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E. L. JONES

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STORAGE RECEPTACLE FOR LIQUEFIED GAS

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4 Sheets-Sheet 1

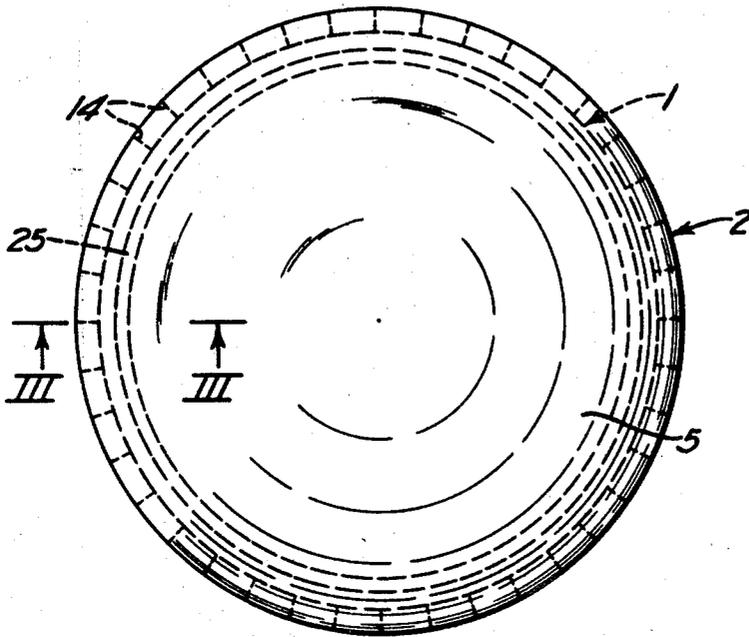


Fig. 1

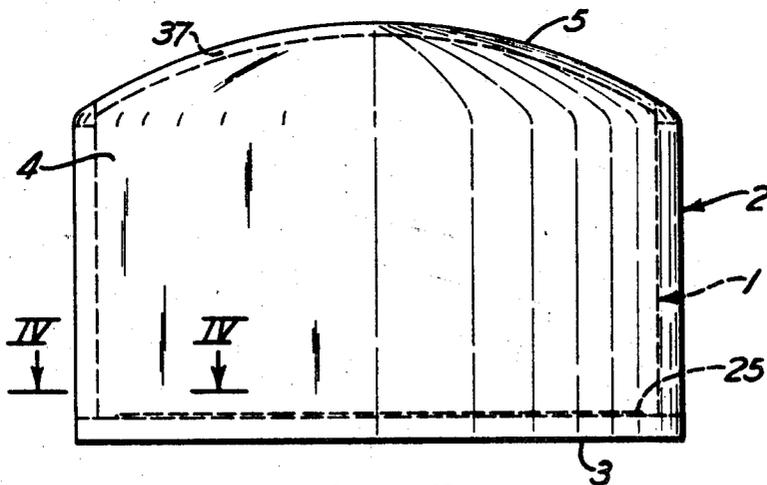


Fig. 2

INVENTOR.
EDWARD L. JONES

BY

Brown, Critchlow, Flick & Decham
ATTORNEYS.

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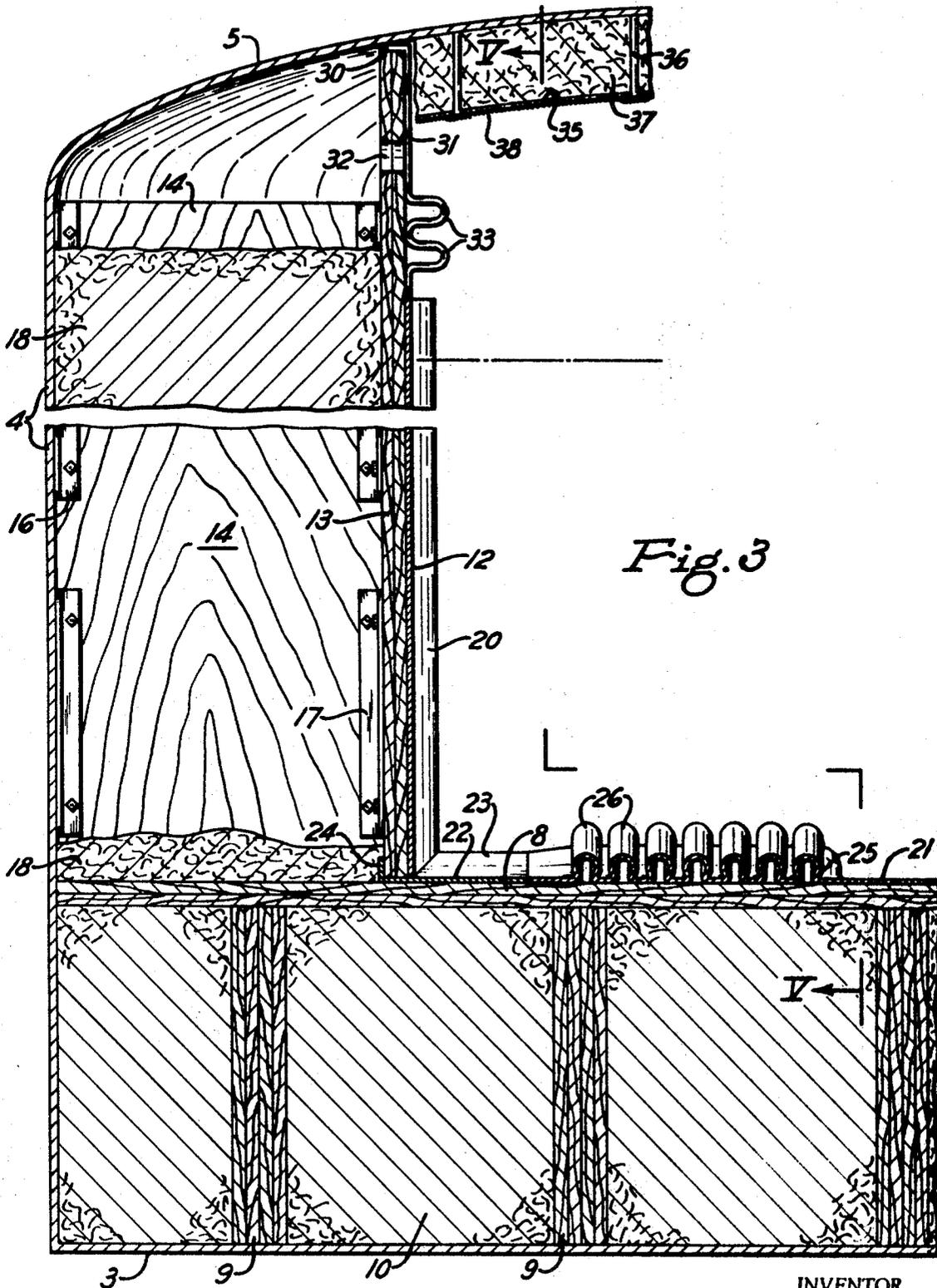


Fig. 3

INVENTOR.
EDWARD L. JONES

BY

Brown, Critchlow, Flick & Peckham.
ATTORNEYS.

Sept. 20, 1971

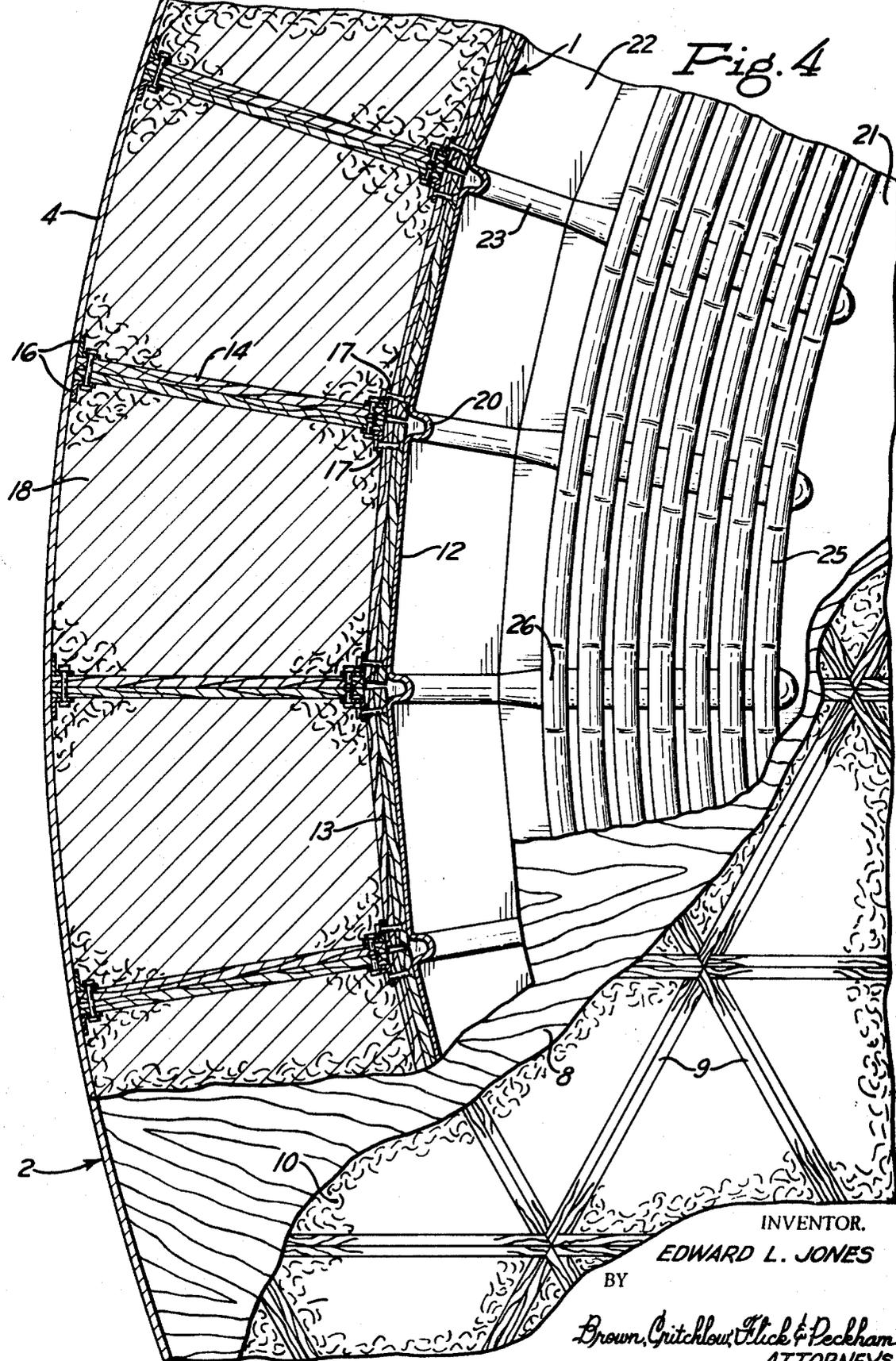
E. L. JONES

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INVENTOR.

EDWARD L. JONES

BY

Brown, Critchlow, Flick & Peckham
ATTORNEYS.

Sept. 20, 1971

E. L. JONES

3,606,067

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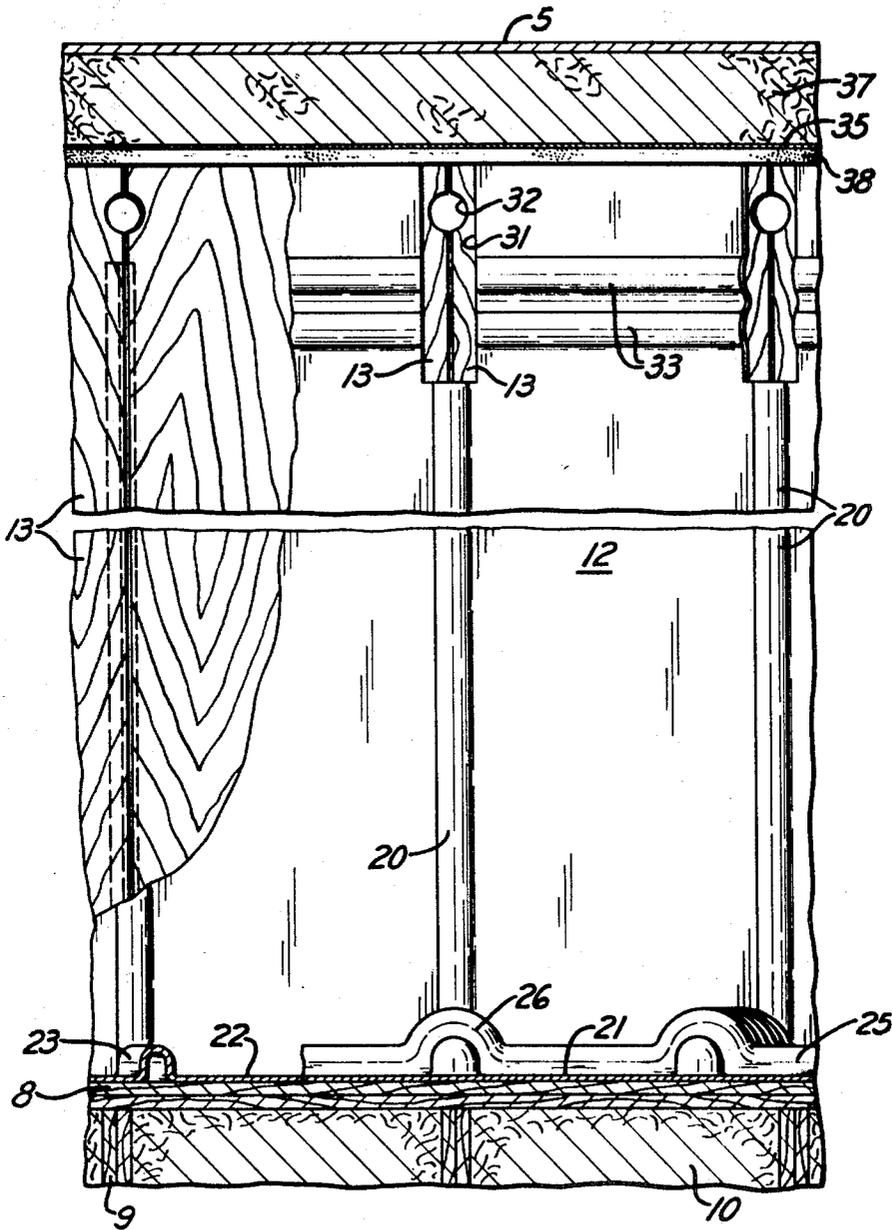


Fig. 5

INVENTOR.
EDWARD L. JONES

BY

Brown, Critchlow, Flick & Peckham
ATTORNEYS.

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3,606,067

STORAGE RECEPTACLE FOR LIQUEFIED GAS

Edward L. Jones, 1281 Beagle Drive,
Bethel Park, Pa. 15102

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6 Claims

ABSTRACT OF THE DISCLOSURE

A tank has a relatively flexible side wall enclosed by a jacket that has a rigid side wall spaced from the tank wall. Rigid panels encircling the tank wall in engagement with it are spaced from the jacket side wall by means of vertical struts. The panels and struts are made of material of very low heat conductivity and transfer the outward pressure of the filled tank to the jacket side wall. The space between the panels and the jacket is filled with thermal insulation. The tank is provided with expansion joints to allow its side wall to remain against the panels under all conditions.

The customary way of making a storage receptacle for liquefied gas, which of course is at an extremely low temperature, is to enclose a rigid tank in a rigid jacket spaced from the tank by insulation. When the tank and jacket expand and contract with temperature changes, the insulation between them is alternately compressed and released, with the result that the insulation is crushed and then separates from the side walls and settles when they move away from it. This leaves the upper part of the tank uninsulated, unless more insulation is added. Also, since both the tank and jacket must have relatively thick walls suitably braced in order to withstand the internal and external pressures upon them, they are expensive to make.

It is among the objects of this invention to provide a storage receptacle for liquefied gas, which is considerably less expensive than those known heretofore, and in which the insulation between the tank and its jacket is not affected by their expansion and contraction.

The preferred embodiment of the invention is illustrated in the accompanying drawings, in which:

FIG. 1 is a plan view of the storage receptacle;

FIG. 2 is a side view;

FIG. 3 is an enlarged fragmentary vertical section taken on the line III—III of FIG. 1;

FIG. 4 is an enlarged fragmentary horizontal section taken on the line IV—IV of FIG. 2; and

FIG. 5 is a fragmentary vertical section taken on the line V—V of FIG. 3.

Referring to the drawings, a tank 1 for extremely cold liquefied gas is completely enclosed by a jacket 2 that is spaced from the tank. The jacket has a flat circular bottom 3 that rests on the ground or on a suitable foundation, a cylindrical side wall 4 and a roof 5, which may be convex as shown but could be flat or some other shape. The side wall of the jacket is thick and rigid enough to satisfactorily resist the outward pressure of the contents of the tank, which is relatively flexible, in a manner that now will be described.

Unlike the jacket, the tank is made of relatively thin metal that is so flexible that the tank would be unable to support its contents without collapsing or rupturing if it were used alone. To support the thin bottom of the tank above the bottom of the jacket, it rests on a rigid floor 8 supported on a plurality of supports 9 mounted on the bottom of the jacket. The floor and its supports are made of low heat conductivity material. One suitable material is wood, especially plywood panels. For supports 9, standard 4 by 8 foot plywood panels can be cut to form 4 by 4 panels which are then stood on edge. By arranging them

to form a large number of triangles, as shown in FIG. 4, they can support one another and at the same time form a very stable network of floor supports. The triangular spaces between the upright panels are filled with thermal insulation 10 of any suitable kind. Vermiculite has been found to be very satisfactory.

Since the cylindrical side wall 12 of the tank is flexible and therefore is susceptible to being deformed or even ruptured by the weight and pressure of the contents of the tank, means are provided for supporting the side wall against deformation. For this purpose the outside of the wall is encircled and covered by rigid panels 13 that engage it but are not attached to it. The panels, which are spaced slightly, are backed up by circumferentially spaced vertical struts 14 that extend across the annular space between the panels and the jacket side wall. Each strut is formed from a pair of panels side by side. The side edges of panels 13 overlap the inner edges of the struts, which hold the panels a fixed distance away from the jacket wall. The struts are attached to the jacket side wall by means of vertical angle irons 16. The edges of each panel 13 are attached to a pair of struts by vertical angles 17. The pair of panels that make up a strut are not fastened together except at their outer edges. Their inner edges are free to move away from and toward each other. Any outward pressure of the tank against panels 13 is transferred through them and the struts to the rigid side wall of the jacket. Panels 13 and the struts are made of very low heat conductivity material, such as wood. Plywood panels are especially suitable. The annular space around the wooden wall is filled between the struts with thermal insulation 18, which again preferably is vermiculite. For best results, there are two or more layers of the panels 13 to make the wooden wall stronger. The layers are secured together.

Assuming that the tank and jacket are at ambient temperature and that there is nothing in the tank, the dimensions should be such that the side wall of the tank engages the encircling panels 13. When the tank is filled with liquefied gas the extreme cold will tend to contract the tank and make it smaller circumferentially. That would tend to draw the tank side wall inwardly away from the encircling panels, which would leave the wall unsupported and therefore subject to deformation and rupture by the contents of the tank. To prevent that from happening, the side wall is provided with expansion joints 20 that allow its circumference to remain constant even though the tank metal contracts with the cold. Consequently, the side wall will remain in contact with the encircling panels, regardless of its temperature.

The expansion joints extend vertically from top to bottom of the side wall and are spaced uniformly around it, one at each strut. The joints are made by providing the wall with inwardly projecting reverse bends so that it appears to be provided with a number of laterally spaced vertical corrugations. It will be seen that when the tank side wall contracts, due to the cold liquid in the tank, the pressure of the liquid against the wall will cause these expansion joints to open wider and thereby allow the wall to retain its original size so that it will remain against the panels.

To prevent the bottom of the tank from interfering with opening of the lower portions of expansion joints 20, the bottom is formed in two parts; a circular central portion 21 and an encircling annular portion 22 spaced from the central portion. The annular portion of the bottom of the tank is provided with a plurality of circumferentially spaced radial expansion joints 23. These joints can be made in the same way as those in the side wall, by providing the annular portion with upwardly projecting reverse bends or corrugations. The outer end of

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each radial expansion joint is connected with the lower end of a vertical expansion joint 20 in the side wall to make one continuous expansion joint. Therefore, the radial and vertical expansion joints can expand and contract together so that the annular portion of the bottom will not interfere with the action of the vertical joints. The bottom extends out beneath panels 13 and has an upturned flange 24 engaging them, so that when liquefied gas is first poured into the tank and the bottom contracts, it will not be able to pull the lower part of the side wall away from the wooden panels.

Since expansion of radial joints 23, due to the cold annular portion 22 of the tank bottom being prevented by the side wall from contracting, will keep the annular portion the same size ring as before, the central portion 21 of the bottom must be free to contract without being restrained by the encircling annular portion. To allow for this contraction, the outer edge of the central portion is joined to the annular portion by an annular expansion joint 25. This joint is formed from numerous concentric circular corrugations, only some of which are shown. To permit this joint, when cold, to keep the same size circumferentially that it had at ambient temperature, the joint itself is provided with a plurality of circumferentially spaced, upwardly arched portions 26 that serve as radial expansion joints. Preferably, they are in line with and welded to the radial expansion joints 23 of the annular portion of the tank bottom. These arched portions of the annular expansion joint, if properly formed and correctly precompressed, will tend to flatten as the metal of the joint contracts with the cold, so the circumference of the annular joint will not change. When the central portion 21 of the tank bottom contracts, it draws the annular expansion joint radially inwardly by flattening the circular corrugations of that joint.

The top of the tank side wall 12 is provided with an outwardly projecting flange 30 that seats on top of the wooden wall. Above the maximum liquid level in the tank its side wall is provided with a vertical slot 31 extending from each vertical expansion joint 20 up the wall and through flange 30. Behind each slot the wooden wall is provided with an opening 32 to allow cold gas from the tank to circulate into the space around the tank, between it and the jacket. To compensate for the tendency of the side wall to contract vertically when cold, it is provided with several horizontal corrugations 33 extending around it above the vertical expansion joints and serving as an expansion joint and also as a spring to support the side wall. These corrugations are broken by slots 31, so they will not interfere with radial expansion of the tank side wall.

It will be seen from the description thus far that the flexible tank is provided with expansion joints which permit its vertical side wall to maintain the same circumference no matter how cold it is, so that the tank can always engage the encircling panels 13 which will support it and prevent it from being distorted or ruptured by the weight and pressure of the liquefied gas inside the tank. Of course, the real support for the side wall of the tank is the encircling rigid side wall of the jacket. When the jacket side wall expands and contracts due to ambient temperature changes, it will force the wooden wall formed of panels 13 to expand or contract likewise, which it is free to do because the inner edges of the panels forming each strut can move toward and away from each other. If the wooden wall is contracted, for example, in this manner, it will force the tank side wall to contract also, which the expansion joints will allow it to do. It may be desirable for the inner edges of the panels forming each strut to be spaced apart when the entire storage receptacle is built, so that they can move either way from that position. It also will be seen that these expansions and contractions have no noticeable effect on the loose insulation 18 between the panels and the side wall of the jacket, because the volume of the space filled with the insulation

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remains substantially constant. Therefore, that insulation is not first compressed and then released, which would cause it to crush and settle. What little variation in space volume that may occur can be taken care of, if desired, by placing cushions of insulation between the struts and the vermiculite. The cushions will compress and expand to compensate for the variations in space volume.

In order to insulate the top of the tank, a thick layer of insulating material is suspended from the jacket roof 5 inside the tank. This can be done by suspending a rigid sheet 25 from the roof by any suitable means, such as low conductivity headed rods 36, and packing the space between the sheet and the roof with insulation 37. The sheet is faced with one or more layers of highly reflective low emissivity material 38, such as aluminum foil. This construction takes advantage of the fact that the vapor between the surface of the liquid and the roof is a good thermal insulator. Convection currents are minimized because the lower portion of the vapor is coldest and most dense while the upper portion of the vapor is warmest and least dense.

I claim:

1. A storage receptacle for liquefied gas, comprising a tank provided with a cylindrical relatively flexible side wall and a bottom, a jacket enclosing the tank and provided with a cylindrical rigid side wall and a bottom and a roof, the side wall and bottom of the jacket being spaced from the tank, rigid panels encircling the tank side wall in engagement therewith, circumferentially spaced vertical struts extending radially across the annular space between said panels and jacket side wall in engagement therewith, the panels and struts being made from material of very low heat conductivity, and thermal insulation filling said annular space, said panels and struts transferring the outward pressure of the filled tank to the jacket side wall, the bottom of the tank including a circular central portion, an annular portion encircling the central portion and spaced therefrom, the annular portion being provided with a plurality of circumferentially spaced radial expansion joints, and an annular expansion joint connecting said two portions of the tank bottom and being formed from a plurality of concentric circular corrugations.

2. A storage receptacle according to claim 1, in which the bottom of the tank extends out beneath said panels and has an upturned flange substantially engaging their outer surfaces.

3. A storage receptacle according to claim 1, in which the tank side wall is provided with circumferentially spaced vertical expansion joints, the lower ends of the vertical expansion joints being connected with the outer ends of the radial expansion joints.

4. A storage receptacle according to claim 1, in which each of said radial expansion joints is an upwardly projecting corrugation, and said annular corrugations are arched upwardly in line with the radial expansion joints to permit circumferential expansion of the annular expansion joint with said annular portion of the tank bottom.

5. A storage receptacle according to claim 3, in which the top of the tank side wall is secured to the top of said panels and is provided with vertically spaced annular corrugations permitting vertical expansion of the side wall, and the tank side wall has slots extending downwardly from its top through said annular corrugations to the tops of said vertical expansion joints.

6. A storage receptacle for liquefied gas, comprising a tank provided with a cylindrical relatively flexible side wall and a bottom of circular horizontal cross-section, a jacket enclosing the tank and provided with a cylindrical rigid side wall and a bottom and a roof, the side wall and bottom of the jacket being spaced from the tank, and low heat conductivity means between said side walls bracing the tank side wall and transferring the outward pressure of the filled tank to the jacket side wall, the bottom of the tank being formed with a plurality of concentric up-

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wardly projecting circular corrugations crossing a plurality of circumferentially spaced upwardly projecting radial corrugations, the circular corrugations being arched over the radial corrugations, and said corrugations forming circumferential and radial expansion joints for the tank bottom, the sides of each circumferential corrugation normally converging downwardly.

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JOSEPH R. LECLAIR, Primary Examiner

J. R. GARRETT, Assistant Examiner

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