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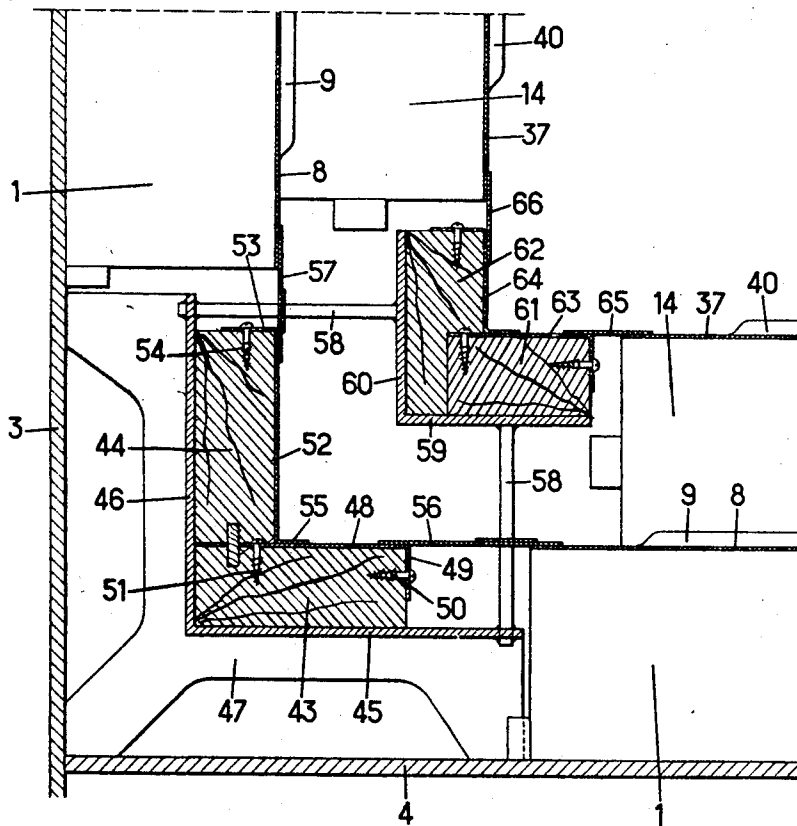
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TANK FOR LIQUEFIED GAS

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3 Sheets-Sheet 1

FIG. 1



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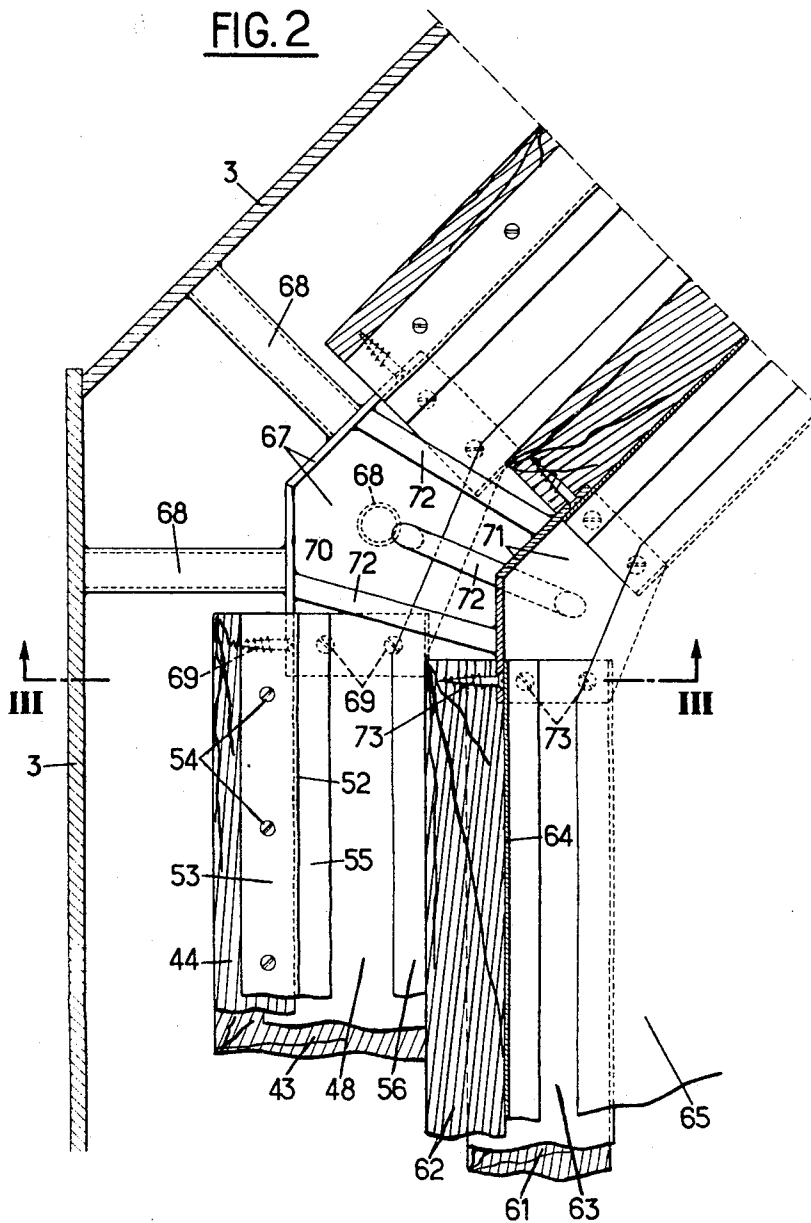
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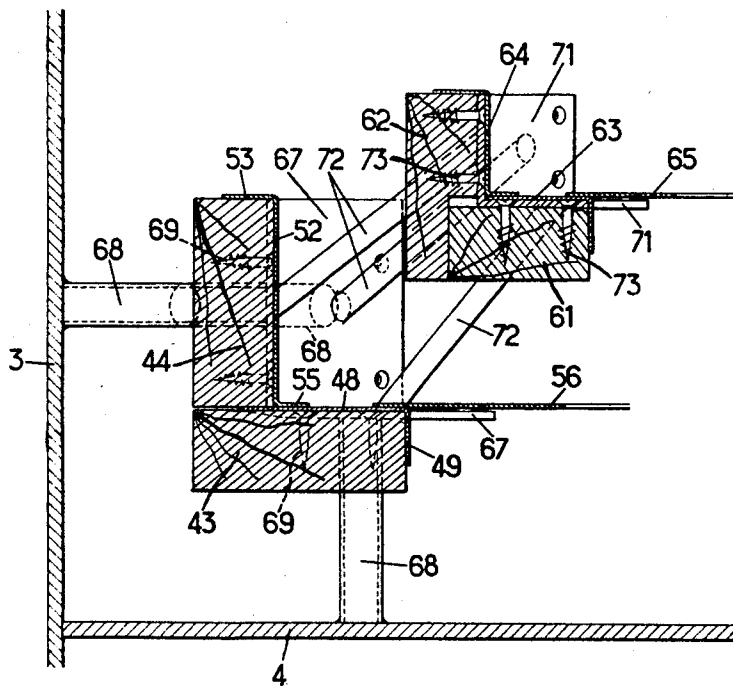
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FIG. 3



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TANK FOR LIQUEFIED GAS

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ABSTRACT OF THE DISCLOSURE

An integral tank structure for ships carrying liquefied gas comprising in succession an inner hull, an outer insulating casing, an outer fluid tight casing, an inner insulating casing and an inner fluid tight casing, the two fluid tight casings being made of thin metal having a low coefficient of expansion, reinforced by transverse frames, and supported at their corners by rigid metallic supports projecting through the insulating casings.

This invention relates to the transportation of liquefied gas, and particularly liquefied natural gas having a high methane content, by sea, and to its storage on land. In order to increase the capacity of ships designed for such transport and reduce the cost of construction of isothermal tanks, it has already been suggested that the tanks be made integral with the ship itself by covering the walls of the compartments of the ship with fluid and heat tight sheathing, generally consisting of two layers, but not in itself rigid, so that the hydrostatic pressures are in fact supported solely by the framework of the ship itself.

The principal difficulty to be overcome in the construction and use of such integral tanks stems from the substantial contractions which result when the temperature of the walls of the tank decreases from the ambient temperature to that of the liquefied gas (-160°C . in the case of methane). To reduce this contraction it is conventional to utilize corrugations running at right angles to each other, which requires an excess of metal. The metals used are ordinarily stainless steel or aluminum alloys, which are not fragile at low temperatures. In view of their complex shapes it is difficult to provide means for supporting them at all ranges of temperature. On the contrary, the principal object of the present invention consists in using a thin smooth wall of an alloy containing 26% nickel, 0.25% carbon and 0.60% manganese, balance substantially all iron, sold under the trademark Invar which is supported at all points by insulating means which is as rigid as possible. However, it is impossible to avoid any contraction whatsoever, even with this special steel, because the tanks are so large, or to avoid the flexing movements of the framework of the ship caused by the surges of the sea, which flexing movements necessarily affect the walls of the tank.

The effect of all these deformations is concentrated at the dihedral corners, since the tank is usually polygonal for convenience in construction, and especially at trihedral corners which are subjected to alternating strains which tend to destroy the fluid-tight sheathing.

The invention seeks to avoid these difficulties by so constructing the dihedral and trihedral corners of the transverse walls of the ship that the inevitable contractions will not cause any distortion thereof.

The object of the present invention is accordingly to provide a new fluid-tight isothermal tank integrated into the framework of a ship between two transverse bulkheads therein and comprising two successive fluid-tight primary and secondary casings, commonly referred to by the U.S. Coast Guard and Marine Insurers as "primary and secondary barriers." These cases are alternated with

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two primary and secondary isothermal insulating casings, said tank being characterized by the fact that the primary and secondary fluid-tight casings terminate near the transverse bulkheads of the ship in a rigid polygonal ring made of strips of the same metal substantially thicker and stronger than the sheets forming the fluid-tight casings. One of these strips is positioned in alignment with the transverse bulkhead and screwed along its two edges onto planks, while the other strip completing the dihedral angle is welded along one of its edges perpendicular to the said one strip, between the two points of attachment thereof, and along its other edge to another plank. The assembly formed by these planks which may comprise several sections free to contract, is connected to a corner of the framework of the ship by supporting hangers suitably spaced and attached directly to this structure in the case of the dihedral angles of the secondary casing, and to supporting chairs interconnected by rods extending through fluid-tight seals in the secondary casing in the case of the dihedral angles of the primary casing. At each corner of the rigid ring are two trihedral corner members made of a special steel, one of which is fastened to the secondary casing and connected directly to the inner hull or double bulkhead by three connecting members, preferably consisting of three stainless steel tubes, and the other of which is fastened to the primary casing and connected to the first corner member by three metallic connecting tubes or rods. The strips forming the dihedral angles of the ring are rigidly welded to the trihedral corner members for the two casings, and the corresponding planks are fastened within each of the corner members by screws spaced from these welds. The screws are covered over after insertion and the rigid ring formed by the dihedral and trihedral corner members are built while strain free at normal temperatures so as to be under elastic strain at the temperature at which the tank holds liquid gas.

In order that the invention may be clearly understood, one representative embodiment thereof will now be described, purely by way of illustration, in connection with the annexed drawings, in which:

FIG. 1 is a partial horizontal cross-section showing one of the dihedral corners;

FIG. 2 is a partial vertical section taken near a transverse bulkhead to show in detail a trihedral corner; and

FIG. 3 is a horizontal section taken along the line III—III of FIG. 2.

In order to build a tank according to the invention, the starting point is naturally a ship comprising an outer hull and its essential supporting framework, and an inner hull, the framework of the boat being positioned between the inner and outer hulls. For convenience in construction the inner hull may have the same general contour as the outer hull, but be more polygonal in character, usually octagonal, that is to say, like a rectangle with four beveled corners. The ship also comprises, from bow to stern, a series of compartments for transporting liquid gas and separated each from the other by double bulkheads comprising two parallel walls spaced by the necessary supporting framework.

Inside each of these compartments is an integral tank comprising two fluid-tight casings alternating with two heat insulating casings. As shown on FIG. 1, there are successively from the inside out the primary fluid-tight casing consisting of the thin plates 37 which are made of a metal which has a low coefficient of expansion and connected together by means of their flanges 40; the heat insulating casing consisting of the insulating boxes 14, the secondary fluid-tight casing consisting of plates 8 connected at their flanges 9, the secondary heat insulating casing consisting of the insulating boxes 1, the inner hull

3, the framework of the ship, and finally the outer hull (not shown).

The transverse walls of the ship, that is to say, those positioned against the double bulkheads 4, are made in the same way as the lateral walls and are each encircled by a rigid ring.

Two of the walls comprising the secondary fluid-tight casing 8 are connected at a dihedral angle in the following manner: Two thick planks 43 and 44, positioned as shown in FIG. 1 are each supported as required by chairs made of two iron plates 45 and 46 welded at right angles to each other and resting on a thick metal bracket 47 which lies in a plane parallel to that of FIG. 1. This bracket 47 is welded to both the plates 45 and 46 and the walls 3 and 4 of the double bulkhead. The planks 43 and 44 are connected to the plates 45 and 46 by means of screws (not shown) which extend perpendicularly into the plank, but are not so tight as to eliminate all play longitudinally of the planks.

The plank 43 in alignment with the casing 8 parallel to the wall 4 of the double bulkhead is first attached, and then covered by a strip 48 of metal having a high nickel content, preferably identical to that from which the plates forming the casing 8 are made, but substantially thicker, for example, 1.5 mm. This strip has an edge 49 bent out at a right angle and attached to the plank 43 by screws 50 while its other edge is attached thereto by means of screws 51. Then the plank 44 is put in place, followed by another strip 52 and analogous to the strip 48, but having two flanges, one, 53, attached by means of screws 54, while the other, 55, abuts the strip 48 to which it is welded in situ after inserting between the strip 48 and the plank a strip of asbestos, not shown.

The strip 48 is then connected to the edge of the secondary casing 8 by means of a cover-joint 56, welded at both edges. In like manner the strip 52 is connected to the secondary casing by means of a cover-joint 57.

Two rods 58, welded to the chairs formed by the members 45, 46 and 47, extend through fluid-tight seals in the cover-joints 56 and 57, using sealing rings, not shown, and support a second chair comprising two rectangular steel plates 59 and 60 welded together at right angles to each other. This second chair supports two planks 61 and 62 which serve the same purpose with respect to the primary casing that the planks 43 and 44 serve with respect to the secondary casing. Metallic strips 63 and 64, like the strips 48 and 52, are fastened in like manner to each other and to the planks 61 and 62. Finally, the cover-joints 65 and 66 connect the strips 63 and 64 to the primary casing in the same way as the said cover-joints 56 and 57.

In order to form each of the rigid rings hereinbefore mentioned it is necessary to connect the ends of each of the angle members formed by the assembly of the strips 48 and 52 or 63 and 64 together to form the corners of the ring, which is polygonal, and generally octagonal. Each trihedral angle is positioned at the intersection of three planes, two of which are parallel to the longitudinal axis of the ship, while the other is perpendicular thereto.

These connections are made by means of trihedral metallic corner members, made of a special steel, for example a steel containing 9% nickel, thicker than the previously mentioned strips, about 8 mm. thick, for example. The corner member 67, formed from three flat plates welded to each other, is connected to the hull of the ship (either the inner hull or the double bulkhead) by connecting members 68 which must be strong enough to resist compression, tension, and buckling, yet have a small section for the transmission of heat. For this reason, recourse is preferably had to sections of stainless steel tubing having a large diameter and thin walls.

The planks 43 and 44 are attached to this corner member 67 by means of screws 69 passing through suitable holes in said corner member, and the strips 48 and 52

have their ends 70 welded to this corner member so as to cover the heads of the screws 69 and insure overall impermeability. The cover-joints 56 and 57 are also welded to the three plates forming the corner member so as to ensure the impermeability of the secondary casing, as well as the transfer of those forces which act directly in the direction of the plane of the transverse wall of the tank, and in the direction of the dihedral angle-members parallel thereto.

It is easy to understand that, since the assembly is welded together at room temperature, when the temperature falls the transverse wall of the tank contracts and exerts traction on the dihedral corners in the direction of the strips 48. These corners concentrate the forces and transmit them to the trihedral corner members. However, since as will be hereinafter seen, the trihedral corner members are rigidly connected to the basic structure of the ship, these forces cannot cause deformation, but only an elastic strain by tensioning the corresponding members. In effect, in view of the high mechanical strength of the materials employed and their very low coefficient of expansion, even at temperatures of the order of -160° , the mechanical strains thus developed as a consequence of temperature changes do not exceed 5 kg./mm.², which is far below the elastic limit of these high nickel content steels.

This embodiment thus resists any tendency toward free play resulting from contractions by mechanically tensioning the entire ring formed by the dihedral corner members. It will also be seen that the effects of tension longitudinally of the dihedral corners is absorbed by the rigidity of the planks 43 and 44 and referred thereby to the supporting chairs.

Turning now to the primary casing, all that has just been said about the secondary casing applies thereto. The other trihedral corner member 71 serves in a manner analogous to that served by the trihedral corner member 67, but on a smaller scale, being supported by three rods 72 fixed to the corner member 67. The planks 61 and 62 are fastened in like manner to this trihedral corner member by means of screws 73, the heads of which are covered by the ends of the strips 63 and 64. These strips, as well as the cover-joints 65 and 66 are welded in a fluid-tight manner directly to the trihedral corner member 71. The method of construction and the manner of functioning under tension is naturally the same.

To sum up, it will be seen that each of the primary and secondary fluid-tight casings of the tank comprises at each end an inflexible transverse wall stretched on a rigid ring which cannot itself be deformed and which is supported at its eight corners as well as by a certain number of intermediate chairs, so that this transverse wall does not undergo any deformation, but only a variation in elastic strain.

In like manner the lateral walls of the tank, which are attached at their ends to the rigid ring, undergo, in response to the decrease in temperature and deformations of the hull of the ship, only an elastic tension.

It will be appreciated that the foregoing embodiment has been described purely by way of example, and may be modified as to detail without thereby departing from the basic principles of the invention as defined by the following claims.

What is claimed is:

1. In combination with a ship having an inner hull and transverse bulkheads, the improved fluid-tight tank for holding liquefied gases which comprises thin inner and outer fluid-tight casings positioned within said inner hull and made of a metal having a low coefficient of expansion, inner and outer insulating casings comprising a material which is a poor conductor of heat, said inner insulating casing being positioned between said fluid-tight casings and said outer insulating casing being positioned between the outer fluid-tight casing and the inner hull and bulkhead, said casings having polygonal sides

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extending transversely of said ship and longitudinal sides connected to said transverse sides to form trihedral corners at the connections between each polygonal side and two adjacent longitudinal sides, a rigid frame peripherally supporting each polygonal side of each fluid-tight casing, rigid metallic support means extending from points near each trihedral corner of the outer fluid-tight casing through the outer insulating casing to said inner hull and to a transverse bulkhead, and additional rigid metallic supporting means extending from points near each trihedral corner of said inner fluid-tight casing to the peripheral supporting frame of said outer fluid-tight casing.

2. The combination claimed in claim 1, according to which said rigid metallic support means are thin walled tubes of stainless steel having a cross-section which is large in proportion to the thickness of the tube walls.

3. The combination claimed in claim 1, according to which said rigid frames are strain free at normal temperatures so as to be stressed by contractions at the temperature of liquefied gas.

4. The combination claimed in claim 1 in which said casings are made of an alloy containing 26% nickel, 0.25% carbon, 0.6% manganese, balance substantially all iron.

5. The combination according to claim 1 in which said peripheral supporting frames comprise wooden planks.

6. The combination according to claim 5 comprising metallic chairs intermediate said trihedral corners, each resting on said inner hull and one of said bulkheads and supporting the wooden planks comprised by the rigid frame of said outer fluid-tight casing.

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7. The combination claimed in claim 6 according to which each of said peripheral supporting frames comprises L-section metallic members on which said planks are seated, and comprising supporting rods extending between the L-section members associated with the inner fluid-tight casing and those associated with the outer fluid-tight casing whereby the former L-section members are supported by the latter.

8. The combination claimed in claim 7 according to which said last mentioned supporting rods pass through openings in the outer fluid-tight casing and said openings are sealed fluid tight.

9. The combination claimed in claim 7 according to which said L-section metallic members are made of the same material as said fluid-tight casings but are thicker.

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