This invention relates, as indicated, to improvements in housings used for storing cold boiling liquids, and more particularly, but not by way of limitation, to an improved wall construction for housings to be used in shipping liquefied natural gas. This is a continuation-in-part of applicant's copending application entitled "Insulating Tank for Cold Boiling Liquids," Serial No. 499,570, filed April 6, 1955, now Patent No. 2,859,895.

In the above-mentioned application I have disclosed and claimed a tank structure utilizing a plurality of louvers spaced at the inner periphery of the vertical walls of a tank in vertically spaced relation. Each louver overlaps the louver below it to provide a series of overlapping, annular-shaped and substantially gas-tight pockets around the inner periphery of the tank. Gas boiling from the liquid stored in the tank and entering the pockets will build up a back pressure in each pocket and limit the penetration of liquid into the pocket. Thus, the liquid is maintained out of direct contact with the tank walls to permit the use of inexpensive materials for the shell of the tank, and minimize evaporation of liquid stored in the tank.

The present invention contemplates an improvement in the above-described structure which particularly adapts the structure for use in shipping or transporting cold boiling liquids. When a cold boiling liquid, such as liquefied natural gas, is being transported, the liquid will be in substantially constant motion in the containing vessel, as contrasted with a substantially quiescent condition in land-based storage tanks. Therefore, when shipping such a cold liquid in a housing having a shell formed out of a material which will not withstand the extremely cold temperature of the liquid, the shell must be protected against the splashing and substantially constant movement of the cold liquid in the housing.

The present invention contemplates a novel wall construction for a housing used in storing or shipping cold boiling liquids, comprising a shell and the combination of a series of louvers forming gas pockets around the inner periphery of the shell, much in the same manner as in the above-mentioned copending application, along with an insulating material so supported in the pockets as to intercept any cold liquid attempting to pass through the pockets from the interior of the housing into contact with the shell. The preferred insulating material provides a multiplicity of minute gas pockets in each of the gas pockets provided by the louvers, such that gas will be trapped at least in the outermost portion of the insulating material to form an additional or supplemental barrier against the flow of the cold liquid in a direction to contact the shell, as well as improve the insulation of the wall. Cold liquid entering the pockets formed by the louvers, as by the liquid being splashed into these pockets, will contact the insulating material barrier and be prevented from further outward movement by the gas trapped in the pores of the insulating material. This invention also contemplates the use of novel and efficient means for supporting the insulating material between the louvers, as well as an arrangement of the insulating material in each of the pockets formed by the louvers which will prevent possible capillary movement of liquid through the insulating material into direct contact with the shell.

An important object of this invention is to increase the safety of shipping cold boiling liquids and simultaneously reducing evaporation of the liquids.

Another object of this invention is to provide a novel wall construction for a housing containing a cold boiling liquid which will insulate the housing and prevent the cold liquid from being splashed or otherwise moved in direct contact with the outer shell of the housing.

A further object of this invention is to maintain a layer of gas between a cold boiling liquid and the inner periphery of a housing containing the liquid, even though the housing is tilted to a substantial degree.

A still further object of this invention is to provide a novel housing for cold boiling liquids which is simple in construction, durable, and may be economically manufactured.

Other objects and advantages of the invention will be evident from the following detailed description, when read in conjunction with the accompanying drawings which schematically illustrate my invention.

In the drawings:

Figure 1 is a partial vertical sectional view through the wall of a housing constructed in accordance with this invention;

Figure 2 is a vertical sectional view through a portion of a tank illustrating a typical use of the present invention; and

Figure 3 is a vertical sectional view through a portion of a ship or the like used for transporting cold boiling liquids to illustrate another use of this invention.

Referring to the drawings in detail, and particularly Fig. 1, reference character 4 generally designates a vertical wall construction for a housing used for either directly or indirectly storing a cold boiling liquid, such as liquefied natural gas, as will be more fully hereinafter set forth. The wall 4 includes a generally vertical shell 5 extending all the way around a housing incorporating the present invention and which may be formed out of any material which is substantially impervious to gas and liquid, such as metal, plastic or some forms of wood. The shell 5 may take any desired form in horizontal cross section, such as substantially circular or rectangular.

It may also be noted here that since the cold boiling liquid is retained out of direct contact with the shell 5, as will be described, this shell may be formed out of a relatively inexpensive material, such as plate or conventional tank steel, which would crack or fracture when subjected to a temperature in the range of the boiling temperature of many cold liquids, such as liquefied natural gas, which has a boiling temperature of from -240 to -258° F. at about atmospheric pressure.

A plurality of louvers 6 are secured around the inner periphery of the vertical shell 5 in vertically spaced relation and extend downwardly and inwardly from the shell 5. It will be understood that in a complete housing, each louver 6 will completely encircle the inner periphery of the shell 5, and each louver 6 is preferably extended around the inner periphery of the shell in a substantially horizontal plane. Also, each louver 6 extends downwardly over at least the next lower louver; that is, the lower inner edge of each louver extends below the upper, outer edge of the next lower louver to provide gas pockets extending inwardly from the inner periphery of the shell 5 a substantial distance, with vertically-adjacent pockets being in overlapping relation.
The louvres 6 are so constructed and secured to the inner periphery of the shell 5 that when a housing incorporating the present wall construction is filled with a cold liquid, gas will enter each pocket 8 at a faster rate than it will escape vertically through the louvres and around the outer edges of the louvres, whereby gas entering each pocket will build up a back pressure and limit the flow of liquid in the respective pocket to a level where the liquid will not come into direct contact with the shell 5. For example, the louvres 6 may be formed out of a gas-impermeable material, such as metal or plastic, and cemented or otherwise sealed around their outer edges to the inner periphery of the shell 5. With this construction, gas may enter and leave the pocket 8 only between the inner edges of the louvres, such that gas boiling into a pocket from liquid stored in the housing will build up a back pressure until the gas begins to bubble upwardly around the inner edge of the louvre 6 and form the top of the respective pocket. However, the louvres 6 may be formed out of a material, such as wood, which has a limited gas permeability, and the louvres may be secured to the inner periphery of the shell 5 with only a sufficiently gas-tight connection that gas will enter each pocket 8 through the space between the inner edges of the louvres forming the respective pocket, through such louvres, and around the outer edges of such louvres at a faster rate than it will escape through the louvres and around the outer edges of the louvres. It may also be noted that the gas barrier provided by the gas in the pockets 8 also functions as an insulation to minimize the transfer of heat from the shell 5 inwardly and minimize evaporation of the cold liquid.

In the preferred construction, the inner periphery of each louvre 6 extends below the outer peripheries of at least the next two lower louvres to provide at least three of the gas pockets 8 extending concentrically around the housing at any particular level in the housing. Thus, in the event one of two of the louvres 6 collapses or is fractured, at least one pocket 8 will still be provided around the inner periphery of the shell 5 at each level in the housing. Also, I prefer to turn the inner peripheral portion 10 of each louvre 6 downwardly into proximity with the upper surface of the next lower louvre to strengthen the louvres and minimize splashing of cold liquid into the pockets 8, as will be more fully hereinafter set forth.

As previously noted, the louvres 6 may be formed out of any suitable material, such as metal, plastic or wood which is either gas impervious or has a limited gas permeability. However, I prefer to form the louvres 6 out of a wood, such as pine or alder, to minimize the conduction of heat from the outer to the inner peripheries of the louvres. Also, I prefer to form the louvres 6 as thin as will permit the louvres to be self-supporting, to further minimize the conduction of heat from the outer to the inner peripheries of the louvres, and to provide a light-weight wall structure.

When the inner peripheries of the louvres 6 are exposed to a cold boiling liquid, as by filling a housing using the wall construction 4 with a cold liquid, a portion of the gas boiling from the cold liquid will be trapped in each of the pockets 8 to maintain the level of the liquid in the lower portion of a respective pocket, and maintain the cold boiling liquid out of direct contact with the inner periphery of the shell 5, as set forth above, as well as for the condition around the cold liquid. However, in the event the wall 4 is tilted to a substantial angle, or the housing having the wall 4 is subjected to substantial movement, a portion of the cold boiling liquid will tend to flow or splash into at least some of the pockets 8, and gas trapped only by the louvres 6 and the shell 5 will not always be sufficient to prevent the cold boiling liquid from coming into direct contact with the inner periphery of the shell. Therefore, a supply of insulating material 12 is supported in each pocket 8 to intercept any cold boiling liquid which may enter the respective pocket.

The insulating material 12 is a porous type, such as balsa wood, cork, a light-weight silica aerogel such as that manufactured by Monsanto Chemical Company under the trademark Santocal, exfoliated vermiculite, blasted clay, dry glass wool, or a homogenous earth, or a porous insulating material is disposed in each of the pockets 8 in an amount to span the length of the respective pocket between the louvres 6 forming the pocket, the pores in the outer portion of the insulating material form a multiplicity of minute gas pockets which become filled with the gas and prevent movement of liquid through the insulating material. Since the shell 5 will be at a higher temperature than the cold liquid at the inner edges of the pockets 8, the outer portion of the insulating material 12 will be warmer than the inner portion of the insulating material. Therefore, a portion of the cold liquid initially brought into contact with the insulating material 12 and entering the insulating material 12 will be vaporized in the outer portion of the insulating material. Since this gas cannot escape to any appreciable extent either through the louvres 6 at the top and bottom of the pocket, or through the shell 5, a back pressure will be developed in the outer portion of the insulating material to form a further gas barrier and prevent movement of the liquid through the respective pocket. The insulating material 12 therefore forms what may be considered a secondary gas barrier to the outward flow of cold liquid into contact with the shell 5. It should also be noted that the insulating material will improve the insulation around the inner periphery of the shell.

Although an insulating material 12 which retains its shape may be used in the pockets 8 and assist in bracing the louvres, I prefer to use a particulated insulating material, such as the "Santocal" noted above, with the insulating material being retained in porous bags 14 formed out of a suitable fabric, such as cotton. The bags 14 of the particulated insulating material may be distorted and more easily installed in the pockets 8. I also prefer to use at least two separate bags 14 of the insulating material in each circumferential portion of each pocket 8, with a space 16 being provided between the bags. The space 16 extends laterally all the way across the respective pocket 8 between the respective louvres 6, either horizontally, as shown, or, for example, vertically, to form a capillary barrier between the bags of insulating material. In the event capillary movement of liquid through the inner bag 14 of the insulating material is experienced, the capillary movement will be stopped in the space 16 to further assure that the cold liquid will not come into direct contact with the shell 5.

When at least two bags 14 of the insulating material are used in each circumferential portion of each pocket 8, the outer bag 14 may be supported by a baffle 18 extending latterly across the respective pocket between the louvres 6 forming the pocket. Each baffle 18 is preferably formed out of a strip of wood which may be wedged into the respective pocket between the respective louvres 6. However, the baffle 18 may be formed out of any desired material to the respective louvres 6 in any desired manner. The baffles 18 not only provide supports for the outermost bags 14, but may also be formed out of a substantially liquid-imperious material to form an additional barrier against outward movement of the cold liquid into contact with the shell 5. The innermost bags 14 may be wedged in the inner portions of the pockets 8 in any desired manner. For example, when the louvres 6 are formed out of relatively thin sheets of wood, the innermost bags 14 may be secured in the desired positions by staples 20 extending through one of the louvres 6 forming each pocket 8 and the material forming the respective bag. It should also be pointed out that although I have stated the bags 14 may be wedged between
5 the respective louvres, the insulating material 12 may actually be rather loose in the pocket and still perform a useful role in insulating the wall 4 and minimizing the amount of liquid which will contact the shell 5.

As previously indicated, the present wall construction may be used in several different ways in the transportation and storage of a cold boiling liquid. For example, the present wall construction may be used as the vertical walls of a tank 22, as illustrated in Fig. 2, for directly holding the cold boiling liquid. The vertical walls 24 of the tank 22 are formed in the same manner as the wall section 4 illustrated in Fig. 1, with the louvres 6 secured along the height of the tank from the bottom of the tank to substantially above the normal liquid level in the tank. The bottom wall 24 of the tank 22 may be suitably protected and insulated in any desired manner, such as by the use of a thick layer 26 of insulating material which will support the liquid stored in the tank and prevent the liquid from contacting the bottom wall 24 of the tank. The top of the tank 22 (not shown) may be constructed in any desired manner which will minimize evaporation of cold liquid stored in the tank.

As the tank 22 is being moved from one location to another, and particularly when the tank 22 is installed aboard a ship, the cold liquid in the tank will be in substantially constant motion and tend to splash or flow into the pockets 8 surrounding the cold liquid. The downwarded inner peripheral portions 10 of the insulating material 12 will minimize the amount of cold liquid which may be splashed into the inner portions of the pockets 8. The cold liquid which does enter the inner portions of the pockets 8 is prevented from coming into contact with the outer shell 5 by the gas in the pockets 8 and the insulation 12, as previously described. It may be further noted that the insulating material 12 is also effective to prevent outward flow of the cold liquid into contact with the outer shell in the event the tank 22 is tilted to an appreciable degree.

The present wall construction may also be used as what may be considered a secondary line of defense in a ship or the like used for transporting cold boiling liquids. As illustrated in Fig. 3, two or more insulated tanks 28 containing the cold boiling liquid are supported in a hold or compartment 30 of a ship. In a normal transporation operation, the cold boiling liquid will be confined within the insulated tanks 28. However, one or more of the insulated tanks 28 may develop a leak and the cold boiling liquid will flow into the hold 30 of the ship. Therefore, the vertical walls of the hold or compartments 30 of the ship are constructed in the same manner as the wall 4 illustrated in Fig. 1. The bottom 32 of the hold 30 is also protected from the leaking cold boiling liquid, as by a thick layer 34 of insulating material. It will then be apparent that in the event some of the cold boiling liquid does leak into the hold 30, the liquid will be retained in the particular section without coming into direct contact with supporting structure of the ship, particularly the hull of the ship, and without any appreciable evaporation of the leaking cold liquid. The top of each hold 30 is also closed by a cover 36 which is suitably insulated (not shown) and sealed to the vessel to prevent leakage of the gas from the hold. Therefore, the ship may proceed to its destination; whereupon the hold 30 containing the leaking insulated tank 28 may be emptied and the insulated tanks 28 removed therefrom, without causing damage to the ship structure.

From the foregoing it will be apparent that the present invention provides a novel wall construction for housings used in storing cold boiling liquids, a plurality of parts or elements as heretofore set forth in the specification and shown in the drawings, it being understood that changes may be made in the precise embodiments disclosed without departing from the spirit and scope of the invention as defined in the following claims.

I claim:

1. In a housing for cold boiling liquids, a gas and liquid impervious shell, a plurality of vertically spaced louvres encircling the inner periphery of the shell and extending downwardly and inwardly from the shell a sufficient distance and so spaced that the inner periphery of each louver extends below the outer peripheries of at least the next two lower louvres to provide at least three overlapping annular gas pockets around the inner periphery of the shell at each level in the shell, and a supply of porous insulating material in each of said pockets positioned to intercept liquid entering the respective pockets from between the inner peripheries of the respective louvres forming the pockets.

2. In a housing for cold boiling liquids, a gas and liquid impervious shell, a plurality of vertically spaced louvres encircling the inner periphery of the shell and extending downwardly and inwardly from the shell, the inner periphery of each louver extending below the outer peripheries of the next lower louver to form a plurality of overlapping annular gas pockets around the inner periphery of the shell, and a supply of porous insulating material in each of said pockets positioned to intercept liquid entering the respective pocket from between the inner peripheries of the respective louvres forming the pocket, said porous insulating material being in particular form and supported in porous bags, with at least one bag of the insulating material in each pocket of a size to form a barrier of insulating material spanning the length of the pocket between the louvres forming the pocket.

3. A construction as defined in claim 2 wherein the louvres are formed out of wood and the insulating material is secured in the pockets by stapling the bags to the louvres.

4. In a housing for cold boiling liquids, a gas and liquid impervious shell, a plurality of vertically spaced louvres encircling the inner periphery of the shell and extending downwardly and inwardly from the shell, the inner periphery of each louver extending below the outer periphery of the next lower louver to form a plurality of overlapping annular gas pockets about the inner periphery of the shell, and a supply of porous insulating material arranged in at least two layers extending in spaced relation across the pocket between the louvres forming the pocket to intercept liquid entering the respective pockets from between the inner peripheries of the respective louvres forming the pockets.

5. A construction as defined in claim 4 characterized further to include a baffle extending across each pocket between each adjacent pair of layers of insulating material.

6. In a housing for cold boiling liquid, a gas and liquid impervious shell, a plurality of vertically spaced louvres encircling the inner surface of the shell and extending downwardly and inwardly from the shell, the inner edge of each louver extending below the outer edge of the next lower louver to form a plurality of overlapping gas pockets around the inner surface of the shell and in which the louvres have an end portion turned downwardly in proximity with the upper surface of the next lower louver, and a supply of porous insulating material in each of said pockets positioned to intercept liquid entering the respective pockets from between the
inner edges of the respective louvres forming the pockets.

7. In a housing for cold boiling liquids, a gas and liquid-impervious shell, a plurality of vertically spaced louvres encircling the inner periphery of the shell and extending downwardly and inwardly from the shell, the inner periphery of each louvre extending below the outer periphery of the next lower louvre to form a plurality of overlapping annular gas pockets around the inner periphery of the shell, a substantially liquid-impervious baffle spanning the length of each pocket between the louvres forming the pocket, porous insulating material resting on each of said baffles and spanning the length of the respective pocket between the louvres forming the pocket, and additional porous insulating material supported in each pocket inwardly of the respective baffle in sufficient quantity to span the length of the pocket between the louvres forming the pocket.

8. A construction as defined in claim 7 wherein the porous insulating material is in particulated form and supported in porous bags.

9. A construction as defined in claim 7 wherein said additional insulating material is arranged in spaced relation from said baffle.

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