Dec. 29, 1953 H. O. CORD ET AL 2,664,220

FLOATING ROOF CONSTRUCTION FOR TANKS

Filed Oct. 23, 1950

2 Sheets-Sheet 1

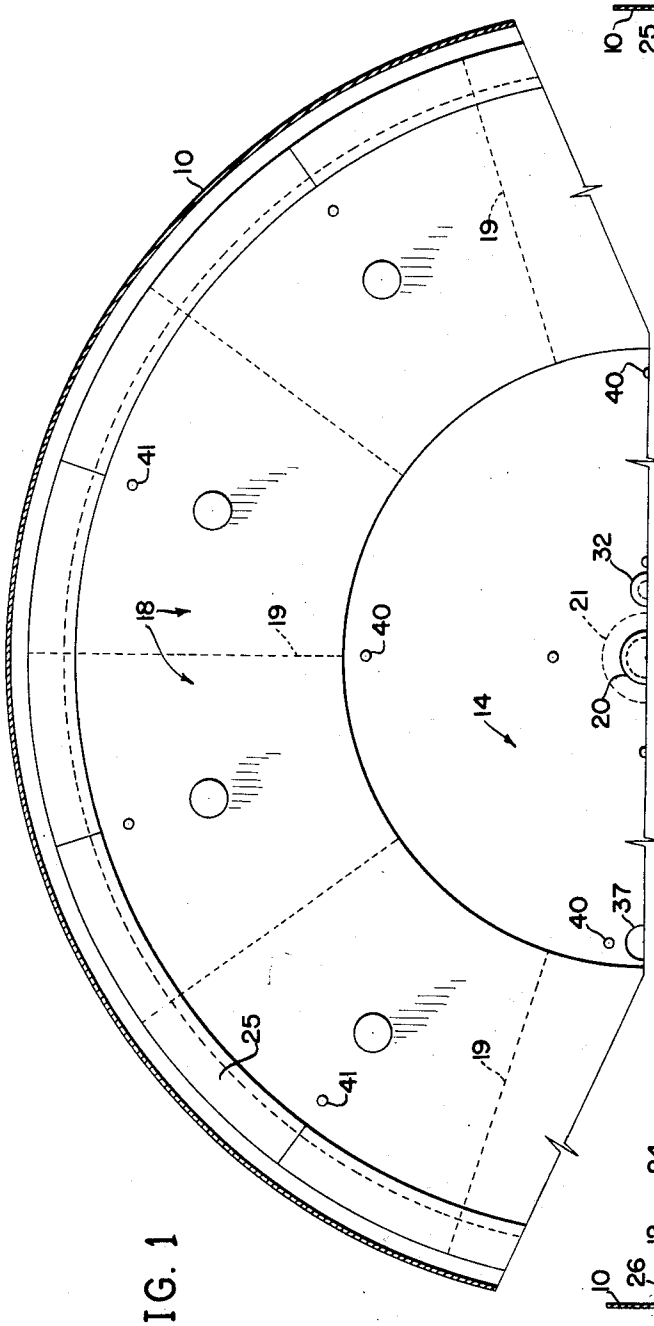


FIG. 1

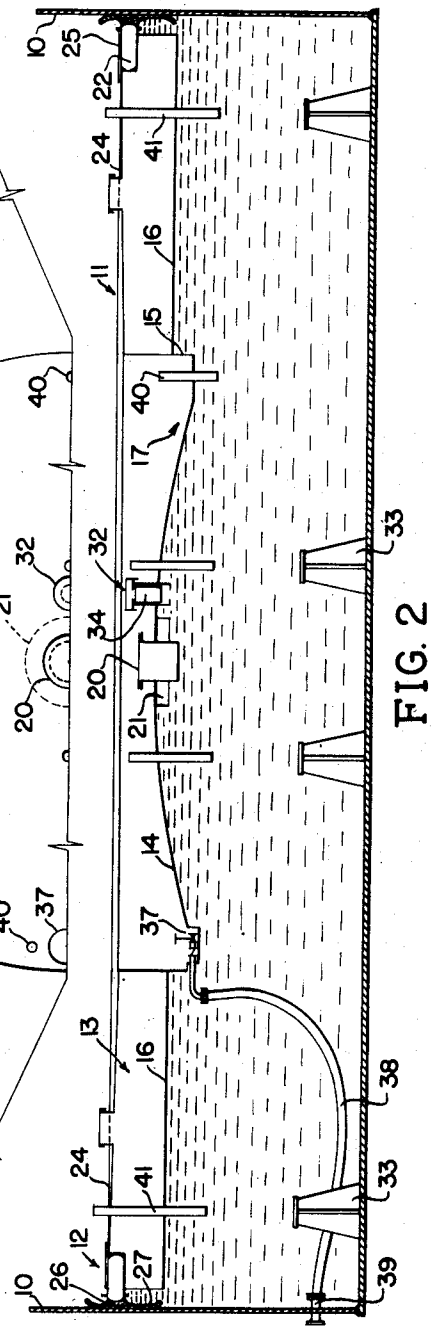


FIG. 2

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FIG. 5

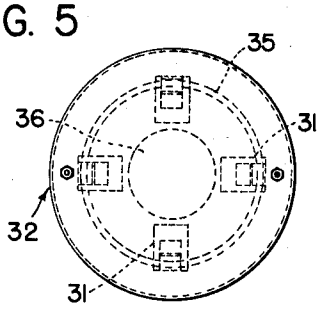


FIG. 3

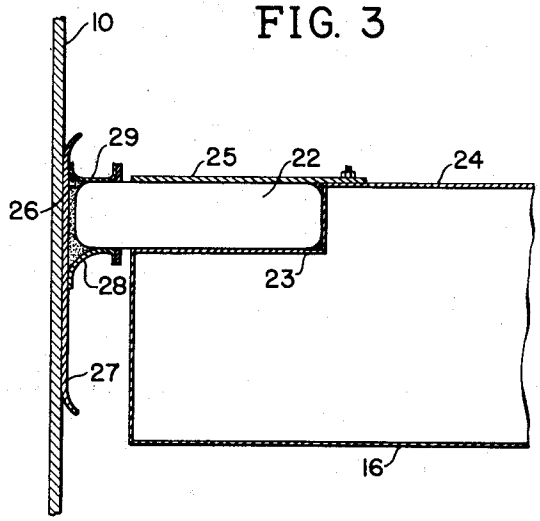


FIG. 6

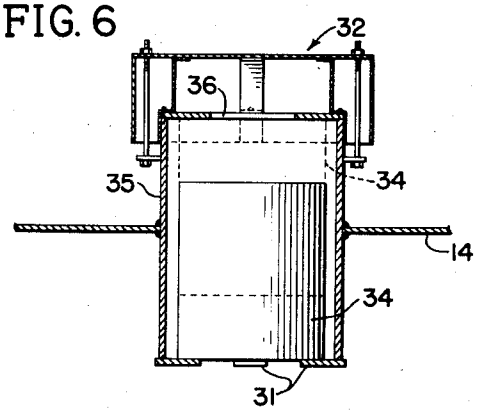


FIG. 4

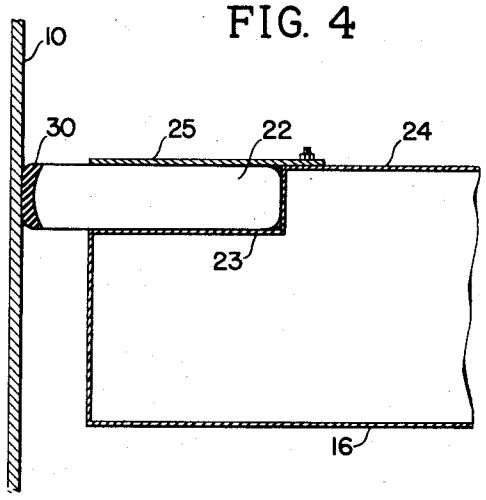
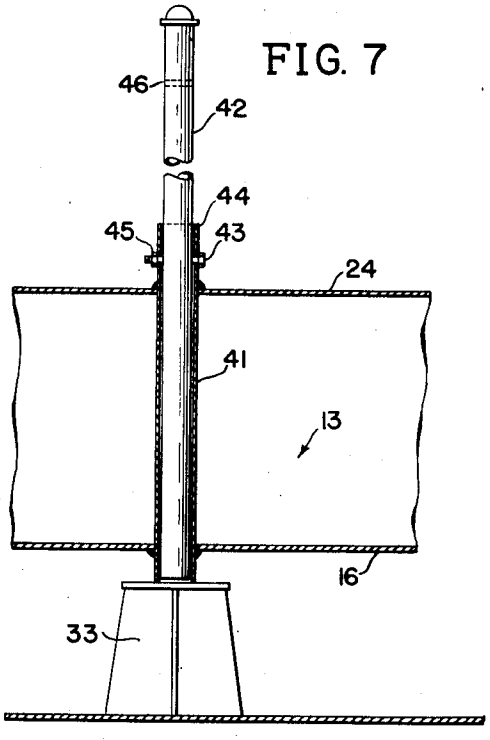


FIG. 7



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FLOATING ROOF CONSTRUCTION FOR TANKS

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Application October 23, 1950, Serial No. 191,648

7 Claims. (Cl. 220—26)

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This invention relates to floating roofs for storage of liquids and particularly to pontoon roofs for tanks used in the storage of volatile liquids.

Floating roofs have heretofore been proposed for storage tanks but they have not been entirely satisfactory. One common problem is the poor seal obtained because of the non-alignment of the vertical shell wall and the floating roof assemblies. Mechanical seals heretofore proposed in an effort to meet this difficulty have involved secondary seals and a multiplicity of moving parts which require considerable maintenance. Another difficulty has been that the vapors from the stored liquid are frequently more corrosive than the liquid itself and for this reason the portion of the floating roof which is not in contact with the liquid has been subject to rapid corrosion. Another problem is that many roofs heretofore proposed have been unstable due to the accumulation of rain water on the roof and the migration of vapors below the roof. In general, existing types of floating roofs have not been adequate for one or several of these reasons and therefore the overall purpose of our invention is to provide an improved floating roof and seal for such storage tanks.

A primary object of our invention is to provide a floating roof constructed and arranged so as to reduce the number of moving parts associated with the roof and seal, increase the stability of the roof under all conditions, and provide efficient drainage of water from the top side of the roof.

It is a further object of our invention to provide a floating tank roof assembly having a peripheral sealing means which will automatically adjust itself to compensate for structural inaccuracies of the roof structure or of the tank wall. Another object is to provide an improved mounting for a sealing shoe and to provide a vapor-tight and resilient support or mounting for a contacting shoe without mechanical levers and trusses. Still another object of the invention is to provide a seal for floating roofs that does not require a supplementary or secondary seal to make it effective.

It is also an object of our invention to provide a large floating roof of the pontoon type having a central crown or deck which avoids sagging disproportionately to the remainder of the roof structure without the use of braces or trussing means.

An additional object of our invention is to provide a floating metal roof which is of such design and construction that the top area is self-draining and wherein the drainage area is designed and arranged to maintain the assembly stable.

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An important object of the invention is to reduce the area of the underside of the deck which is exposed to vapors and therefore liable to corrode. A more specific object is to provide a vented floating structure which eliminates or prevents the accumulation of vapors above the liquid in the tank. These and other objects of our invention become apparent to those skilled in the art as the description thereof proceeds.

Briefly we attain the objects of our invention by providing a novel assembly including a large annular pontoon and a central deck supported by the pontoon and which is crowned upward at the center. The top surface of the pontoon ring is pitched toward the central deck of the roof and a collecting trough is formed at junction of the central deck with the inner wall of the pontoon. The annular pontoon is of sufficient radial extent to provide air insulation for much of the liquid surface area, thereby minimizing the tendency to vaporize, and any vaporization that does occur is under the central deck portion of the roof. The roof assembly normally rides on the liquid surface with the crowned center deck in contact with the liquid, and vapors are trapped in this area. A vent is fixed to the crowned deck for preventing the accumulation of vapors and for giving vacuum relief when the tank is being discharged. An auxiliary central pontoon supports the crowned deck.

At the outer periphery of the roof assembly we provide a flexible sealing ring which extends between the roof and the tank shell. This seal comprises an air cell inflated sufficiently to engage firmly but gently the tank shell. The air cell is nested in a recess built into the top deck of the pontoon ring and is held in place by removable top deck plates. The air cell exerts an outward radial pressure continuously around the circumference of the roof and comprises a vertically flexible and radially adjustable seal. The contacting edge of the cell may be provided with a heavy rubber boot or a metal shoe.

Further details of the invention will be described in connection with the embodiments illustrated in the attached drawings which form a part hereof and wherein:

Figure 1 is a partial plan view of our floating roof;

Figure 2 is a vertical section of the general assembly;

Figures 3 and 4 show details of embodiments of the pontoon and air cell assemblies;

Figure 5 is a plan view of a vacuum and bleeder vent;

Figure 6 is a vertical section of the vent of Figure 5; and

Figure 7 is a vertical section illustrating our adjustable support for the floating roof.

The tank shown in the accompanying drawings comprises a shell 10 and a floating roof 11. Around the inner surface of the shell and carried at the periphery of the floating roof 11 is a flexible seal 12. In Figures 1 and 2, the roof 11 includes an annular or ring pontoon means 13 which floats on the liquid within the tank shell 10. Overlying the area enclosed by the pontoon assembly 13 is a deck 14 which is crowned upwardly and fixed at its periphery to the rim 15 which is an extension of the inner side of the pontoon assembly 13. The periphery of the crowned deck 14 is well below the lower deck 16 of pontoon 13, thereby providing a collection trough 17 which is interposed between the deck 14 and the pontoon assembly 13. The top of the pontoon ring 13 is pitched inwardly toward the trough 17. Due to the slope of the top deck 24 and the shape of the crowned center deck 14, all rain water is drained to the annular collecting trough 17. This results in a stable floating roof under substantially all reasonable loading conditions and confines the accumulation of water to a relatively small portion of the roof thereby avoiding general corrosion difficulties.

To give the pontoon assembly the required stability the pontoon ring 13 is divided into a number of compartments 18 by radial bulk heads 19. By projecting the inner edge or rim 15 of the pontoon 13 below the bottom deck 16, any vapors due to boiling which collect within the permanently crowned center deck 14 do not tend to travel from under the center deck to the outer edge of the roof 11.

The center deck 14 of the roof 11 is permanently crowned upwardly to provide a sloping surface toward the rim 15. At the apex of the crowned deck 14 is a manhole 20 and about the manhole is installed a small shallow pontoon 21 for supporting the crown under various loadings and to maintain the proper curvature of the roof at all times. The center deck 14 is preferably of a single plate thickness.

The novel system for sealing the space between the periphery of the roof 11 and the tank shell 10 is illustrated in Figures 1 to 4. This seal is in the form of continuous gas-tight, weatherproof air cell 22 made of a flexible sheet material which is unaffected by the liquid being stored in the container. When this liquid is gasoline or the or the like, the cell may be made of synthetic rubber, neoprene, or similar material. The cell 22 is inflated with sufficient air pressure, for example, about 20 p. s. i., to engage shell 10 firmly without binding.

The air cell 22 is supported within a recess 23 built into the top deck 24 of the pontoon ring 13 and removably held in place by bolted plates 25. The air cell 22 exerts an outward radial force continuously about the circumference of the roof 11 sufficient to compensate for irregularities and misalignment between the shell 10 and the floating roof 11. The outer face of the air cell 22 in contact with the shell 10 can be provided with a suitable wall-contacting element, two forms of such being illustrated in Figures 3 and 4 of the drawings.

A short metal shoe 27 may be attached to the air cell 22, the exposed portion of the cell serving as a vertically flexible and radially extendable

hanger for the wall contactor. A channel 26 formed by brackets 28 and 29 fixed to shoe 27 accommodates the free edge of the cell 22 as shown in Figure 3. Sponge rubber or other packing can be placed about the portion of the air cell 22 within channel 26. A suitable material for shoe 27 is flexible 16 gage galvanized steel plate stock.

As shown in Figure 4, the outer face of the air cell 22 in contact with the shell 10 can be provided with a wall contactor comprising a heavy tough rubber boot 30 that is an integral part of the air cell 22, and such boot will give good wearing qualities when the tank wall is relatively smooth and non-abrasive.

The peripheral air cell 22 can be divided into a plurality of overlapping sections, each section forming a separate unit that can be bolted in place separately within recess 23 by plate 25, thus forming a divided ring or annulus around the periphery of the roof 11 flush with the upper deck 24 of pontoon 13. Shoe 27 and channel 26 are similarly segmented and overlapped. Such assembly construction including the removable bolted plates 25 and the sectioned air cells 22 make it possible to repair and maintain the floating roof assembly without taking the tank out of service. Thus a section of the peripheral seal may be replaced, if necessary, without disturbing the remainder of the roof.

By providing our flexible seal assembly, it is possible to eliminate conventional shoe hangers having a multiplicity of small iron parts consisting of springs, bars, bolts, washers and the like, and to eliminate secondary seals. The air cell 22 brings the shoe 27 or the boot 30 into direct contact with the shell 10 and forms a seal which makes a secondary seal unnecessary.

The floating roof construction described above permits all portions of the lower deck 16 of the pontoon 13 and the underside of the crowned deck 14 to be in contact with the liquid thereby avoiding exposure to corrosive vapors. To accomplish this a combination vacuum and bleeder vent 32 shown in Figures 5 and 6 is mounted near the high point on the crown of the center deck 14 as shown in Figure 2. The valve 32 opens as soon as the liquid level is lowered with reference to the underside of the deck 14 and relieves vacuum or discharges vapors from below the center deck 14 of the roof 11.

The valve assembly 32 comprises a hollow aluminum float cylinder 34 which is maintained within valve cage 35, supported by straps 31, and adapted to move into sealing contact with port 36 when the cylinder 34 is in the liquid. Likewise, when sufficient vapors have accumulated below the crowned deck 14 so as to depress the float cylinder 34 downwardly, the port 36 is exposed and vapors are expelled therethrough until the relative liquid level is restored and float 34 is again in its closed position. By this means there is no appreciable portion of the roof 11 which is exposed to tank vapors for very long and underside corrosion is materially reduced.

Collecting trough 17 accumulates normal rain water and it is withdrawn from sump 37 by flexible drain 38 which may comprise a synthetic rubber hose and which terminates at an outlet connection 39 in the shell 10. Emergency pipe drains 40 are also provided within the collection trough 17 as a protection against an unusual accumulation of water on the roof in the event of an extremely heavy rainfall or thaw.

It is desired that the floating roof assembly be

permitted to move downwardly as far as possible within the tank if maximum discharge of stored liquid is to be obtained. On the other hand, it is necessary to be able to support the roof assembly within the empty tank at a distance above the bottom sufficient to permit access by a workman.

In Figure 7 is illustrated a means for supporting the roof at two such levels within the empty tank. Adjustable legs 42 extend through the pontoon 13 to support the roof assembly 11 at two different levels on pedestals 33 on the floor of the tank. The legs 42 pass within sleeves 41 which are provided with key pin 43 for engagement with flange 44 at two different levels 45 and 46 which can be selected from the exterior of the tank while the roof 11 is floating on the stored liquid.

From the above it will be apparent that we have attained the objects of our invention and have devised an improved floating roof tank assembly which avoids the use of a multiplicity of mechanical elements heretofore found necessary in providing a satisfactory seal. Likewise we have devised a floating roof which is unique in its compensation for misalignment of the roof and tank wall. In addition, we have provided a novel roof structure which is stable under varying load conditions and which diminishes or eliminates the accumulation of vapors below the roof proper with the attendant corrosion problem.

Although we have described our invention in terms of specific examples which have been set forth in considerable detail, it should be understood that these are by way of illustration only and that our invention is not limited thereto, since other embodiments will become apparent to those skilled in the art in view of our disclosure. Accordingly, modifications of our invention are contemplated without departing from the spirit of the described invention or the scope of the appended claims.

We claim:

1. An apparatus for storing volatile liquids comprising a cylindrical shell, a roof member vertically movable in the shell, a contact shoe seal between said shell and said roof, a peripheral recess in said roof member, and an inflated deformable annular cell means having its inner peripheral portion within the said recess to provide a flexible and extendable support for said contact shoe between said roof and said shell.

2. The apparatus of claim 1 wherein the contact shoe seal comprises a boot integral with the said annular cell means.

3. In an apparatus for storing volatile liquids comprising a cylindrical shell, a roof member vertically movable in the shell and a contact shoe between said shell and said roof, the improvement including a flexible and radially extendable shoe hanger supporting said contact shoe and comprising an inflated annular cell fixed within a recess at the periphery of said roof member and extending radially therefrom.

4. An apparatus for storing volatile liquids comprising a cylindrical shell, a vertically movable circular roof means in the shell, an annular recess on the periphery of said roof means, an inflated annular casing member having a major portion thereof recessed within said recess and a minor portion extending radially therefrom, a contact shoe means supported by the minor portion of said casing member, said roof means comprising an annular pontoon of substantial

depth, an inwardly pitched upper surface on said pontoon, a metal sheet crowned deck overlying the area within the annular pontoon, the periphery of said deck being fixed to the lower part of said annular pontoon to provide an annular trough at the boundary thereof, a second pontoon member fixed centrally below the crowned deck and supporting the central portion of said crowned deck, valve means communicating through said crowned deck with the space below said crowned deck, and adjustable columns slidably extending through sleeves in said annular pontoon with pin means extending through said sleeves and columns to support said roof means.

5. A floating roof for use in a storage tank comprising a flat conical plate-like structure, an upturned wall around said structure at the periphery thereof, an annular pontoon fixed to said upturned wall and extending radially therefrom to a point adjacent the wall of such storage tank, a recess at the outer periphery of said annular pontoon, a flexible wall seal extending from the outer periphery of said annular pontoon comprising an annular inflated cell means within said recess in the outer wall of said pontoon and extending radially therefrom, a flexible metal shoe carried by said cell and contacting the wall of said tank, a manhole in the apex of said conical structure, a shallow pontoon surrounding said manhole on the lower side of said structure to support said structure on a liquid surface, a drainage trough at the junction of said upturned wall and the periphery of said conical structure, and float-operated valve means carried by said conical structure adjacent said manhole for venting the volume under said conical structure.

6. A storage tank for liquid comprising a cylindrical shell, a vertically movable roof means within said shell, a contact shoe means between said shell and said roof means, an annular recess in the periphery of said roof, inflated annular casing means having a major portion thereof recessed within said recess and a minor portion extending radially therefrom, said minor portion of said casing providing a cantilever support for said contact shoe means, said roof means comprising an annular pontoon, a central crown deck of thin gage metal overlying the area bounded by the annular pontoon, a cylindrical wall depending from the inner wall of said pontoon to the periphery of said deck, a continuous collection trough below said pontoon bounded by said cylindrical wall and by the portion of said crown adjacent said wall, a generally circular pontoon member fixed centrally below the crown deck and supporting the central portion of said crown, the base of said pontoon member and of said annular pontoon being at substantially the same level, and a float valve means communicating through said crown deck adjacent said pontoon member with the space below said crown whereby said crown is maintained free of vapor.

7. A floating roof assembly of relatively large diameter adapted to be floated on a liquid within a tank, an annular recess on the periphery of said assembly, inflated annular casing means having a major portion thereof recessed within said recess and a minor portion thereof extending radially therefrom, a contact shoe means supported by the minor portion of said casing, said assembly consisting essentially of a rigid annular pontoon having an inwardly pitched upper deck, an inner pontoon wall extending below the lower deck surface of said pontoon, a central crowned deck portion of a single thickness of metal hav-

ing its peripheral base edge attached to the lower edge of said pontoon wall, a shallow pontoon of minor area as compared to said annular pontoon disposed below the apex of said crown, an annular drainage trough wholly below said annular pontoon, a flexible drain conduit communicating with said annular trough and discharging below the said annular pontoon and deck, said pontoons normally floating with their bases at the same liquid level, and the apex of said central deck portion being substantially below the level of the upper deck of said annular pontoon.

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