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EXPANSIBLE CONTAINER FOR LOW-TEMPERATURE FLUID

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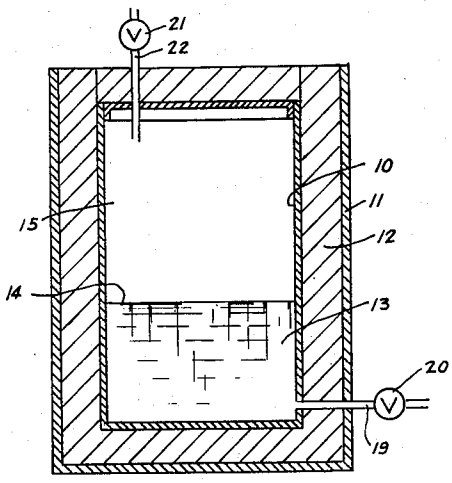


FIG. 1

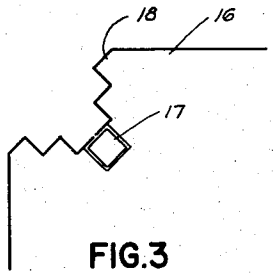


FIG. 3

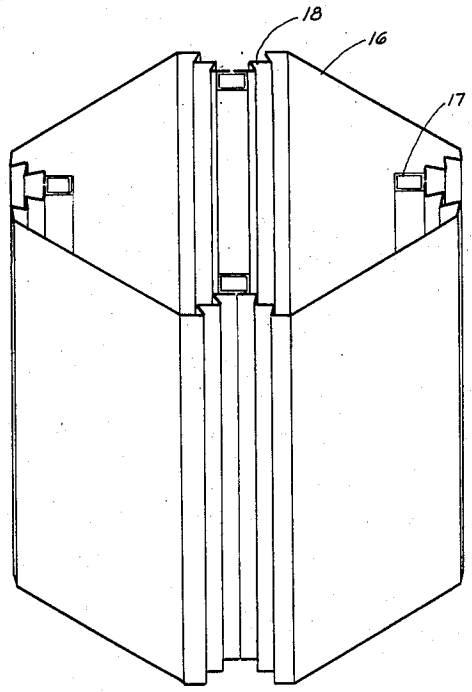


FIG. 2

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EXPANSIBLE CONTAINER FOR LOW-TEMPERATURE FLUID

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9 Claims. (Cl. 220—9)

This invention relates to storing and shipping liquefied gases at low temperatures and more particularly to the storing and handling of such liquefied gases in large metal tanks which are surrounded by insulating materials.

Many types of containers suitable for handling liquids which must be maintained at relatively low temperatures are known and used. One of the most common of these is the metal tank set completely within another tank or receptacle with insulation material placed in the space between the inside metal tank and the outside receptacle. Because the inside tank is metal it possesses a coefficient of thermal expansion and hence is subject to contraction and expansion when exposed to temperature changes. The problem of expansion and contraction becomes markedly acute at the temperatures normally encountered in the handling of liquefied gases because the temperature differential between the liquefied gas temperature and normal room temperature is very great.

In the case where the inside tank designed for storing or shipping liquefied gases is completely surrounded by an insulating material, such as balsa or cellular glass for example, contraction of the tank walls when the liquefied gas is added means that the walls pull away from the insulating material leaving a void area between the outside wall of the tank and the insulation material. There are cases where it is desirable to design the inside tank, containing the liquefied gases, so that it will depend for support upon the layer of insulation material and the outside wall of the receptacle surrounding the insulation material. When this is desirable, it may readily be seen that gaps between the walls of the inside tank and the insulating material would lead to stresses in the tank walls brought about by the removal of the needed structural support otherwise offered by the outside receptacle and the insulation material and by the pressure of the liquid and/or of the gas within the inner tank. Repetition of the cooling-warming cycle, brought about by the addition and removal of the liquefied gas, and hence the stresses set up after a relatively short period, may cause the inner tank to fail. This is particularly true when the inner tank is intentionally fabricated of thin gauge metal which is incapable by itself of maintaining shape under the liquid and/or pressure load.

Moreover, if the inner tank containing the liquefied gas is only partially filled a large temperature gradient will exist in the gas column above the liquid level. This means that the tank walls will also exhibit a marked temperature gradient approximating the temperature gradient in the gas because of the very low thermal conductivity of metal walls at the low temperatures involved. The resulting temperature gradients introduce additional stresses in the walls which may be partially relieved by the tank design of this invention.

It therefore becomes evident that it would be desirable to have metal storage tanks which have relatively thin metal walls and which can depend upon the outside receptacle for structural support, thus reducing the

weight and cost of the storage or shipping tank. One way in which the tank may be made to meet these requirements is to make some portions of the tank expansible.

It is therefore an object of this invention to provide a tank, suitable for storing and shipping liquefied gases, which may be constructed of thin metal walls, thus resulting in lower construction costs.

It is another object to provide receptacles, suitable for storing and shipping liquefied gases, which can remain continuously in contact with insulating material surrounding the walls for support.

It is another object to provide an inner receptacle for storing and shipping liquefied gases which depends for a portion of its structural support upon an outside receptacle.

It is a further object of this invention to provide receptacles, suitable for storing and shipping liquefied gases, which are expansible under the hydrostatic load and/or under the pressure built up within the receptacle by the vaporization of the liquid into gas.

These and other objects will appear in the following discussion which is presented with reference to the accompanying drawing in which—

Fig. 1 represents a cross-sectional view of the type of tank construction to which this invention is applicable;

Fig. 2 is a diagrammatical view of four walls of the expansible tank of this invention, and

Fig. 3 is a detail drawing of the welding of the expansible members.

By the process of this invention, a tank suitable for storage and transportation of liquefied gases is made expansible to allow the sides of the tank to remain substantially continuously in contact with the insulation layer and hence make fuller use of the additional structural support offered by the insulation layer and/or the outside receptacle. The tank is made expansible by the construction of the tank of prismatic shape with a corner portion in the form of a stapped member, hereinafter identified as a bellows type arrangement, joining the vertical walls, and by providing a stiffening or reinforcing member in the base portion of the bellows to prevent collapse, particularly when formed of a highly resilient and deformable material. The bellows construction employed to join the side walls of the tank and to form the corner portions therebetween may also be employed in the top and bottom walls to permit the corresponding type of expansion and contraction without the development of stresses otherwise occasioned by the movements which would take place in the side walls. The rectangular bellows permit each of the walls and the roof and bottom wall to move in a direction normal to its own plane when it is subjected to a slight pressure by the gas or liquid contained within the tank to compensate for the change in dimension upon expansion or contraction of the metal thereby to enable the walls to remain substantially continuously in contact with the layer of insulation for support.

The expansible tank of this invention may be further explained with reference to the figures.

In Fig. 1 there is shown a simplified cross-sectional view of the general type of tank used for storing or shipping liquefied gases. The tank will be a polyhedron configuration and preferably one which is a rectangular parallelepiped. The inner tank **10**, designed to contain the liquefied gas **13**, is placed within a surrounding vessel **11** and insulating material **12** placed between them. Such a tank may be equipped with a filling line **22** in which is placed a pressure-regulating valve **21** to provide proper gas venting, and with a draw-off line **19** incorporating valve **20**. When the sides, top and bottom of tank **10** press closely on the insulating material, tank **10** forms

an integral unit with tank 11 and tank 10 may therefore be of a lighter weight, thinner construction than if this integration did not exist. When the walls of tank 10 are cooled by the introduction of the liquefied gas, they contract, if made in the conventional manner, and pull away from the insulation and destroy the necessary integration and interaction.

In a tank such as shown in Fig. 1 the surrounding vessel 11 may be eliminated where insulation 12 is of such structural material, for example, cellular glass, cork or balsa wood, that it forms a strong outside receptacle. In such a case by maintaining the tank walls 10 in contact with insulating material 12, a strong integral unit is achieved without the additional tank 11.

In Fig. 2 it is shown how four walls of the inside tank 10 which actually contain the liquefied gas are made expansible in accordance with the practice of this invention. The tank of Fig. 2 has a rigid frame 17 made of stiffening members. Tank wall 16 is connected to the tank frame 17 by means of rectangular bellows 18 which are welded or otherwise joined at their lines of contact with frame 17. Sufficient freedom of movement is provided by the convolutions of the bellows to permit wall 16 to move back and forth from its corresponding frame member 17 in a direction normal to the plane of the wall. In similar fashion the top of the tank may also be connected by means of bellows. It is not necessary to equip the bottom of the tank with an expansible wall since the weight of the liquid contained will be sufficient to keep the bottom tightly pressed against its insulation. Furthermore, the bellows, if they are used on the bottom wall, would normally always be contracted.

Fig. 3 illustrates in detail an example of a rigid member and the way in which the bellows 18 may be joined to this member 17 and tank wall 16. Other forms of rigid members, such as I-beams, may be used equally well.

The components, including walls, stiffening members and bellows, of the tank of this invention are conveniently constructed from stainless steel. However, other suitable metals, such as aluminum or alloys, which possess the desired structural strength, may be used.

The number of bellows, their size and thickness of bellows materials will be determined by the design conditions set for the system. In general, the number of bellows is a function of the thickness of bellows material, the pressures at which they must work, the extension of the walls required and upon the stresses involved, the higher the stresses the fewer bellows required. As an example of the number of bellows which may be used, assume a tank which is 33 feet by 28 feet at the base and 50 feet high. In such a tank, if the bellows material is 0.05 inch thick, a bellows with 44 convolutions would be considered advisable while if the bellows material is 0.125 inch thick, some 18 convolutions are desirable.

The size of the tanks to which the expansible sides of this invention are applicable will vary with design conditions, particularly with the internal pressure in the tank. That is, the higher the internal pressure, the smaller the tank should be to prevent "racking" of the bellows. The extension of the bellows is also dependent upon the size of the tank. The larger the tank, the greater extension required.

The bellows may be formed by any suitable means such as by welding sections together along their longitudinal edges or by folding the convolutions to shape. The bellows are then preferably welded to the supporting means and the tank walls to form the completed tank which is hermetically sealed to contain the liquefied gas.

The supporting or stiffening member 17 may comprise an elongate member of rectangular shape, as shown, but it may equally comprise an elongate member of bar or polygonal shape. In the preferred embodiment, the stiffening member is arranged with one of its flat sides in abutting relationship with the flat face innermost in the corner construction embodying the expansible bellows. It will be apparent that the stiffening member can also be fixed to the bellows portion along one of the edges or corner portions of the stiffening member, as shown in Fig. 4, thereby to provide for still greater resiliency or deformation in the wall construction without sacrifice of rigidity or support. It is preferred to embody the bellows as a corner of the polyhedron but it will be apparent that the bellows can be incorporated into a wall portion intermediate its ends, as illustrated in the top wall in Fig. 3. While it can extend outwardly from the top wall, it would be apparent that in the side and bottom walls of the tank the bellows would extend inwardly into the tank.

Thus, by the use of the expansible tanks of this invention, there are provided means for continuously keeping the outside of the tank walls in contact with the insulating material surrounding the tank which in turn means that thin-walled tanks may be used since the tank can be structurally supported by the insulation and the outside tank or by the insulation alone.

We claim:

1. A tank for the storage of a liquid, the boiling point of which differs widely from the ambient temperature, consisting of an inner shell housing said liquid and which is subject to noticeable expansion and contraction due to temperature changes, a thermal insulating material surrounding the inner shell, said inner shell having the shape of a polyhedron and being provided with an expansible member at each of a plurality of the edges of the sides of said polyhedron, each such expansible member being in the form of a bellows member, each such bellows member being hermetically sealed along one edge to the contiguous edge of the side which it joins, a rigid member disposed parallel to said contiguous edge and secured thereto, the rigid members of said edges of said polyhedron constituting a supporting frame for said polyhedron, whereby the inner shell remains continuously substantially in contact with the insulating material.

2. A tank according to claim 1 wherein said inner shell is coated with a thermal insulating material having structural strength.

3. A tank according to claim 1 wherein an outer shell surrounds and remains continuously in contact with the insulating material.

4. A tank according to claim 1 wherein said inner shell is a rectangular parallelepiped.

5. A tank according to claim 1 wherein all of the edges of the sides of said inner shell are provided with said expansible member.

6. A tank according to claim 1 wherein a frame defines the shape of said inner shell, said frame comprising a plurality of straight rigid members and supporting the side of said inner shell, each of a plurality of the edges of said sides being hermetically joined to said frame by means of a bellows member.

7. A tank according to claim 1 wherein said bellows members extend outwardly from the inner shell.

8. A tank according to claim 1 wherein said bellows members extend inwardly into the inner shell.

9. A tank of large capacity for the storage of a liquefied natural gas at about atmospheric pressure consisting of an inner shell formed of metal capable of retaining its ductility at the low temperature of the liquefield gas and which is subject to change in dimensions due to expansion and contraction in response to temperature change, an outer shell surrounding the inner shell in spaced relation therewith to provide an open space in between filled with thermal insulating material, said inner shell having the shape of a polyhedron which is formed of thin metal walls, an expansible member at each of a plurality of the edges of the sides of said polyhedron, each such expansible member being in the form of a bellows member, each such bellows member extending inwardly into the inner shell and being hermetically sealed along its edges

to the contiguous edges of the side adjacent thereto to interconnect the adjacent sides in sealing relationship therebetween, a rigid member disposed parallel to said contiguous edge and secured thereto, the rigid members of said edges of said polyhedron constituting a supporting frame for said polyhedron, whereby the inner shell remains continuously substantially in contact with the insulating material and depends upon the outer shell of the insulating material layer for structural support.

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