Nov. 27, 1951 L. P. ZICK 2,576,167

FLUID STORAGE VESSEL

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Fig. 1.

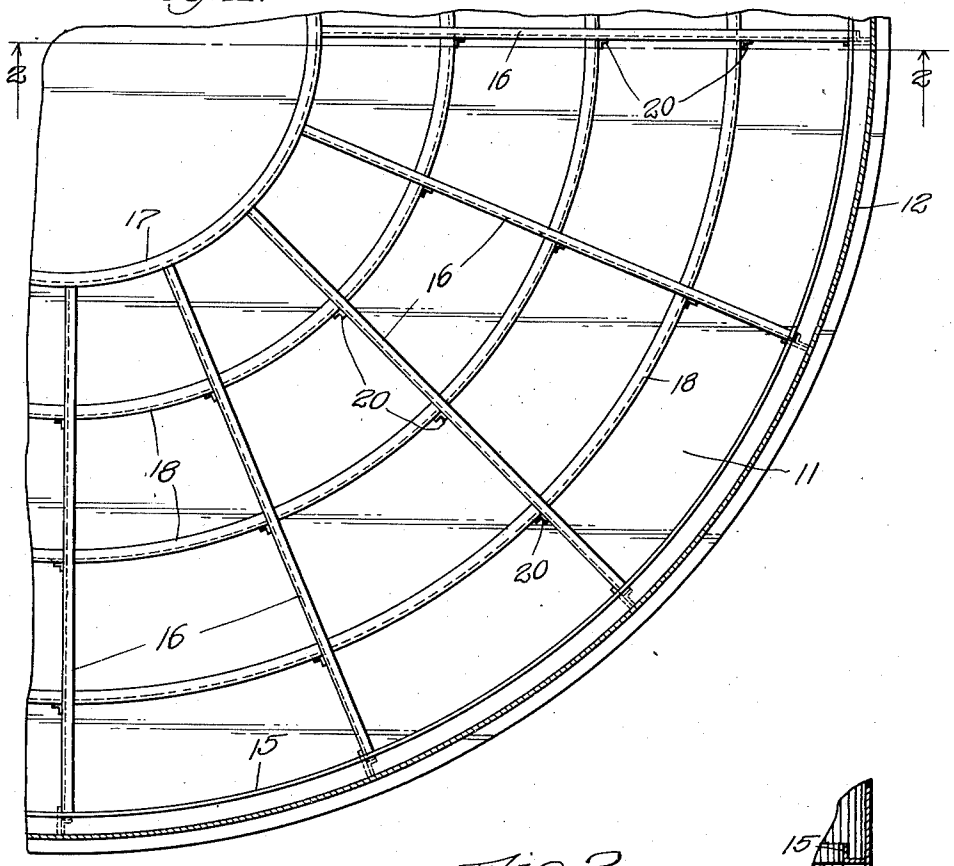
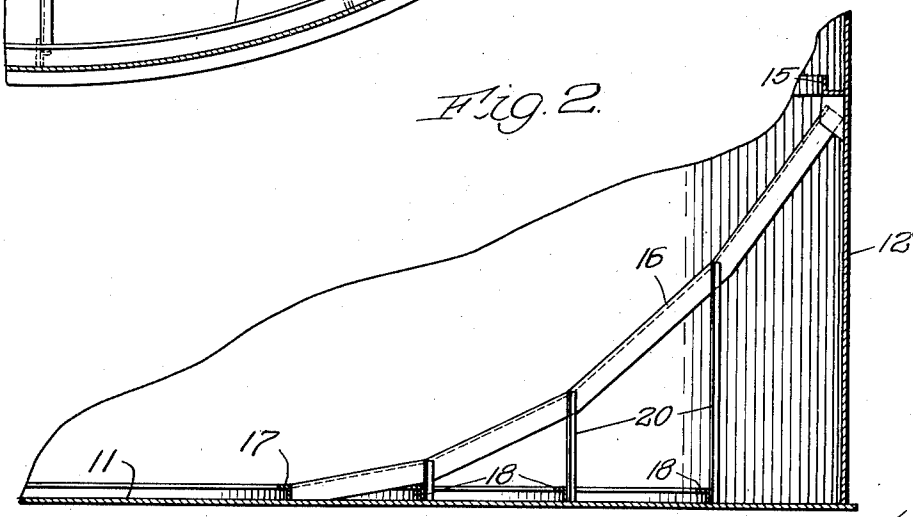


Fig. 2.



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Fig. 3.

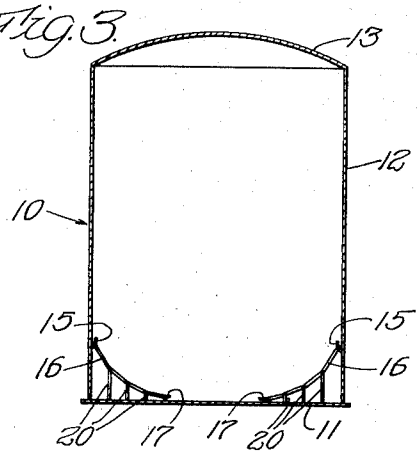


Fig. 4.

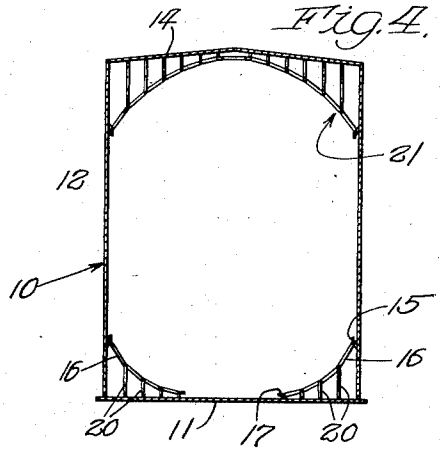


Fig. 5.

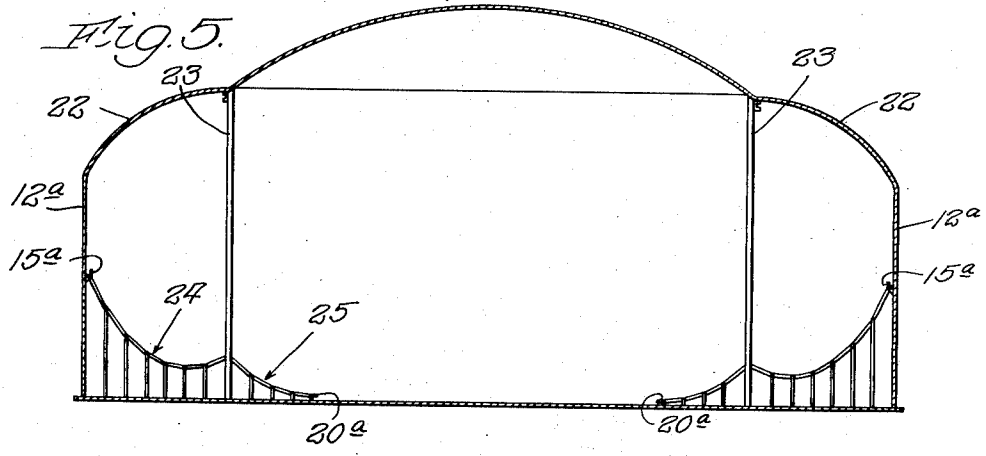
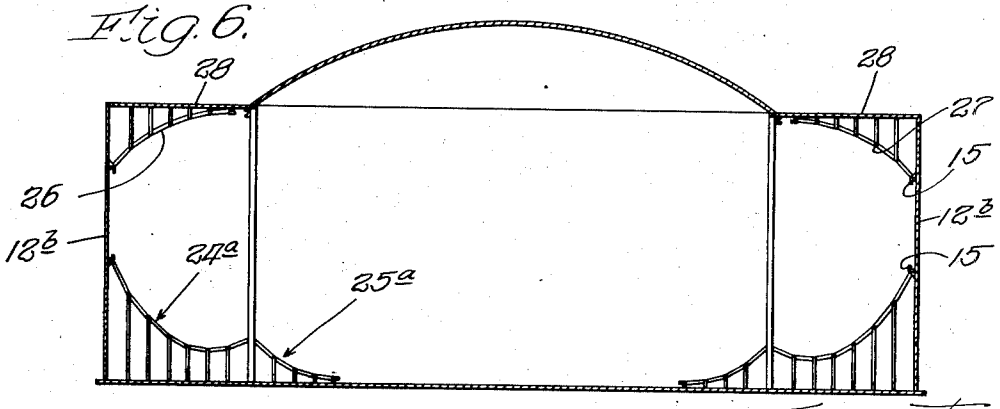


Fig. 6.



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Fig. 7.

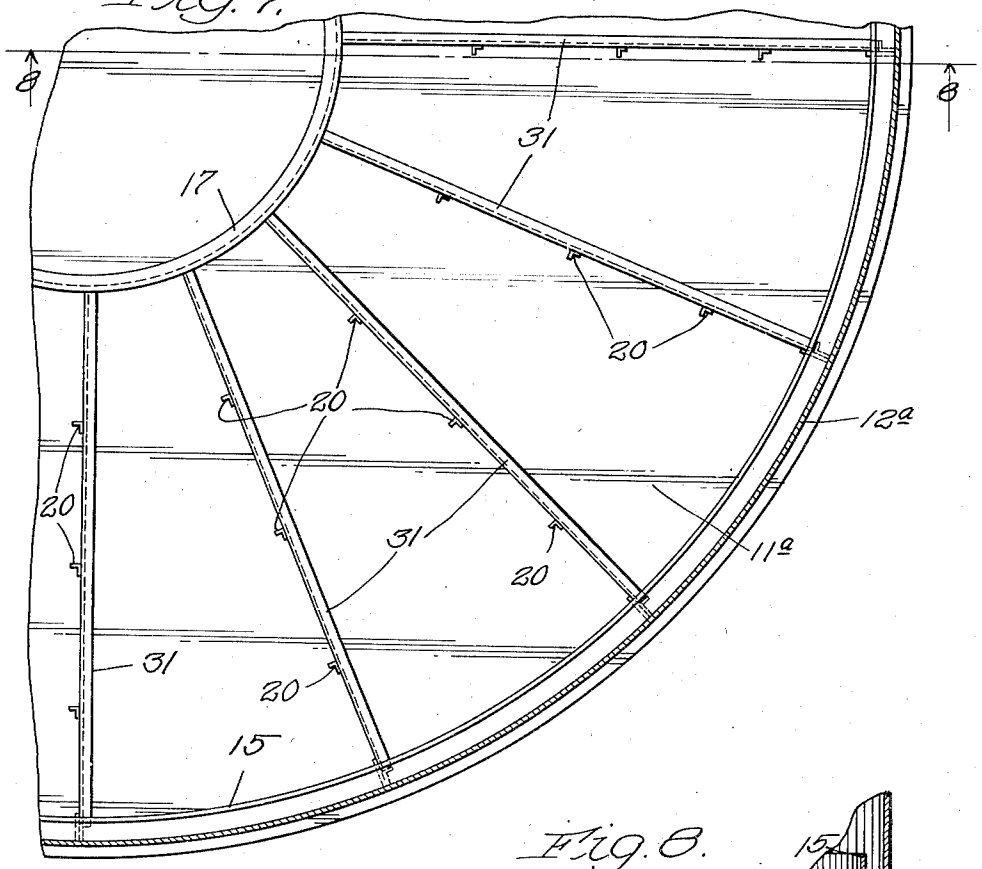
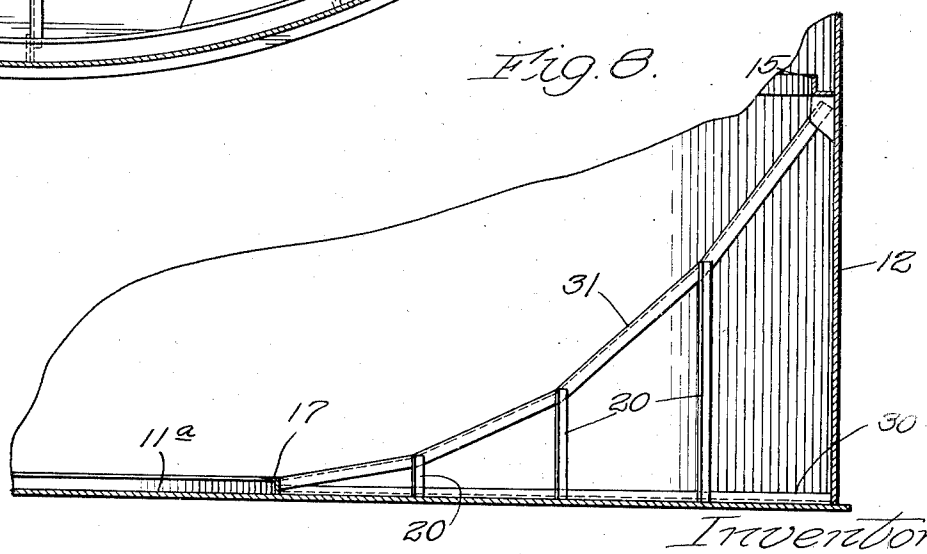


Fig. 8.



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Patented Nov. 27, 1951

2,576,167

UNITED STATES PATENT OFFICE

2,576,167

FLUID STORAGE VESSEL

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Application May 2, 1947, Serial No. 745,558

12 Claims. (Cl. 220—71)

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This invention relates to storage tanks, and more particularly to a storage tank specifically designed to withstand internal pressure.

Liquid storage vessels having a flat bottom, cylindrical sides and a cone or domed roof are the simplest and least expensive to fabricate of all varieties of tanks. As heretofore manufactured, however, such tanks were not adaptable for use where internal gas pressures are developed within the tank. Considerable work has been done in the development of storage tanks to adapt them to withstand high internal pressures, but all such tanks have the common fault of complexity of structure.

I have invented and am herein disclosing and claiming a storage tank which may take the form of a simple, cylindrical, flat bottom and domed or coned roof tank which is capable of withstanding internal pressures.

Broadly, I achieve this result by providing stress carrying members having a shape similar to a catenary and being connected to the sides and bottom or top of the vessel by a plurality of vertical tie members.

The invention will be described as embodied in the accompanying drawings in which:

Fig. 1 is a horizontal section, partially broken away for clarity of illustration, through a portion of a liquid storage tank embodying the invention;

Fig. 2 is a vertical section along line 2—2 of Fig. 1;

Figs. 3 to 6, inclusive, are vertical sections through liquid storage tanks of various shapes showing different applications of the invention;

Fig. 7 is a horizontal section, partially broken away for clarity of illustration, through a liquid storage tank embodying a modified form of the invention; and,

Fig. 8 is a vertical section along line 8—8 of Fig. 7.

Referring now to Figs. 3 and 4, 10 indicates a liquid storage tank having a flat bottom 11, cylindrical side walls 12 and a domed roof 13 or cone roof 14. Secured to the inner portion of the side walls is a ring compression member in the form of an angular girder 15 welded to the walls, which member extends about the interior of the tank on a horizontal plane. Welded to the member 15 is a stress member 16 having its opposite end secured to the bottom 11 of the tank.

In the embodiment shown, the stress member 16 comprises a steel girder having generally the shape of a catenary. Other forms of stress members may be provided, for example, a steel plate having two edges adapted to be welded to

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the side walls and bottom, respectively, of the tank and having a third edge generally in the shape of a catenary. For the purposes of this disclosure and the annexed claims, all such stress carrying members will be hereinafter referred to as catenaries or as tension members substantially in the shape of a catenary.

Secured to the bottom of the tank are a plurality of circumferential stiffeners 18, which in the embodiment shown in Fig. 1, comprise angle irons formed into a circle and welded to the bottom of the tank. If desired, the circumferential stiffeners 18 may be in the form of segments of a circle rather than complete circles, as shown. A plurality of vertical tie members 20 have one end welded to the stiffeners and the other end welded to the catenary.

In the embodiment shown in Fig. 3, the catenary is employed only to strengthen the side walls and the bottom, while in Fig. 4, a second catenary 21 is attached to the side walls and the roof to strengthen the latter member also.

In the embodiment shown in Fig. 5, the side walls of the tank have a lower portion 12a in cylindrical form and an upper portion 22 in the form of a cusp circle. Vertical supporting columns 23 are connected to the bottom of the tank and to the roof at the juncture of the cusp circle to the roof. The catenary shown in that figure comprises a first portion 24 having the outer end attached to a ring compression member 15a and the inner end attached to the supporting post 23, and a second catenary 25 having one end attached to the supporting post and the other end attached to the inner circular segment 20a.

In the embodiment shown in Fig. 6, a storage tank has catenaries 24a and 25a between the side walls and bottom similar to that just described in Fig. 5 and is provided with additional catenaries 26 and 27 extending between the upper portion of the side walls 12b and a flat portion 28 of the roof.

The embodiments shown in Figs. 7 and 8 are similar in most respects to that shown in Figs. 1 and 2 with the exception that circumferential stiffeners 18 are replaced with radial stiffeners 30 which are attached to the bottom 11a of the tank directly beneath the catenaries 31. Vertical tie members 20 extend between the catenary and the radial stiffeners as in the previous embodiments.

In describing the manner in which my invention permits the use of the simple tank as a vessel which can be subjected to internal pressure, it will be understood that the pressure on a flat

bottom cannot be effective in resisting upward pressure on the roof until after the bottom or a portion thereof has risen off the foundation. Therefore, when the tank is empty of liquid but under gas pressure, more of the bottom must rise than when liquid is present in combination with gas pressure. The total vertical load transferred to the bottom is the total upward pressure on the roof less the weight of all of the structure except the portion of the bottom which remains in contact with the foundation. Upward pressure on the roof is transferred to the shell and is transferred to the bottom by the shell and by the catenary. The ring compression member resists horizontal forces tending to bulge the tank inward (although this member may be omitted if enough of the shell is made to act so that the internal pressure on the shell balances the horizontal component of the forces exerted by the catenary). The force on the shell is transferred to the catenary in tension which transfers the force in tension to the stiffeners by means of the vertical tie members and to the bottom plates at the inner end of the catenary. The stiffeners, whether they be the circular or radial type, transfer the load to the bottom of the tank and resist tendencies of the bottom to bend. In the preferred construction, the horizontal component of the forces at the supporting posts balance each other so that the posts exhibit no tendency to bend with internal pressure. Furthermore, each catenary is so proportioned that the horizontal component at every load point is the same.

With this type of construction, foundations for the tank would not require excavation, special tamping or special materials as do most pressure vessels resting directly on the ground. Also as there is no dead space below the bottom capacity line, the tank may be drained through the nozzle connection of the shell.

The invention is applicable not only to conventional flat bottom storage tanks of the vertical cylinder type, but also to other types of structures of parts thereof, for example, it can be applied to the roof, bottom, ends and sides of a vessel having the shape of a rectangular parallelepiped.

While I have shown and described my invention in its preferred embodiment, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. In a fluid storage tank having a bottom, a top and side walls between the top and bottom, means stressing the tank against internal pressure comprising a tension member substantially in the shape of a catenary attached to the bottom and attached to the side wall at a point above the bottom, and a plurality of vertical tie members having one end attached to the tension member and having the other end connected to the bottom.

2. In a fluid storage tank having a bottom, a top and side walls between the top and bottom, means stressing the tank against internal pressure comprising a tension member substantially in the shape of a catenary having one end attached to the bottom and having the other end attached to the side wall above the bottom, a plurality of stiffeners attached to the bottom and a plurality of vertical tie members having one end attached to the tension member and having the other end attached to the stiffeners.

3. In a fluid storage tank having a bottom, a top and side walls between the top and bottom, means stressing the tank against internal pressure comprising a ring compression member attached to the side walls above the bottom, a tension member substantially in the shape of a catenary attached to the bottom and to the ring compression member, and a plurality of vertical tie members having one end attached to the tension member and having the other end connected to the bottom.

4. In a fluid storage tank having a flat bottom, a top and side walls, said side walls having at lease a portion substantially cylindrical in shape, means for stressing the tank against internal pressure comprising a ring compression member attached to the cylindrical portion of the side walls above the bottom of the tank, a tension member substantially in the shape of a catenary attached to the bottom and to the ring compression member, a plurality of stiffeners attached to the bottom and a plurality of vertical tie members having one end attached to the tension member and having the other end attached to the stiffeners.

5. Apparatus of the character described in claim 4 in which said ring compression member is adapted to resist horizontal forces exerted by the tension member in response to internal pressure.

6. Apparatus of the character described in claim 4 in which said bottom stiffeners are in the form of concentric circles.

7. Apparatus of the character described in claim 4 in which said bottom stiffeners are in the form of circular segments.

8. Apparatus of the character described in claim 4 in which said bottom stiffeners are in the form of radial segments.

9. In a fluid storage tank having a substantially flat bottom and substantially vertical side walls, means stressing the vessel against internal pressure comprising a tension member substantially in the shape of a catenary having one end attached to the bottom of the tank and having the other end attached to the side walls at a point above the bottom, and a vertical tie member attached to the tension member intermediate its ends and attached to the bottom of the tank.

10. Apparatus of the character described in claim 9 in which said vertical tie member is connected at its lower end to a stiffener attached to the bottom of the tank.

11. In a fluid storage tank having a first portion lying in one plane and a second portion lying in another plane, means stressing said portions agaist distortion from internal pressure comprising a tension member substantially in the shape of a catenary having one end attached to said first portion and having the other end attached to said second portion, a plurality of tie members attached to said tension member and to one of said portions, said tie members lying in a plane substantially perpendicular to the last mentioned portion.

12. In a fluid storage tank having a flat bottom, vertical side walls, a top, and supporting posts between the top and bottom, means stressing the vessel against internal pressure comprising a first tension member substantially in the shape of a catenary having one end attached to the post above the bottom and having the other end attached to the side walls above the bottom, a second tension member substantially in the shape of a catenary attached to the post above the bot-

tom and to the bottom, and a plurality of vertical tie members attached to the tension members and to the bottom of the tank.

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