Sept. 20, 1966 P. HERRENSCHMIDT 3,273,740

TANK FOR LIQUEFIED NATURAL GAS AND OTHER PRODUCTS STORED AT LOW TEMPERATURES

Filed Sept. 3, 1963

5 Sheets-Sheet 1

FIG. 1

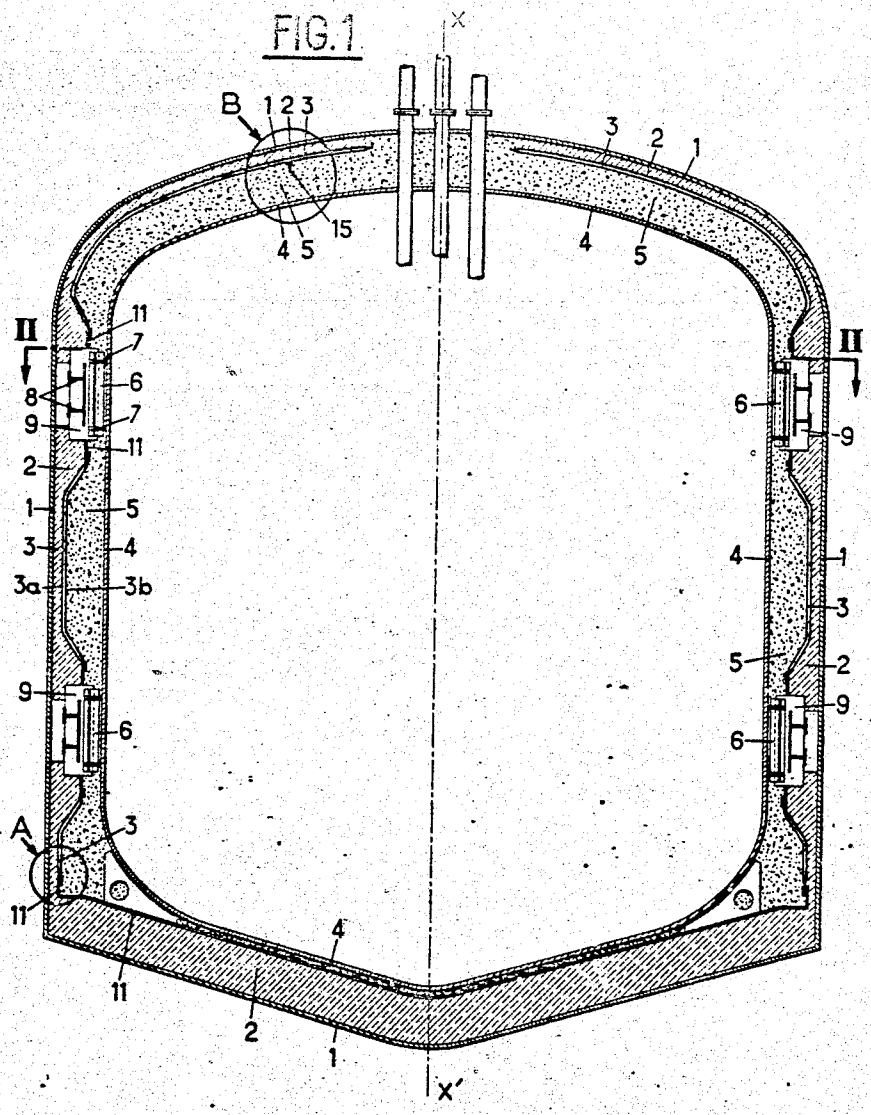

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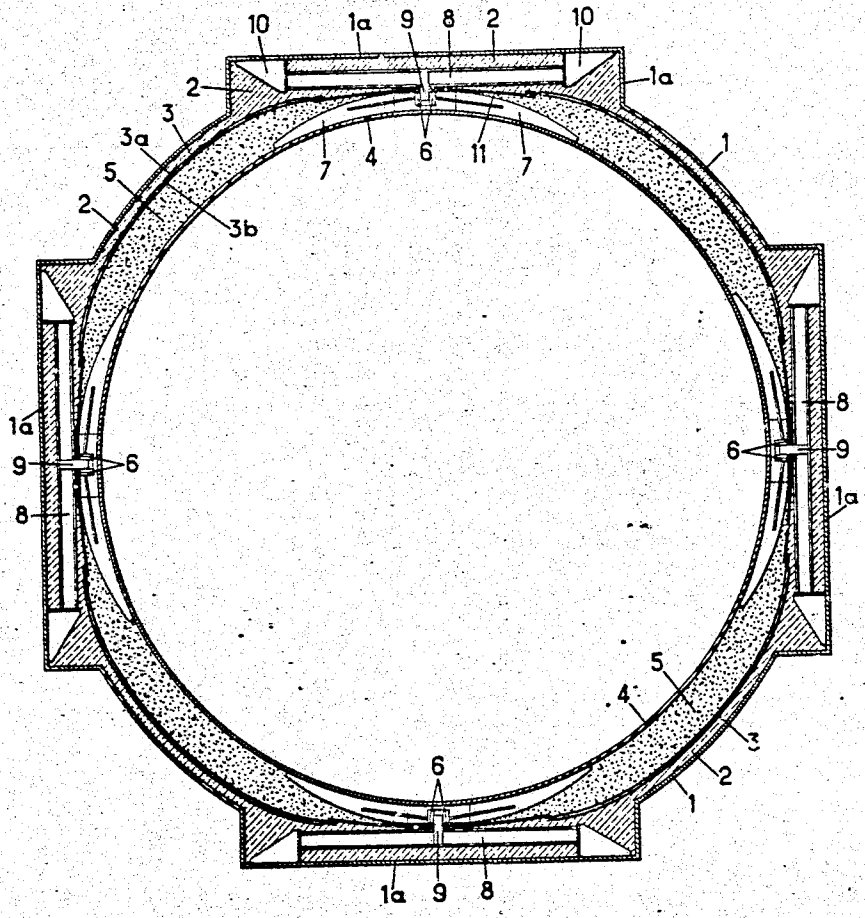
FIG.2



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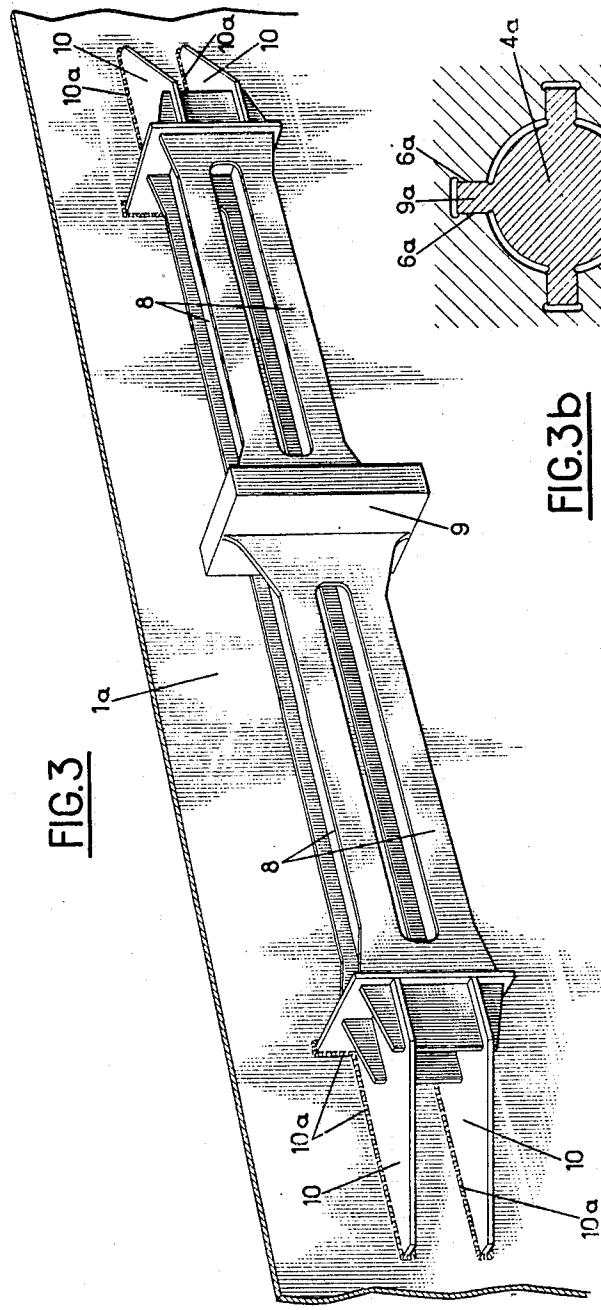

FIG.3

FIG.3b

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FIG.4

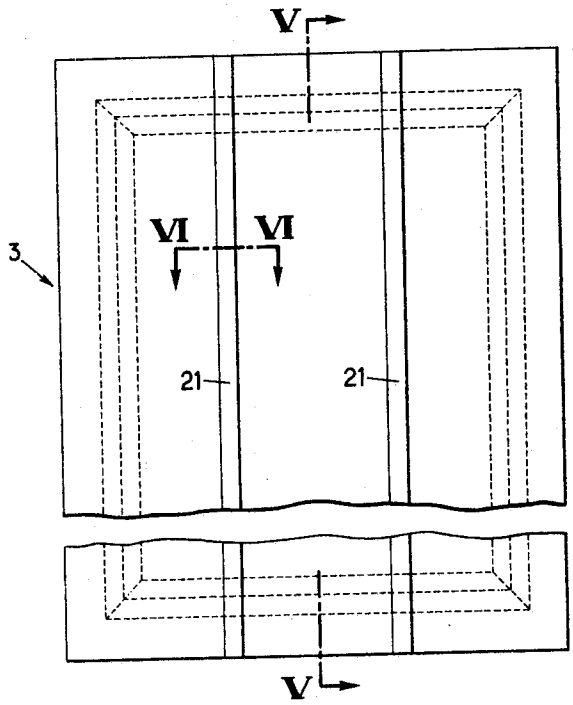

FIG.5

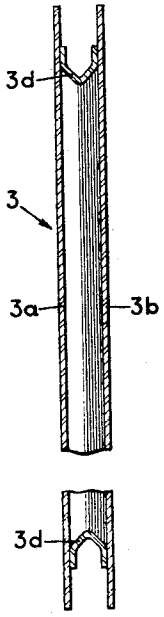

FIG.7

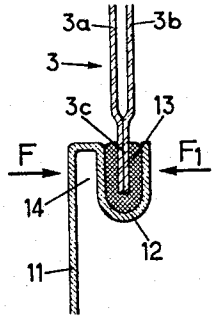

FIG.6

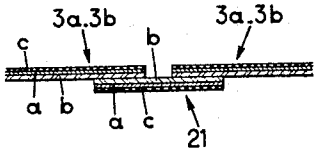

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FIG.8

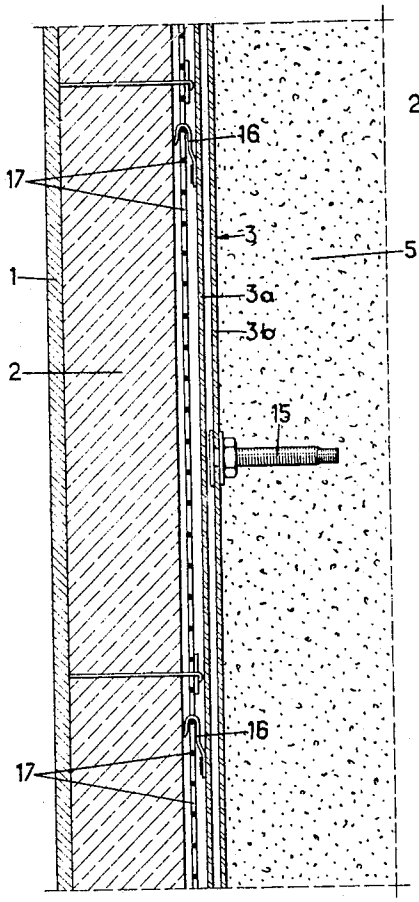


FIG.9

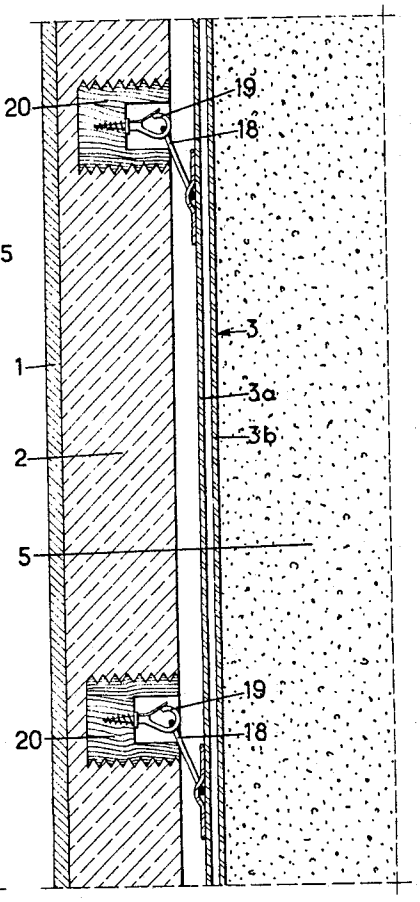
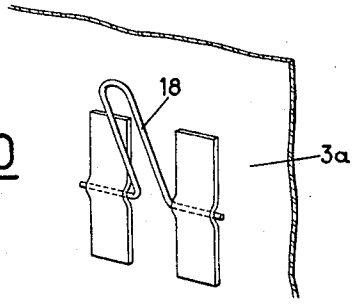


FIG.10



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3,273,740

TANK FOR LIQUEFIED NATURAL GAS AND OTHER PRODUCTS STORED AT LOW TEMPERATURES

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Claims priority, application France, May 7, 1963, 933,980, Patent 1,364,070
8 Claims. (Cl. 220—15)

It is customary to store liquefied natural gas at a very low temperature, and because of this temperature there are serious safety and construction problems attendant on its storage and transportation. The conventional precautions consist in providing barrier walls surrounding the storage tanks, but this arrangement is not practical if the tank is installed on a ship.

It is the object of the present invention to provide a new article of manufacture comprising a tank designed to be mounted in a ship and adapted to the transportation of liquefied gas, or any other product, at a low temperature. Since the tank is to be mounted in a ship, it must have an especially high safety factor, and it is essentially characterized by the fact that it comprises the following components, concentrically positioned, and spaced by partially solid and partially pulverulent insulating means:

An inner tank made of metal which is resilient at a low temperature, designed to contain the cold product which is to be transported;

An outer casing which may be integral with the hull of a ship or may even be constituted by said hull;

An intermediate casing or barrier layer, which is partially deformable and designed to hold in the product being transported in case the inner tank leaks, and thus protect the framework of the ship against cold. This intermediate casing has no shape of its own, but is supported by the solid insulation and consists preferably of steel plates positioned at individual points about the tank, to which flexible multi-ply panels are bonded. These panels may consist of assemblies formed from cloth reinforced with metal and a plastic film.

In accordance with the present invention, the inner tank and the outer casing are connected by relatively flexible guide means of the relatively slidable tongue and groove type, so that:

(a) The tank may contract and expand both radially and vertically and is thus protected against deformation;

(b) The inertial forces of the reservoir are referred to the framework of the ship and vice-versa, so as to insure equilibruim therebetween;

(c) A thermal resistance is interposed between outer casing and the inner tank, which resistance opposes an inacceptable transfer of calories to the contents of the inner tank.

In order that the invention may be more clearly understood, one representative embodiment thereof will now be described, with reference to the accompanying drawings, in which:

FIG. 1 is a vertical section through this embodiment of the invention;

FIG. 2 is a sectional view taken along the line II—II of FIG. 1;

FIG. 3 is a perspective view showing the detail of one of the tongue members which guide the inner tank relative to the outer casing;

FIG. 3*b* is a schematic view showing how the inner tank is expansibly mounted within the outer casing;

FIG. 4 is an elevational view showing part of the deformable intermediate casing, which is made of a compound material;

FIG. 5 is a sectional view taken along the line V—V of FIG. 4;

FIG. 6 is a sectional view taken along the line VI—VI of FIG. 4;

FIG. 7 is a view showing the encircled portions A on FIGURE 1 on an enlarged scale and showing the mounting of elements constituting the barrier layer on the plates which are provided at specific points on the tank;

FIG. 8 is a sectional view showing on an enlarged scale the part B which is encircled on FIG. 1;

FIG. 9 shows alternative construction for the part shown on FIG. 8; and

FIG. 10 shows a detail of the means for attaching the barrier layer to its supporting insulation.

Referring now to the drawings, it will be seen that the tank according to the invention comprises an outer casing **1**, for example the steel hull of a ship, to the inner surface of which the solid supporting insulation is attached. This solid insulation is preferably foamed plastic of the type described in U.S. Patent No. 3,158,459 to Jacques Guilhem. As used in the present specification and in the accompanying claims, the term "solid" is intended to indicate that the material does not flow under moderate pressure but does not indicate that the material is free from internal voids.

On the inner surface of the insulation **2** is mounted, by any suitable means, an intermediate casing or barrier layer, which is partially deformable, and designated as a whole by reference numeral **3**. This barrier layer, which is hereinafter described in detail, is associated, through a layer **5** of pulverulent insulating material, with the inner tank **4** which contains the cold product which is to be transported.

When the tank is installed in a ship, the inner tank **4** is subjected to inertial forces and torques which it refers to the framework of the ship. This first problem is particularly difficult to solve because these forces are quite large and it is necessary to avoid any construction capable of constituting means for conducting heat between the inner tank and the hull of the ship, which is ordinarily made of steel, a metal which becomes somewhat brittle at temperatures below −5° C.

Another problem is the following:

It is generally known that when two bodies having different temperatures or different rates of expansion in response to heat are to be connected together, it is impossible to employ rigid means for that purpose.

It must be possible for expansion and contraction to take place freely in order to avoid deformation, and in some cases, destruction of the structure.

This is particularly the case when dealing with tanks according to the invention, when they are made integral with a ship, since the inner tank contracts when in use and expands thereafter, in all three dimensions.

It is, moreover, necessary to insure that the structure holds together by seeing to it that the weight within the tank is always transmitted to the bottom of the ship and that inertial forces are transmitted to its lateral walls and transverse bulkheads.

These conditions have been practically fulfilled by means of an arrangement which constitutes an improvement on the one described in the publication "Mecanique" for the month of August 1942, and shown on FIG. 3*b* of the attached drawings in order to simplify the explanation of the invention.

This figure shows an outer member **1***a* and an inner member **4***a* which may be respectively compared to the outer casing **1** and the inner tank **4** of the tank according to the invention, these two members being connected by tongues **9***a* and grooves **6***a*.

This assembly, as set forth in the said publication, permits the expansion and contraction of the two members, while keeping them mechanically connected, that is to say, provides for their mutual guidance at **6***a*.

The device according to the invention, which is based on this known guidance principle, has been improved so as to solve the problems of heat insulating the tank, the construction and mounting of the improved device on the deformable wall **3**, and its mounting on the inner tank **4** and the outer casing **1**, so as to produce an assembly which embodies one of the essential characteristics of the present invention.

Such a device is constructed as follows:

The casing **1** comprises, in the example illustrated, four diametrically opposed niches **1***a* (FIG. 2).

In each of these niches two plates **6** are mounted parallel to the axis *x*–*x*′ (FIG. 1) to form slideways secured by gussets **7** mounted on the tank **4** to the right of internal reinforcements (which are not shown, in order to simplify the drawing).

Tongues **9** formed or mounted on beams **8**, which may have an H section, as shown in FIG. 3, slide with a predetermined clearance, in the grooves **6**. These beams have a certain flexibility and are provided at each end with gussets **10** welded at **10***a* to the casing **1**. These gussets are shaped to space the beams **8** and consequently the tongues **9** a little way inside of and away from the casing **1**.

This assembly is positioned in the space containing the heat insulation and is thus covered partly by pulverulent insulating material **5** and partly by solid insulating material **2**.

It should be noted that despite its metallic nature, this assembly—which is particularly adapted to the transmission of substantial forces from the inner tank **4** to the hull of the ship—does not constitute a path for the conduction of heat between these two members, because the beams **8**, which are positioned parallel to the iso-thermal surfaces, introduce, on account of their length, a substantial resistance to the passage of heat. Thus the volume of heat conducted by this assembly to the contents of the inner tank **4** remains small.

It should also be noted that the arrangement according to the invention permits the stress to be distributed among a plurality of gussets **7**, thus simplifying the design problem. Moreover, the flexibility of the beams **8** provides a certain angular freedom for the tongues **9** and makes it possible for them to conform, under stress to the slideways **6**.

Since the lateral surfaces of the tongues **9** are positioned in diametral planes, the inner tank **4** may contract freely in a radial direction, and contraction may also take place in a direction parallel to the axis *x*–*x*′ (FIG. 1) of the tank, without encountering any obstruction, on account of the shape of the members **6** and **9**.

In order that the value of the improved construction hereinbefore described may be appreciated, it should be pointed out that the kinematic arrangement shown in FIG. 3*b* is already known for use in constructing tanks for holding liquefied natural gas, but slideways and tongues of hard wood have heretofore been suggested. Such constructions are not suitable for use in a ship designed to hold large tanks which contain a large volume of liquid, because they rely on the use of wood. It is furthermore known that wood has mechanical characteristics which are inferior to those of metallic members. On the contrary, as has been hereinbefore mentioned, the arrangement according to the present invention is perfectly suited to the transmission of substantial forces (of the order of 500 tons, for example), but nevertheless effectively resists the transfer of heat.

Independently of the problems hereinbefore described, and resolved by the invention, the manufacture of tanks for liquefied gas or other products held at low temperatures poses a third equally important problem.

As previously indicated, such tanks must be provided with barrier walls. When these tanks are installed on the ground, this barrier wall usually consists of small walls of earth positioned around the tank. On the contrary, when the tanks are installed in a ship (as in the present case), such an arrangement is impossible. For this reason, in accordance with the invention, the flexible casing **3** is inserted between the insulation **2** and the internal tank **4**. This casing, which forms a barrier layer, preferably comprises an assembly of panels made of two films **3***a*–**3***b* of a conventional compound heat-weldable material, each comprising a layer of metal *a*, a layer of plastic material *b*, and a layer of textile material *c* (FIG. 6).

The films **3***a* and **3***b* are sealed fluid tightly to each other by means of a bellows **3***d* also made of a compound material (as shown in FIG. 5), in order to control the fluid-tightness of the seals during construction. For this purpose a valve **15** (FIG. 1 and FIG. 8) is positioned in the walls of each of the cushions which are formed in this manner, and the valve permits their expansion.

The double wall formed in this way is kept in place on the supporting insulation **2** by attaching means consisting of hooks **16**, or pins, inserted into a grille **17** (FIG. 8), so as to keep the wall **3** from sagging.

Another embodiment of the said attaching means is shown on FIG. 9. Clips **18** are snapped into screw-hooks **19** screwed into inserts **20** which are themselves screwed into the insulation **2**. The points of attachment are so spaced that the barrier layer can contract without rupturing, if accidentally chilled.

At certain special points, that is to say, at the bottom and in the zones adjacent the members **6**, **7**, **8**, **9** and **10**, the barrier layer **3** consists of a simple plate of metal **11** adapted to low temperature applications, since the nature of the compound material is such that it cannot transmit force.

According to one characteristic of the present invention, the plates **11** and the surfaces made of complex material are connected in the following way:

A gutter **12** is formed in the edge of each plate **11**, and the adjacent edges **3***c* of the heat-weldable panels **3** are inserted therein. These panels are connected to each other by heat-sealed strips **21** (FIG. 6) and their connection to the gutter is made fluid-tight by means of packing **13** which sticks to both the gutter and the compound material forming the wall **3**.

It should be noted that if the cold contents accidentally come into contact with the barrier layer **3**, an empty space **14** between the gutter **12** and the plate **11** ensures symmetrical cooling of the gutter **12**.

In this way, the gutter exerts uniform pressure like the jaws of a vise, on the material **13**, and consequently on the edge **3***c* which is positioned therein, as a consequence of contraction in the directions of the arrows F and F1 (FIG. 7), the coefficient of contraction of the material **13** being less than that of the metal forming the gutter **12**.

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. A tank for transporting fluids at low temperatures comprising an inner casing made of a metal which is resilient at said temperatures, a relatively rigid outer casing, an intermediate deformable casing between said inner and outer casing, interfitting relatively slidable tongue and groove means extending through said intermediate casing, said tongue means being attached to one of said inner and outer casings and said groove means to the other so as to guide said inner casing as it expands and contracts relative to the outer casing, and solid insulation between said intermediate casing and one of said

inner and outer casings and pulverulent insulation between said intermediate casing and the other of said inner and outer casings.

2. A tank as claimed in claim 1 comprising a grille carried by said solid insulation, said intermediate casing being hooked onto said grille.

3. A tank as claimed in claim 1 comprising plugs seated in said solid insulation and screw hooks seated in said plugs, said intermediate casing being attached to and carried by said screw-hooks.

4. A tank as claimed in claim 1 in which said tongues are mounted on elongated bars having a limited flexibility and attached only near their respective ends to said outer casing, said groove means comprising pairs of parallel plates attached to the inner casing by gussets, said tongue and groove means extending through both said solid and pulverulent insulation but offering substantial resistance to the passage of heat therealong.

5. A tank as claimed in claim 1 in which the intermediate casing is supported by the solid insulation and comprises a plurality of metal plates sealed to and spaced by flexible multi-ply panels.

6. A tank as claimed in claim 5 in which the said panels are made of cloth reinforced with metal and lined with a plastic material.

7. A tank as claimed in claim 5 in which the metal plates connecting the multi-ply panels carry at their edges gutters which receive the edges of the multi-ply panels, the joints between said panels and plates being rendered fluid tight by means of adhesive packing in said gutters.

8. A tank as claimed in claim 5 in which said panels are expansible pneumatic cushions, each comprising a pair of parallel sheets connected by a flexible bellows.

References Cited by the Examiner

UNITED STATES PATENTS

1,249,785	12/1917	Layman et al.	
1,918,335	11/1927	Heylandt	220—9
2,916,179	12/1959	Monroe	220—15
3,007,596	11/1961	Matsch	220—9
3,090,517	5/1963	Morrison	220—9
3,147,878	9/1964	Wissmiller	220—9
3,150,797	9/1964	Yamamoto	220—15

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