks and a header interconnecting each of said means outside of the tank for use in the passage of liquid into and out of each of the tanks, outlet means communicating with the upper portion of each of said tanks for bleeding off vapors released by the liquid methane within said tanks, and means communicating said outlet means with the porous insulation for circulating vapors released from the tanks through the insulation for extracting heat from the insulated space.

4. Means for storing and shipping cold boiling liquid comprising the combination of a rigid shell of large dimension, a plurality of gas-tight metal tanks of smaller dimension located within the shell and in spaced relation with the walls thereof, a liquefied low boiling gas maintained at about atmospheric pressure within said tanks, a solid porous thermal insulating material filling the space between the outer walls of said tanks and the inner wall of said shell and in which the pores of the insulation are interconnected for the free passage of vapors and liquids therethrough, a liquid supply manifold, means communicating the liquid supply manifold with the lower portion of each of said tanks for the passage of the liquefied gas into and out of said tanks, a gas discharge manifold and means communicating the upper portion of each of said tanks with the gas discharge manifold for the release of vapors from said tanks, and means communicating the gas discharge means with the porous insulation for circulation of released vapors therethrough whereby the pressure in the insulation and in the tanks is uniform and heat is extracted from the insulation material.

5. Means for storing and shipping a cold boiling liquefied natural gas comprising the combination of a rigid shell of large dimension, a plurality of gas-tight metal tanks of smaller dimension located as a cluster within the shell in spaced relation with the walls thereof and in side by side relation out of contact one with another without insulation in between, a liquefied low boiling natural gas maintained at about atmospheric pressure within said tanks, a solid porous thermal insulating material having structural strength sufficient to support load filling the space between the outer walls of the outer tanks and the inner wall of said shell, a liquid supply manifold, means communicating the liquid supply manifold with the lower portion of each of said tanks for passage of the liquefied natural gas into and out of said tanks, a gas discharge manifold, and means communicating the upper portion of each of said tanks with the gas discharge manifold for the release of vapors from said tanks.

References Cited in the file of this patent

UNITED STATES PATENTS

644,259	Ostergren	Feb. 27, 1900
1,789,532	Morrell	Jan. 20, 1931
2,437,909	Cooper	Mar. 16, 1948
2,687,618	Bergstrom	Aug. 31, 1954