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SHIPBOARD INSTALLATION OF ELONGATED PRESSURE VESSELS

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2 Sheets-Sheet 1

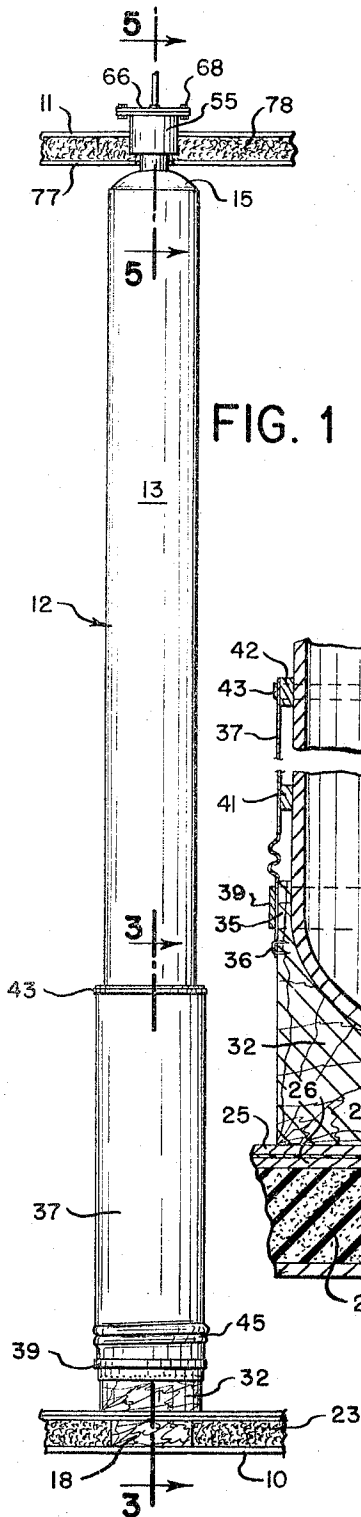


FIG. 1

FIG. 2

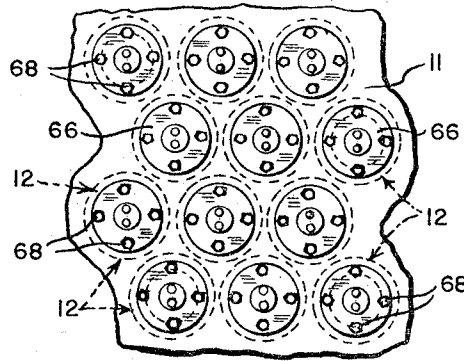
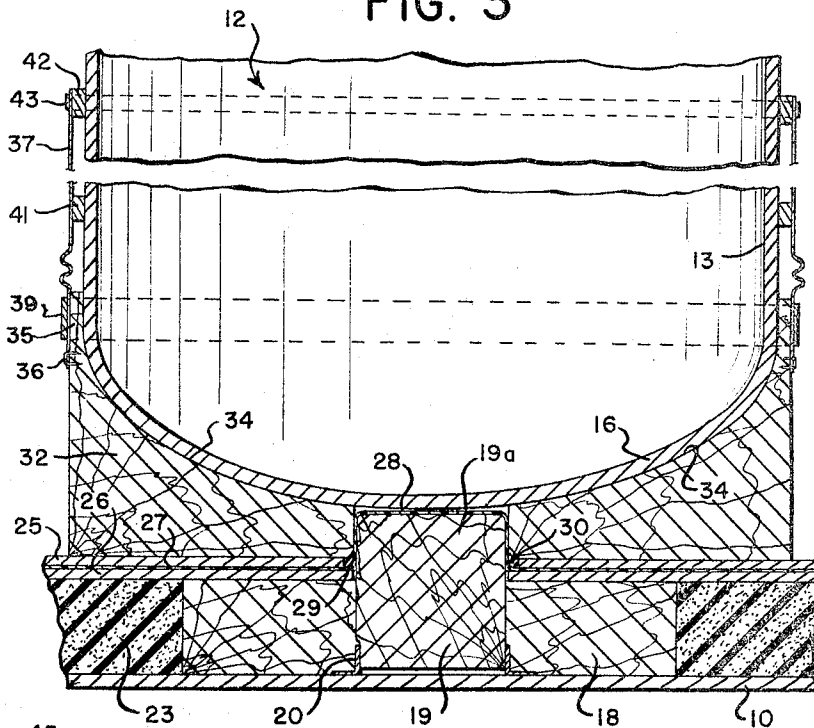


FIG. 3



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FIG. 4

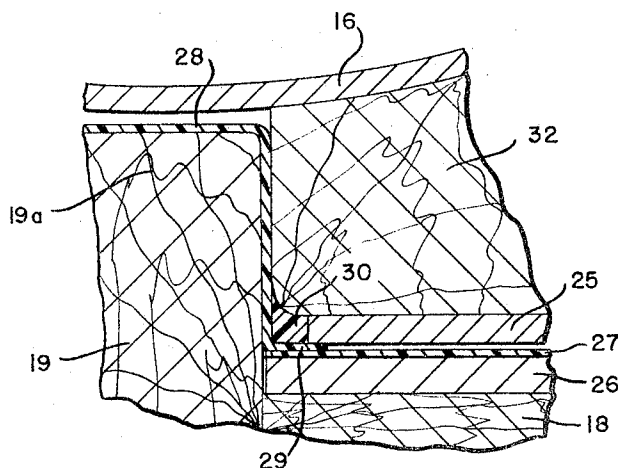


FIG. 5

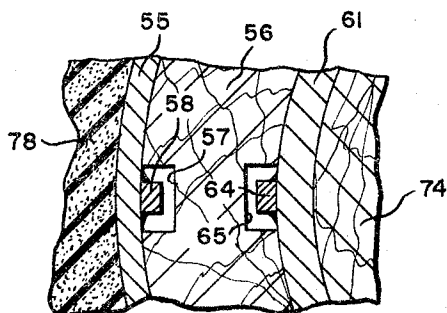
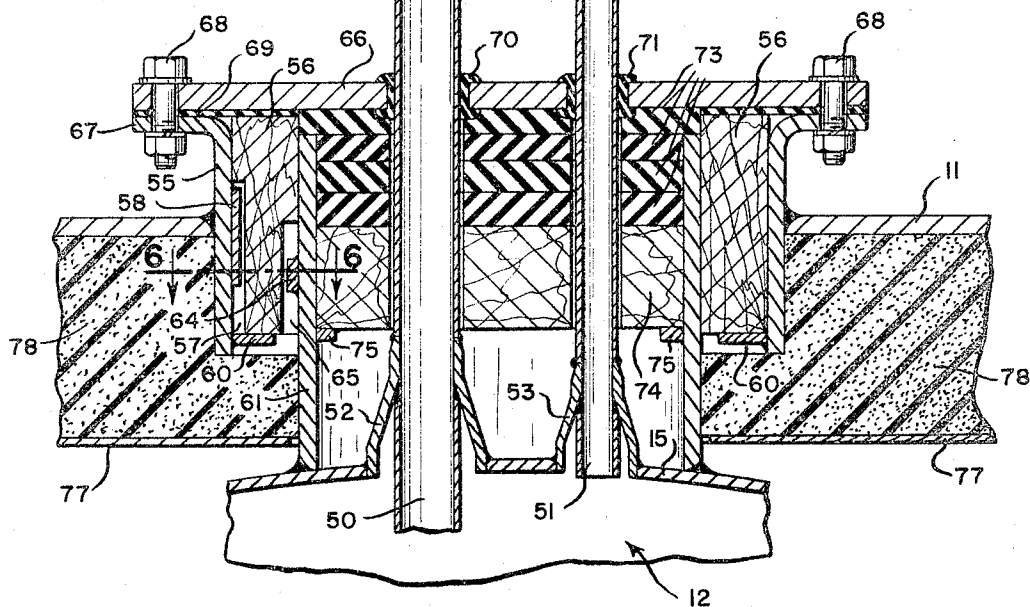


FIG. 6

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SHIPBOARD INSTALLATION OF ELONGATED PRESSURE VESSELS

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This invention relates to shipboard installation means for elongated vessels adapted to contain a refrigerated pressurized natural gas cargo. More particularly, it concerns structure for enclosing and supporting such vessels vertically in an optimum manner in the hold of a ship.

Important advances have recently been made in the transportation of natural gas hydrocarbon mixtures which have created a need for shipboard installation means specifically designed for elongated pressure vessels containing the gas cargo under moderate refrigeration and compression. Considerable design work has otherwise been reported on the installation of stable broad-based containers, but it offers very little to the enclosure and support of a multiplicity of long cylindrical pressure vessels of the type with which this invention is concerned.

The object of the new installation means is to support the vessels against all static and inertial forces which they are likely to encounter during use, to protect them and the ship structure from damage in the unlikely but not impossible event of leakage of the cold compressed cargo, and to accommodate all changes in dimensions occurring in the vessels and the ship structure as a result of temperature variations. The installation means is to surround the vessels with thermal insulation and is to avoid all attachments to the vessels at which stresses might concentrate. All of these ends are to be achieved by means which are simple and economical both in assembly and material costs and which possess a stable operating life over protracted periods of time.

Broadly stated, the shipboard installation means for elongated pressure vessels disposed vertically in a hold between upper and lower deck structures comprises a pad on the lower deck structure under each vessel. A shear plug is located on the lower deck structure and extends through and up from each pad. A secondary barrier covers the lower deck structure over the pads and closely caps the upper end portion of each shear plug. Disposed on the secondary barrier closely about the capped portion of each shear plug is a support bowl formed with a concave seat receiving the lower end of the associated vessel. A jacket extends upwardly from each bowl around the lower end portion of the associated vessel. A collar extends through the upper deck structure over each vessel. Attached to the upper end of each vessel is an extension member extending into the associated collar and restrained against all but vertical limited movement with respect thereto.

A preferred embodiment of the structure of the invention is described hereinbelow with reference to the accompanying drawing, wherein

FIG. 1 is a fragmentary elevation showing one vessel mounted in the hold of the ship;

FIG. 2 is a fragmentary plan showing several vessels nested together in the hold;

FIG. 3 is an enlarged fragmentary section partly broken away taken along the line 3-3 of FIG. 1;

FIG. 4 is an enlarged fragmentary section showing details of the structure of FIG. 3;

FIG. 5 is an enlarged fragmentary section taken along the line 5-5 of FIG. 1; and

FIG. 6 is an enlarged fragmentary section taken along the line 6-6 of FIG. 5.

Referring first to FIGS. 1 and 2, part of the hold of a ship is shown defined by lower and upper deck structures 10 and 11 respectively. A multiplicity of cylindrical pressure vessels 12, one of which is shown in FIG. 1 and several of which are shown in FIG. 2 nested together, are disposed vertically in the hold between the lower and upper deck structures 10 and 11. Each vessel may have a length-to-diameter ratio of 15:1 or more, the greater part of which length is defined by a cylindrical wall 13 closed off by rounded ends 15 and 16 (for the latter, see FIG. 3). A cargo of moderately refrigerated and compressed natural gas is loaded in and removed from each vessel 12 by appropriate access conduit means which extends upwardly from the upper end of each vessel.

Underlying installation means for each vessel 12 includes a flat annular balsa pad 18 resting directly on the lower deck structure 10 axially beneath its associated vessel. A cylindrical wooden shear plug 19 extends through each pad 18 and is located with respect to the lower deck structure by a circular seat defined by angle clips 20, which permits only rotatable and upward vertical movement of the plug 19. The seat defined by the angle clips 20 is slightly eccentric relative to the axis of the shear plug 19 so that by rotating the shear plug there may be some lateral displacement of its axis. In this way the various supporting elements positioned by the wooden shear plug as described below may be shifted laterally to accommodate any misalignment of the center line of the associated vessel.

To insulate the hold and to isolate the ship's structure from damage in the event of leakage of the cold cargo, a secondary barrier extends throughout the bottom of the hold and may be continued up a substantial distance against the bulkheads around the lower deck structure of the hold. This secondary barrier includes a foamed insulating layer 23 of polyurethane covering the lower deck structure 10 between the various pads 18. A double-ply wooden wall, advantageously formed of two sheets of plywood 25 and 26, covers the foamed insulating layer 23 and the pads 18 between the upper portion 19a of each shear plug 19. As shown in FIGS. 3 and 4, a continuous film 27 of polytetrafluorethylene extends between the plies of this wall throughout the entire area of the secondary barrier. Where the upper portions 19a of the shear plugs 19 extend through the plywood wall a preformed cap 28 of polytetrafluorethylene film is fitted over each upper portion 19a and is heat sealed at 29 to the adjacent film 27 so that there is no interruption in the continuous inert plastic layer. Packing 30 of polytetrafluorethylene may be deposited along the edge of the upper plywood sheet 25 as shown in FIG. 4 to complete this capped barrier over the upper portion 19a of each respective shear plug 19.

Disposed on the secondary barrier closely about the capped portions 19a of each shear plug 19 is an annular wooden support bowl 32 immediately beneath and coaxial with the associated vessel 12. Each bowl 32 is formed with a concave seat 34 receiving the rounded lower end 16 of the associated vessel 12 in mating ball-and-socket engagement which permits the vessel 12 to be displaced angularly to a certain degree with respect to the bowl. The bottom of the concave seat 34 is at an elevation above the upper plywood sheet 25 such that there is clearance between the upper portion 19a of the associated shear plug 19 and the lowermost portion of the rounded end 16 of the vessel. The outside diameter of each bowl 32 is slightly greater than that of the cylindrical wall 13 of the vessel 12 so that a peripheral flange portion 35 of the bowl can extend upwardly about the vessel.

Attached to the flange portion 35 of each bowl 32 by fasteners 36 is the lower edge of a cylindrical jacket 37 of aluminum sheet which extends upwardly, say about six feet or so, about the lower end of the vessel 12. A stainless steel shrink ring 39 is secured about this lower edge of the jacket 37 to hold it tightly against the flange portion 35 of the bowl in sealed relation thereto. A plurality of spacer rings or blocks 41 may be attached to the inside of the jacket 37 at various levels to space it from the wall 13 of the vessel 12 while the upper end of the jacket is held on a wooden ring 42 against the wall 13 of the vessel 12 by a circumferential strap 43. Since each vessel 12 is subject to changes in length due to the extreme temperature differentials which arise during loading and unloading, the jacket must accommodate vertical expansion and contraction and this is done by forming it with circumferential corrugations 45 in a horizontal plane.

The overlying support means for each vessel 12 is shown in detail in FIGS. 5 and 6. The access conduit means comprises a pair of conduits 50 and 51 which extend through respective flared fittings 52 and 53 into the upper rounded end 15 of the vessel 12. The access conduit 50 may extend in a suitable manner to the very bottom of the vessel 12 while the other access conduit 51 terminates immediately within the upper rounded end 15 of the vessel as shown in FIG. 5. A collar 55 is fixed within an aperture formed in the upper deck structure 11 of the ship concentrically above each vessel 12. A wooden ring 56 is fitted closely within each collar 55 and is formed with a vertical groove 57 into which a key 58 on the collar 55 extends loosely as shown in FIG. 6. This permits slight rotation of the wooden ring 56 with respect to the collar 55 while the ring is otherwise supported in the collar by an underlying flange 60. Welded concentrically to the upper rounded end of each vessel 12 is a cylinder 61 disposed about the access conduits 50 and 51. The cylinder 61 extends closely through the associated wooden ring 56 and is restrained against all but vertical and limited rotatable movement with respect thereto, the latter being permitted by another vertical groove 65 in the wooden ring 56 which loosely receives a key 64 secured to the cylinder 61. A cover 66 is disposed over an upper flange 67 on each collar by bolts 68 and the joint between them is sealed by a gasket 69. Each of the access conduits 50 and 51 projects through the cover 66 and is sealed with respect thereto by respective rubber grommets 70 and 71. A stack of compressible rubber pads 73 is disposed in sealed relation about the access conduits 50 and 51 over the top of and within the cylinder 61 beneath the cover 66. This stack of pads 73 overlies a wooden block 74 supported within the cylinder 61 by an internal flange 75. Over a false overhead 77 is a foamed insulating layer 78 of polyurethane which covers the entire underside of the upper deck structure 11 around the various associated cylinders 61 and collars 55.

By supplementing the foamed insulating layers 23 and 78 with similar layers against the bulkheads defining the side walls of the hold, a substantially continuous lining of insulation is provided which can maintain the temperature of the cargo in the vessels 12 at a substantially constant level over a long voyage without induced refrigeration. At the only points where the foamed insulation must be interrupted, immediately above and below each vessel, the installation means of the invention avoids virtually all metal-to-metal heat leakage paths by the use of wooden elements such as the pads 18, shear plugs 19, bowls 32, ring 56 and block 74. If gas cargo were to leak from any of the vessels 12 it would expand and chill to extremely low temperature which could very well shatter load-bearing metal structures which it contacts, but the polytetrafluorethylene film 27 and caps 28 offer total protection to the ship structure in this regard and the thermal shock-resistant jacket 37 does the same for the vessels 12. Polytetrafluorethylene is particularly advantageous for

this purpose because it is heat-formable and remains stretchable even at very low temperatures.

As the vessels 12 expand and contract in length when subjected to loading and unloading of gas mixtures at widely varying temperatures, the cylinder 61 on the top of each bottle slides up or down in the wooden ring 56 in the associated collar 55 and no stress concentration develops as a result of the temperature changes. This dimensional variation in the length of each vessel 12 cannot adversely affect its jacket 37 because the corrugations 45 in the jacket compensate for all relative movement between them. Relative motion between the ship's structure and each vessel caused by temperature changes or the normal strain on a hull in heavy seas is similarly neutralized by the ball-and-socket joint between each vessel and its support bowl and by the collar which allows all but lateral motion of the top of the vessel.

Downward vertical forces are resisted by the bowl under each vessel and upward vertical forces by the weight of the vessel, perhaps supplemented by hydraulic hold-down means not described in detail herein. At the bottom of each vessel, horizontal forces can only slide it up the walls of the bowl, which is a motion resisted by its weight, and this force on the bowl is resisted by the shear plug anchored to the ship's structure. At the top of each vessel, horizontal displacement is completely restrained by the wooden ring about the cylinder 61. In each case, the various accelerations which may arise during operation are dampened by wooden members which do not transmit vibration or shock to or from the remainder of the ship structure.

We claim:

1. Shipboard installation means for elongated pressure vessels disposed vertically in a hold between upper and lower deck structures, said installation means comprising

- (a) a pad on the lower deck structure under each vessel,
- (b) a shear plug located on the lower deck structure and extending through and up from each pad,
- (c) a secondary barrier covering the lower deck structure over the pads and closely capping the upper portion of each shear plug,
- (d) a support bowl disposed on the secondary barrier closely about the capped portion of each shear plug and formed with a concave seat receiving the lower end of the associated vessel,
- (e) a jacket extending upwardly from each bowl around the lower end portion of the associated vessel,
- (f) a collar extending through the upper deck structure over each vessel, and
- (g) an extension member attached to the upper end of each vessel extending into the associated collar and restrained against all but vertical and limited rotatable movement with respect thereto.

2. Shipboard installation means for elongated pressure vessels rounded at their lower ends and disposed vertically in a hold between upper and lower deck structures, said installation means comprising

- (a) an annular pad on the lower deck structure under each vessel,
- (b) a shear plug located on the lower deck structure and extending closely through and up from each pad,
- (c) a secondary barrier including a continuous film of polytetrafluorethylene covering the lower deck structure over the pads and closely capping the upper portion of each shear plug,
- (d) a support bowl disposed on the secondary barrier closely about the capped portion of each shear plug and formed with a concave seat receiving the rounded lower end of the associated vessel,
- (e) a vertically expansible metal jacket extending upwardly from each bowl around the lower end portion of the associated vessel,
- (f) a collar extending through the upper deck structure over each vessel, and

(g) a cylinder attached to the upper end of each vessel and extending upwardly into the associated collar and restrained against all but vertical and limited rotatable movement with respect thereto.

3. Shipboard installation means for elongated vessels containing refrigerated pressurized natural gas and disposed vertically in a hold between upper and lower deck structures, each vessel having access conduit means extending through its upper end and being rounded at its lower end, said installation means comprising

- (a) an annular pad on the lower deck structure under each vessel,
- (b) a cylindrical shear plug located on the lower deck structure and extending closely through and up from each pad,
- (c) a secondary barrier including a continuous film of polytetrafluorethylene covering the lower deck structure over the pads and closely capping the upper portion of each shear plug,
- (d) an annular support bowl disposed on the secondary barrier closely about the capped portion of each shear plug and formed with a concave seat receiving the rounded lower end of the associated vessel in mating ball-and-socket engagement,
- (e) a vertically expansible metal jacket extending upwardly from sealed engagement with each bowl around the lower end portion of the associated vessel,
- (f) a collar extending through the upper deck structure over each vessel,
- (g) a cylinder attached to and extending upwardly from the upper end of each vessel about its access conduit means into the associated collar and restrained against all but vertical and limited rotatable movement with respect thereto, and
- (h) a cover disposed in sealed relation over each collar and about each associated access conduit means.

4. Shipboard installation means for elongated substantially cylindrical vessels containing refrigerated pressurized natural gas and disposed vertically in a hold between upper and lower deck structures, each vessel having access conduit means extending through its upper end and being rounded at its lower end, said installation means comprising

- (a) a flat annular balsa pad on the lower deck structure under each vessel;
- (b) a cylindrical wooden shear plug located on the lower deck structure and extending closely through and eccentrically up from each pad in slideable rotatable engagement therewith;
- (c) a secondary barrier comprising
 - (i) a first foamed insulating layer covering the lower deck structure between the pads,
 - (ii) a double ply wooden wall covering the first foamed insulating layer and the pads between the upper portion of the shear plugs, and
 - (iii) a continuous film of polytetrafluorethylene extending between the plies of said wall and closely capping the upper portion of each shear plug;
- (d) an annular wooden support bowl disposed on the secondary barrier closely about the capped portion of each shear plug and formed with a concave seat receiving the rounded lower end of the associated vessel in mating ball-and-socket engagement;
- (e) a cylindrical vertically expansible metal jacket extending upwardly from sealed engagement with each bowl around the lower end portion of the associated vessel;
- (f) a collar extending through the upper deck structure over each vessel;
- (g) a wooden ring fitted closely within each collar;
- (h) a cylinder attached to and extending upwardly from the upper end of each vessel about its access conduit means and closely through the associated

ring and restrained against all but vertical and limited rotatable movement with respect thereto;

- (i) a cover disposed in sealed relation over each collar and about each associated access conduit means;
- (j) wooden and elastomeric support means for each access conduit means within each cylinder and ring and under each cover; and
- (k) a second foamed insulating layer covering the underside of the upper deck structure around the cylinders and collars.

5. In the shipboard installation of elongated pressure vessels disposed vertically in a hold on a deck structure, underlying installation means comprising

- (a) a pad on the deck structure under each vessel,
- (b) a shear plug located on the deck structure and extending through and up from each pad,
- (c) a secondary barrier covering the deck structure over the pads and closely capping the upper portion of each shear plug, and
- (d) a support bowl disposed on the secondary barrier closely about the capped portion of each shear plug and formed with a concave seat receiving the lower end of the associated vessel.

6. In the shipboard installation of elongated pressure vessels rounded at their lower ends and disposed vertically in a hold on a deck structure, underlying installation means comprising

- (a) an annular pad on the deck structure under each vessel,
- (b) a shear plug located on the deck structure and extending closely through and up from each pad,
- (c) a secondary barrier including a continuous film of polytetrafluorethylene covering the deck structure over the pads and closely capping the upper portion of each shear plug, and
- (d) a support bowl disposed on the secondary barrier closely about the capped portion of each shear plug and formed with a concave seat receiving the rounded lower end of the associated vessel.

7. In the shipboard installation of elongated vessels containing refrigerated pressurized natural gas and disposed vertically in a hold on a deck structure, underlying installation means comprising

- (a) an annular pad on the deck structure under each vessel,
- (b) a cylindrical shear plug located on the deck structure and extending closely through and up from each pad,
- (c) a secondary barrier including a continuous film of polytetrafluorethylene covering the deck structure over the pads and closely capping the upper portion of each shear plug, and
- (d) an annular support bowl disposed on the secondary barrier closely about the capped portion of each shear plug and formed with a concave seat receiving the rounded lower end of the associated vessel in mating ball-and-socket engagement.

8. In the shipboard installation of elongated substantially cylindrical vessels containing refrigerated pressurized natural gas, each vessel being disposed vertically in a hold on a deck structure and being rounded at its lower end, underlying installation means comprising

- (a) a flat annular balsa pad on the deck structure under each vessel;
- (b) a cylindrical wooden shear plug located on the deck structure and extending closely through and eccentrically up from each pad in slideable rotatable engagement therewith;
- (c) a secondary barrier comprising
 - (i) a first foamed insulating layer covering the deck structure between the pads,
 - (ii) a double ply wooden wall covering the first foamed insulating layer and the pads between the upper portion of the shear plugs, and

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- (iii) a continuous film of polytetrafluoroethylene extending between the plies of said wall and closely capping the upper portion of each shear plug, and
- (d) an annular wooden support bowl disposed on the secondary barrier closely about the capped portion of each shear plug and formed with a concave seat receiving the rounded lower end of the associated vessel in mating ball-and-socket engagement.

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Dedication

3,270,700.—*Harold B. Kohn*, Yonkers and *Morgan Chuan-Yuan Sze*, Garden City, N.Y., *Harold L. Cook, Jr.*, Bellaire, Tex., *Herbert C. Secord*, Little Cheverells, Markyate, Herts, England and *Oystein Arvesen*, Haslum, Norway. SHIPBOARD INSTALLATION OF ELONGATED PRESSURE VESSELS. Patent dated Sept. 6, 1966. Dedication filed Sept. 16, 1971, by the assignee, *Vehoc Corporation*.

Hereby dedicates to the Public the entire remaining term of said patent.
[*Official Gazette December 28, 1971.*]