United States Patent

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[54] **SELF-SUPPORTING CARGO TANK WITH PARTIALLY PERFORATED SANDWICH PANELS**
6 Claims, 3 Drawing Figs.

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[51] Int. Cl. B65d 7/22
[50] Field of Search .... 220/15, 10, 9(A'), 9(B); 114/74(A)

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ABSTRACT: A self-supporting, rigid metal cargo tank for cryogenic fluids such as liquefield gases constructed of partially perforated sandwich panels, *i.e.*, panels having two spaced sheet metal walls with internal metal bracing interconnecting them and forming cells to provide a light but strong and rigid panel structure, one of these two walls being perforated and the other being liquid-tight, in such a way that the liquid-tightness runs in some areas at the inside face of the tank and in other areas at the outside face, to prevent pockets of gas being trapped by the internal cellular structure and at the same time provide maximum strength and rigidity of the tank for a given amount of metal employed.

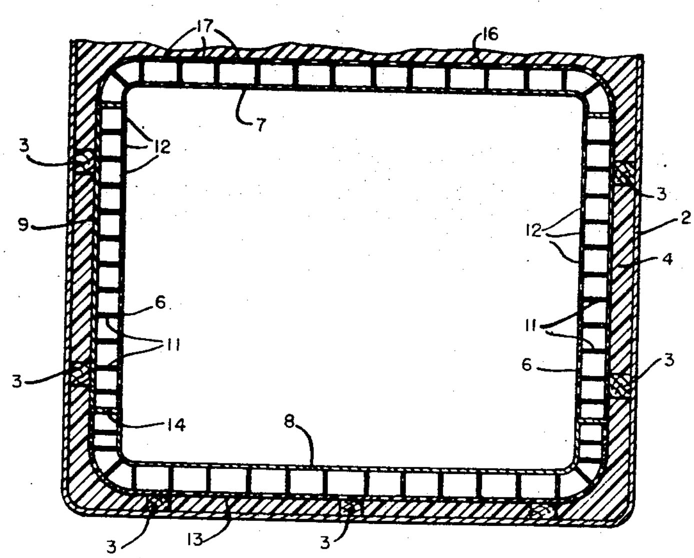


FIG. 1.

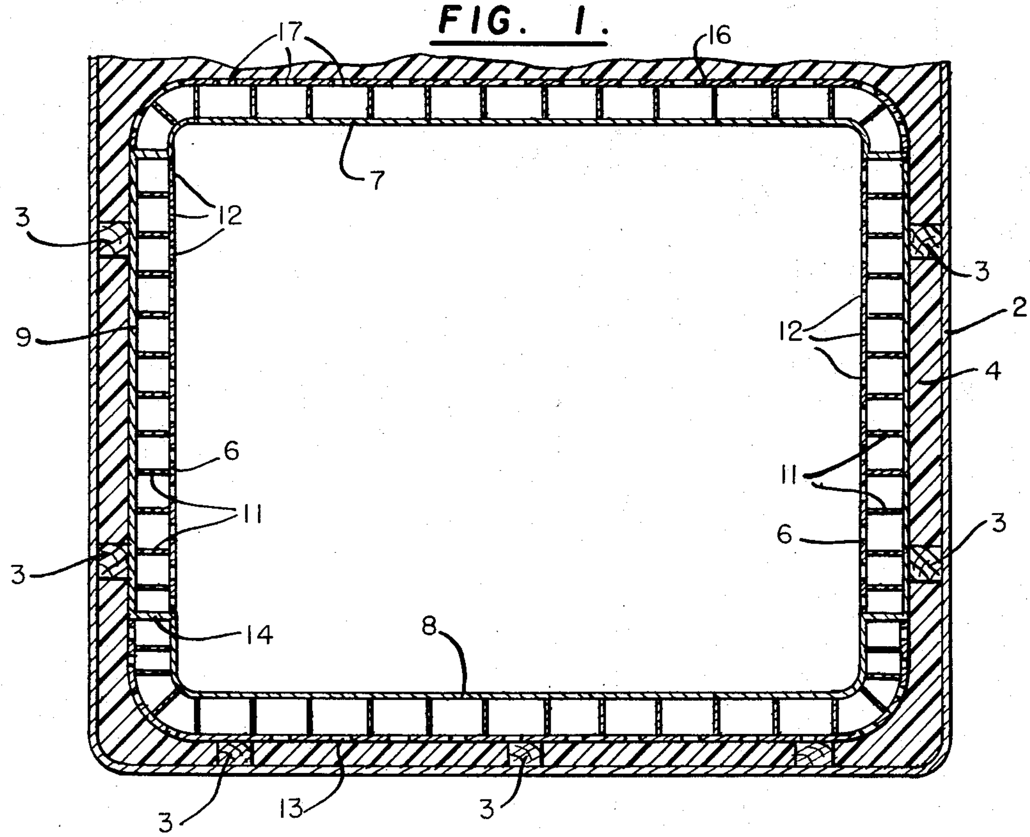


FIG. 2.

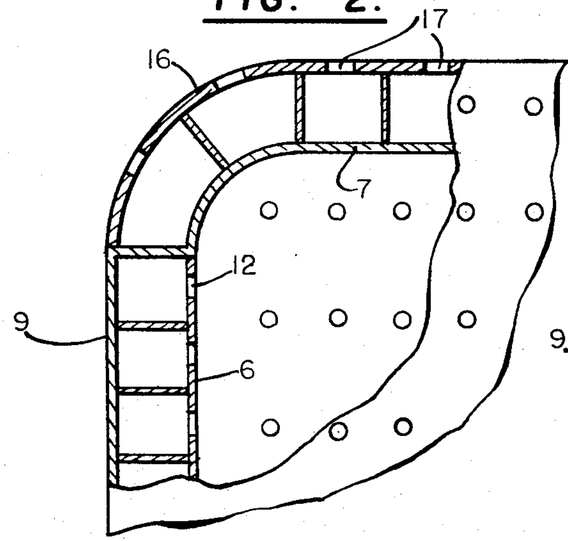
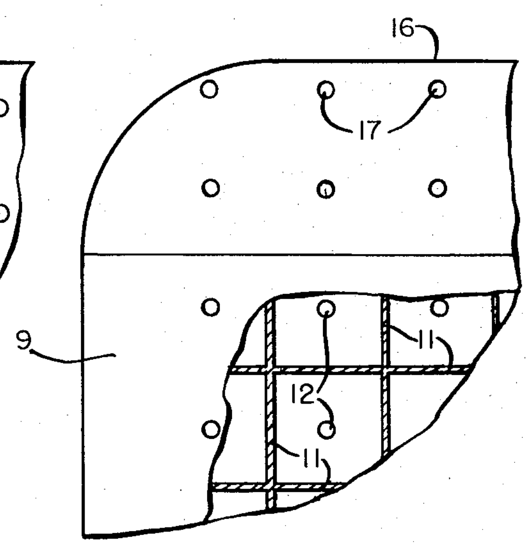


FIG. 3.



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SELF-SUPPORTING CARGO TANK WITH PARTIALLY PERFORATED SANDWICH PANELS

This invention relates to tanks for the storage and transportation of liquids in large volume and at a temperature differing widely from ambient temperature. The invention is primarily intended for polygonal tanks, for very cold liquids such as liquefied gases at near atmospheric pressure, and for use as self-supporting cargo vessels in transportation means such as a marine tanker.

In designing such tanks for large volumes of liquid, difficulty arises in the provision of means for providing sufficient structural strength for service as self-supporting cargo tanks, that is, the ability to hold the liquid within the tank without depending upon the structure of the ship itself for aid in support of the walls of the tank against buckling. The situation is further aggravated by (1) the roll and pitch of the ship which creates unbalanced pressure in one or other of the walls of the tank, and (2) the thermal gradient which exists throughout the depth of the tank, especially when the latter is only partially filled with liquid at a temperature widely differing from ambient temperature.

It has been common practice in polygonal tanks formed of flat plates to augment the structural strength of the tank by vertical stiffening beams of relatively large section modulus. However, such arrangement has the disadvantage that the vertical beams not only become highly stressed in themselves but stresses are introduced into them due to the thermal gradient in the tank in that they do not permit the bottom of the tank freely to contract or expand relative to the top of the tank without introducing bending moments in the vertical beams.

In order to meet this problem there was proposed in U.S. Pat. No. 2,982,441 (Farrell) a tank construction comprising a tank of polygonal shape in horizontal cross section having walls formed of high strength fluid and vapor impervious material, a plurality of vertically spaced apart, horizontally disposed stiffening and reinforcing members extending substantially continuously about the entire inner faces of the upright walls extending substantially throughout the lengths thereof and fixed thereto to form a part of the walls and at least one horizontally disposed elongate cross tie member interconnecting each of the adjacent walls of the tank and extending angularly between the adjacent sections of the attached horizontally arranged and vertically spaced apart reinforcing members.

Tanks used to be constructed separately from the tankers, and, when assembled, were mounted in the cargo holds of the tankers. However, the current trend is towards larger capacity tankers and for simplicity and economy these require larger size tanks rather than a greater number of small tanks. The large tanks present the difficulty that they are heavy and bulky and the size of a tank which can be pre-assembled and then mounted in a tanker is limited by the loading capacity of shipyard cranes. It is, therefore, desirable to adopt a design of tank which is as light in weight as possible and can be assembled within a cargo hold of a tanker to form a tank. But the provision of large numbers of stiffening members render this more difficult.

Moreover, large self-supporting tanks are exceedingly expensive, as ordinary steel is not suitable due to embrittlement at the low temperatures involved, and expensive materials must be used, so that it is important to minimize the amount of metal employed, while maintaining the desired necessary structural strength.

It has also been previously proposed to construct such tanks with two walls interconnected by internal metal bracing to form an internal cellular structure. Such a structure is shown for example, in U.S. Pat. No. 3,246,789. It is also known to use sandwich panels for constructing the double walls of such tanks, such panels being constructed of two sheet metal walls interconnected by internal metal bracing to form an internal cellular structure. Such a structure is shown, for example, in Messer U.S. Pat. No. 3,150,793. In these constructions the internal metal bracing provides such reinforcement that thinner metal plate can be used for the walls than would otherwise be required and reduces the number and/or section modulus of the stiffening members required.

In such construction both of the double walls are intended to be liquid-tight, the inner wall serving as a primary barrier and the outer wall serving as a secondary barrier in the event of failure of the primary barrier. Such constructions have a number of disadvantages. One disadvantage is that because both walls are required to be liquid-tight and capable of withstanding the hydrostatic cargo loads and inertia forces, they must each be of substantial thickness. A second disadvantage is that, should fracture of the primary barrier inner wall occur so that inflammable fluid cargo enters the space between the walls, this represents a substantial source of danger when the tank has been emptied, due both to expansion and possible rupturing of the cells, and also to the slow release of inflammable gas into the empty tank where it can mix with air and may present hazard.

An object of the invention is to provide a tank construction in which the minimum amount of metal is employed, while maintaining the necessary structural strength.

Another object of the invention is to provide a tank construction in which the number and/or section modulus of the stiffening members are reduced, thereby reducing the metal employed and facilitating assembly of the tank, in situ, in the cargo hold of a tank.

According to the present invention there is provided a self-supporting, rigid metal cargo tank for cold fluids, such as liquefied gases, constructed of partially perforated sandwich panels having two spaced sheet metal walls with internal metal bracing interconnecting them and forming cells to provide a light but strong and rigid panel structure, one of these two walls being perforated and other being liquid-tight, in such a way that the liquid-tightness runs in some areas at the inside face of the tank and in other areas at the outside face.

Preferably the arrangement is such that the inner side wall is liquid-tight up to a certain height from the bottom of the tank, is then perforated almost till the top of the tank, the corresponding outer side wall being perforated, the liquid cargo being allowed to enter the space between the double side walls over that part where the outer side wall is liquid-tight.

This construction has the advantage of providing maximum strength and rigidity of the tank for a given amount of metal employed and at the same time, preventing pockets of gas being trapped at the top and liquid at the bottom by the internal cellular structure.

The tank construction of the present invention requires less metal than a conventional single wall tank because the internal metal bracing between the walls provides such reinforcement that the total thickness of the two walls may be less than the thickness of the wall of a conventional single wall tank and reduces the number and/or section modulus of the additional stiffening members required. The tank construction of the present invention requires slightly less metal than a double wall tank because, in the latter, where each wall is intended to be fluid tight and to be capable of withstanding the hydrostatic loads and inertia forces exerted by the cargo the plates must be of substantial thickness, but in the present invention only one of the two walls at any part of the tank require to be liquid-tight so that the adjacent parts of the other wall can be thinner.

In the tank construction of the present invention perforations or apertures are deliberately provided so that all of the cells have access to either the internal or external atmosphere, as the case may be, at all times and are visible, either from the inside or outside of the tank, as the case may be when the tank is empty so that it can be ascertained whether these perforations or apertures are blocked. This avoids the necessity for means for feeding and regulating the pressure of inert gas which would have to be provided in association with the space between the walls of a double wall double barrier tank.

It is to be clearly understood that the tank construction of the present invention is intended as a primary barrier only.

Where a secondary barrier is required this can for example, be provided by and incorporated within the thermal insulation lining the cargo hold as known per se. This thermal insulation can be of any suitable known construction for this purpose. This has the advantage that the secondary barrier is completely independent of the primary barrier so that any rupture of the primary barrier will not prejudice the secondary barrier. On the other hand, when the walls of a double wall tank constitute the primary and secondary barriers this is unreliable because a crack starting in the plating forming the inner wall primary barrier can propagate through the connecting web of the central metal bracing and into the secondary barrier outer wall.

The utilization of the space between the walls of the tank construction for carrying liquid cargo increases the cargo carrying capacity of the tank compared with a double wall double barrier tank of the same external dimensions.

One specific structural example of the tank construction in accordance with the invention will now be described with reference to the drawings, wherein:

FIG. 1 is a schematic transverse cross-sectional view through a tanker containing a tank constructed in accordance with the invention;

FIG. 2 shows an upper corner of a tank according to the invention, partly in section to reveal in detail the internal construction; and

FIG. 3 is a view of the same corner as in FIG. 2, with part of the outer covering of the said wall removed to show the cellular construction and perforations.

As shown in FIG. 1, the tank is carried within the hull of a vessel 2, within which it is supported by any suitable means, shown as wood spacers 3, the intervening space being filled with any suitable insulation. In practice, various other insulating schemes for the tank may be employed as is well known in the art, but since the particular insulation employed is no part of the present invention, which is concerned solely with the metal tank structure, it will be understood that the insulation 4 represents any known insulation scheme for such tanks although such insulation will, in most cases constitute a secondary barrier as known per se. The tank itself is made up of metal sandwich panels, which are preferably extended and which may be of any suitable type, having inner side walls, as shown at 6, a top wall as shown at 7, and a bottom inner wall as shown at 8. Inner walls 6 are connected to outer walls 9 by internal metal bracing 11, shown as a series of horizontal and vertical members criss-crossing to form a series of internal cells between the walls 6 and 9. Although the cells are shown as rectangular for simplicity, it is also well known to use hexagonal cells as shown in the U.S. Pat. No. 3,150,793. In accordance with the present invention, the cells of walls 6 are perforated as indicated at 12 in FIGS. 1 and 3. In the case of the tank floor, the wall 8 is imperforate and made liquid-tight but its opposite wall 13 is perforated similar to wall 6. The liquid tightness of wall 8 is continued along section 14 to the outer wall 9, so that a liquid-tight tank is obtained consisting of walls 8 and 9 joined together in liquid-tight fashion. The same principle is applied to the end walls of the tank (not shown) and the liquid-tightness is carried on from the side and end walls to the ceiling wall 7 of the tank, its corresponding outer panel wall 16 being perforated as shown at 17, in the same manner as described above. Due to the perforations 12 on the side walls of the tank, the effective capacity of the tank is increased by the space corresponding to the distance between the walls 6 and 9. However, the rigidity is that of a conventional sandwich-type tank wall, and an aluminum tank of this construction may give a saving in metal of about 14 percent, as compared to a conventional single wall tank construction. The inner surface of the top is made tight to prevent pockets of gas being trapped by the cellular structure. The inner surface of the bottom is tight to facilitate drainage of liquid to the cargo pump within the bottom of the inner wall of the tank. The top and bottom double skins are less deep than the sides; the lost capacity is therefore small. The vertical sides, having greater thickness, represent more capacity which is utilized by transferring the tightness to the outside. If the entire inner surface were made the primary barrier, there would be a loss of about 2 percent in capacity.

All parts of the tank are of the same material, which may be any suitable metal (including an alloy) not subject to cold embrittlement at the temperature of liquefied gas.

The tank may be provided with a number of additional horizontal and/or vertical stiffeners (not shown) internally of the inner wall of the tank.

I claim:

1. a. A self-supporting rigid metal cargo tank for cryogenic fluids such a liquefied gas, said tank having side walls and top and bottom walls;
   b. at least some of said walls being in the form of sandwich panels consisting of two metal sheets with internal sheet metal bracing interconnecting said sheets and forming cells to provide a light, strong and rigid panel structure;
   c. one of said two sheets being perforated to provide access to each of said cells, the other of said two sheets being fluid-tight;
   d. the fluid-tight sheet being in some areas of the tank at the inside face of the tank and in other areas at the outside face of the tank; and
   e. said fluid-tight sheets being joined to each other in a fluid-tight manner to provide a fluid-tight tank structure.

2. The invention as claimed in claim 1, the fluid-tight sheet portion of said panels being on the inside at the bottom of the tank and on the outside over at least most of the side walls of the tank.

3. The invention as claimed in claim 2, the fluid-tight sheet portion of the tank being of thicker sheet material than the perforated sheet portion.

4. The invention as claimed in claim 3, the internal sheet metal bracing between the two metal sheets of said sandwich panelling being of thinner sheet material than the fluid-tight sheet portion.

5. The invention as claimed in claim 4, the fluid-tight sheet portion being on the inside of the tank for a short distance up from the bottom.

6. The invention as claimed in claim 5, the fluid-tight sheet portion being on the inside at the top wall of the tank.