

[54] **LIQUID CRYOGEN STORAGE TANK
FOR SHORE, SHIP OR BARGE**

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[51] Int. Cl.B65d 25/18
[58] Field of Search220/9 LG, 9 F, 10, 9 A; 114/74 A

[56] **References Cited**

UNITED STATES PATENTS			
3,319,431	5/1967	Clarke et al.....	114/74 A X
3,420,396	1/1969	Bridges et al.....	220/9 A
3,106,307	10/1963	Morrison.....	220/9 F
3,331,525	7/1967	Coehn.....	114/74 A X
3,379,330	4/1968	Perkins, Jr.....	220/9 A

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[57] **ABSTRACT**

A container for cryogenic fluids is described wherein a first layer of insulating blocks completely lines the interior of the container and at least a portion of one face of each block is bonded to the interior of the container by a cryogenic adhesive. The sides of the insulating blocks have a contractable insulating material completely surrounding them. At least a second layer of insulating blocks is bonded to the first layer of blocks; at least about 2 percent of the areas common to the faces of the first and second layers of blocks are bonded. The sides of the second layer of blocks are surrounded by a contractable insulating material. The face areas common to the blocks that are not bonded preferably have a substantially non-friction material attached thereto. The layers of blocks are arranged so that there are no direct heat paths to the walls of the container. A membrane of Invar completely covers the interior of the container and is sufficiently bonded to the interior layer of blocks to support the Invar. Optionally, another layer of insulating blocks can be bonded to the Invar and then another layer of Invar bonded to this layer of blocks— this is preferred for containers useful in transporting cryogen. Where the container is stationary, the top of the container does not have to have the membrane of Invar.

15 Claims, 4 Drawing Figures

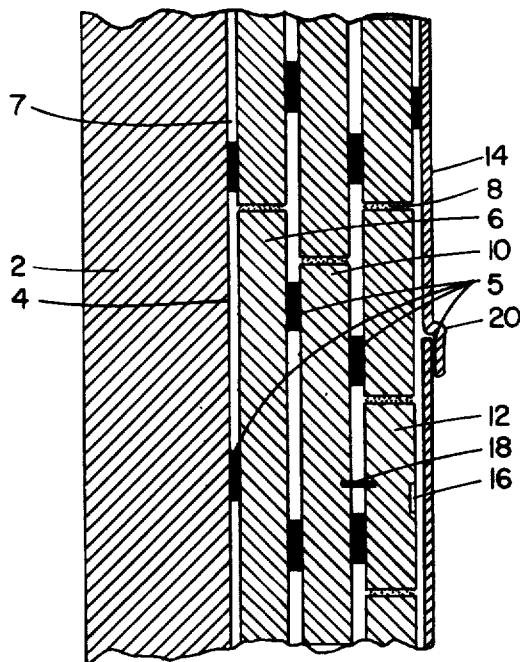


Fig. 1

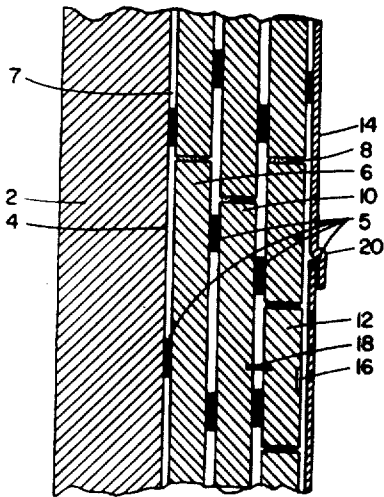


Fig. 3

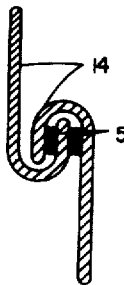


Fig. 2

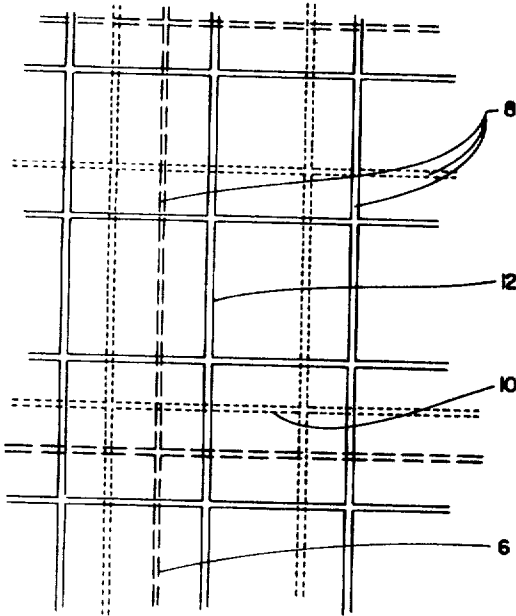
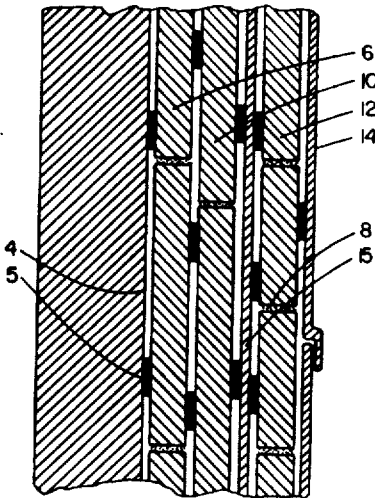


Fig. 4



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BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to internally insulated containers for the confinement of cryogenic fluids and more specifically to a load-bearing insulating material that does not permit direct heat path to the container walls. On the interior of the insulating blocks, a membrane of Invar is bonded to the insulating blocks. The container can be used to transport cryogen or contain cryogen in a stationary position.

2. Description of the Prior Art

U.S. Pat. No. 2,859,895 to Beckwith teaches a method of insulating the shell of a methane storage tank. The insulation is defined as "a wall made of a multiplicity of separate blocks or strips or panels of a light, permeable, preferably straight-grained, natural or synthetic wood-like material having a high insulating factor." The blocks are mounted on the walls by glue and are staggered so that the glue planes are not interrupted.

U.S. Pat. No. 3,106,307 to Morrison teaches a combination of a layer of air-laden polystyrene protecting an inner layer of freon-laden polyurethane.

U.S. Pat. No. 3,136,135 to Rigby et al. teaches the use of foamed polyvinyl chloride or foamed polystyrene to insulate a tanker for shipping liquefied natural gas.

U.S. Pat. No. 3,367,492 to Pratt et al. teaches insulating the inner wall of an LNG tanker with foam encapsulated in fiberglass reinforced urethane material. The encapsulated foam is partitioned to form blocks and the blocks attached to the wall by mechanical means. The blocks are joined together by a joint assembly fastened to the blocks with grooves and adhesive.

U.S. Pat. No. 3,367,527 to Darlington teaches a cryogenic container internally insulated with moisture-free insulating blocks (blocks can be encapsulated in a plastic material, e.g., polyurethane). The blocks lie in juxtaposition with adjoining faces abutting. One face of the block is secured to the interior of the shell and the remaining faces are independent of the adjoining insulating blocks.

SUMMARY OF THE INVENTION

Applicant has discovered a novel method of designing a cryogen tank that provides for differential expansion between insulating materials and at the same time supports an interior layer of Invar. This is accomplished by lining the inside of the container with:

1. a first layer of insulating blocks, one face of the blocks bonded to the interior wall of the container and the blocks arranged side by side, the blocks having sufficient space between them to provide for expansion and contraction over a temperature range of about 72° to about -350° without shearing the blocks from the wall,
2. a contractable and expandable insulating material filling at least a portion of the space between the sides of the blocks,
3. at least a second layer of insulating blocks arranged over said first layer so that no direct paths of heat loss are permitted to the shell of the con-

tainer, the blocks arranged side by side and spaced as in (1),

4. a contractable and expandable insulating material filling at least a portion of the space between the second layer of blocks,
5. the faces common to the blocks within the first and second layers bonded with a cryogenic adhesive on at least 2% of the area common to the faces, and
6. a membrane of Invar completely lining the exposed face of the second layer of blocks and attached thereto by adhering with a cryogenic adhesive at least 2 percent of the area common to the blocks and the Invar.

The insulating blocks are self-supporting. Differential expansion of the insulating blocks is accommodated by the contractable and expandable insulating material placed between the sides of the blocks. The Invar is supported by the insulating blocks.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a cross section of the container wall with layers of insulating blocks and a layer of Invar.

FIG. 2 is a side view of the insulating blocks showing how the blocks overlap other insulating blocks so that no direct paths of heat are permitted to the container wall.

FIG. 3 illustrates a preferred way of bonding layers of Invar together.

FIG. 4 is a cross sectional view of a preferred container wherein one layer of Invar is sandwiched between insulating blocks and then a final layer of Invar is attached to the exposed layer of insulating blocks.

FIG. 1 is a cross section of the container wall. Wall 2 can be steel, concrete or like material. Such is representative of the container wall of, for instance, an ocean-going tanker to transport LNG (liquefied natural gas). Interior of the wall 4 is connected to the face of the first layer of insulating blocks 6 by cryogenic adhesive bond 5. Space 8 between blocks 6 is filled with a contractable and expandable insulating material such as sponge urethane, strips of fiberglass, or like materials. The second layer of insulating blocks 10 is attached to the first layer of insulating blocks 6 by cryogenic adhesive bond 5. Also, the spaces 8 between the second layer of insulating blocks 10 are filled with the insulating material. The areas common to the faces between the blocks that are not bonded can be coated with a substantially nonfriction material at 7, e.g., Teflon or like material, to prevent abrasion between the blocks when thermal expansion and contraction moves the blocks. Optionally, a third layer of insulating blocks 12 are attached to the second layer of insulating blocks 10, via bonding at 5 the faces common to the blocks. Again, the space 8 between insulating blocks 12 is filled with the insulating material. The layers of blocks 6, 10, and 12 are placed such that no direct heat passes are permitted to wall 4 of the container. Attached to the exposed face of insulating blocks 12 is a membrane or layer of Invar 14. The membrane of Invar 14 is attached at 5 to the inside of insulating blocks 12 by a cryogenic adhesive. Invar 14 can be connected to other layers of Invar by overlapping as shown at 20. The overlap of Invar is attached to the underlap of Invar by

a cryogenic adhesive. Suction cups 16 can be previously countersunk flush to the face of insulation blocks 12 and bonded to the blocks, the cups useful to hold the Invar in place until the adhesive cures.

Optionally, the Invar can be attached to other layers of Invar by folding back about one-half inch at the edge of each Invar sheet and then locking these 180° folds together as shown in FIG. 3. Locking of the folds can be effected by cryogenic adhesive or by mechanical means.

FIG. 2 is an inside view of the insulating blocks before the Invar is attached to the exposed face of insulating blocks 12. FIG. 2 shows that the insulating blocks are arranged side by side and that they have space 8 between the sides of the blocks. The third layer of insulating blocks 12 is staggered over the second layer of insulating blocks 10 and the latter blocks staggered over the first layer of insulating blocks 6 such that no direct pass of heat leak is permitted to wall 4. Fastening means such as wood pegs 18 in FIG. 1 can be used to adjoin or fasten the faces of insulating blocks to each other and hold the blocks in place during the curing of the cryogenic adhesive. A preferred embodiment of the invention is that blocks 12 are smaller in area than blocks 10 and the latter blocks are smaller in area than blocks 6.

FIG. 4 represents a preferred embodiment of the invention. A first layer 6, second layer 10, and third layer 12 of insulation blocks and a membrane of Invar 14 are arranged as in FIG. 1, except that an additional membrane of Invar 15 is sandwiched between layer 10 and layer 12. The faces of insulation blocks 10 and 12 that are common to the Invar are bonded to the sandwiched Invar layer 15. This embodiment is preferred when the container is used to transport LNG, e.g., a ship.

BRIEF DESCRIPTION OF PREFERRED EMBODIMENTS

Applicant's invention teaches a novel method of cryogenic tank fabrication. This method provides a means for differential expansion between insulating blocks and also provides a means of fastening the insulating blocks to the inside of the container. The insulating blocks are arranged in such a manner to prevent direct pass of heat leaks to the container wall. Invar (36 percent nickel and 64 percent steel) or a like material, completely covers the interior of container when the container is used to transport cryogen. When the container is a stationary insulation, the container top may only need the insulation, i.e., the membrane of Invar is not necessary. The insulating blocks support the Invar.

The insulating blocks can be made of any material which has good insulating characteristics and which has a relatively low temperature coefficient of expansion. Examples of preferred materials include foamed polyvinyl chloride (this material has a low conductivity of heat and has high strength), foamed glass, foamed urethane, encapsulated perlite, and like materials. The insulating material may be encapsulated by a protective covering, e.g., plywood, etc. The insulating material must be absolutely free of water vapor. Optionally, a positive pressure of an inert gas (the gas is dehydrated) can be maintained within the space containing the insulating blocks.

The insulating blocks are adhered or bonded to the inside wall of the container, to adjoining insulating blocks and to the Invar by a cryogenic adhesive. Preferably, the adhesive has a high tensile strength, e.g. 8,000 psi and higher at the cryogenic temperature. Examples of useful cryogenic adhesives include (1) a two part polyurethane mixture marketed by the Narmco Division of the Whittaker Corp. and composed of 90 percent by weight formulation No. 7343 and 10 percent by weight of formulation No. 7139; (2) a two part polyester mixture marketed by DuPont composed of 97 percent by volume formulation No. 96990 and 3 percent by volume formulation No. RC805; (3) a two part polyurethane mixture marketed by the CPR Division of the Upjohn Company composed 90 percent by weight formulation CPR 2050 and 10 percent by weight formulation MOCA; (4) formula No. G207 marketed by Goodyear, and like materials.

The areas between the container walls and the faces of the insulation blocks and between the faces of the blocks that need be bonded are only the areas needed to support the insulation blocks and the Invar. All of the area, i.e., 100 percent, is desirably not bonded since such would not permit much freedom of movement during thermal expansion and contraction. It is preferred that at least about 2 percent of the areas common to the interior wall and first layer of blocks and to the layers of blocks and to the insulating blocks and Invar be bonded. Also, each block must be bonded to the wall of the container and thereafter each block bonded to at least one block it overlays.

The insulating blocks are attached one to the other by the cryogenic adhesive. Sufficient bonding is needed to transfer the load (weight of Invar and blocks) from the outer-tank to the inner-tank.

The spaces between the blocks are filled with contractable and expandable insulation material, e.g., sponged urethane, fiberglass, etc. Such accommodates the differential expansion of the blocks. The space should be sufficiently wide to permit expansion and contraction of the blocks over the operating temperature range of the container without shearing the blocks from the walls of the container or other blocks. Examples of temperature ranges include ambient temperature (e.g., 72° F.) to about -350° F. and preferably about 72° F. to about -320° F. and more preferably about 72° F. to about -260° F. at atmospheric pressure.

The blocks are arranged one over the other, or the layers of blocks staggered so that no direct pass of heat is permitted in case of a leak. That is, the second layer of blocks is placed onto the first layer of insulating blocks is an "offset pattern" such that the joints do not line up with each other, see FIG. 2. Also, each block within the second layer is bonded to at least one block in the first layer of insulating blocks. As mentioned earlier, at least about 2 percent of each face area of the blocks is bonded. The non-bonded surfaces of the face areas common to the insulating blocks can be coated with a substantially non-friction material, e.g., Teflon film or like material to prevent abrasion between the layers of insulating blocks as they expand and contract due to temperature changes, i.e., as the blocks move relative to each other.

After the insulating blocks are attached, the exposed face of the last layer of insulating block is covered with

a membrane of Invar. Also, a membrane of Invar may be sandwiched between the insulating blocks. The Invar is preferably about 10 to about 35 mils thick. The Invar may be joined together by overlapping one Invar layer over another layer of Invar and then bonding the contiguous surface with a cryogenic adhesive. Besides lapping the joints of Invar and then bonding them, it may be advantageous to use mechanical means to join the Invar. Such can be accomplished by folding back about one-half inch on the edge of each Invar sheet and then locking the 180° folds together as shown in FIG. 3. The locking can be effected by mechanical means, or a cryogenic adhesive or any suitable means. The Invar can be securely held in position by suction cups countersunk into the insulating blocks and flush with the insulating blocks, the cups supporting the Invar while the cryogenic adhesive is curing. Only a portion of the area contiguous to the layer of insulating blocks and Invar is coated with the adhesive, the minimum area being that which is needed to support the Invar. At least about 2 percent of the Invar area is sufficient.

The insulating blocks can be joined with wood pegs. Also, the insulating blocks contiguous to the interior of the tank can be joined with wood pegs, e.g., such pegs may be previously bonded to the interior of the wall. Such is helpful in temporarily supporting the blocks while the adhesive cures.

The container can be any building material which provides sufficient structural strength to contain the cryogenic material. Examples include reinforced concrete, steel, alloys, synthetic materials such as plastics, etc. Reinforced concrete is the preferred construction material for barges since the weight of the concrete provides ballast. Also, the barge can substitute for shore storage and the cryogen replenished merely by shuttling barges.

A minimum of two layers of the insulating blocks is recommended with this invention. However, three layers is preferred and more than three layers are useful for certain cases. It is evident that the temperature differential between the outside of the container and cryogen will govern the number of insulating block layers as well as the thickness of the insulating blocks. Preferably, the insulating blocks closer to the cryogen are smaller in area than the blocks contiguous to the shell of the container--such a design will permit a larger degree of thermal expansion and contraction next to the cryogen. The larger insulating blocks, i.e., the blocks contiguous to the shell of the container, will still have sufficient capability to expand and contract although the degree of expansion and contraction will not be as great as the insulating blocks closer to the cryogen. Preferably the intermediate layer of blocks has an area intermediate in size of the smaller and larger area blocks. This is preferred since the insulating blocks closer to the cryogen will necessarily have a larger degree of expansion and contraction than the insulating blocks removed from the cryogen.

Where the container is to be used on a ship, it is preferred that a membrane of Invar be sandwiched between the layers of insulation blocks and then a membrane of Invar completely line the exposed face of the first layer of insulating blocks. For example, FIG. 4 is a preferred design.

It is intended that all equivalents obvious to those skilled in the art be incorporated within the scope of the invention as defined within the specification and appended claims.

What is claimed is:

1. a container for the confinement of cryogenic fluids comprising:
 1. an outer shell,
 2. a first layer of a plurality of insulating blocks lining the interior of the shell, at least about 2 percent of the face area of one side of each block is bonded with a cryogenic adhesive to the interior of the shell and the blocks arranged side by side, the blocks having sufficient space between the sides of the blocks to permit expansion and contraction of the blocks over the operating temperature range of the container without shearing the blocks from the interior of the shell,
 3. a contractable and expandable insulating material completely surrounding each block and filling at least a portion of the space between the sides of the blocks,
 4. at least a second layer of a plurality of insulating blocks lining the interior of the first layer of blocks and arranged over said first layer so that no direct path of heat loss is permitted to the shell of the container, the blocks arranged side by side as in (2) and at least 2 percent of the face area of each block contiguous to the face of the block within the first layer are bonded with a cryogenic adhesive to the first layer of blocks,
 5. a contractable and expandable insulating material surrounding the second layer of insulating blocks and filling at least a portion of the space between the blocks,
 6. a membrane of Invar lining at least the walls and the bottom of the interior of the second layer of the insulating blocks and attached thereto by bonding with a cryogenic adhesive at least a sufficient portion of the area common to the blocks and the Invar to support the Invar.
2. The container of claim 1 wherein at least three layers of insulating blocks are attached to the interior of the shell.
3. The container of claim 2 wherein a membrane of Invar is sandwiched between the second and third layers and is bonded to portions of each insulating block face common to the Invar.
4. The container of claim 1 wherein the contractable and expandable insulating material completely surrounds each insulating block and is flush with the sides of the blocks.
5. The container of claim 1 wherein the insulating block is either foamed polyvinyl chloride, foamed glass, or foamed urethane.
- b. The container of claim 1 wherein the insulating blocks closer to the Invar are smaller in area than the first layer of insulating blocks.
7. The container of claim 1 wherein the operating temperature range of the container is about 72° F. to about -350° F.
8. The container of claim 1 wherein the operating temperature range of the container is about 72° F. to about -260° F.

9. The container of claim 1 wherein the Invar completely lines the interior of the second layer of insulating blocks.

10. A container for the confinement of cryogenic fluids comprising:

1. a shell

2. a first layer of insulating blocks completely lining the interior wall of the shell, at least a portion of one face of each block bonded by a cryogenic adhesive to the interior of the shell and the blocks arranged side by side, the blocks having sufficient space between them to permit expansion and contraction of the blocks over a temperature range of about 72° F. to about -350° F. without shearing the blocks from the interior wall,

3. a second layer of insulating blocks completely lining the interior of the first layer of insulating blocks and arranged over said first layer so that no direct path of heat loss is permitted to the shell of the container, the blocks arranged side by side with sufficient space as defined in (2),

4. a third layer of insulating blocks completely lining the interior of the second layer of insulating blocks and arranged over said second layer of insulating blocks so that no direct path of heat loss is permitted to the shell of the container, the blocks arranged side by side with sufficient space as defined in (2),

5. a contractable and expandable insulating material completely surrounding each block within the first, second, and third layers of blocks and filling

at least a portion of the space between the blocks within these layers,

6. at least about 2 percent of the face areas of each block within the first, second, and third layers of blocks that are common to each other are bonded with a cryogenic adhesive, and

7. a membrane of Invar completely lining the interior of the third layer of the insulating blocks and attached thereto by bonding with a cryogenic adhesive at least a sufficient portion of the area common to the third layer of blocks and the Invar to support the Invar.

11. The container of claim 10 wherein the operating temperature range is about 72° F. to about -260° F.

12. The container of claim 10 wherein the contractable and expandable insulating material that completely surrounds the blocks is flush with the sides of the blocks.

13. The container of claim 10 wherein the insulating blocks are composed of either polyvinyl chloride, foam glass or foam urethane.

14. The container of claim 10 wherein the insulating blocks closest to the Invar are smaller in area than the insulating blocks adhered to the interior of the shell.

15. The container of claim 10 wherein a membrane of Invar is sandwiched between the second and third layers of insulating blocks and at least 2 percent of the areas common to each face of the blocks and Invar are bonded with a cryogenic adhesive.

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