March 14, 1944. W. G. LAIRD 2,344,436

FLOATING ROOF STORAGE APPARATUS FOR VOLATILE LIQUIDS

Filed Aug. 6, 1940

Fig. 1.

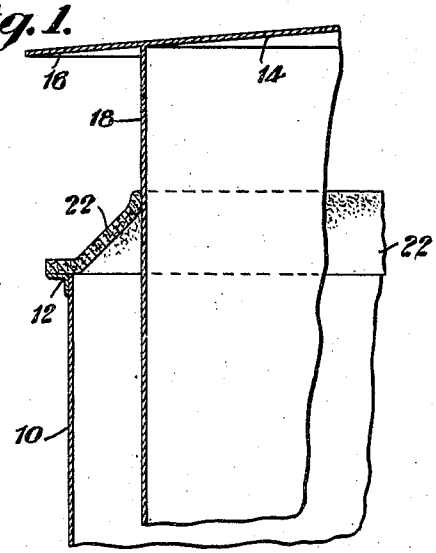


Fig. 2.

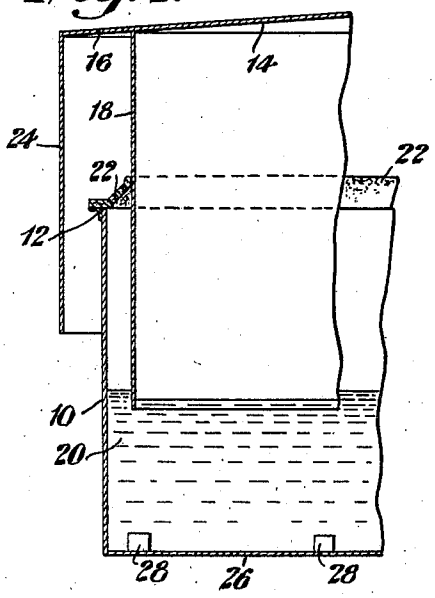


Fig. 3.

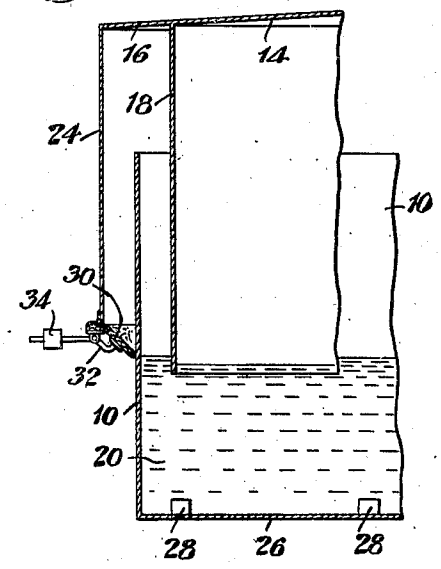
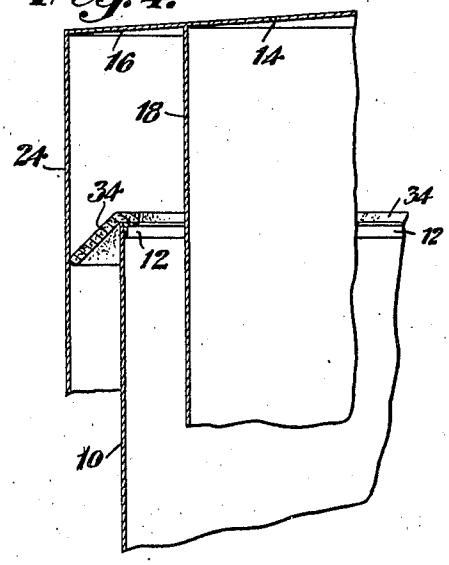


Fig. 4.



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FLOATING ROOF STORAGE APPARATUS FOR VOLATILE LIQUIDS

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7 Claims. (Cl. 220—26)

This invention relates to improvements in floating roof storage apparatus for volatile liquids, especially such apparatus as is now used for the storage of relatively volatile petroleum products such as gasoline and crude petroleum. More particularly the invention relates to improvements in floating roof tanks of relatively large diameters, usually in excess of 100 feet, employed for storing petroleum oils.

As far as known, the latest form of floating roof tank now used to a considerable extent in the petroleum industry comprises a large tank and floating roof or deck of slightly smaller diameter than the inside of the tank resting directly on the liquid therein and floated by means of pontoons. This type of roof is also provided with an elaborate resilient seal for closing the space between the roof and tank wall consisting of vertical metal shoes bearing against the tank wall connected together and with the roof proper by a rubberized fabric material. The resilient seal is usually supported by means of hinged braces or supports fastened to the floating roof proper.

Floating roofs of this type are very expensive, but at the same time include no means for conserving or saving the volatile gases and vapors evolved from the stored liquid such as gasoline or crude oil. The resilient seal does not prevent escape of gas and vapors, but merely serves to prevent free access of the wind or air to the liquid between the tank wall and the floating roof proper. Furthermore, floating roofs of the type described are expensive to maintain because the upper portion of the tanks and all of the roof mechanism are open to the atmosphere and therefore trap dust, water, sand, snow, etc. The resilient seal operates against a tank wall wetted by the stored liquid so that considerable contamination and obstruction is encountered, especially in crude oil storage tanks. Furthermore, the interior surface of the tank is subjected alternately to the liquid in the tank and to the oxidizing effect of the atmosphere and corrosion occurs, so that in the case of refined products contamination or change of color may occur.

Having in mind the elaborateness, high cost and disadvantages associated with the present type of floating roof storage apparatus, the primary object of the present invention is the provision of a floating roof tank provided with a resilient seal, which will be relatively inexpensive, free from contaminating influences, and at the same time be effective for the conservation of evolved gases and vapors.

According to the present invention, the improvements in liquid storage apparatus comprise in general a storage tank for example of the large cylindrical type, a sheet metal roof adapted to be supported by the liquid in the tank and adapted to move relatively to the side wall of the tank as the liquid level in the tank varies, the floating roof including a metal roof plate preferably above the tank wall and a depending metal curtain wall or apron, for example, of the general shape of the tank wall secured in fluid-tight manner to the roof plate near the periphery thereof inside the tank wall with its lower edge normally sealing in the liquid in the tank, and a resilient annular closure member or seal mounted in contact with the tank wall, for example, on top of the tank wall and adapted to enclose the space between the curtain wall and tank wall to retard evaporation of and protect the liquid therebetween.

With such an improved storage apparatus for liquids, to be described and elaborated more in detail hereinafter, the following improvements and advantages over prior art storage tanks are attained:

1. Practically complete elimination of contamination of the stored liquid from dust, dirt, water, etc.

2. Substantial savings in the cost of the floating roof.

3. Avoidance of contamination of the resilient closure seal by the stored liquid.

4. Avoidance of contact of the resilient closure seal with tank surfaces wetted by the stored liquid.

5. Reduction in the fire hazard.

6. Discharges tank atmosphere instead of drawing air into the tank area as the tank is emptied.

7. Increased utility and reduced unit cost by providing full liquid capacity storage as well as large gas and vapor storage and conservation.

Other features, improvements and advantages of the liquid storage apparatus of the present invention will be apparent to those skilled in the art from the following description of certain illustrated examples made in connection with the accompanying drawing in which:

Fig. 1 is an enlarged vertical transverse section through the upper portion of a cylindrical liquid storage tank illustrating one form of the invention.

Figs. 2, 3 and 4 are views similar to Fig. 1, illustrating further forms of the invention, except that Figs. 2 and 3 are on a smaller scale and show the lower portion of the tank.

Referring to Fig. 1 of the drawing, the improvements of the present invention are shown applied to a cylindrical tank having a wall 10 provided with a top curb 12. In this instance the floating roof for the tank comprises a roof plate 14 having an extended portion 16 which projects substantially over the tank wall 10 and which may be integral or a separate plate. The roof plate 14 may be flat, but is preferably erected in cambered form, as shown, so as better to withstand internal pressure and readily shed rain water which is discharged outside the tank wall 10 over extension 16. The floating roof also includes an annular or cylindrical sheet metal curtain wall or apron 18 which generally conforms to the shape of the wall 10 and extends slightly inside the wall 10, its lower edge normally sealing in the liquid 20 (Figs. 2 and 3) in the tank. The roof plate 14, while preferably placed as shown, may be secured to the curtain wall 18 at any desired level from about a foot above the lower edge of the curtain to the top, in line with the plate 16.

In the form of the apparatus shown in Fig. 1, the space between the wall 10 and the curtain 18 is enclosed by means of a resilient sealing member 22 which is attached to the curb 12 by any suitable or well-known means (not shown). The member 22 (as also members 30 and 34, (Figs. 3 and 4) may comprise a mat seal of the type shown and claimed in the applicant's pending application Serial No. 332,659, filed May 1, 1940 (which is not a gas-tight seal), or any other type of suitable sealing member may be employed. The present invention is not concerned with the specific type of seal used to enclose the space between the curtain 18 and the wall 10, but the mat seal described in the above-mentioned application is preferred. It is particularly applicable to the form of tank shown in Fig. 1 of the drawing, since the seal is inclined upwardly toward the curtain wall 18 and serves to deflect or shed any extraneous matter which is not diverted by the roof plate extension 16.

The curtain 18 is of sufficient depth to seal in any liquid normally maintained in the tank (Figs. 2 and 3), and at the same time keep the roof plate 16, and in the preferred form plate 14, above the wall 10 and sealing member 22. Curtain 18 is attached in fluid-tight manner to plate or sheet 14, and also preferably fluid-tight to the annular plate 16.

The modification of the invention shown in Fig. 2 comprises, in addition to the elements shown in Fig. 1, an outside curtain or apron 24 attached to the rim of the extension 16. This curtain 24 normally encloses a substantial portion of the tank wall 10 and the sealing member 22, and thereby more perfectly prevents access of extraneous matter to the liquid in the tank. This curtain furthermore practically prevents the usual wind action. It will be noted that the curtain 24 is somewhat shorter than the curtain wall 18, to permit access to the sealing member 22 by elevating the floating roof, so that the sealing member is exposed while the curtain wall 18 is still sealed in the liquid in the tank. The elevation of the floating roof in this manner permits repair or replacement of the sealing member 22.

Figs. 2 and 3 show the tank more completely than Figs. 1 and 4, and these views include a portion of a bottom plate 26 on which is mounted landing blocks 28 so that the curtain wall 18 will be supported slightly above the bottom of the tank, when the liquid is removed or the gas under the roof plate 14 is removed sufficiently to let the roof curtain settle to its lowermost position in the tank. In addition to the landing blocks 28 any suitable supporting means may be used to support the roof plate and take the weight of the roof. Such a structure is not shown, but is commonly employed in connection with floating roofs or decks.

Fig. 3 shows a further modification of the invention illustrated in Figs. 1 and 2 in which the annular resilient sealing member is mounted on the lower portion of the apron or curtain 24, so that it bears against the outside of the tank wall 10 as the roof moves up and down in the tank with the changes in liquid level or in the volume of gas inside the curtain wall 18. The resilient sealing member as shown in Fig. 3 comprises a mat or other form of resilient seal 30 fastened to the bottom portion of the curtain 24 by means of suitable clamping elements (not shown). The member 30 is illustrated as inclined downwardly (preferably) with respect to the curtain 24 against the tank wall 10 and forced or held against the tank wall by means of suitable pivoted bracket levers 32, spaced at suitable intervals around the tank. These bracket levers 32 may be provided with weights 34, or springs or other suitable means for holding the annular sealing member 30 in sliding contact with the outside of the tank wall 10. The member 30 may be placed horizontally or inclined upwardly if desired.

Fig. 4 shows a further modification of the floating roof tank in which the inside and outside curtains are employed as in Figs. 2 and 3, but in which the sealing member 34 is attached to the top of the tank wall 10 and bears against the inside of the curtain 24. The annular sealing member 34 may be inclined downwardly or upwardly from the tank wall 10 and any suitable means (not shown) may be employed for causing the member to bear against the curtain 24. In many cases such a property (springiness and rigidity) may be inherent in the sealing member itself, so that outside springs or weighted brackets will be unnecessary.

In all modifications of the floating roof tank shown in Figs. 2, 3 and 4, the curtain 24 is preferably secured in fluid-tight manner to the extension 16, and in at least Figs. 2 and 3, these curtains are preferably shorter than the curtain walls 18. However, this may be unnecessary, as for example when the curtain wall 24 is merely bolted to a flange on the extension 16 and can be readily removed.

The improved floating roof of the present invention must of necessity be held in substantially horizontal or level position, so that the lower edge of curtain 18 is substantially horizontal and the curtains 18 and 24 move parallel with respect to the tank wall. The floating roof may be stabilized and maintained in this desired position by any suitable means as for example by means of a cable or plurality of cables fastened to the tank wall and/or bottom and the roof including curtains 18 and 24, in the various ways described in the applicant's application, Serial No. 329,875, filed April 16, 1940, for "Storage tanks for oils and other liquids." Alternatively, the floating roof may be held in a suitable horizontal position by other guide means known in the art.

The liquid to be stored in the tank may be in-

troduced thereinto or removed therefrom by suitable piping or swing lines (not shown). Likewise suitable means (not shown) may be provided for removing vapors and gases from under the floating roof or for supplying gas thereto, such means preferably including a swing line or equivalent for supplying and removing gases from directly under the roof plate 14. However, a gas line terminating slightly above the top of the tank wall 10 within the curtain wall 18 is suitable for supplying and removing gas. It will be apparent that the improved liquid storage tank of the present invention may be employed as a breather tank and connected to one or more storage tanks provided with fixed vapor-tight roofs. When the tank is connected in this manner, gas and vapor from adjoining tanks, as well as those evolved from the liquid in the tank itself, will collect under the floating roof within the curtain wall 18, for example, during the day time, and at night when the tanks become cooler the floating roof will supply gas to the outside tanks, and settle to a corresponding degree.

It will be apparent that the floating roof will move up and down in the tank as the liquid level therein so moves, and that it will also move in response to changes in the volume of gases under the roof within the curtain wall 18. If gas is withdrawn abnormally, the roof may settle so that the curtain wall rests directly on the landing blocks 28 and the liquid level rises inside the curtain wall 18 to the level outside.

The floating roof is also preferably provided with an automatic safety valve (not shown) of usual and well-known structure, adapted to prevent the creation of a vacuum under the roof. Such a valve will also admit air under the roof when it is in a low position in the tank and when the oil or other stored liquid is being withdrawn. It is preferred however in such cases to supply outside gas under the floating roof to maintain a gas layer, so that the roof is at all times except when the tank is empty, supported by a gas layer above the liquid level within the curtain 18. The safety valve referred to may also be arranged to discharge gas automatically in preference to permitting gas to bubble around the lower edge of the curtain wall 18 as when too much gas is supplied to or evolved in the tank.

From the foregoing description of the various forms of apparatus of the present invention, it will be apparent that the applicant has provided a floating roof storage tank which is effective for preventing excessive vapor losses, not only from the liquid stored therein, but also from liquids stored in other closed tanks having their vapor spaces connected with the improved tank of the present invention. The floating roof is furthermore arranged to trap and retain considerable and variable volumes of gases and vapors, and thereby avoid the usual losses and prevent breathing of air into connected tanks such as those provided with vapor-tight roofs. The annular resilient sealing means of the present invention is furthermore so arranged as to accomplish the results and objects of the invention in connection with the use of the extension plate 16 and the curtain wall 18 or curtain walls 18 and 24.

The improved liquid storage tank of the present invention greatly reduces the hazard from fire in storing inflammable liquids because the floating roof including the curtain 24 actually prevents air from filling the enclosed area of the tank as is common with ordinary floating roofs. This is very important when tanks are being emptied. In the present form of tank, air fills the whole area in the tank above the floating roof.

Various modifications may be made in the different elements of the improved floating roof liquid storage tanks, but such changes are to be understood as included within the spirit and scope of the present invention, as defined by the claims.

Having thus described the invention in its preferred form, what is claimed as new is:

1. In an apparatus for storing large volumes of liquids and for reducing the loss due to the evaporation of stored liquids such as petroleum products, an upright cylindrical storage tank of large diameter, a sheet metal roof adapted to be floated by the liquid in the tank and to move verticallly relative to the side wall of the tank as the liquid level in the tank varies, said roof comprising a metal roof plate above and extending over the tank wall and two depending annular metal curtains secured to the roof plate near the periphery thereof, one of said curtains being inside near the tank wall secured in a fluid-tight manner to said plate and normally extending into and sealing in the stored liquid in the tank, the other curtain being outside and near the tank wall and adapted to enclose a substantial portion of the heighth thereof, and a resilient annular closure member interposed between the tank wall and one of said metal curtains enclosing the space above the liquid around the inside curtain, said closure member being adapted to permit the passage of gas into and from said space but adapted to prevent the free circulation of air into said space.

2. An apparatus for storing liquids as defined by claim 1 in which said annular closure member is mounted between the tank wall and the outside curtain.

3. An apparatus for storing liquids as defined by claim 1 in which said closure member is fixed to the upper portion of the tank wall and bears against one of said curtains in sliding contact therewith.

4. An apparatus for storing liquids as defined by claim 1 in which said annular closure member is fixed to the lower portion of said outside curtain and bears against the outer side of said tank wall in sliding engagement therewith.

5. An apparatus for storing liquids as defined by claim 1 in which said closure member is fixed to the upper portion of the tank wall and bears against one of said curtains in sliding contact therewith and in which the outside curtain is shorter than the inside curtain to an extent adapted to permit access to said closure member when the roof is in substantially its maximum elevated position.

6. An apparatus as defined by claim 1 in which said annular closure is fixed to one part of the apparatus and in a position to avoid contact with surfaces of the apparatus wetted by the liquid in the tank as the level of the liquid in the tank varies.

7. A tank structure for storing volatile liquids and gases having a side wall comprising an outer-lower stationary vertical annular wall section and a vertically movable section including an inner-upper annular wall section of slightly smaller diameter than and spaced from said lower wall section, a roof secured in fluid-tight manner to the top of the upper wall section, said

upper wall section being open at the bottom and of sufficient depth to extend from a point above the lower wall section to normally seal in the liquid when stored therein, an annular shield attached to the top portion of the upper wall section overlying said stationary wall, and an annular closure member attached to the upper part of the stationary wall section and mounted in sliding contact with the outer surface of the other section enclosing the space between said wall sections but adapted to permit the passage of gas to and from said space, thereby reducing evaporation of liquid between said wall sections.

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