United States Patent

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[54] **SUPPORTING MEANS FOR INDEPENDENT TANKS**
12 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** ..... **220/15,** 114/74 A
[51] **Int. Cl.** **B65d 25/00**
[50] **Field of Search** ..... 220/9 A, 15; 114/74 A

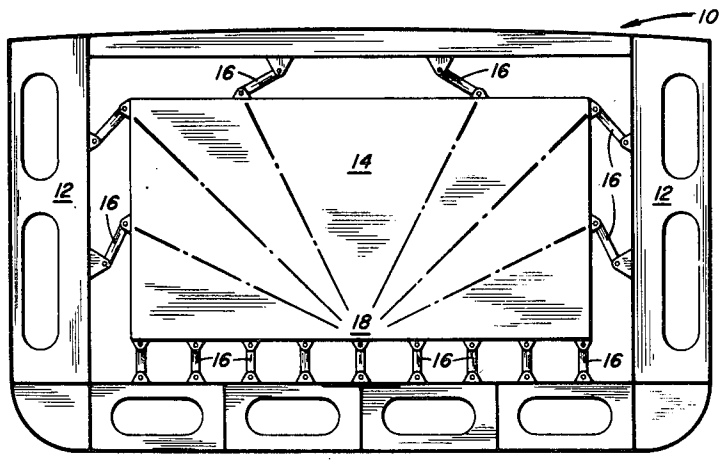
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ABSTRACT: A system for supporting tanks housed in the holds of ships, which tanks serve to transport cargo at relatively high or relatively low temperatures and which tanks, as a consequence, are subject to substantial contractions and expansions. The supporting system comprises a plurality of supporting arms positioned around the tank so that the length of each arm is substantially at a right angle with respect to an imaginary line drawn between the arm and the center of contraction and expansion of the tank. In another embodiment of the invention, the length of each supporting arm increases as the distance between the arm and the center of contraction and expansion increases. In a further embodiment of the invention, the coefficients of expansion of the respective supporting arms are varied in such a manner that the arms nearest the center of contraction and expansion of the tank have a lower coefficient of expansion than do the arms most remote from the center of contraction and expansion. In still a further embodiment of the invention, the individual supporting arms are provided with insulation bushings between the arms and the tank, these bushings serving to regulate the thermal gradient across the arms and thus to regulate the contraction and expansion characteristics of same.



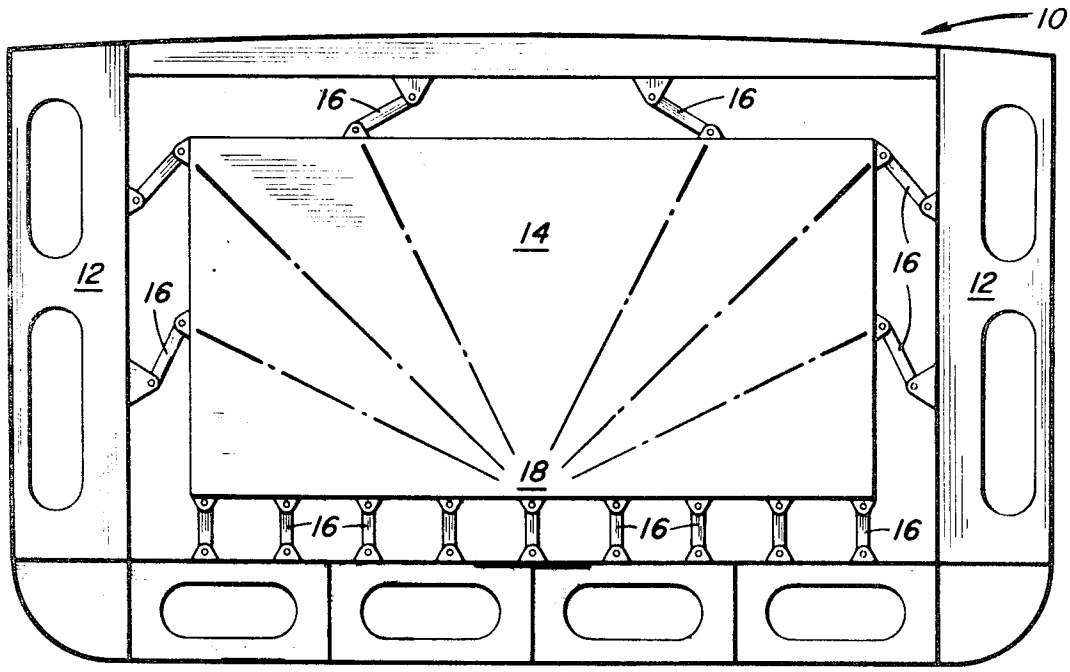


FIG. 1

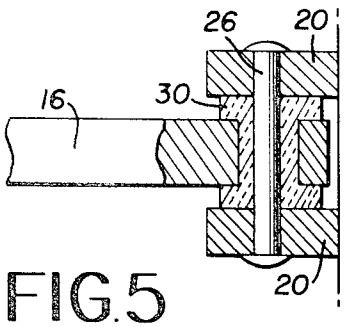


FIG. 5

FIG. 2

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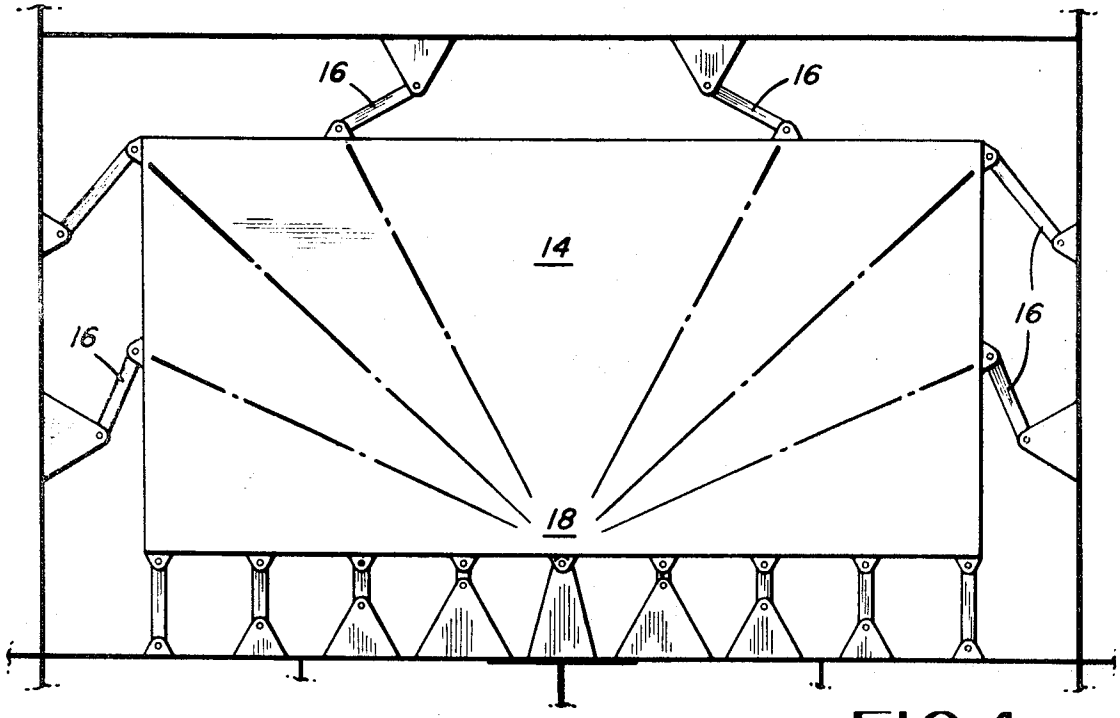


FIG. 4

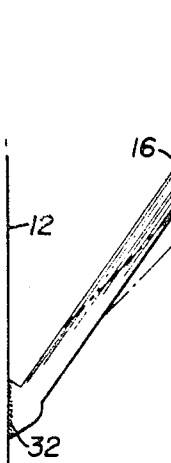


FIG. 6

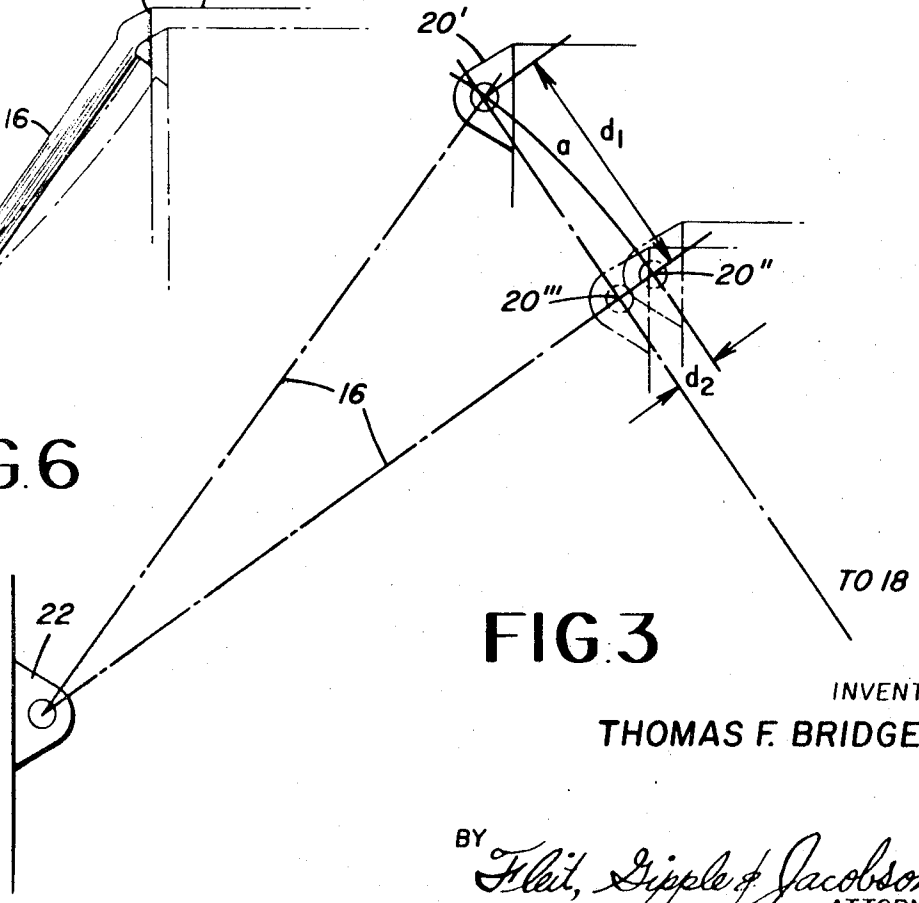


FIG. 3

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SUPPORTING MEANS FOR INDEPENDENT TANKS

BACKGROUND OF THE INVENTION

In the marine transportation of cargo such as chlorine, customarily transported at moderately low temperatures, cargo such as cryogenic materials, customarily transported at extremely low temperatures, and cargo, such as liquid sulfur, customarily transported at high temperatures, the containment tanks are subject to extreme dimensional changes. During transportation, the tanks assume the temperature of the material contained therein but, while the tanks are empty, they assume ambient temperature.

In view of the above, the tanks must naturally be supported within the hold of the associated ship in such a manner that expansion and contraction are allowed without excessive stress on the ship structure or on the tank itself. At the same time, however, the tanks must be supported in such a manner that they are securely maintained within the hold of the ship so that tank shifting is avoided when the ship rolls during its journey. The simultaneous attainment of these apparently conflicting modes of operation is a difficult task.

SUMMARY OF THE INVENTION

The present invention relates to a supporting system for maintaining containment tanks within the hold of the ship in such a manner that the tanks are allowed to expand and contract without exerting substantial stresses on the structure of the ship or on the tanks themselves. In the present invention, the tanks are also maintained in a relatively fixed position within the hold of the ship. Thus, the tanks are constrained against shifting when the ship rolls.

More particularly, in the present invention, a containment tank is positioned within the hold of the ship and the tank is supported by a plurality of supporting arms, which arms encompass the structure of the tank. The supporting arms are arranged in such a manner that they are either rigidly or pivotally fixed to the tank and to the structure of the ship. Each supporting arm is positioned so that its longitudinal dimension is at substantially a right angle with respect to the imaginary line drawn between the point of the arm attachment at the tank and the center of contraction and expansion of the tank.

As the invention is herein described, the tank is viewed as expanding and contracting about a point located in the center of the tank bottom. The center of contraction and expansion is taken to be as such so as to conform to the custom of providing keys and keyways at the tank bottom. It should be noted, however, that the present invention functions equally well if the center of contraction and expansion were positioned otherwise.

By arranging the supporting arms as described above, the supporting structure maintains the tank in position while allowing thermal contraction and expansion without introducing high stresses into the tank or structure of the ship. At the same time, the supporting structure prevents excessive movement of the tank in the hold of the ship when the ship is at sea. Preferably, the supporting arms are positioned so as to most efficiently support the tank either before or after cool down or heat up. The determination of the initial position of the supporting arms is a design consideration and within the purview of the ship and tank designer.

In another embodiment of the invention, the supporting arms are of different lengths so that the thermal growth of the tank is always in a straight line toward the center of contraction and expansion of the tank.

In still a further embodiment of the invention, the thermal growth is maintained in the above-noted straight line relationship by varying the coefficients of expansion of the supporting arms with respect to the position of these arms from the center of thermal growth. Aluminum arms may be used for high coefficient of expansion applications, and invar arms may be used for low coefficient of expansion applications.

In yet another embodiment of the invention, the contraction and expansion of the supporting arms are controlled by positioning insulating bearings, such as Teflon, intermediate the arms and the tank. Such control of contraction and expansion is a result of a change in the thermal gradient associated with the arms.

Accordingly, it is the main object of the invention to provide a system for supporting containment tanks within the hold of a ship so that the tanks may expand or contract without causing stresses in either the tanks or the structure of the ship and so that the tanks are securely housed within the hold of the ship during each leg of a voyage.

This and other objects of the invention, as well as many of the attendant advantages thereof, will become more readily apparent when reference is made to the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a cross section through the hull of a ship provided with the supporting system of the present invention;

FIG. **2** is an enlarged view of one bracket system contemplated by the present invention and showing the positions of the brackets under initial and final conditions;

FIG. **3** is a schematic drawing illustrating the initial bracket position, the final bracket position and a position of the bracket under conditions when the length of the supporting arm is fixed;

FIG. **4** is a cross-sectional view similar to that shown in FIG. **1**, but illustrating a second embodiment of the present invention.

FIG. **5** is a top view of a bracket system, partially in section, showing the placement of an insulating bushing; and

FIG. **6** is a side view of a bracket arrangement constructed in accordance with a further embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

With reference first to FIG. **1**, a ship adapted with the supporting system of the present invention is shown generally at **10**. The hull of the ship is indicated at **12**, and positioned within the hold of the ship **10** is a containment tank **14**, which tank is adapted for transporting liquids at relatively low or high temperatures. The tank **14** is, then, subject to substantial dimensional changes.

Serving to support the containment tank **14** in the hold of the ship **10** are a plurality of supporting arms **16**, which arms are connected, at one end, to the tank **14** and which are connected, at the opposite end, to the structure of the ship **10**. While the supporting arms **16** are illustrated as being pin-mounted on the tank **14** and on the structure of the ship **10**, it should be understood that the supporting arms may be rigidly and permanently secured to the tank and the ship structure.

As shown in FIG. **1**, the supporting arms **16** encircle the entire structure of the tank **14**. In this manner, the tank **14** is supported, in its entirety, by the supporting arms **16**. However, as will undoubtedly be appreciated by those skilled in the art, additional supporting members may be provided just so long as they allow for the expansion and contraction of the tank as contemplated by the supporting system of the present invention.

Each supporting arm **16** is positioned in such a manner that its length lies in a direction substantially perpendicular to the imaginary line drawn between the point of attachment to the tank **14** and the center of contraction and expansion of the tank. The numeral **18** indicates the center of contraction and expansion.

When the tank **14** contracts, so do the individual supporting arms **16**. As a consequence, the tank may be viewed as lowering, in its entirety, while its top and side structural members contract toward the center of contraction and expansion **18**. The supporting arms **16** are secured in such a manner that they allow for the free dimensional changes in the tanks as described above. To perfect the above-discussed freedom, the

supporting arms on the side walls of the tank 14 connect to the tank at a point higher than the point at which they connect to the structure of the ship. Similarly, on the top of the tank 14, the supporting arms connect to the tank at points more outboard than they connect to the structure of the ship.

With reference now to FIG. 2, there is shown, in solid lines, the position of the tank 14 with respect to the structure of the ship when the tank is in its warm state. A supporting arm 16 is attached to a pair of brackets 20 and 22, which brackets are secured, respectively, to the tank 14 and to a wall 24 forming part of the structure of the ship. While the supporting arm 16 is connected to the tank and the structure of the ship by means of pins 26 and 28, respectively, it is contemplated by the present invention that the pins be omitted and that the supporting arms be connected either directly to the tank and the structure of the ship or to the respective brackets in a rigid manner. Such an arrangement is shown in FIG. 6, wherein a supporting arm 16 is welded at 32 and 34, respectively, to the hull 12 of the ship and the containment tank 14.

With continuing reference to FIG. 2, the position of the tank 14 and supporting arm 16, in its final and cooled position, is indicated, in an exaggerated form, by means of phantom lines. As noted above, by supporting the tank as contemplated by the present invention, the supporting structure maintains the tank in a relatively stable position while allowing thermal contraction and expansion without introducing high stresses into either the tank or the structure of the ship. At the same time, the supporting arms prevent the movement of the tank in the ship when the ship is at sea.

With reference now to FIG. 3, there is shown an exaggerated schematic diagram of the relative positions of a single bracket 20 attached to the tank 14 as the tank contracts with respect to the fixed center of contraction 18. The initial position of the bracket 20, while the tank is in its warm state, is shown at 20'. If only the tank contracted, then the position of the bracket 20 would be as shown at 20'' after the tank has cooled. However, since each supporting arm 16 also contracts, the supporting arm plays a part in determining the final position of the bracket 20. When, in actuality, the tank and supporting arms have contracted, the final position of the bracket 20 is indicated 20'''. As seen in this figure, the contraction from the position of the bracket indicated by 20' to the position of the bracket indicated by 20''' is in a straight line. This is ideal, the tank being supported with a minimum of stress.

Since expansion or contraction of a point on the tank, with respect to the fixed structure of the ship, is dependent upon the distance from that point to the center of contraction and expansion of the tank, the ideal situation of linear contraction may be accomplished by varying the lengths of the individual supporting arms, by varying the coefficients of expansion of these supporting arms or by varying the thermal gradients associated with the supporting arms, according to the following relationship.

If D = initial distance from bracket to center of contraction and expansion;

L = initial length of supporting arm;

k_1 = coefficient of thermal expansion of tank;

k_2 = coefficient of thermal expansion of supporting arm;

t_0 = initial ambient temperature;

t_1 = final mean temperature of tank material between center of contraction and expansion bracket;

t_2 = temperature of supporting arm at tank; and

t_3 = temperature of supporting arm at ship's structure; then

$d_1 = Dk_1(t_0 - t_1)$

and

$d_2 = Lk_2(t_3 - t_2)$.

To maintain the line defined by d_1 in alignment with the center of contraction and expansion, the contraction of the supporting arm must equal the height of the segment of the circle indicated by the arc "a." This height equals

$$\sqrt{L - L^2 - d_1^2}.$$

Therefore, it is desired that

$$\sqrt{L - L^2 - [Dk_1(t_0 - t_1)]^2} = Lk_2(t_3 - t_2).$$

or written another way, that

$$L = \sqrt{\frac{[Dk_1(t_0 - t_1)]^2}{1 - [1 - k_2(t_3 - t_2)]^2}}$$

It is thus seen that as "D" becomes larger, so too must "L" to maintain the desired straight-line contraction. Alternatively, if it is desired that "L" remain constant, the straight-line contraction may be accomplished by acting on "k_2."

With reference then to FIG. 4, there is illustrated a supporting system contemplated by the present invention wherein the lengths of the respective supporting arms vary in accordance with the above set of equations to effect straight-line contraction of the tank. In this Figure, the lengths of the respective supporting arms increase as the distance from the supporting arms to the center of contraction and expansion of the tank increases. This becomes necessary since the tank contracts as the temperature of the material housed therein is lowered and in a manner proportional to the length of material from the point of interest to the center of contraction and expansion. It should be noted that since the supporting arms are cold on one end, the end adjacent the tank, and are warm on the other, the contraction percentage may be viewed as approximately one-half of the tank contraction percentage.

Above, there have been described several embodiments of the present invention. It should be noted, however, that these embodiments are described for illustrative purposes only and are in a simplified form for ease of understanding. It is therefore important to understand that the invention may be practiced other than as described above. For example, the independent tanks may be insulated or uninsulated, depending upon the temperature of the cargo or the quality of the structural steel of the ship. Also, the structure of the ship may be insulated and so too may be the supporting arms. This last-mentioned arrangement is shown in FIG. 5, wherein the supporting arm 16 is mounted on the brackets 20, and is pivoted thereto by means of pin 26. An insulating bushing 30 maintains the supporting arms 16 thermally insulated from the brackets 20. Means for introducing or removing heat from the portions of the supporting arms adjacent the structure of the ship may also be provided if the tanks are uninsulated or when there is insulation only on the structure of the ship. In addition to the above, the supporting arms may be spaced so as to provide primary structural support for the cargo tank plating, thereby allowing reductions in cargo tank weight. The loads from the liquids in the cargo tank are then transmitted directly to the structure of the ship. This latter feature is important since, in conventional integrated-tank structures, necessary insulation prevents inspection of the primary and secondary barriers; but by employing the present invention, insulation is not necessary due to the thermal gradient across the arms and, as a consequence, an inspection space is provided.

What is claimed is:

1. A system for supporting cargo tanks within the hold of a ship and comprising a plurality of supporting arms associated with the tanks and with the structure of the ship, each arm movably connecting said tank to the structure of said ship, and each arm positioned so that its principal axis is at substantially a right angle with respect to an imaginary line drawn between said axis at the tank-connected end of said arm and the center of thermal contraction and expansion of said tank, wherein the supporting arms encompass the tank and wherein the supporting arms on the sides and top of the tank are positioned and connected in such a manner that the tank may freely contract toward and expand from its center of thermal expansion and contraction as a result of thermal changes in the tank.

2. The system of claim 1, wherein said supporting arms are rigidly secured to the tank and to the structure of the ship.

3. The system of claim 1, wherein each supporting arm is rotatably pinned to the tank and to the structure of the ship.

4. The system as defined in claim 1, wherein the supporting arms contract and expand with the tank.

5. The system as defined in claim 1, wherein the supporting arms encompass the tank; wherein the center of thermal expansion and contraction of the tank is at a point near the center of the tank bottom; wherein the supporting arms on the sidewalls of said tank are secured to the tank at a point higher than the point at which said arms are secured to the structure of the ship; and wherein the supporting arms at the top of the tank are connected to the tank at a point more outboard than the point at which the supporting arms are connected to the structure of the ship.

6. The system as defined in claim 1, wherein the tank and supporting arms are associated in such a manner that the thermal growth and contraction of the tank and arms results in the movement of the junctions of the tank and arms in a straight line toward the center of contraction and expansion of the tank.

7. The system as defined in claim 6, wherein the lengths of the respective supporting arms increase as the distanced increases between the arms and the center of thermal contraction and expansion of the tank.

8. The system as defined in claim 6, wherein the thermal coefficients of expansion of the respective arms are dissimilar.

9. The system as defined in claim 6, wherein each arm is connected both to the tank and to the structure of the ship, and wherein the tank is insulated from the structure of the ship and connected thereto by means of insulating bushings associated with at least one end of each arm.

10. A system for supporting cargo tanks within the hold of a ship and comprising a plurality of supporting arms associated with the tanks and with the structure of the ship, each arm movably connecting said tank to the structure of said ship, and each arm positioned so that its principal axis is at substantially a right angle with respect to an imaginary line drawn between said axis at the tank-connected end of said arm and the center of thermal contraction and expansion of said tank; wherein the tank and supporting arms are associated in such a manner that the thermal growth and contraction of the tank and arms results in the movement of the junctions of the tank and arms in a straight line toward the center of contraction and expansion of the tank; and wherein the lengths of the respective supporting arms increase as the distance increases between the arms and the center of thermal contraction and expansion of the tank.

11. A system for supporting cargo tanks within the hold of a ship and comprising a plurality of supporting arms associated with the tanks and with the structure of the ship, each arm moveably connecting said tank to the structure of said ship, and each arm positioned so that its principal axis is at substantially a right angle with respect to an imaginary line drawn between said axis at the tank-connected end of said arm and the center of thermal contraction and expansion of said tank, wherein the supporting arms encompass the tank and wherein the supporting arms on the sides and top of the tank are positioned and connected in such a manner that the tank may freely contract toward and expand from its center of thermal expansion and contraction as a result of thermal changes in the tank, wherein the tank and supporting arms are associated in such a manner that the thermal growth and contraction of the tank and arms results in the movement of the junctions of the tank and arms in a straight line toward the center of contraction and expansion of the tank; and wherein the thermal coefficients of expansion of the respective arms are dissimilar.

12. A system for supporting cargo tanks within the hold of a ship and comprising a plurality of supporting arms associated with the tanks and with the structure of the ship, each arm moveably connecting said tank to the structure of said ship, and each arm positioned so that its principal axis is at substantially a right angle with respect to an imaginary line drawn between said axis at the tank-connected end of said arm and the center of thermal contraction and expansion of said tank, wherein the supporting arms encompass the tank and wherein the supporting arms on the sides and top of the tank are positioned and connected in such a manner that the tank may freely contract toward and expand from its center of thermal expansion and contraction as a result of thermal changes in the tank, wherein the supporting arms encompass the tank; wherein the center of thermal expansion and contraction of the tank is at a point near the center of the tank bottom; wherein the supporting arms on the side walls of said tank are secured to the tank at a point higher than the point at which said arms are secured to the structure of the ship; and wherein the supporting arms at the top of the tank are connected to the tank at a point more outboard than the point at which the supporting arms are connected to the structure of the ship.

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