Jan. 7, 1964 L. E. ANDERSON ETAL 3,116,850

TUBE SEAL FOR FLOATING ROOF STORAGE TANK

Filed April 12, 1962 2 Sheets-Sheet 1

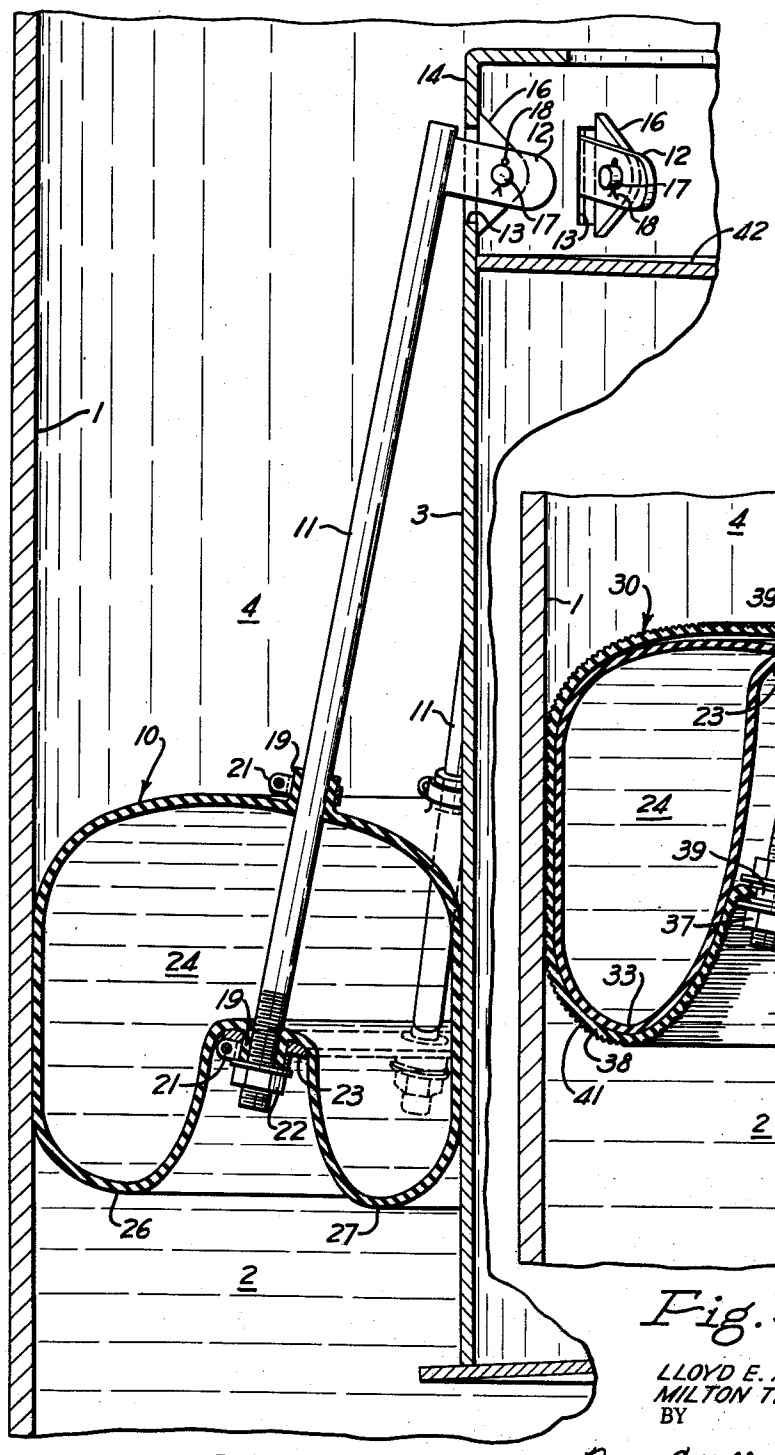


Fig. 1

Fig. 4

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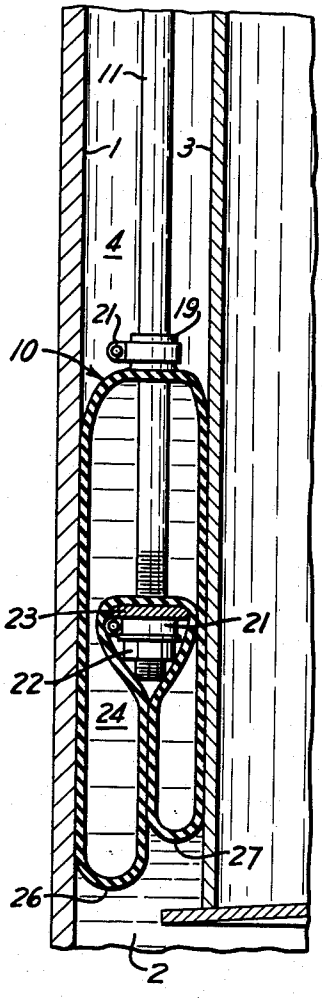


Fig. 2

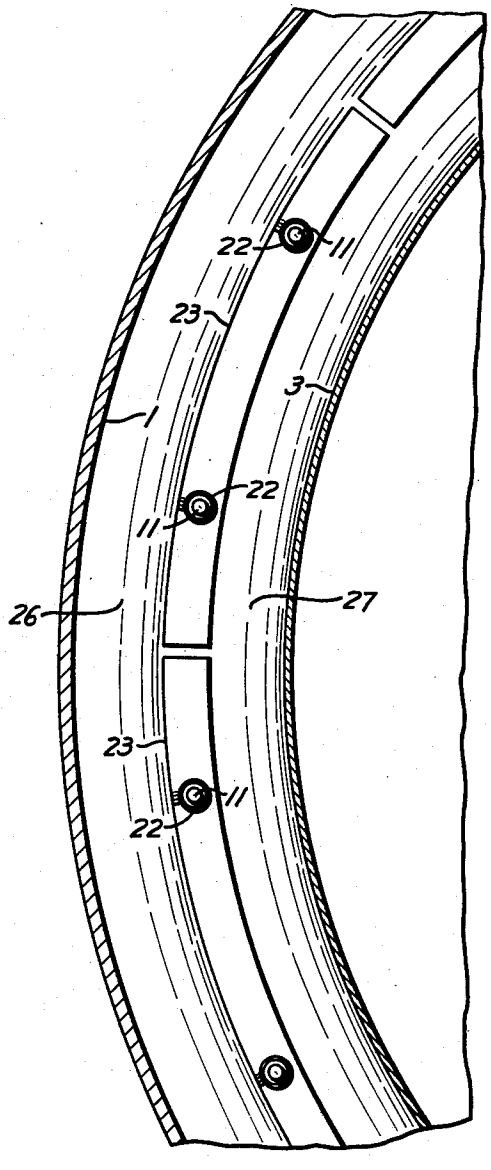


Fig. 3

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TUBE SEAL FOR FLOATING ROOF STORAGE TANK

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This invention relates to means for sealing the annular space between roof and tank shell in a floating roof storage tank of the type used, for example, to store volatile petroleum products, thereby to prevent the evaporation and escape of volatile constituents from the tank.

It is among the objects of this invention to provide an improved seal, of the type referred to, that will accommodate large variations in tank diameter due to out-of-roundness of the tank shell; that will also accommodate maximum horizontal movement of the floating roof within the tank shell; and that can be installed, and removed for maintenance, from the upper deck of the floating roof.

The foregoing and other objects will be apparent from the following description of the invention, in connection with the attached drawings, in which:

FIG. 1 is a fragmentary elevation, partly in section, of a portion of a fluid storage tank of the floating roof type, showing the tube seal of this invention for sealing the annular space between the tank shell and floating roof;

FIG. 2 shows the cross section profile of the same tube seal when deformed by compression into a narrower annular space;

FIG. 3 is a view of the underside of the seal of FIG. 1, showing the arrangement of hanger rods and ring bars; and

FIG. 4 is a cross section profile of a modified form of seal.

In accordance with the present invention, the seal is an annular flexible tube filled with liquid and adapted to rest on the surface of the stored liquid in the tank, in the annular space between the floating roof and tank shell. The tube seal is supported from the roof by a number of circumferentially spaced hanger rods, which are pivotally connected at one end to the roof and which have their other end passing through the top and bottom of the tube and connected to horizontal ring bars. These bars underly and support the tube between hanger rods and normally divide the lower portion of the tube into two concentric lobes, depending on either side of the bars. By their ability to separate and draw together, these lobes give the tube seal added capacity to accommodate variations in the annular space about the floating roof.

Referring to FIGS. 1–3, a cylindrical tank shell **1** is partially filled with a liquid **2**, such as gasolene, on which floats a conventional floating roof **3**. Liquid displaced by the floating roof rises into the annular space **4** between the roof and tank shell. The sealing member **10** is made of treated fabric, such as nylon reinforced Buna-N fabric, which is formed either into a continuous tube of generally toroidal shape that extends completely around the tank between roof and shell, or into a series of tubular segments that are joined together to make a continuous tube. The tube is supported from the tank roof by a plurality of hanger rods **11**, which are preferably spaced 3.14 feet apart along the length of the tube. The upper end of each rod is provided with a laterally extending ear **12**, which passes through a vertical slot **13** on the upper rim **14** of the roof and is pivotally secured to a bracket **16** by a pin **17** and cotter pin **18**. The lower end of each hanger bar passes through the top and bottom portions

of tube **10**, at or near the midline of those portions. In the embodiment shown in FIG. 1, the rod passes through rubber nozzles **19**, which are vulcanized to the central top and bottom portions of tube **10** and secured therein by hose clamps **21**. Tube **10** is held on the hanger rods by threaded nuts **22**, which also support horizontally extending ring bars **23**. The latter underlie and support the central bottom portion of tube **10** adjacent each pair of hanger bars, as shown in FIG. 3. The ends of adjacent bars are spaced apart sufficiently to allow for some radial movement of the ring bars. The bars are preferably curved (in plan view) to the approximate curvature of the midsection of the annular space **4**, as shown in FIG. 3. It may also be desirable to curve the bars slightly in section and to round their upper edges, so as to fit the adjacent, arcuate bottom of the sealing tube. By the arrangement described, tube **10** may be filled with a liquid **24**, preferably a little heavier than the stored liquid **2**, and be adequately supported from the roof of the tank.

Since the floating roof may occasionally be displaced to one side of the tank by external forces and since the diameter of the tank may vary due to out-of-roundness of the tank shell, the width of the annular space to be sealed is likely to vary. Accordingly, tube **10** is so designed that, in its normal position with the roof concentric with the shell, as shown in FIG. 1, the liquid-filled fabric will hang down in two lobes **26** and **27** on either side of ring bars **23**. In other words, the hanger rods and ring bars divide the lower portion of the tube into these two concentric lobes. When the annular space **4** varies in width, as when either the shell is out of round or the roof is displaced from its normally concentric position within the shell, then the lobes will become more pronounced and come together below the ends of the hanger rods **11** on that side of the tank where they are compressed, as shown in FIG. 2; and at the same time, due to hydrostatic pressure, the lobes will separate and flatten out into a more nearly circular (or rectangular) cross section profile on the other side of the tank. These changes in the tube profile will be accompanied by a transfer of fluid inside the tube, corresponding to changes in area of the tube's cross sections. It will be noted from FIG. 2 that the tube may be compressed on one side to the width of ring bar **23** before any rigid structure limits the compression. Likewise, the tube may expand laterally to the extent permitted by its own size and shape without limitation from any rigid structure. The cross section profile of the tube at any spot will be determined by the relation between (1) the length of the perimeter of the cross section and the distance separating the top and bottom portions of the tube along the hanger rods **11** and (2) the width of the annular space **4** at that spot.

The sealing member shown in FIG. 4 is a tube **30** similar to that of FIG. 1, except that the central top and bottom portions of the tube in FIG. 4 are clamped tightly together at each hanger rod **31** (instead of being vertically spaced apart, as in FIG. 1) between ring bar **23** beneath the tube and clamping nuts **32** on a threaded portion of the hanger rod. This construction partitions the tube radially into two nearly separate concentric lobes **33** and **34**. However, the two lobes are not sealed from each other between hanger rods, so that fluid may be transferred from one lobe to the other under various operating conditions. In the embodiment of FIG. 4, the hanger rods preferably project well below ring bars **23**; and on the lower ends of those rods are mounted washers **36** and nuts **37** for clamping the lower edge of a continuous scuff band **38**, provided with eyelets **39** through which the hanger rod passes. The scuff band extends around the outer lobe **33** of the sealing tube in contact with the

tank shell and has its upper edge, also provided with eyelets, similarly clamped. The scuff band tends to limit the vertical displacement of the outer lobe **33**, acting as a hold-down when the roof is moving downwards. In the absence of a scuff band, the same hold-down function can be obtained from a series of straps, attached to the hanger rods in the same way as the scuff band. Again, if the scuff band is made of a ribbed fabric with the ribbing **41** etxending horizontally, it will tend to reduce the capillary flow of stored liquid along the tank shell wall. The scuff band, being more resistant to wear than the fabric of the tube, may be used to advantage (with the seal of FIG. 1, as well as that of FIG. 4) in storage tanks having relatively rough inner tank shell surfaces, such as gunnited tanks, that are likely to abrade the more delicate fabric of the sealing tube itself. The scuff band is needed, if at all, only around the outer lobe of the tube, because that lobe alone slides relative to an adjacent surface (the tank shell). The seal moves with the roof, so that there is no relative sliding movement between the inner lobe and the roof wall.

The seal shown in FIG. 4 acts essentially in the same way, under similar conditions, as that of FIG. 1, already described. Each seal is characterized by its capacity to accommodate large variations in the width of the annular space between the roof and tank shell, produced either by lateral shifting of the roof or by out-of-roundness of the shell, without reducing the effectiveness of the seal. Further, the means for supporting the seal from the rim of the roof permits the seal to be installed, or removed for inspection or repair, from the roof deck **42**. It will be understood, of course, that the hanger rods, which also act as holddowns for the tube seal, will have a length determined by the height of liquid **2** in the annular space **4**, this height being a function of the displacement of the tank roof.

According to the provisions of the patent statutes, we have explained the principles of my invention and have illustrated and described what we now conisder to represent its best embodiment. However, we 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.

We claim:

1. In a floating roof storage tank, a seal for sealing the annular space between the roof and tank shell, comprising a flexible tube disposed in the annular space, tube suporting means that include circumferentially spaced hanger rods each having one end pivotally connected to the roof and having the other end passing through top and bottom portions of the tube and connected to a horizontal ring bar underlying and supporting the tube between adjacent hanger rods, the ring bar dividing the bottom portion of the tube into two normally depending lobes, said tube supporting means extending from the wall of the roof into the annular space a radial distance less than the minimum lateral thickness of the tube when fully compressed laterally, thereby to permit maximum lateral displacement of the roof relative to the shell by limiting such displacement solely by compression of the tube, and liquid within the tube to maintain its sides in sealing contact with the roof and shell.

2. Apparatus in accordance with claim 1, in which the top and bottom portions of the tube are clamped together at each hanger rod.

3. Apparatus according to claim 1, in which the top and bottom portions of the tube are spaced apart vertically at each hanger rod.

4. Apparatus according to claim 1 that also includes means for vertically spacing the top portion of the tube from the bottom portion at each hanger rod and means for preventing intermixing of liquid stored in the tank and liquid contained in the tube.

5. Apparatus according to claim 1 in which the hanger rods act as a hold-down for the tube as a whole and in which additional hold-down means are provided for the outer lobe and adjacent outer portions of the tube.

6. Apparatus according to claim 5, in which the additional hold-down means comprise a scuff band having an edge secured to the hanger rods above the tubular seal and having the other edge secured below the horizontal ring bar, the scuff band overlying the radially outermost lobe and an adjacent upper part of the tubular seal.

7. Apparatus according to claim 1, in which each hanger rod is connected to the roof by a laterally extending ear connected to the upper end of the rod, the roof having an opening for receiving the free end of the ear, and pin means inside the roof pivotally connecting the free end of the ear to the roof.

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