March 19, 1957 J. H. WIGGINS 2,785,825

LIQUID STORAGE TANK AND GAS HOLDER

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FIG. 1.

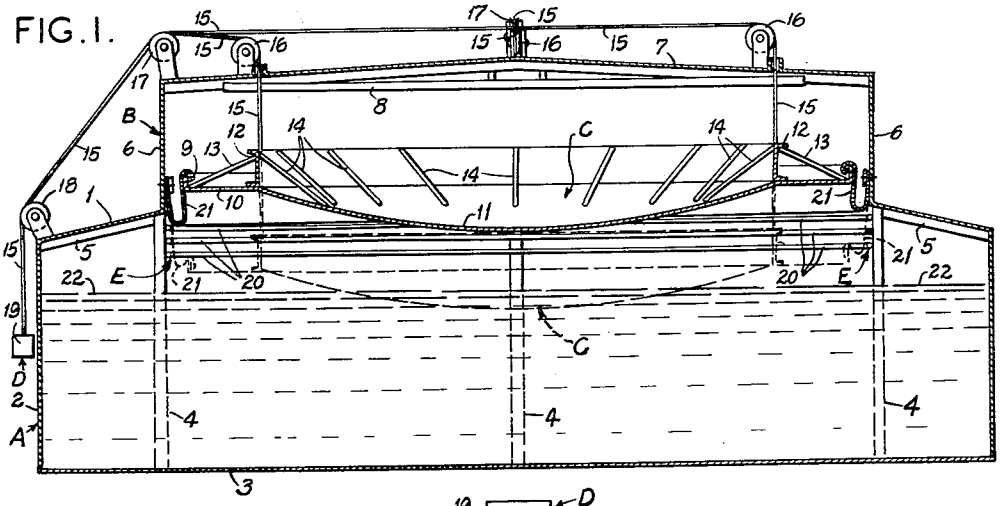
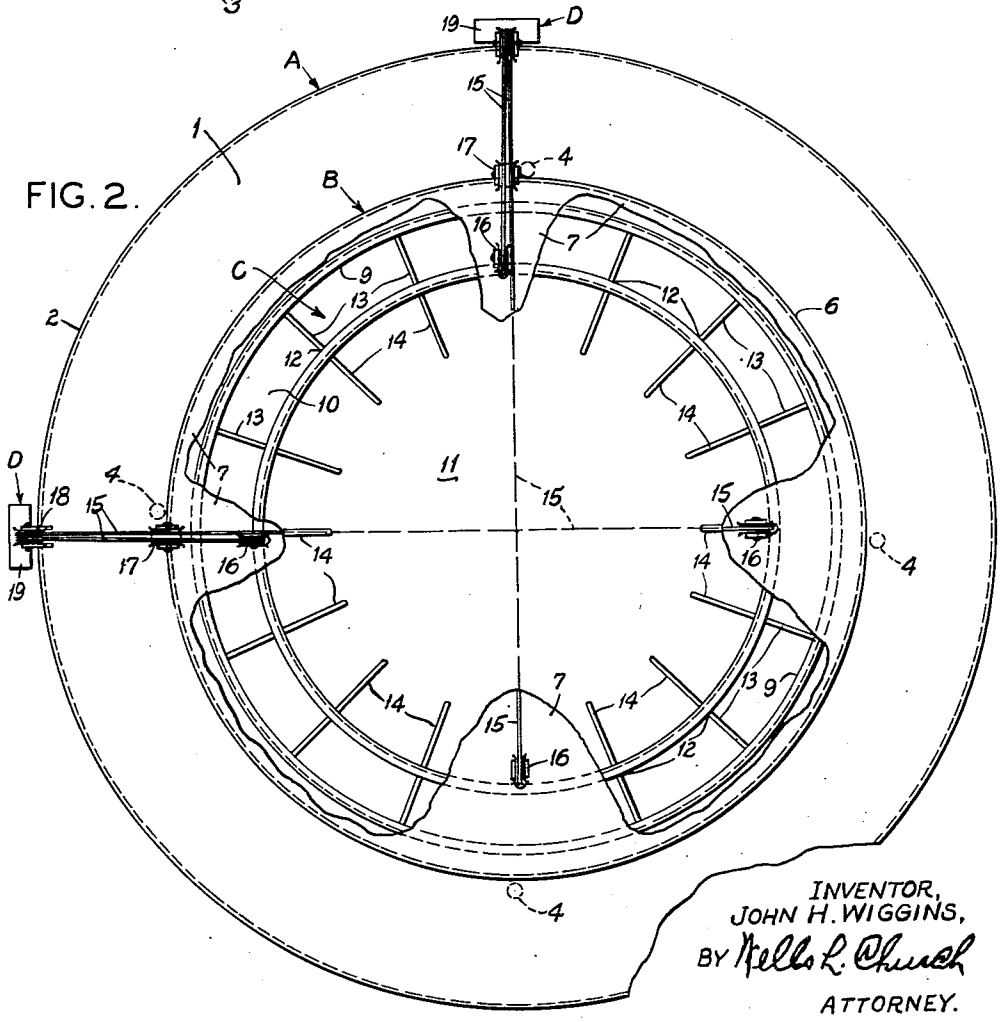


FIG. 2.



INVENTOR,
JOHN H. WIGGINS,
BY Wells L. Church
ATTORNEY.

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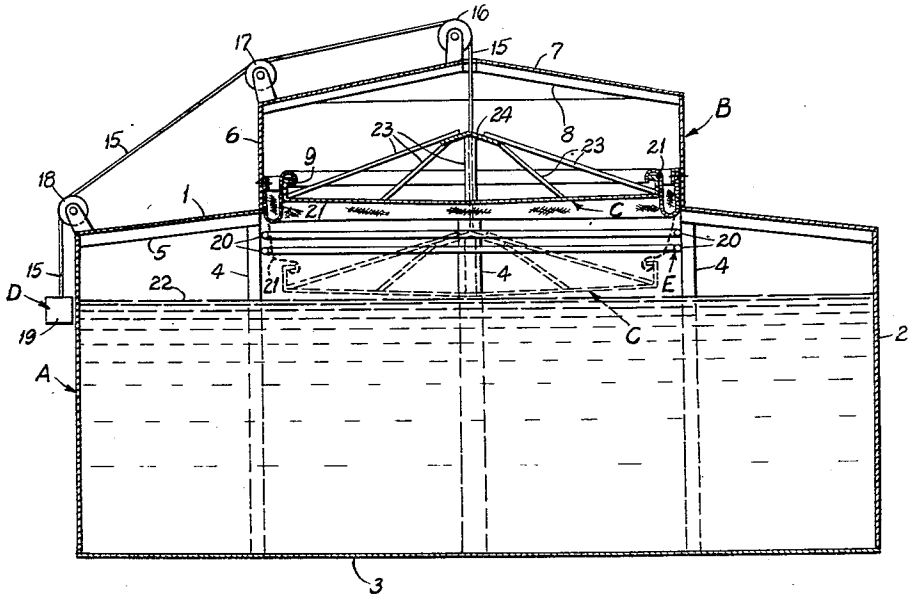
FIG. 3.



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JOHN H. WIGGINS,
BY Wells L. Church
ATTORNEY.

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LIQUID STORAGE TANK AND GAS HOLDER

John H. Wiggins, Chicago, Ill.

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6 Claims. (Cl. 220—85)

This invention relates to liquid storage tanks and gas holders, and particularly apparatus of the kind that comprise a tank adapted to hold volatile liquids, and a gas holder mounted on said tank and provided with a gas and vapor storage chamber whose top wall can move vertically, upwardly and downwardly, so as to vary the internal volume of the storage chamber of the gas holder which is located above and in direct communication with the interior of the liquid tank so as to permit gases and vapors evolved from the liquid stored in the tank to expand and pass into the storage chamber of the gas holder, and also permit condensate produced in the gas holder to return to the body of liquid stored in the tank. While I have herein illustrated my invention embodied in a combined liquid tank and gas holder, I wish it to be understood that my invention is applicable to gas holders that are used solely for storing gases and also gas holders of the kind used in vapor balancing systems for volatile oil tanks, wherein the storage chamber of a gas holder is connected by conduits with a plurality of tanks that hold volatile oil so that vapors evolved from the oil in the said tanks during the day time can accumulate in the storage chamber of the gas holder and thereafter during the night, said gases can be fed back to the oil tanks.

My invention has for its main object, to reduce the cost, improve the operation and reduce the overall height of apparatus of the kind that consist of a piston type, dry seal gas holder mounted on and supported by a liquid storage tank.

Another object is to reduce or minimize the possibility of error or inaccuracy in the operation of gaging the liquid in a combined gas holder and liquid tank of the kind just referred to, and

Still another object of my invention is to provide a gas holder piston of novel design that is particularly adapted for use in large size gas holders having storage chambers of relatively great diameters. Other objects and desirable features of my invention will hereafter be pointed out.

Figure 1 of the drawings is a vertical, transverse sectional view of a combined gas holder and liquid tank constructed in accordance with my invention.

Figure 2 is a top plan view with portions of the weather roof of the gas holder broken away so as to more clearly illustrate the construction of the piston, and

Figure 3 is a vertical, transverse sectional view illustrating a design or type of construction particularly adapted for use in apparatus in which the piston of the gas holder is of relatively small diameter.

In the accompanying drawings which illustrate the preferred form of my invention, the reference character A designates, as an entirety, a tank that is adapted to hold liquid, usually oil from which gases and vapors are evolved in the day time due to the tank becoming heated by the

sun's rays, B designates a gas holder mounted on and supported by said tank, C designates a vertically movable piston that forms the top wall of the gas and vapor storage chamber of said gas holder, D designates a counterweighting mechanism attached to said piston C and designed so as to equal or be slightly greater than all of the dead weight of the piston and the fabric seal and other parts attached to or carried by the piston and E designates an annular back stop member attached to the lower end portion of the side wall of the gas holder and extending downwardly into the liquid tank A so as to form an abutment surface against which the fabric sealing element for the piston bears in certain positions of the piston.

The tank A has a bottom 3, a cylindrical side wall 2, a partial roof 1 of annular form attached to the top edge of the tank side wall 2 and projecting inwardly from same as shown in Figure 1 and a supporting structure for said roof portion 1 composed of an annular row of posts 4 on the interior of the tank attached at their upper ends to roof rafters 5 whose outer ends are attached to the tank side wall 2. Also the tank A is provided with a pressure relief valve and a vacuum relief valve, not shown, which valves may be of conventional construction and operation.

The gas holder B is provided with an annular side wall 6 that is preferably attached to the inner edge of the roof portion 1 of the tank in vertical alignment with the roof supporting posts 4, and a weather roof 7 is attached to the top edge of said side wall 6 so as to protect the piston C of the gas holder from rain, snow and the like, said weather roof being supported by trusses or beams 8 attached at their outer ends to the side wall 6. The piston C is of novel construction and is adapted for use in any kind of piston type gas holder where it is essential or desirable that the piston be of relatively great diameter, of stiff construction and of minimum weight. My improved piston in addition to having the above mentioned desirable characteristics is easy to fabricate and it is of relatively small overall height or depth, thereby making it particularly adapted for use in a combined liquid tank and gas holder of the type or kind in which the piston, at times, moves downwardly into close proximity or touching engagement with the liquid stored in the tank. The piston C is fabricated from metal plates and in the form of my invention shown in Figure 1 consists of a diaphragm provided with a dish shaped or concavo-convex central portion 11 whose outer perimeter merges into a substantially flat, annular peripheral portion 10 whose outer edge is attached to a stiff or rigid reinforcing member 9 of annular form, the central portion 11 of the piston being arranged with its convex surface presented downwardly. A beam and compression member 12 is attached to the top side of the piston preferably at the point where the flat peripheral portion 10 merges into the curved central portion 11, and inclined tension and strut members are preferably used to tie the top edge portion of the beam 12 to the two portions 10 and 11 of the piston located outside of and inside of said beam 12. Thus as shown in Figure 1 there is a group of inclined tension and strut members 13 attached to the top edge portion of the beam 12 and to the outer edge of the flat peripheral portion 10 of the piston and there is a group of inclined tension and strut members 14 attached to the top portion of the beam 12 and to the dished central portion of the piston at a point some distance inwardly from the perimeter of said dished portion. The beam 12 extends circumferentially around the piston as illustrated in Figure 2 and is herein shown

as being of annular form but it could be of other shape or outline.

The counterbalancing mechanism D for the piston C comprises two pairs of chains or cables **15** attached to the top edge of the beam **12** in spaced relation around the circumference of same, said cables leading upwardly from said beam over sheaves or pulleys mounted on the weather roof **7** of the gas holder and the annular roof portion **1** of the tank, and thence downwardly to counterbalance weights **19** located on the exterior of the side wall **2** of the tank. In the counterbalancing mechanism herein shown one pair of said cables are attached to the beam **12** adjacent opposite ends of one diameter of the piston and lead to a single weight **19** to which both cables are attached, and the other pair of cables are attached to said beam adjacent opposite ends of the other diameter of the piston and lead to a single weight **19** to which both of said cables are attached as shown in Figure 2. Said cables pass over four single sheaves or pulleys **16** mounted on the top side of the weather roof **7** in approximately direct vertical alignment with the beam member **12**. Each pair of said cables also passes over one double sheave or pulley **17** mounted on the edge portion of the roof **7** in alignment with the side wall **6** of the gas holder and one double sheave or pulley **18** mounted at the outer edge of the roof portion **1** of the liquid tank directly above the side wall **2** of said tank. One advantage gained by mounting the sheaves **18** on the tank at the upper end of the tank side, is that a large portion of the counterweight load is taken off the posts **4** and rafters **5** that support the annular roof portion **1** of the tank. However, the main advantage of a counter-weighting mechanism of the construction above described is that ample room or space is provided for the vertical travel of the weights **19** not withstanding the fact that the piston moves downwardly a considerable distance below the bottom edge of the side wall **6** of the gas holder. In other words, if the sheaves **18** were omitted and the weights **19** were hung from the sheaves **17** at the upper end of the side wall **6** of the gas holder, there would not be sufficient room to provide for the vertical travel of said weights, due to the fact that said side wall **6** is mounted on the roof portion **1** of the tank and is not high or deep enough to provide for sufficient travel of the weights to permit the piston to move downwardly to a point below the bottom edge of the side-wall **6** of the gas holder unless movable pulleys were rigged up with the pulleys **17** so as to move only half the vertical distance of travel of the piston. Such a construction would be more complicated and expensive than my improved mechanism, and it would necessitate the use of counterweights of double the mass or weight of the counterweights **19** of my mechanism.

The space between the piston and the side wall **6** of the gas holder is sealed by a flexible, curtain like sealing element **21** made of gas tight fabric. Said sealing element is of annular shape or form in general outline and is attached at its inner and outer edges to the piston and to the side wall **6** of the gas holder. It is of sufficient area or fullness to permit the piston to move upwardly until the top edge of the beam **12** on the piston comes into engagement with the supporting structure for the weather roof **7** of the gas holder, and move downwardly a certain distance into the tank A into close proximity or touching engagement with the surface **22** of the liquid as indicated by the broken line C^1 in Figure 1. In order to back up the sealing element **21** and absorb strains to which it is subjected when the tank is under a minus pressure, an annular back stop or abutment surface E is attached to the lower end portion of the side wall **6** of the gas holder so as to form, in effect, an extension on said side wall that projects downwardly into the tank A. Said back stop E may be formed from metal plates or from a plurality of horizontally disposed annular members **20** arranged in superimposed, spaced relation. When the piston approaches the end of its downward stroke, the sealing element **21** arrests the downward movement of the piston and holds it suspended from the side wall **6** of the gas holder.

Figure 3 illustrates another embodiment of my invention in which the side wall **6** of the gas holder is of sufficiently small diameter to overcome the necessity of attaching an annular compression and beam member and tension and compression struts to the top side of the piston. In such a structure it is practicable to attach the cables of the counterbalancing mechanism to a center plate **24** arranged above the piston and connected with the peripheral portion of the piston by inclined tension members **23**.

In an apparatus of the construction shown in Figure 1, the counterweighting mechanism lifts the piston C and the sealing element **21** attached to the piston, so normally operates at say 0.03″ vacuum at the top and increasing to about 0.10″ vacuum when the piston is being pulled down near the end of its downward stroke. At empty the piston stops and is prevented from descending further into the tank by vertical tension in the sealing element **21**. Then said sealing element is pulled out until it bears against the back stop or abutment surface **20**. The vacuum vent (not shown) on the roof portion **1** of the tank then opens and provides pressure relief for the tank. Said vacuum vent may be set at 0.5″ H_2O. When the piston moves upwardly the member **12** on the top side of the piston engages the roof supporting structure of the gas holder and pressure will then build up until the pressure vent (not shown) on the roof **1** of the tank opens and provides pressure relief for the tank. Said pressure vent may be set at plus 1″ H_2O. The vacuum shows about how much tension the sealing element will have to support when the piston is hanging from said sealing element, and the vacuum vent on the tank opens. If the piston counterweights create 0.1″ H_2O vacuum at the bottom of the piston stroke and the vent valve opens at 0.5″ H_2O vacuum, then the excess vacuum at that time is 0.5″ minus 0.1″ or 0.4″ H_2O vacuum. The pressure shows: If the valve opens at 1″ H_2O and the piston weighs 0.7″ H_2O, then the net uplift on the piston is 1.0″—0.7″ or 0.3″ H_2O pressure which the struts **13** and **14** have to overcome in compression. At all times when not under positive pressure, the strut members **13** and **14** are under tension. When the pressure vent of the tank is open, the uplift of the gas in the tank may be greater than the weight of the piston and hence the strut members **13** and **14** will then take compression. The flat peripheral portion **10** of the piston can be about 30% of the total area of the piston and the area bounded by the circle of attachment of strut members **14** to the piston and beam member **12** can also be about 30% of the total piston area. Thus these two 30% areas of the piston hang on the beam **12** and the tensions of **13** balance the tensions of **14** and hence there is no accumulation of compression in the top portion of beam **12**, due to supporting area **10** of the piston and part of area **11**. This then leaves only about 40% of the total area of the piston to be carried by simple compression applied to the bottom of beam **12** by the dished portion **11** of the piston. Pressure forces exerted upon the two 30% areas are of course transmitted respectively to the upper portion of the beam **12** through the strut members **13** and **14** and produce substantially equal torsional (beam twisting) moments about the center of the beam in opposite directions. Since these moments are substantially equal, but opposite in direction, they tend to balance and counteract each other, thereby minimizing the torsional stresses to which the beam will be subjected. In addition, the heavy member **12** which also acts as a circular beam between cable attachments, is greatly shortened by placing it a substantial portion of the piston radius inside the annular reinforcing member **9** attached to the peripheral edge of the piston. The result of the above described arrangement of parts, is that a great deal of fabrication, erection and steel is

saved in member 12. Still another desirable feature of a piston that is constructed, shaped and mounted in the manner above described is that when it approaches the end of its downward stroke, the convex shaped central portion 11 of the piston progressively engages the liquid in the tank instead of plunging into the liquid over its entire area, thereby increasing the fullness the tank can have before expansion volume of the piston is affected.

Due to the fact that the vertically movable top wall portion of the storage chamber of the gas holder consists of the piston C which is constructed entirely of steel, I am not limited at all as to how large a diameter said chamber may have. I prefer to make said chamber of relatively great diameter as this enables me to decrease the lift or rise of the piston for a given volume, it reduced the depth of the side wall of the gas holder and hence the overall height of the apparatus, and it reduces the amount of expensive gas tight fabric used as the sealing element for the piston, thereby effecting a considerable saving in the cost of building the apparatus and also cutting down evaporation loss as there is always some loss of gasoline vapor through a fabric piston sealing element by permeation. Still another advantage of my apparatus which is extremely desirable from an operation standpoint, is that it eliminates for practical purposes, the possibility of error or inaccuracy in the operation of gaging the liquid in the tank. In my apparatus the piston of the gas holder is completely counterbalanced and pulls a very slight vacuum. Hence, when the gage hatch of the tank is opened, any excess vacuum that may be in the tank is immediately relieved, the piston does not displace any liquid because the piston is more than counterbalanced and does not float on the liquid or cause the liquid to be displaced due to the weight of the piston. Suppose for example the vacuum in the tank is —0.3" H_2O when the gage hatch is opened. Immediately a very small volume of air flows through the hatch into the tank until the vacuum is reduced to 0.1" H_2O vacuum which is the amount created by the counter-weight of the piston. During gaging, air will continue to flow into the tank through the gaging hatch, but at such a slow rate at the 0.1" H_2O vacuum for the couple of minutes required for gaging that there is no appreciable evaporation loss caused thereby. From the foregoing it will be seen that my improved structure has two outstanding advantages as follows: first, no gaging error which is extremely important, and second practically no evaporation loss while gaging through an open hole in the tank, due to the very small difference in pressure inside the tank and the atmosphere.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a gas holder, the combination of an annular side wall, a metal piston arranged to move vertically within said side wall, a flexible, fabric sealing element for the piston attached to said side wall and to the periphery of the piston, said piston having a substantially flat, horizontally disposed peripheral portion and a substantially concavo-convex shaped central portion whose convexed side is disposed downwardly, a substantially annular shaped reinforcing beam attached to the top side of the piston at the point where the said peripheral and central portions of the piston merge, and oppositely inclined tension and compression struts attached to the top edge of said beam and to portions of the piston lying at opposite sides of said beam.

2. A structure of the kind described in claim 1, which also includes a counter-weighting mechanism for the piston attached to the beam on the top side of the piston.

3. A structure of the kind described in claim 1, wherein the substantially flat peripheral portion of the piston constitutes approximately 30% of the total area of the piston and the said oppositely inclined struts are so disposed that when they are in tension, the tensions of the struts lying at one side of the beam on the top side of the piston substantially balance the tensions of the struts lying at the opposite side of said beam.

4. An apparatus for storing liquids and gases, comprising a liquid tank provided with a side wall and a partial roof of annular form attached to and projecting inwardly from the top edge of the tank side wall, a gas holder mounted on said tank and provided with an annular side wall attached to and projecting upwardly from the inner edge of the annular roof of the tank, a counter-weighted metal piston arranged to move vertically within the side wall of the gas-holder and also to descend into the tank, said piston having a substantially flat horizontally disposed peripheral portion surrounding and merging into a substantially concavo-convexed shaped central portion arranged with its convexed surface disposed downwardly, a substantially circular beam attached to the top side of the piston at approximately the point where said peripheral and said central portions of said piston merge, a flexible, fabric sealing element for said piston attached to the piston and to the side wall of the gas-holder and proportioned so that when the piston moves downwardly into the tank said sealing element arrests and limits the downward movement of the piston, and a stationary annular back stop arranged in the upper portion of the tank at a point below and in vertical alignment with the side wall of the gas-holder so as to form an abutment surface for said fabric sealing element when said piston is located inside the tank at a point lower than the annular roof of the tank, the counter-weighting mechanism for the piston comprising cables that are joined to said beam in spaced relation around the circumference of said beam.

5. In a gas-holder, the combination of an annular side wall, a metal piston arranged to move vertically within said side wall, sealing means about the periphery of said piston cooperating with said side wall to prevent leakage of gas between said piston and said side wall, said piston having a substantially flat, horizontally disposed peripheral portion and a substantially concavo-convex shaped central portion whose convexed side is disposed downwardly, a substantially annular shaped reinforcing beam attached to the top side of the piston at the point where the said peripheral and central portions of the piston merge, and oppositely inclined tension and compression struts attached to the top edge of said beam and to portions of the piston lying at opposite sides of said beam.

6. In a storage tank for fluids having an upstanding substantially cylindrical side wall, the combination comprising, a vertically movable, substantially circular, piston-like diaphragm disposed within the tank and providing a top wall for the fluid containing space in the tank, sealing means about the periphery of said diaphragm cooperating with the side wall of the tank to prevent leakage of fluid between said diaphragm and the wall of the tank, an upstanding, rigid, annular reinforcing beam arranged concentrically upon said diaphragm and extending upwardly therefrom, said beam dividing said diaphragm into a central portion encompassed by said beam and an annular peripheral portion extending radially outwardly from said beam, said central portion of said piston-like diaphragm being concavo-convex in shape with its convex surface disposed downwardly, a plurality of circumferentially spaced struts extending diagonally upwardly from said peripheral portion of said diaphragm to the upper portion of said beam whereby pressure forces exerted upon said peripheral portion of said diaphragm will be transmitted to said beam and will produce a torsional moment thereabout in a first direction, and a plurality of additional circumferentially spaced struts extending diagonally upwardly from the concave side of said central portion of said diaphragm to the upper portion of said beam for transmitting to said beam corresponding pressure forces exerted upon said central portion of said diaphragm so as to produce another torsional moment about said beam in the opposite direction, said torsional moments thereby

tending to balance and counteract each other to minimize the torsional stresses in said beam.

References Cited in the file of this patent

UNITED STATES PATENTS

135,172	Tiffany	Jan. 21, 1873
1,666,666	Pew	Apr. 17, 1928
1,879,572	Speegle	Sept. 27, 1932
2,050,685	Wiggins	Aug. 11, 1936
2,050,686	Wiggins	Aug. 11, 1936
2,282,772	Wiggins	May 12, 1942
2,408,538	Wiggins	Oct. 1, 1946
2,624,490	Fino et al.	Jan. 6, 1953

FOREIGN PATENTS

1,029,176	France	Mar. 4, 1953