Sept. 29, 1964 E. M. SCHLUMBERGER 3,150,795

MEMBRANE TANKS

Filed April 18, 1962

Fig. 1

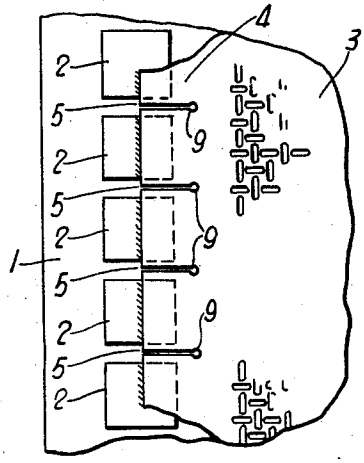


Fig. 2

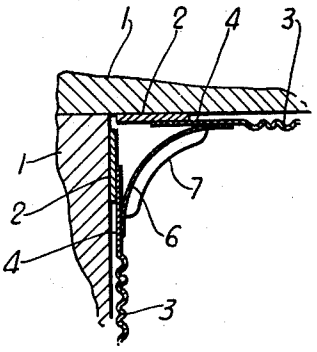
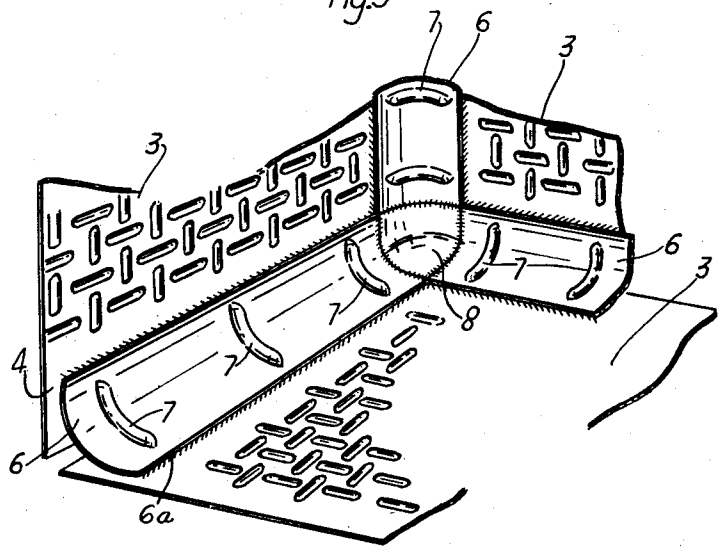


Fig. 3



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MEMBRANE TANKS

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6 Claims. (Cl. 220—9)

This invention relates to membrane tanks for containing fluids at a temperature considerably below ambient temperature.

In the storage of very cold liquids in large metal tanks, difficulties arise due to the stresses set up in the tank walls following contraction and expansion of the metal if these walls are restrained. This is particularly so with so-called "membrane tanks" which comprise thin metal walls and floor resting against a thermal insulation layer, which layer takes the weight of the contents of the tank, the metal walls and floor merely acting as a barrier preventing the liquid coming into contact with the thermal insulation. Clearly in such tanks the thin metal walls and floor have to be fixed to the supporting insulation at appropraite points and, if flat metal sheet is used, then on contraction severe stresses are set up in the sheet which, if great enough, lead to permanent deformation or even to rupture.

Similar problems arise when thin metal sheet is used as a barrier to prevent escape of cold gases in the case of a rupture of, or a leak from, a vessel containing cold low-boiling liquids, i.e., where a thin metal sheet tank is used as a secondary barrier around a primary container. For the sake of convenience, such thin metal sheet tanks are also herein called "membrane tanks."

To avoid the severe stresses arising in such cases, it is possible to use metal sheet provided with protrusions such as corrugations, dimples or wrinkles, which deform on contraction but return to their original shape on subsequent expansion.

Problems arise in the construction of membrane tanks particularly in connection with the fixing of the thin metal walls and floor to the supporting insulation and in connection with the sealing of the corners where the walls meet each other and where they meet the floor. The present invention provides a membrane tank construction in which these problems are solved.

Accordingly, the present invention provides a prismatic or cylindrical tank for containing fluids at a temperature considerably below ambient temperature which comprises

(*a*) a load-bearing floor and a load-bearing wall or walls formed of thermal insulating material,

(*b*) small metal members fixed to the thermal insulating material in the corners between the floor and the wall or walls and, where there is more than one wall, in the corners between the walls,

(*c*) metal sheets provided with protrusions, said sheets covering said floor and wall or walls and having plain edges which are fixed on to said small metal members,

(*d*) slots in the plain edges of said sheets between the small metal members,

(*e*) along each corner between the floor and the wall or walls and, where there is more than one wall, between the walls, a gutter-like strip of metal sealed to the plain edges of the metal sheets forming the corner, and

(*f*) in any corner where three gutter-like strips meet, a sheet metal member sealed to the ends of the three gutter-like strips.

Preferably, the gutter-like strips are provided with corrugations across their width to allow for contraction and expansion. These corrugations should preferably not extend right across the strips but should stop short at the

longitudinal edges of the strips so that there are continuous plain edges to the strips by which they may be welded on the plain edges of the metal sheet covering the walls and floor. The roof of the tank and means for filling and emptying may be of any conventional type but preferably the tank is fitted with a rigid metal roof and a trunk in the roof through which the filling and emptying conduits pass.

The metal employed will depend on the temperature to which the tank is to be subjected. For storing liquefied natural gas, nitrogen or helium at about atmospheric pressure, stainless steel and aluminium alloys are particularly suitable.

The invention is illustrated with reference to the accompanying drawings in which

FIGURE 1 shows a part of a wall or the floor of a prismatic membrane tank and the method of attachment of the metal sheet to the insulation,

FIGURE 2 shows a cross section through a corner between two walls, and

FIGURE 3 shows a perspective view of a completed corner between two walls and the floor.

Referring to FIGURE 1, **1** is a load-bearing wall or floor made of a thermal insulating material, such as balsa wood panels with a plywood facing. This wall or floor is part of a prismatic structure having four side walls and a floor. Fixed on this wall or floor near an angle where it meets another wall is a series of small metal members **2** which are fixed on to the wall or floor, for example by screws or nails.

These metal members **2** are sufficiently small that the contraction and expansion to which they will be subjected when the membrane tank is in use will not be sufficient to deform them. A certain amount of play in the fixing to the wall or floor **1** may be left (for example by using screws in slotted holes in the metal member) to allow the member **2** to move slightly on contraction and expansion. These members **2** may be strips or other rectangular pieces. The shape employed is not important but they should preferably be made of the same metal as the metal sheet they are to support.

The metal sheet **3** is provided with protrusions, which, in the embodiment as shown in the drawings, have the form of dimples, and it has a narrow edge **4** which is not provided with protrusions.

In this specification, the term "dimple" means a small hollow in a sheet, the depth of which hollow is substantially greater than the thickness of the sheet, thus resulting in a corresponding protuberance on the other side of the sheet. It also means the said corresponding protuberance. It will be clear that instead of "dimpled" metal sheet also metal sheet having other types of protrusions can be used, for example metal sheet provided with corrugations or wrinkles.

The edge **4** is slotted at a series of points **5**, which points correspond to the spaces between the series of metal members **2**. The slotting of the edge **4** in this way is essential to allow for contraction and expansion of the edge **4** of the metal sheet **3**. Preferably, the slots terminate in a circular cut-out as at **9** to avoid stress concentrations. The edge **4** of the sheet **3** is fixed to the metal members **2** by welding or other suitable means, for example screwing. Edge **4** extends well beyond cut-outs **9**, to provide a continuous line of junction with a gutter-like strip **6**, described below, and thus forms a continuous leak-proof seal.

In this way, the walls and floor of metal sheet **3** are affixed to the thermal insulation at the angles and corners. If the thermal insulation is made of a soft material unable to take the loads involved, then blocks of hard thermal insulation may be built in to take these loads.

FIGURE 2 shows a cross-section view of a completed angle and in it reference numerals **1**, **2**, **3** and **4** have the same significance as in FIGURE 1. When the two walls (or wall and floor) of metal sheet **3** have been fixed in place, a gutter-like strip of metal **6** is sealed, for example by welding, to the plain edges **4** of the metal sheets **3** just inward of the ends of the slots. As shown, this gutter-like strip **6** has transverse corrugations **7**, which give the strip **6** the required apparent elasticity lengthwise but which finish short of the edges **6***a* of the strip.

FIGURE 3 shows the metal parts of the completed corner between two walls and the floor and in it reference numerals **3**, **6** and **7** have the same significance as in FIGURES 1 and 2. To complete the corner, a sheet metal member **8** is sealed, for example by welding, to the ends of the three gutter-like strips **6** to make a fluid-tight container.

If desired, after the gutter-like strip **6** has been fixed in place, the transverse corrugations **7** can be extended into the sheet **3** by a forming-in-place process such as vacuum forming while heating. However, this extension of the corrugations **7** is not necessary because after welding the gutter-like member **6** and plain edge of the sheet **3**, when the metal is cooled down to the low temperature of use, the weld is stressed beyond the yield point and is permanently elongated. When the temperature returns to normal, the weld is compressed and takes an undulating form.

For good results, it is preferred that the length of the small metal members **2** be about the same as the distance between the two corrugations **7** on the gutter-like strip **6**. For a dimpled sheet 0.25 mm. thick, the radius of the gutter-like strip **6** would be about 15 cm., the radius of the corrugations **7** in it about 25 mm. and the distance between two corrugations **7** about 10 cm.

While the foregoing description applies particularly to prismatic tanks, it will be clear that the invention can be applied to cylindrical tanks. In this case, the methods of fixing the sheets and sealing the corners will apply to the continuous corner running around the edge of the floor where it meets the cylindrical wall of the tank.

The spaces between the dimpled metal sheet and the load-bearing surfaces may be filled with a resilient filler.

The thermal insulation may be of any suitable type such as balsa wood, quippo cork, foamed plastics, glass, asbestos, jute fibres, mineral wool or cellular gypsum. Where the thermal insulation material has structural strength, such as balsa wood, quippo and corkboard, it may be used directly to support the metal sheets **3**, but it is preferably lined with a stronger material such as plywood, on which lining the metal sheets **3** are supported. Where loose thermal insulating materials are used, then a supporting surface of a strong material, such as plywood, must be constructed to take the weight of the metal sheet tank and its contents.

I claim:

1. A tank for containing fluids at a temperature considerably below ambient temperature which comprises

(*a*) a load-bearing floor and at least one load-bearing wall formed of thermal insulating material,

(*b*) small sheet metal members fixed to the thermal insulating material in the corner between the floor and the wall,

(*c*) metal sheets provided with protrusions, said sheets covering said floor and wall and having edges which are fixed on to said small metal members, and planar portions inwardly of said edges,

(*d*) slots extending from said edges part way into said planar portions of the sheets between the small metal members,

(*e*) a gutter-like strip of metal extending along each corner between the floor and the wall and sealed to the planar portions of the metal sheets inwardly of the inner ends of said slots and forming the corner between said sheets.

2. A tank as claimed in claim 1 in which the protrusions in the metal sheet are in the form of dimples.

3. A tank as claimed in claim 1 in which the protrusions in the metal sheet are in the form of corrugations.

4. A tank for containing fluids at a temperature considerably below ambient temperature which comprises

(*a*) a load-bearing floor and at least two adjacent walls all meeting in a corner, and formed of thermal insulating material,

(*b*) small sheet metal members fixed to the thermal insulating material in the angles between the floor and the walls and in the angles between the walls,

(*c*) metal sheets provided with protrusions, said sheets covering said floor and walls and having edges which are fixed on to said small metal members, and planar portions inwardly of said edges,

(*d*) slots extending from said edges part way into the planar portions of said sheets between the small metal members,

(*e*) along each angle between the floor and the walls and between the walls, a gutter-like strip of metal extending along each corner and sealed to the planar portions of the metal sheets inwardly of the inner ends of said slots and forming a fluid-tight angle joint between said sheets, and

(*f*) in each corner where three gutter-like strips meet, a sheet metal member sealed in fluid-tight manner to the ends of the three gutter-like strips.

5. The invention according to claim 4, each of said slots terminating in a circular cut-out to relieve stresses due to expansion and contraction.

6. The invention according to claim 4, said gutter-like strips being provided with corrugations at right angles to their longitudinal axes.

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