Dec. 26, 1961 L. E. ANDERSON, SR 3,014,613

VAPOR SEAL FOR FUEL STORAGE TANK OF FLOATING ROOF TYPE

Filed May 17, 1960 2 Sheets-Sheet 1

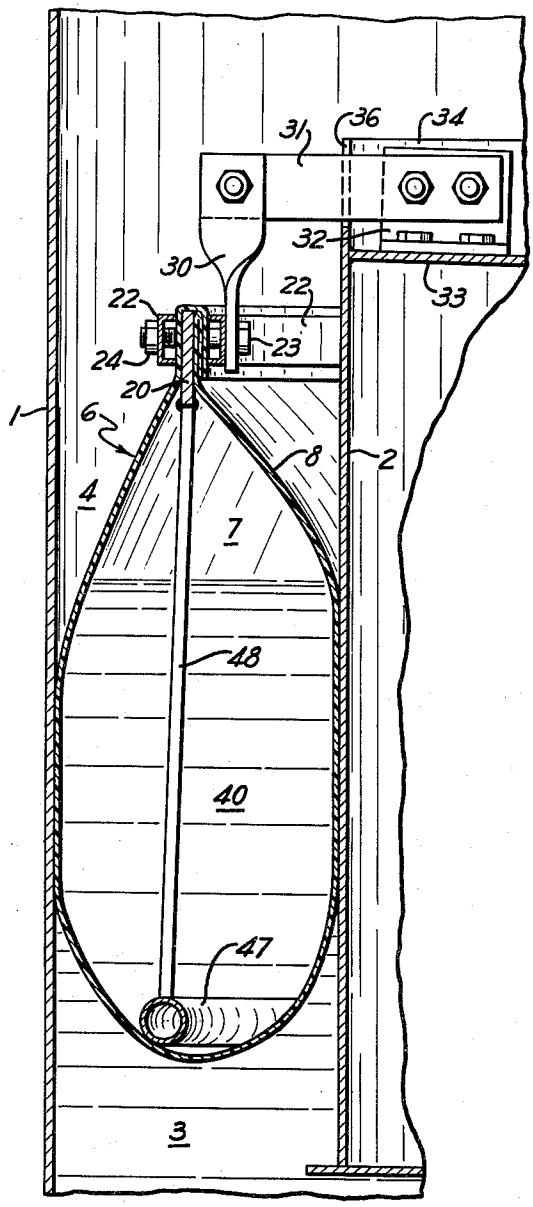


Fig. 2

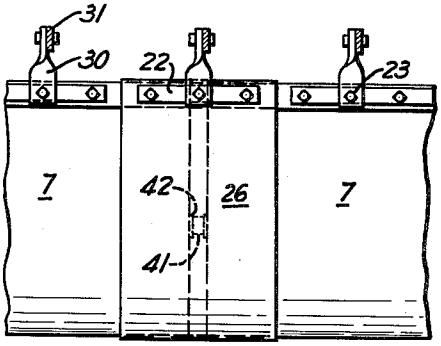


Fig. 3

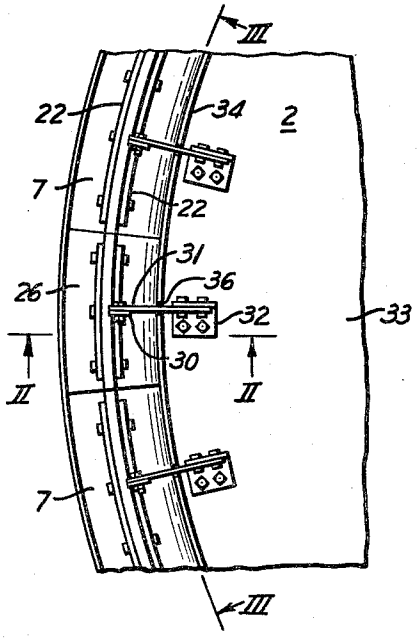


Fig. 1

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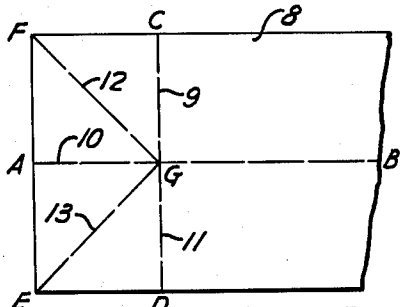


Fig. 5

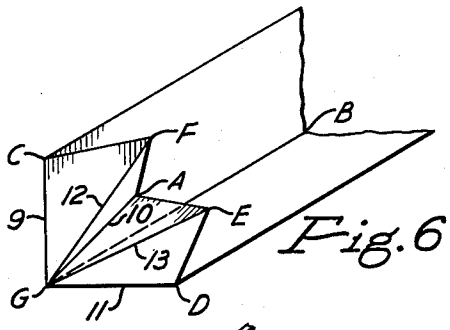


Fig. 6

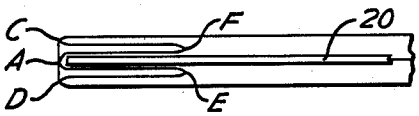


Fig. 7

Fig. 4

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VAPOR SEAL FOR FUEL STORAGE TANK OF FLOATING ROOF TYPE

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This invention relates to a vapor seal for use in fuel storage tanks having a cylindrical shell and a cylindrical roof portion spaced from the shell and floating on liquid stored in the tank. More particularly, this invention relates to, and has among its objects the provision of, means for sealing the annular space between the tank shell and the floating roof portion, in which a series of flexible container sections are arranged end to end in said annular space and are adapted to be partly filled with a liquid and thereby inflated to press against the sides of the shell and roof portion to seal the space therebetween, and in which the flexible container sections also act as spacing means between the tank shell and the floating roof portion to maintain the latter in a position that is substantially concentric with the shell.

Other objects of the invention will be apparent from the following description of a preferred embodiment in connection with the accompanying drawings, in which:

FIG. 1 represents a fragmentary plan view of part of a fuel storage tank, showing a portion of the tank shell and the floating roof with the sealing means of this invention in the annular space therebetween;

FIG. 2 is a sectional elevation along the line II—II of FIG. 1;

FIG. 3 is a side elevation along the line III—III of FIG. 1, showing two adjacent flexible container sections and the means used for covering the joint between those sections;

FIG. 4 is an enlarged isometric view of a portion of one of the sectional containers showing the means for sealing the tops of those containers to make them leak-proof; and

FIGS. 5–7 are diagrams showing how a flat rectangular sheet of sealing material may be folded to form a sectional container with liquid-tight ends.

In accordance with this invention, the means for sealing the annular space between a tank shell and a floating roof portion of a fuel storage tank includes a series of separate flexible container sections adapted to be partly filled with liquid and arranged end to end in such annular space. Means are provided to support the container sections from the roof portion of the tank, with the container sections partly immersed in the liquid stored in the tank. In addition, conduit means are provided for interconnecting adjacent ends of adjacent container sections to equalize the level of liquid in all of the sections.

In the drawings only so much of a fuel storage tank is shown as is pertinent to the present invention. The tank includes a cylindrical shell 1 and a floating roof portion 2, which is positioned inside of and spaced from the shell and floats on a body of liquid 3 stored in the tank. The annular space 4 between the shell and the roof portion is sealed against evaporation of fluid in the tank by inflatable sealing means 6. The sealing means includes a series of separate flexible container sections 7 that are partly filled with liquid and disposed end to end in the annular space 4, with the container sections partly immersed in the liquid that is stored in the tank. The container sections 7 are made from sealing material, such as rubber or plastic, that is not affected by the liquid stored in the tank, and are preferably reinforced with fabric so that they will be durable and strong. Each container section is in the form of a bag that will assume a deformable, somewhat tear-drop cross section when inflated with a liquid. The container sections may conveniently be made from a flat rectangular sheet of sealing material, which is folded to provide leak-proof ends with all of the edges of the sheet meeting at the top where they are clamped together to provide a sealed container.

The method of forming a container section from a flat rectangular sheet 8 is shown in FIGS. 5–7. The sheet is first creased lengthwise down the middle, i.e., along the line AB in FIG. 5. It is then creased along a transverse line adjacent each of its ends (since the ends are symmetrical, only one end is shown in FIGS. 5–7), i.e., along the line CD in FIG. 5. The line CD is parallel to the end of the sheet and spaced therefrom a distance equal to one-half the width of the sheet. The sheet is then folded, as shown in FIG. 6, along the lines AB and CD, but with the corners E and F tucked inward towards the opposite end of the sheet along diagonal creases EG and FG. When the folds are completed, the end of the sheet will have the appearance shown in FIG. 7, in which the edges of the original sheet are arranged side by side at the top of the container. It will be apparent from FIGS. 5–7 that each end of the folded sheet includes three projecting vertical folds of two plies each arranged side by side. These folds are identified by numerals 9, 10, and 11, and they correspond to lines CG, AG, and DG, respectively. These three projecting folds are separated by two indented inclined folds, represented by numerals 12 and 13, which correspond to the diagonal lines EG and FG in FIG. 5. A similar container, but with less flexibility in its end sections, can be formed with points E and F and folds 12 and 13 on the outside of the container and with fold 10 enclosing folds 9 and 11.

To close the top of the container, a closure bar 20, having a narrow rectangular cross section, is placed inside the container with the ends of the bar between the folds 10 at each end of the container. The upper edge 21 of the bar may be even with the edges of the sheet 8, but is preferably spaced below and parallel to those edges by an amount sufficient to permit the edges to be folded over the bar as shown in FIG. 4. In either case, the edge portions of the sheet are pressed together by clamping bars 22 on either side of closure bar 20 and held by bolts 23 and nuts 24. The clamping bars are preferably channel shaped with the legs of the channels pressing against sheet 8 to obtain more effective sealing pressure. The closure bars 20 and clamping bars 22 are slightly curved to conform to the curvature of the annular space 4. As shown in the drawings, the clamping bars are shorter than the length of a single container section and are positioned approximately in the middle of each section, so that the adjacent pairs of clamping bars extend across the adjacent ends of adjacent container sections. In this way, alternate pairs of clamping bars act as splice bars joining the container sections in abutting end to end relation to form a continuous annulus. Since the ends of the container sections, due to their folded construction, are not in perfect sealing engagement with each other, it is desirable to cover the adjacent end portions of adjacent container sections with a rectangular auxiliary sheet 26 of sealing material (see FIG. 3). The ends of this auxiliary sheet are incorporated in the turned over folds of sheet 8 and clamped in sealing engagement therewith by means of the same clamping bars 22.

The container sections 7 are supported on hangers 30, bolted to the clamping bars 22. The hangers are pivotally connected to horizontal arms 31, which are secured to brackets 32 bolted to the deck 33 of the roof portion of the tank. The parapet 34 of the roof portion extending

above the deck is provided with slots 36 through which the arms extend. This construction permits the container sections to remain centered in the annular space 4 when the roof portion moves slightly to one side or the other of the tank.

When each of the container sections 7 is partially filled with a liquid 40, which may be the same as or different from the liquid stored in the tank, the sections are inflated and assume (when hanging free) a substantially teardrop cross section, the folds at the ends of the sections tending to open up, as shown in FIG. 4. The sides of the container sections and the auxiliary sheets press against the inside of the shell 1 and the outside of the roof portion 2 flattening those sides to provide a large sealing area that is readily deformable to conform to any surface irregularities on the shell or roof. At the same time, the hydrostatic pressure in the containers holds the roof substantially concentric with the shell. To equalize the hydrostatic pressure in the separate container sections, it is desirable to provide a fluid connection between the sections, for example, by means of a short conduit or nipple 41 connected to the adjacent ends of the container sections. These nipples may have a threaded exterior and may be secured to the ends of each container below the normal level of liquid therein by threaded couplings 42. The size of the openings in nipples 41 may be controlled to provide for a time lag of desired duration in equalizing the liquid levels of the various container sections, so that hydrostatic pressures can build up temporarily in some sections to oppose shifting of the tank roof from its normal concentric position inside the shell.

Since the roof portion rises and falls relative to the shell with changes in the liquid level 3 in the tank, the container sections provide a continuous sliding seal between the roof and shell. To prevent the sections from sticking to the walls of the shell and roof, when the roof moves downwards, it is desirable to provide some form of hold down for the bottom of the container sections. For this purpose, a metal tube 47, curved to conform to the curvature of the annular space 4, is supported by rods 48 welded or otherwise secured to the bottom of the closure bar 20 in each container section.

It is among the advantages of the sealing means herein provided that they are relatively inexpensive to make and install, particularly if the container sections are made from folded rectangular sheets. In addition, the use of sectional seals permits the removal of one or more sections for repair or replacement without removing the other sections. A further advantage is that the hydrostatic pressure of liquid in the flexible container sections is used to hold the roof portion of the tank substantially concentric with the shell.

According to the provisions of the patent statutes, I have explained the principle of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. In a liquid fuel storage tank having a cylindrical shell and a cylindrical roof portion disposed within and spaced from the shell and adapted to float on the liquid stored therein, means for sealing the annular space between the roof portion and the shell, comprising: a series of separate flexible container sections adapted to be partly filled with liquid and arranged end to end in said annular space, each container section being formed from a flat rectangular sheet of flexible sealing material folded to form a bag-like container, each end of said container including three projecting vertical folds of two plies each arranged side by side and separated by two indented inclined folds of two plies each arranged side by side, and

with all of the edges of said folded sheet being in substantially alignment adjacent the top of the container, means for clamping said edges in sealing engagement to form a leak-proof container, and means secured to the roof portion for supporting the container sections partly immersed in the liquid stored in the tank.

2. Apparatus according to claim 1, in which the two outer projecting folds are along a line on the flat sheet that is parallel to the end of the sheet and spaced therefrom one half the width of the sheet, and in which the middle projecting fold is along a line on the flat sheet joining the midpoint of an end of the sheet and the midpoint of said transverse line, and in which the two indented inclined folds are along lines on the flat sheet extending from two corners of the sheet to the midpoint of said transverse line.

3. Apparatus according to claim 1, in which the top edges of the container section are sealed by means of a closure bar extending from one end to the other of the container section and positioned within the container and a pair of opposed clamping bars outside the container forcing adjacent plies of sealing material against each other and against the closure bar.

4. In a liquid fuel storage tank having a cylindrical shell and a cylindrical roof portion disposed within and spaced from the shell and adapted to float on the liquid stored therein, means for sealing the annular space between the roof portion and the shell, comprising: a series of separate flexible container sections adapted to be partly filled with liquid and arranged end to end in said annular space, each container section being formed from a substantially rectangular sheet of flexible sealing material folded to form a completely enclosed bag-like container with the edges of said folded sheet adjacent the top of the container, means for clamping said edges in sealing engagement to form a leakproof container, means secured to the roof portion for supporting the container sections partly immersed in the liquid stored in the tank, and conduit means interconnecting adjacent ends of adjacent container sections, said conduit means having a restricted passage therethrough for providing a time delay in equalizing the liquid levels of the container sections, thereby tending to maintain the roof portion concentric with the tank shell.

5. In a liquid fuel storage tank having a cylindrical shell and a cylindrical roof portion disposed within and spaced from the shell and adapted to float on the liquid stored therein, means for sealing the annular space between the roof portion and the shell, comprising: a series of separate flexible container sections adapted to be partly filled with liquid and arranged end to end in said annular space, each container section being formed from a substantially rectangular sheet of flexible sealing material folded to form a completely enclosed bag-like container, each end of said container including three projecting vertical folds of two plies each and two indented inclined folds of two plies each, the folds being so disposed that all of the edges of said folded sheet are in substantial alignment adjacent the top of the container, means for clamping said aligned edges in sealing engagement to form a leakproof container, and means secured to the roof portion for supporting the container sections partly immersed in the liquid stored in the tank.

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