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Yamamoto

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[54] **METHOD OF CONSTRUCTING A LOW TEMPERATURE LIQUEFIED GAS TANK OF A MEMBRANE TYPE**

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[52] **U.S. Cl.** .... **29/455;** 29/460; 29/463; 29/469; 114/74 A; 220/9 LG

[51] **Int. Cl.** **B21d 39/00**

[58] **Field of Search** .... 29/157 R, 428, 455, 460, 29/463, 469; 114/.5 T, 74 A, 74 R; 220/1 B, 9 LG, 9 A

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[57] **ABSTRACT**

A method of constructing a low temperature liquefied gas tank of a membrane type comprising an inner membranous vessel provided at the inside of a rigid outer vessel with interposition of a heat insulating layer, said inner membranous vessel being formed to have at least one seam at side wall portions thereof, characterized by the steps of provisionally forming said inner membranous vessel at least in two parts to be connected with each other along said seam, said two parts being formed as oversized so that adjacent edge portions of said two parts overlap one over the other by an amount corresponding to the contraction of said inner membranous vessel in a low temperature operating condition, displacing the side wall portions of said two parts relative to each other so as to eliminate the overlapping of said adjacent edge portions, connecting said adjacent edge portions with each other to form said seam while keeping said side wall portions displaced as before, and filling up a space left between said outer vessel and side wall portions of said inner membranous vessel with a compression resistant heat insulating material to form said heat insulating layer while maintaining said side wall portions in a displaced state, whereby said inner membranous vessel is formed to have a marginal slack which compensates for the contraction thereof in a low temperature operating condition.

10 Claims, 3 Drawing Figures

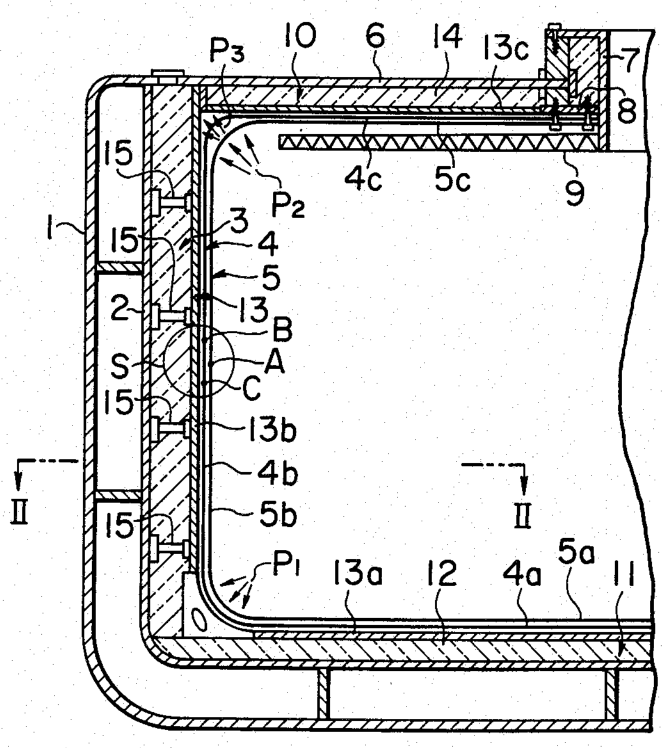
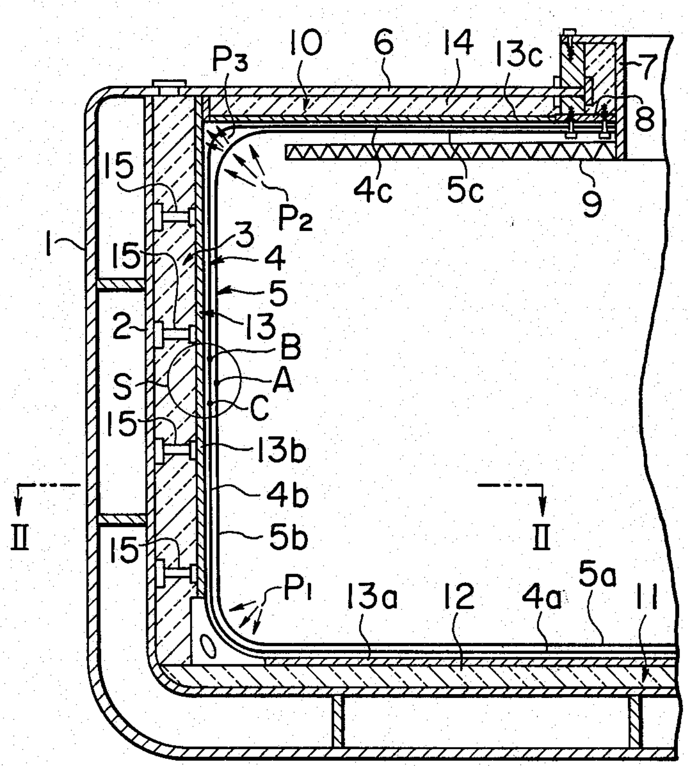


FIG. 1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14
13c
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13
B
S
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II
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P1
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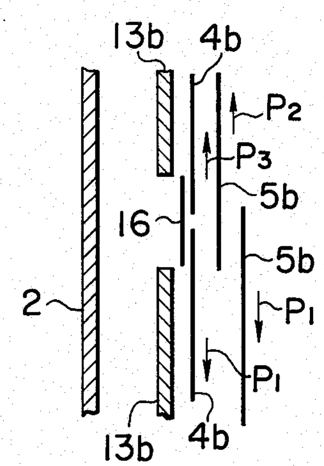
4a
5a
11

FIG. 3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P3
5b
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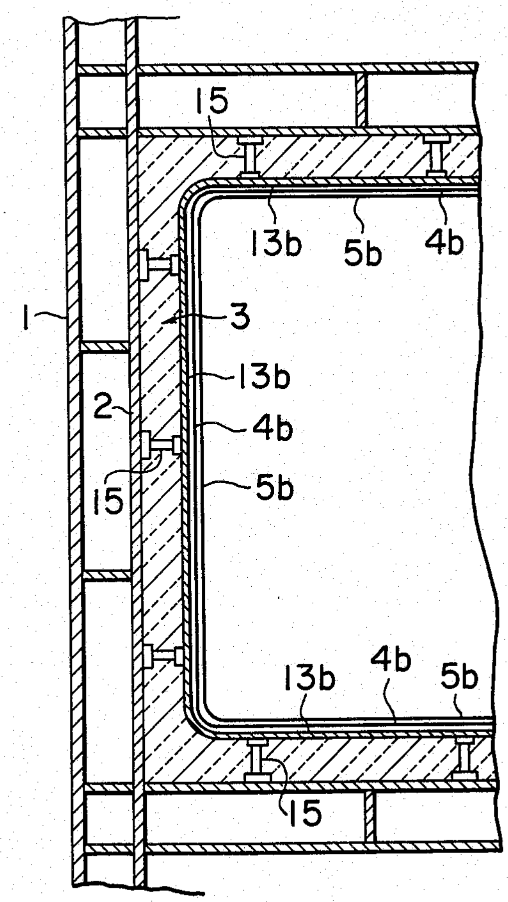
2
P1
P1
13b
4b

FIG. 2



METHOD OF CONSTRUCTING A LOW TEMPERATURE LIQUEFIED GAS TANK OF A MEMBRANE TYPE

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates to a method of constructing a low temperature liquefied gas tank of a membrane type for containing low temperature liquefied gases such as natural gases or petroleum gases which are in a gaseous state at room temperature and can be liquefied at low temperature under atmospheric pressure.

2. Description of the Prior Art:

A tank of this kind is generally composed of an outer vessel of a rigid structure, a heat insulating layer provided at the inside of said outer vessel and an inner membranous vessel provided further at the inside of said heating insulating layer. The inner vessel is made of a thin plate and is adapted to be readily deformed by internal pressure and to come into close contact with the surface of the heat insulating layer so as to transmit the internal pressure applied by the low temperature liquefied gases loaded in the inner vessel to the outer vessel by way of the heat insulating layer thereby finally supporting the load by the outer vessel.

Conventionally, the low temperature liquefied gas tank of the membrane type of the abovementioned structure has been constructed in a manner that the outer vessel is first constructed and then the heat insulating layer is constructed at the inside of the outer vessel by employing various kinds of heat insulating materials having compression resisting characteristic or by forming the heat insulating layer as a composite layer composed of heat insulating materials and reinforcing members so as to obtain a compression resisting heat insulating layer. Finally a thin plate of a low temperature resisting material such as nickel steel, stainless steel or aluminum is extended over the inside surface of the heat insulating layer to form a fluid-tight membranous vessel. According to the conventional method of construction, the tank can be constructed to have an inner membranous vessel closely fitting over the inside surface of the heat insulating layer, or in other words, the inner membranous vessel can be ideally so formed that the thin plate forming the inner membranous vessel is subject only to a compression force acting in the direction of its thickness under application of hydraulic pressure exerted from the inside of the inner membranous vessel. However, in a low temperature loaded condition when the membranous inner vessel is actually loaded with low temperature liquefied gases, the inner membranous vessel will contract with respect to the supporting surface provided by the heat insulating layer due to the low temperature caused by the low temperature liquified gases loaded therein, while it is expanded by the internal pressure exerted by the flow temperature liquefied gases loaded therein so as to compensate for the contraction due to low temperature. Therefore, the inner membranous vessel is actually supported by the heat insulating layer under the application of a compression force acting in the direction of the thickness of the thin plate forming the inner vessel as well as a tensile force acting along the surface of the thin plate forming the inner vessel.

As mentioned above, the inner vessel of the low temperature liquefied gas tank of the membrane type is subject to changes of conditions from a normal temperature, unloaded condition to a low temperature, loaded condition by loading or unloading the tank with low temperature liquefied gases. Due to such changes in conditions, the inner vessel undergoes complicated deformations under the action of thermal stress. Therefore, it is not desirable to apply any restriction to the inner vessel which will prevent the deformations of the inner vessel since such a restriction will cause a stress concentration in the inner vessel. To avoid such a stress concentration, it is proposed to form the wall of the inner vessel in the shape of complicated corrugations or formed with convex and concave surfaces in a normal temperature unloaded condition so that in a low temperature loaded condition to corrugated or convexed and concaved wall portions of the inner vessel contract to prevent smooth membranous wall portions which come in close contact with the inside surface of the heat insulating layer and are uniformly supported thereon. However, in this case, it is difficult to form an inner vessel having corrugated wall portions or convexed and concaved wall portions of a complicated structure, and therefore, there is the drawback that the overall construction cost of the tank becomes very high.

SUMMARY OF THE INVENTION

Therefore, it is the object of this invention to provide a novel method of construction a low temperature liquefied gas tank of a membrane type by which the inner membranous vessel is constructed, in a very simple manner, so as to subject the vessel to the most favorable stress condition in a low temperature loaded condition without being provided with complicated corrugations or convexed and concaved portions.

The abovementioned object is accomplished, according to this invention, by a method of constructing a low temperature liquefied gas tank of a membrane type, said tank comprising an outer vessel of a rigid structure, a heat insulating layer provided at the inside of said outer vessel, and an inner membranous vessel provided further at the inside of said heat insulating layer, said inner membranous vessel being formed to have at least one seam at the said wall portions thereof, characterized by the steps of provisionally forming said inner membranous vessel in two parts to be connected with each other along said seam, said two parts being formed as oversized portions so that adjacent edge portions of said two parts overlap with each by an amount coresponding to the contraction of said inner membranous vessel in a low temperature operating condition. Thus, under a load condition, the side wall portions of said two parts are displaced relative to each other so as to cancel the amount of overlapping of said adjacent edge portions. Said adjacent edge portions are connected with each other to form said seam while maintaining said side wall portions displaced as before, and the space left between said outer vessel and said side wall portions of said inner membranous vessel are filled with a heat insulating maerial having compression resisting characteristics to form said heat insulating layer while keeping said side wall portions displaced as before.

By the method of this invention as described above, the peripheral length of the inner vessel is made larger than that of the inner surface of the heat insulating layer by such a simple method that the inner vessel is formed in two parts which overlap with each other a predetermined amount along the adjacent edge portions and the adjacent edge portions are connected with each other to form a seam while keeping the adjacent edge portions displaced relatives to each other so as to be adapted to cancel said overlapping upon contraction of the vessel. Thus the marginal slack thus formed compensates for the contraction of the inner vessel in a low temperature operating condition. Furthermore, since in this case the inner vessel is constructed prior to the formation of the heat insulating layer, the inner vessel in construction is approachable from opposite sides thereof, and therefore, the welding of the thin plates to form the inner vessel and the inspection of the welded portions are very easily achieved and the reliability of the welded portions is very much improved. This advantage is more effective in case of a double-layered inner vessel which comprises two membranous vessels piled one over the other or one enclosing the other, the outer one (hereinunder called first inner vessel) being in contact with the heat insulating layer, the inner one (hereinunder called second inner vessel) being adapted to contain liquefied gases therein. In this situation, first inner vessel is adapted to serve also as a secondary barrier wall against a leakage occuring in the second inner vessel. Conventionally, a secondary barrier wall is generally provided within the heat insulating layer to be extended adjacent the inner surface thereof to prevent the invasion of the liquid from leaking out of the inner vessel into the heat insulating layer, and has a complicated structure. By employing the double-layered inner vessel as described above, no special secondary barrier wall is required.

The heat insulating material for forming the heat insulating layer having a compression resisting characteristic may be selected from various kinds of materials according to particular portions of the heat insulating layer. As a material to be used for forming the side wall portions, there may be used pearlite concrete which is pressure resistant and can be molded as a wall on the site. A heat insulating material substantially composed of foamed sulfur may be used. Foam concrete including foamed sulfur or foamed glass as a reinforcing material may also be used by being molded on the site.

BRIEF DESCRIPTION OF THE DRAWING

The present invention will become more fully understood from the detailed description given herinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention and wherein,

FIG. 1 is a cross-sectinoal view of a part of a tanker ship for transporting low temperature liquefied gases;

FIG. 2 is a section along line II—II in FIG. 1; and

FIG. 3 shows part S in FIG. 1 in a condition before the connections are completed.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the following, description is made with reference to the accompanying drawing to show an embodiment of the method of this invention applied for the construction of a low temperature liquefied gas tank for a tanker ship, especially a low temperature liquefied gas tank having a double-layered membrane type structure.

Referring to the drawing, reference numerals 1 and 2 designate an outer hull and an inner full of a tanker ship, respectively, and at the inside of the inner hull is provided at heat insulating layer 3, and further at the inside of said heat insulating layer are provided a first inner vessel 4 and a second inner vessel 5 made of membranes and positioned as layered in that order. The first and second inner vessels 4 and 5 of a membrane structure are both made of thin plates of a low temperature resisting material such as nickel steel, stainless steel, aluminium, etc. The first inner vessel 4 is made of a thinner plate than the second inner vessel 5 such that, for example, when the first inner vessel 4 is made of a plate having thickness of 1 – 2 mm, the second inner vessel 5 is made of a plate having thickness of 3 – 8 mm. However, the relation of the thicknesses of the plates forming the first and second inner vessels may be reversed.

Although the tanker ship is shown in the drawing as of a type having a single deck 6, this invention may also be applied to a tanker ship of a double deck type. The first and second inner vessels 4 and 5 are arranged to be freely slidable over the inner surface of the heat insulating layer 3 except at the central roof portions thereof located around a lower end portion of a rigid dome 7 where they are fluid-tightly mounted to a flange 7 provided at the lower end of said rigid dome. From the lower end of the dome 7 are radially extended a number of cantilevers 9 which suspend the roof portions of the first and second inner vessels 4 and 5 so as to be freely slidable over the inner surface of a heat insulating layer 10 provided at the underside of the single deck 6.

The first and second inner vessels 4 and 5 are each formed substantially in a polygonal shape and are each formed to include cylindrical edge portions and spherical corner portions. The cylindrical edge portions or the spherical corner portions are adapted to support the internal pressure exerted from the inside of the inner vessel by hoop tension of the thin plate forming cylindrical edge portions or spherical corner portions, except those portions located at the bottom edge or corner portions. However, the first inner vessel 4 is subject to no internal pressure when no leakage occurs at the second inner vessel 5. When the first inner vessel 4 is made of a thinner plate than the second inner vessel 5, the radius of curvature at the cylindrical edge portions or the shperical corner portions of the first inner vessel are selected to be shorter than those of the second inner vessel so as to limit the hoop tension at the edge or corner portions within an acceptable value.

The low temperature liquefied gas tank of a membrane type as mentioned above is constructed according to the method of this invention in the following manner: When the hull has been constructed except the deck portion, a bottom heat insulating layer 11 is provided over the bottom portion of the hull. The bottom heat inuslating layer may preferablly be formed of pearlite concrete, foamed polyurethane, a composite heat insulating matterial including a honeycomb structure packed with glass wool, a heat insulating material substantially composed of sulfur, or other proper pressure resistant heat insulating materials. Upon a layer 12 formed of such heat insulating materials is extended a bottom portion 13*a* of a protecting plate 13 made of plywood, etc., and thereabove are placed bottom panel members 4*a* and 5*a* to form the first and second inner vessels 4 and 5, respectively. These bottom panel members are preferably prepared to include the cylindrical edge portions as well as the spherical corner portions.

Next, scaffolds are constructed in a space to form the side wall heat insulating layer 3, and by utilizing the scaffolds as jigs or employing proper jigs in addition, thin plates to form the side wall portions 4*b* and 5*b* of the first and second inner vessels 4 and 5 up to points A and C (actually horizontal lines), respectively, are held in their positions and are connected with the bottom panel members 4*a* and 5*a*, respectively. Thereafter, the connecred portions are inspected.

Apart from the construction processes as mentioned above, a structural assembly is prepared outside the hull to include the deck 6, heat insulating mateial 14 and roof portion 13*c* of the protecting plate provided at the inside of the deck 6 and roof panel members 4*c* and 5*c* to form the first and second inner vessels 4 and 5, respectively, said panel members including cylindrical edge portions as well as spherical corner portions to form the shoulder portions of the inner vessels. The cantilevers 9, radially mounted at the lower end portion of the rigid dome prevent the roof portions of the inner vessels from falling down. The assembly is suspended by a proper suspension means such as a crane and transferred to the normal mounting position in the hull. Thereafter, thin plates are connected to the edge portions of the roof panel members to form upper half portions of the side wall portions 4*b* and 5*b* of the first and second inner vessels. In this case, the edge portions of the upper and lower half portions of the side wall portion 5*b* of the second inner vessel 5 are adapted to overlap one another by an amount corresponding to the contraction of the inner vessel in a low temperature operating condition, as shown in FIG. 3. However, it is not necessary to form the first inner vessel 4 at the same location as the second inner vessel 5 although adjacent edge portions of the first and second inner vessel may be arranged to be normally opposing each other.

Next, by employing proper pushing means not shown in the drawing, the cylindrical edge portions and the spherical corner portions arranged along the peripheries of the bottom panel members 4*a* and 5*a* are urged in the direction of arrow P1. In the same manner, the cylindrical edge portions and the spherical corner portions arranged along the periphery of the roof panel member 5*c* are urged in the direction of arrow P2 in a predetermined amount. Furthermore, by employing proper drawing means, the cylindrical edge portions and the spherical corner portions arranged along the periphery of the roof panel member 4*c* of the first inner vessel 4 are drawn in the direction of arrow P3 to draw the lower end portion of the thin plate connected to the roof panel member 4*c* to form the upper half portion of the side wall portion 4*b* up to point B (actually a horizontal line). Then, by maintaining the stressed condition, the upper half portion and the lower half portion of the second inner vessel are connected with each other at point A. In this case, it is preferably that the first inner vessel 4 is prepared to be incomplete in a region between points B and C so that the welding connection of the second inner vessel at point A as well as the inspection of the welded portion thereof can be performed at opposite sides thereof. After the welding as well as the inspection thereof at point A of the second inner vessel 5 have been finished, a belt plate 16 having a width corresponding to the distance between points B and C is used to cover the incomplete portion left between the upper half portion and the lower half portion of the first inner vessel 4 and said plate is welded to the adjacent edges of the upper and lower half portions at of vessel 4 points B and C. Thereafter, the welded poritons are inspected. After the construction of the inner vessels has been completed in the abovementioned manner, the jigs applied to the cylindrical edge portions and the spherical corner portions located adjacent the bottom and roof poritons of the first and second inner vessels 4 and 5 are removed.

In the abovementioned embodiment, the process of overlapping and seaming under biasing for the compensation of the contraction of the inner vessel in a low temperature operating condtion is applied to a portion of the side wall of the inner vessel. However, such a process may be applied to a plurality of portions so that a divided portion of the overall amount of compensation is undertaken at each portion.

As for the construction of the protecting plate 13*b*, it may be positioned at its location together with the side wall portions 4*b* and 5*b* of the inner vessels by provisionally preparing the protecting plate to be incomplete in the same region as the first inner vessel. In this case the incomplete portion of the protecting plate is repaired by a belt member of the same material after the joining of the first inner vessel has been completed.

After the construction of the tank has been completed as mentioned above, proper supporting means 15 such as oil-hydraulic jacks are mounted in the space to form the side wall heat insulating layer 3 to support the protecting plate 13*b*, the side wall portion 4*b* of the first inner vessel and the side wall portion 5*b* of the second inner vessel against the side wall portion of the inner hull 2. By actuating the supporting means the flat side wall portions of the inner vessels are urged toward the inside of the tank in an amount to compensate for the contraction of the inner vessesl in a low temperature operating condition. Then, by maintaining the inwardly urged condition of the flat side wall portions of the inner vessels, the space left between the protecting plate 13*b* and the inner hull 2 is filled up with a heat insulating material charged therein to gradually form the heat insulating layer 3 from the bottom portion to the top portion thereof. In the process of charging the heat insulating material, the protecting plate 13*b* serves as a weir plate to prevent the heat insulating material from leaking onto the surface of the first inner vessel. The protecting plate 13*b* also serves as a portector for protecting the first inner vessel from directly contacting the heat insulating layerr in a low temperature loaded condition. In the process of filling up the space to form the heat insulating layer 3, every time when the level of the charged heat insulating material reaches one of the jacks 15, the jack is removed after the heat insulating layer has been solidified and fixed. In order to prevent the protecting plate and the side wall portions of the inner vessel form being urged toward the inside of the tank beyond the position determine by the jacks due to the pressure applied by the charged heat insulating material, it is advantageous if the inside space of the inner membranous vessel is maintained at a positive pressure of about 0.3 kg/cm^2. The scaffold provisionally mounted in the space to form the heat insulating layer may be removed before the filling up of the space is started.

As a material preferably used to fill up the space to form the heat insulating layer 3, is proposed bead of foamed sulfur mixed with foaming concrete as a binding agent. Such as material is further improved in its anti-shock or anti-collapsing characteristics by being mixed with glass wool, pearlite or some other reinforcing material. Furthermore, since sulfur is easily foamed when it is mixed with a foaming agent and heated up beyond its melting temperture, a foamed sulfur heat insulating layer can be formed on the site. When the low temperature liquefied gas tank of the membrane type constructed in the abovementioned manner is filled with low temperature liquefied gases, the inner membranous vessesl **4** and **5**, having contracted contain dimensions just fitting the space defined by the protecting plates **13***b* and **13***c*, and therefore, the inner membranous vessels are supported by the supporting surface at the most desireable condition, that is, in a low temperature loaded condition.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications are intended to be included within the scope of the following claims.

I claim:

1. A method of constructing a low temperature liquefied gas tank of the membrane type, said tank comprising an other vessel of a rigid structure, a heat insulating layer provided at the inside of said outer vessel, flat side wall portions provided at the inside of said heat insulating layer and an inner membranous vessel provided further at the inside of said flat side wall portions, said inner membranous vessel being formed to have curved edge portions and at least one substantially flat seam at the flat side wall portions thereof, characterized by the steps of provisionally forming said inner membranous vessel in two parts to be connected with each other along said seam, said two parts being formed as oversized portions so that the adjacent edge portions of said two parts overlap with each other by an amount corresponding to the contraction of said inner membranous vessel at low temperature operating conditions, displacing the side wall portions of said two parts relative to each other along the surface thereof so as to eliminate the overlapping of said adjacent edge portions, said displacing being effected by provisionally shortening the radius of curvature of said curved edge portions, connecting said adjacent edge portions with each other to form said seam while keeping said side wall portions displaced, and filling up a space left between said outer vessel and said wall portions of said inner membranous vessel with a heat insulating material having compression resisting characteristics to form said heat insulating layer while still maintaining said side wall portions in a displaced state.

2. A method according to claim **1**, wherein at least one of said adjacent portions of said two parts is adapted to be provided with a belt member having a width corresponding to the overlapping amount of said adjacent edge portions.

3. A method according to claim **1**, wherein said inner membranous vessel is formed as a double-layered membranous vessel including first and second membranous vessels, said first membranous vessel enclosing said second membranous vessel therein.

4. A method according to cliam **3**, wherein, said first inner membranous vessel comprises two parts, at least one of said adjacent edge portions of said two parts being provided with a belt member having a width corresponding to the overlapping amount of said adjacent edge portions.

5. The method of claim **3**, wherein the first inner membranous vessel comprises two parts which, when displaced, defined an incomplete portion between the adjacent edges of said two parts, said adjacent edges being joined together by a belt having a width at least as large as the distance between said adjacent edges.

6. A method according to claim **1**, wherein a protecting plate is mounted at the outside of said side wall portion of said inner membranous vessel before said space disposed between said outer vessel and said side wall portion of said inner membranous vessel is filled will a heat insulating material.

7. A method according to claim **1**, wherein said inner membranous vessel is provided with a positive pressure sufficient to support the side wall portions thereof against the pressure applied by the heat insulating material charged into the space to form said heat insulating layer when said heat insulating layer is being formed.

8. A method according to claim **1**, wherein the radius of curvature of said curved edge portions is shortened by applying a pressing force to said curved edge portions from the inside of the inner vessel.

9. A method according to claim **1**, wherein the radius of curvature of said curved edge portions is shortened by applying a drawing force to said curved edge portions from the outside of the inner vessel.

10. The method according to claim **1**, wherein the heat-insulating material is foamed sulfur containing glass wool as a reinforcing material.

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