Aug. 7, 1951 A. S. FEILD 2,563,016

FLOATING ROOF STORAGE TANK

Filed Jan. 11, 1947 3 Sheets-Sheet 1

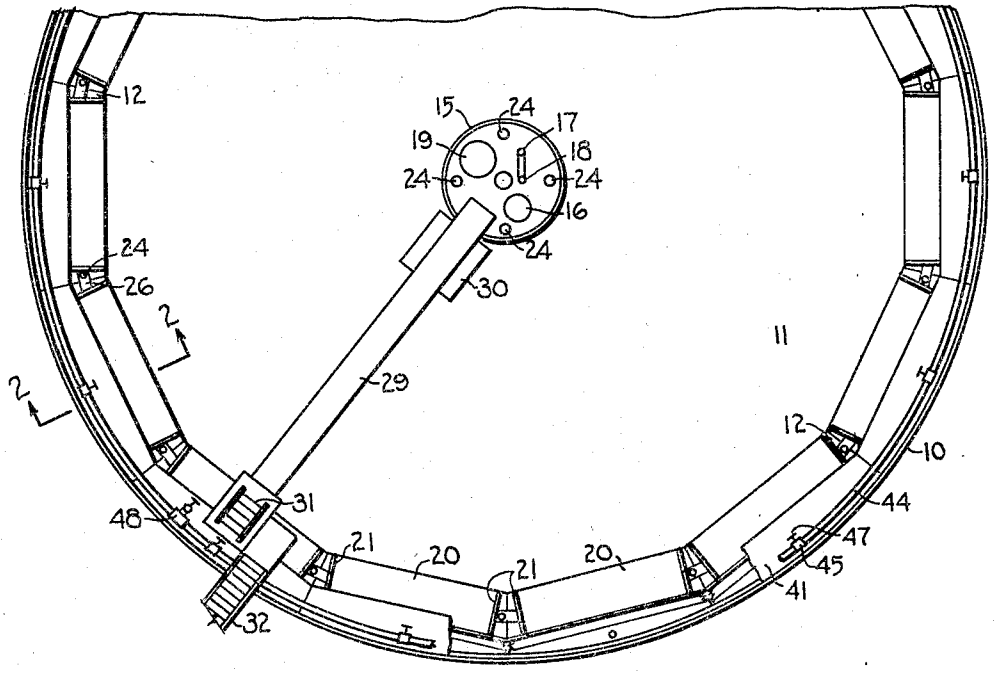


Fig. 1

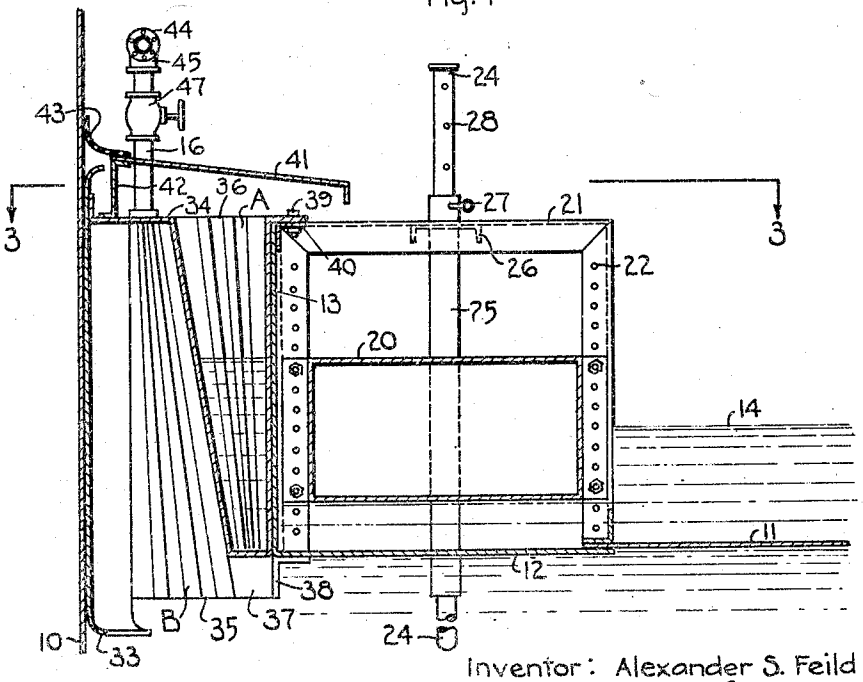


Fig. 2

Inventor: Alexander S. Feild

By his Attorney: Oswald H. Milmore

Aug. 7, 1951 A. S. FEILD 2,563,016

FLOATING ROOF STORAGE TANK

Filed Jan. 11, 1947 3 Sheets-Sheet 2

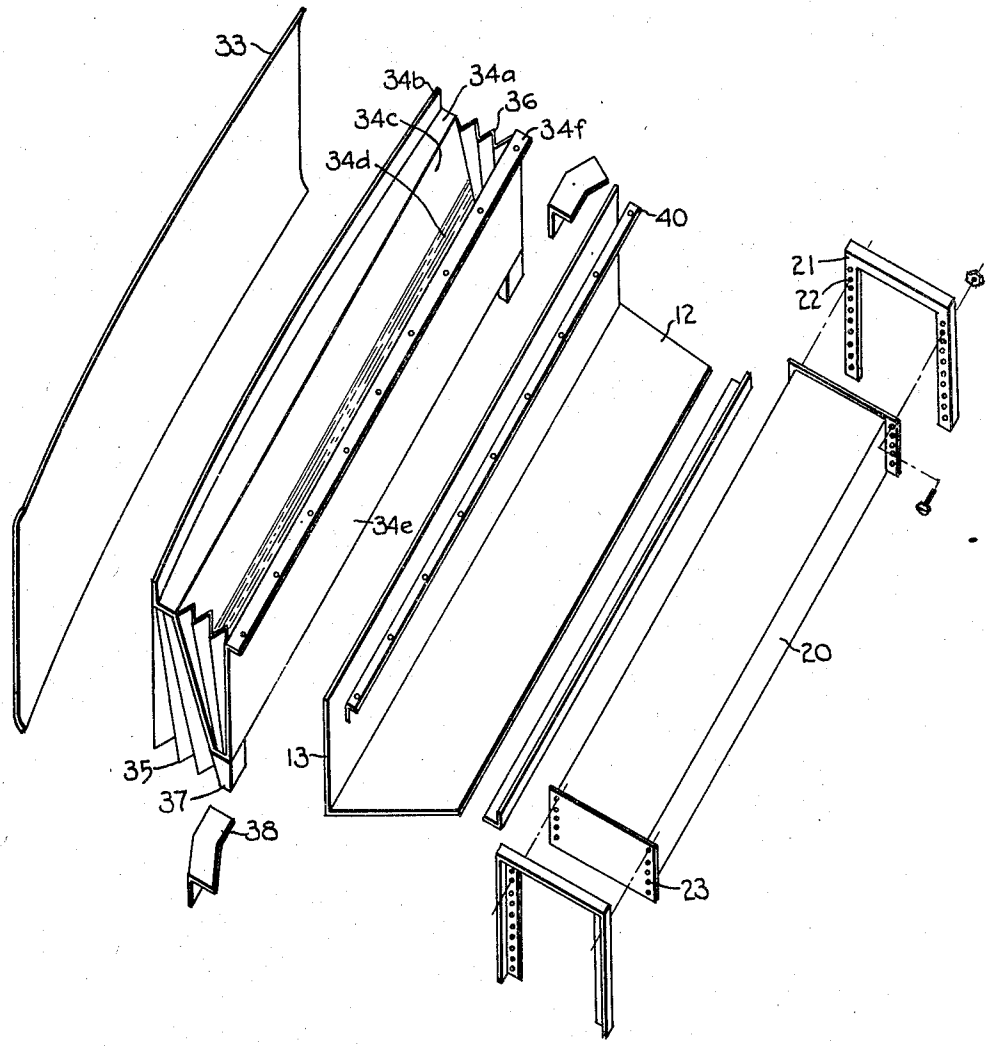


Fig. 4

Inventor: Alexander S. Feild

By his Attorney: Oswald J. Milmore

Aug. 7, 1951 A. S. FEILD 2,563,016

FLOATING ROOF STORAGE TANK

Filed Jan. 11, 1947 3 Sheets-Sheet 3

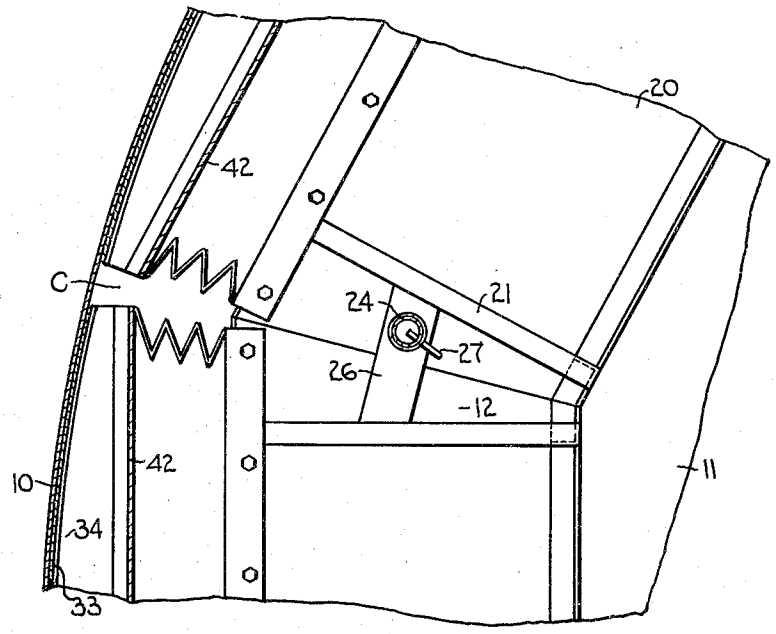


Fig. 3

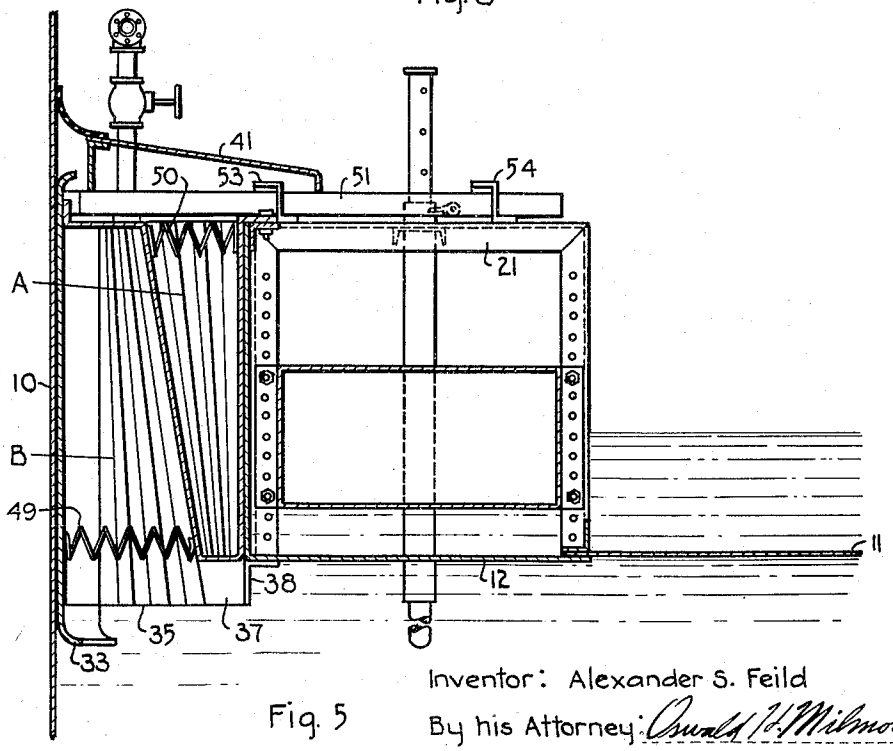


Fig. 5

Inventor: Alexander S. Feild

By his Attorney: Oswald J. Milmore

Patented Aug. 7, 1951 2,563,016

UNITED STATES PATENT OFFICE

2,563,016

FLOATING ROOF STORAGE TANKS

Alexander S. Feild, Houston, Tex., assignor to Shell Development Company, San Francisco, Calif., a corporation of Delaware

Application January 11, 1947, Serial No. 721,629

15 Claims. Cl. 220—26)

1

This invention relates to storage tanks suitable for storing volatile liquids, such as gasoline and other petroleum products, of the type having a roof floating on the stored liquid and vertically movable within the tank shell to change the storage space as the stored liquid is introduced into or drained from the tank. The instant invention is, more particularly, concerned with the structure between the tank wall and the floating roof provided to seal the annular space around the roof against evaporation losses and for centering the floating roof within the tank shell.

Storage tanks of this type are commonly circular and are provided with circular floating roofs having diameters smaller than the inside diameter of the tank, leaving an annular space between the tank and the floating roof. Friction means, such as a plurality of shoes or runners, supported by the roof, are urged yieldably outwardly against the tank wall, and a flexible septum, made of impregnated fabric, or of natural or synthetic rubber seals the space between the friction means and the roof, this space being variable due to the yieldable arrangement.

Such septa are curved around the roof and the flexure occurring as the width of the annular space varies is not along straight lines, but along a curve or along a number of short and irregular creases. It is, therefore, not feasible to employ more durable materials, such as metal, for the septa with the constructions now in use. Sealing means containing such septa have been found to be expensive and difficult to maintain and repair because the flexible septa are subject to rapid deterioration due to weathering and the action of corrosive vapors from the stored liquid. They are also fire hazards because such fabrics and other flexible materials are destroyed by fire, and a fire at one point on the rim of the roof usually spreads all around the rim.

It is an object of this invention to provide a seal for a floating roof which can be constructed entirely of fire-proof and durable material, such as metal or similar resilient material, although the invention is directed to the arrangement of parts whereby such materials of construction may be utilized, and is not to be limited to the use of such materials. Ancillary to this object, it is a purpose to provide a sealing arrangement between a sealing shoe and the tank comprising durable material, such as metal or plastic, wherein relative motion is made possible by bending the durable material along one or more straight hinge lines and permitting hinge-like movement

2

about said lines, either by constructing the seal out of resilient material which will flex along said hinge line or lines, or by providing vapor-tight hinges along such lines.

It is a further object of the invention to provide an improved sealing arrangement for floating roof storage tanks which will center the roof within the tank shell by automatically providing an increased horizontal thrust between the roof and the portion of the tank shell toward which the roof has been displaced, whereby it is not necessary to provide rigid vertical columns within the tank. A subsidiary object is to center the roof within the tank by means of hydraulic pressure.

A further object is to provide sectional sealing elements for floating roof storage tanks that are readily removable and replaceable individually without draining the tank of its stored liquid.

Still another object of the invention is to provide sealing elements for floating roof storage tanks that utilize the pressure of vapors generated from volatile stored liquid to urge the sealing shoes against the tank wall. Ancillary to this object, it is an object to provide means for equalizing the pressure of the vapors acting upon different sealing elements, thereby obviating inequalities in pressures which would be created, for example, by differences in temperature at different points of the perimeter.

Another object of the invention is to provide a floating roof storage tank in which the force urging the shoes against the tank wall can be easily regulated, and in which excess vapors acting upon the sealing elements can be vented.

A further object of the invention is to provide a sealing element for a floating roof storage tank comprising a sectional shoe pressed against the tank wall by the combined action of vapors generated by the stored liquid and trapped within a bellows, and by an auxiliary pressure element comprising a bellows filled with a liquid.

Other objects of the invention will become apparent from the following description, taken together with the drawings, in which:

Fig. 1 is a plan view of a storage tank constructed according to my invention;

Fig. 2 is an enlarged fragmentary sectional view taken on line 2—2 of Fig. 1;

Fig. 3 is a fragmentary horizontal section view taken on line 3—3 of Fig. 2;

Fig. 4 is an exploded perspective view showing the parts of the sealing element;

Fig. 5 is a fragmentary vertical cross-sectional view, similar to Fig. 2, showing certain modifications.

It is an important feature of this invention to provide an improved sealing structure between the floating roof and the sealing shoe which engages the tank wall by joining the roof and shoe by means of a sealing sheet of durable material constructed to permit hinge-like rotation or flexure along straight lines. Such a sheet is fixed both to the sealing shoe and to the floating roof by vapor-tight connections, and, by flexing, permits the distance between the sealing shoe and the floating roof to vary, as is necessary to allow for irregularities in the shape of the tank wall.

Such sheets of durable material have straight hinge lines extending preferably tangentially to the outline of the floating roof. To cover the entire periphery of the roof they are arranged end to end in sections. It is not necessary to make the roof circular; in fact, another important feature of this invention is a polygonal construction of the floating roof, whereby the straight sealing sections can be mounted at the edges of the roof. The invention is not, however, limited to polygonal roofs, since it is possible to mount straight sealing sections on top of a circular roof.

Hinge-like motion along the straight hinge lines is most conveniently effected by making the sealing sheet of resilient or spring-like metal or plastic. The sealing sheet may, however, be constructed of several pieces of stiffer material and motion achieved by installing hinges at the hinge lines.

According to one embodiment of the present invention, a floating roof is sealed against the tank by a plurality of sectional sealing elements, each sealing element comprising a sealing shoe and a compartmented pressure seal provided with a sealing sheet corrugated to have straight flexure lines. In the specific embodiment described below, fourteen sectional sealing elements are used to seal the perimeter of the roof, but this number may be varied.

The sealing shoe may be of conventional form. The compartmented pressure seal comprises three longitudinal walls movably joined together so that the two outer side walls may be moved apart or brought nearer each other by substantially parallel motion, and arranged to form two compartments: One compartment is trough shaped, and is formed by a side wall and the medial wall; the other compartment is in the form of an inverted trough, and is formed by the other side wall and the medial wall. Each compartment has its ends closed by means of bellows. The walls are urged apart by means of fluids and/or spring or similar devices. One side wall is at the roof and the other at the sealing shoe, whereby the shoe is urged outwardly and the space between the roof and sealing shoe is sealed.

Referring to the drawing, the invention is shown applied to a storage tank having a circular side wall 10. The floating roof comprises a central portion 11, constructed of thin, resilient metal (it being understood that such portion would be constructed of many small sections or plates, joined together and may be provided with dams, not shown, to reduce wash of the water when the roof is tilted) and heavier marginal rim angles 12, having upright legs 13. The rim angles 12 give the roof a polygonal outline, and the upright legs 13 are joined together to provide a water-tight rim. Legs 13 should extend to above the hydrostatic head of the stored liquid to prevent overflow thereof from the annular space between the tank wall and the roof onto the roof deck.

The sealing elements may be applied to any type of floating roof, including roofs supported by pontoons floating on the stored liquid, and single-deck or double-deck roofs. The elements have been shown, in the drawings, as applied to a single-deck pressure roof, in which a layer of water, 14, is placed on top of the roof to weight it and to counteract the vaporization of the liquids. Such a roof may be provided with a circular stiffening angle 15 at the center, within which are mounted a manhole 16, water-supply and overflow pipes 17 and 18 (connected to a point outside of the tank by means of a flexible hose beneath the roof, not shown) and an emergency dump valve 19 for dumping water from the roof into the tank when the weight of the water becomes too great with respect to the pressure of the fluid stored within the tank. The details of these valves and of the water-supply and drainage systems are shown in greater detail in my copending application Ser. No. 721,630, filed January 11, 1947.

Because of the greater weight of the stiffened rim angles 12 and the pressure elements, such a floating roof would tend to bulge upwardly in the center, were not some provision made to balance the loads. This balance is effected by providing pontoons 20 over the angle rims, secured by inverted U-frames 21. As is seen from Fig. 4, the height of the pontoon can be adjusted by bolting the pontoon at any height on the frames 21 by passing bolts through the holes 22 of the frame and holes 23 provided in the end flange plates of the pontoons. By lowering the pontoons a greater submergence in the water 14 and a correspondingly greater lift on the rim angles 12 is provided. The pontoon construction and balancing of loads is more fully described and claimed in the aforesaid copending application.

To support the roof on the tank bottom when the tank is drained, a plurality of legs 24 is provided, four being shown within the stiffening angle 15 and one between each pair of adjacent pontoons. The legs are vertically adjustable and slide within a telescoping tube 25 (see Fig. 2) extending through and sealed to the rim angle 12. Rigidity is insured by mounting channel bars 26 between adjacent frames 21 and welding the tubes 25 into holes therethrough. The height of the legs 24 may be adjusted by inserting a pin 27 through a transverse hole in the tube 25 and through any one of the holes 28 in the leg. The vertical thrust is carried partly by the frame 21 and partly by the direct connection between the tube 25 and the rim angle 12. 29 is a gangway, supported by rectangular pontoon 30 and by the upright leg 13 of one of the angle rims 12. 31 and 32 are ladders.

Turning now to the novel sealing elements with which this invention is particularly concerned, each sectional sealing element comprises a sealing shoe 33 curved to fit against the tank wall and having the top and bottom edges turned inwardly to ride over irregularities of the wall. The compartmented pressure seal includes a sealing sheet or plate 34 of resilient metal folded and shaped as follows: The outer horizontal shelf 34*a* has the general shape of a segment of a circle, and has an upturned flange 34*b*, curved to fit

the curvature of the sealing shoe. The sealing shoe is attached to the plate by welding to the flange **34***b*. At the inner edge of the shelf the plate is folded downwardly to provide the medial wall **34***c*. At the bottom two approximately right-angle folds provide a narrow width of floor **34***d*. The width of this floor and the width of the shelf **34***a* are such as to accommodate the bellows (to be described). The inner rising portion **34***e*, forming the inner wall, has a flange **34***f* at its top. It will be seen that a trough or inner compartment A is formed between the inner wall **34***e* and the medial wall **34***c*, and that an inverted trough or outer compartment B is formed between the medial wall **34***c* and the inner face of the sealing shoe **33**.

The fold between the outer shelf and the medial wall and at least one (preferably both) of the folds between the medial wall and the inner wall should be straight lines. This permits the outer wall or shoe to move away from or towards the inner wall with substantially parallel movement, primarily by flexure at the straight-line folds, some lesser amount of bending also taking place in the outer shelf, medial wall and floor. Such relatively parallel motion is necessary when the roof moves horizontally. Under certain conditions, however, a limited degree of angular motion between the shoe **33** and the roof is required. This would occur, for example, when the roof is tilted by wind or uneven distribution of the water on its surface. It is apparent that the construction described is not restricted to parallel motion but permits also a limited angular movement.

While I have shown the inner and medial walls to be formed of the same piece **34** and the outer wall to be identical with the sealing shoe **33**, it is evident that any other arrangement of parts may be employed, and that the only essential requirement is that the walls have the relative motion described. Thus, a greater or a smaller number of parts may be employed, for forming the compartment walls, and hinges may be placed at the folds, if desired.

It will be seen that by providing a roof of polygonal instead of circular outline it becomes possible to achieve improved sealing between the tank wall and the floating roof, since durable materials such as metal can be flexed or hinged only along straight lines.

The ends of the compartments are provided with yieldable end closures, such as corrugated metal bellows **35** and **36**. They are welded or otherwise sealed against the walls of the compartments and the shelf and floor. As is seen from Fig. 2, the bellows **35** extend several inches below the level of the rim angle **12**. The inner margin of each bellows **35** is welded to a depending liquid seal plate **37**, attached to the bottom of the inner wall **34***e*. Liquid seal plates **37** from adjacent pressure seals are fitted closely together, so as to prevent the escape of vapors collected against the bottom of the roof into the space between adjacent pressure seals. To assist in closing the gap between such liquid seal plates **37** a short angle piece **38**, bent to conform to the angular displacement of adjacent pressure seals, may be mounted beneath the rim seal **12**. The outer face of the angle piece **38** abuts the inner faces of the plates **37**. The space may also be sealed by other means, such as gaskets or by a tongue-and-groove or chamfered joint between adjacent plates **37**.

The pressure seal is mounted on the roof by bolts **39** engaging an angle **40** permanently affixed to the leg **13** of the rim angle **12**. A rain shield **41**, constructed of thin, sheet metal is optionally provided to prevent rain water from entering the inner compartment A. The shield is supported by a Z-shaped rain gutter **42** mounted on the shelf **34***a* and extending the length of the shelf, whereby water seeping into the space above the shelf is prevented from flowing into the compartment A. Such water, occurring only in minor amounts, discharges into the space between adjacent sealing elements, as will be seen from Fig. 3. A curved shingle **43** engages the tank wall and leads water to the shed **41**; it is constructed of flexible material, such as rubber or fabric, although more durable materials may be employed. The rain shields **41** are constructed in sections corresponding to the sealing elements, there being an overlap between adjacent sections to provide a continuous shield.

A further optional feature of the pressure seal is the vapor pressure equalizer. It comprises an annular pipe **44** provided with a T fitting **45** over each outer compartment B, and connected to such compartments by riser pipes **46** and valves **47**. The T's **45** have bolted flanges to permit a section of the pipe **44** to be readily removed.

Water or other liquid is placed into each inner compartment A as shown. This liquid, acting over the entire length of each pressure seal, exerts a constant pressure tending to distend compartment A and the bellows **36**. This thrust is transmitted to the sealing shoe **33** mainly through the outer shelf **34***a*, and in part by the vapors in the compartment B, as described below. When the roof is fortuitously displaced toward one side of the tank the bellows are compressed, the walls of the compartment A on the side nearest the tank are brought nearer together, and the level of the liquid therein rises. This increased head results in an increased hydraulic pressure against the medial wall and a greater threat on the sealing shoe. Simultaneously, in the pressure seal at the diametrically opposite side, the roof has moved away from the tank wall, with the opposite effects, resulting in a lowering of the liquid level and a decrease in the horizontal thrust. These two effects conspire to impose a centering force on the roof.

The outer compartment B of the pressure seals are filled with vapors generated from the stored liquid. Because, in the construction described herein, these compartments are effectively and reliably sealed against the escape of vapors, a considerable pressure is built up therein, depending upon the volatility and temperature of the liquid. Some vapors are unavoidable formed beneath the floating roof, regardless of the pressure imposed on the stored liquid by the weighted roof. Such vapors are able to seep into the outer compartments B, passing beneath the floor **34***d* of compartments A, between the liquid seal plates **37** and the angles **38**. Such vapors cannot, however, pass into the space C (see Fig. 3) between sealing elements, because they are trapped by the liquid seal plates **37**, angles **38**, and the downwardly extending bellows **35**. Some evaporation losses are possible from the surface of the stored liquid in the spaces C, which are open to the atmosphere. In a typical tank having a diameter of 60 feet, each of these spaces is only about 10 sq. inches in area, and the fourteen spaces C around the rim of the roof present a total evaporation area of less than one square foot. This is less than 0.04% of the total area of the roof and is negligible.

The vapors in the outer compartments B urge the wall 34c and the sealing shoe 33 apart, thereby applying an even pressure against the outer wall throughout its height and length. When the liquid stored is highly volatile and a greater sealing force is required, the increasing pressure in the compartments B automatically results in a greater sealing pressure.

Because the sealing shoe 33 and the inner wall 34e are, in the usual horizontal movement of the roof, constrained to move substantially only in translation or parallel motion, it is evident that the distension of one compartment results in a corresponding distension of the other compartment. But the pressure of the vapors within compartment B is, under given conditions of volatility and temperature, more or less fixed, so that the increased thrust caused by a rise in the level of the liquid in the compartment A is transmitted largely through the shelf 34a. Thus, when the compartments are compressed to cause a rise in the liquid level in compartment A, the level of the stored liquid in compartment B is at first depressed, with a slight increase in pressure (assuming the valve 47 to be closed). When, however, the liquid is depressed to below the level of the liquid seal plates 37 the gas escapes and no further rise in vapor pressure occurs. Moreover, when the vapor pressure equalizer is installed and the valve 47 is open the gas will escape through the pipes 44 and 46 to enter a compartment on the diametrically opposite side of the tank.

The horizontal centering thrust created by the liquid in the compartments A can be regulated by filling them with a greater or smaller amount of liquid. The pressures in the compartments B are equalized by the vapor pressure equalizer, thereby automatically permitting the flow of gas from the side of the tank exposed to the heat of the sun. The maximum pressure may be regulated by a pressure relief valve 48.

The sealing elements can be easily removed for repair and replaced without draining the tank. To remove a sectional element, all valves 47 are closed, and two sections of the pipe 44 are removed at the flanges of the T fittings 45 of the section to be removed and at adjacent sections, after which the openings at the adjacent sections may be closed by blanks and the other valves 47 again opened. The bolts 39 are removed, and the sectional sealing element lifted out of place.

I have found it to be desirable to construct all metal parts of corrosion-resistant material, such as aluminum.

Fig. 5 illustrates a modified arrangement of the sectional sealing element, the modifications whereof may be employed separately or in combination in the arrangement previously disclosed. A plurality of compression springs 49 are mounted in the lower part of the compartment B, urging the sealing shoe and the medial wall 34c apart. This is desirable under certain conditions when the vapor pressure is insufficient to apply an even pressure against the sealing shoe. A similar series of compression springs 50 is mounted in the compartment A; they may be used together with or in lieu of the liquid.

When the plate 34 is constructed of very lightweight material it may not have sufficient strength to support the shoe 33. In such case it is desirable to provide a separate support for the shoe. This is effected by means of a pair of horizontal beams, one for each end of the shoe. One of such beams is shown in Fig. 5 at 51, secured to the sealing shoe 33 at 52, and passing beneath the rain gutter 42. The beam has a close fit with this gutter to prevent the flow of water through the hole. The beam is slidably supported by means of angle bar 53 and 54 mounted on the frames 21.

The beams 51 are, further, useful in connection with the use of the springs 50, not for supporting weight of the shoe 33, but for depressing it. The pressure of the vapors within the compartment B exert a considerable lifting force, which is, in the embodiments previously described, counteracted by the weight of the liquid in the compartment A. When, however, springs 50 are used in lieu of the liquid, it is necessary to urge the shoe downward. This is achieved by the beam 51.

Many modifications in the construction and arrangement of parts will be apparent to those skilled in the art without departing from the spirit and scope of the invention.

I claim as my invention:

1. In a floating roof tank, a sealing element comprising a curved sealing shoe engaging the wall of the tank, a substantially horizontal, segmental shelf having its curved, outer portion secured and sealed to the inner face of the sealing shoe, a sealing sheet of resilient material joined directly to the inner chord of said shelf to form a first straight hinge line at said chord and extending downwardly therefrom to the roof and sealed thereto along a second straight hinge line, arranged so that the distance between the shoe and the roof may be varied by hinge-like movement about said hinge line, and means urging the upper part of the sealing sheet rotatively outwardly from the roof about said second hinge line, said shelf being made of resilient material affording sufficient rigidity to transmit a horizontal thrust outwardly from said sealing sheet to the sealing shoe.

2. In a floating roof tank, a sealing element comprising a sealing shoe engaging the tank wall and a compartmented pressure seal connecting said shoe and the roof and comprising a sealing sheet sealed to said shoe and roof shaped to provide a horizontal upright trough and a horizontal inverted trough horizontally adjacent to said upright trough and having straight hinge lines parallel to the length of the troughs, and yieldable closure means at the ends of both troughs.

3. In a floating roof tank, a sealing element comprising a sealing shoe engaging the tank wall and a compartmented pressure seal connecting said shoe and the roof, and comprising a sealing sheet of resilient material folded along straight lines to provide a horizontal upright trough and a horizontal inverted trough horizontally adjacent to and having a common wall with said upright trough and having hinge lines along said folds, and yieldable closure means at the ends of both troughs.

4. In a floating roof tank, a sealing element comprising a sealing shoe engaging the tank wall and a compartmented pressure seal connecting said shoe and the roof, and comprising a sealing sheet of durable material sealed to said shoe and roof shaped to provide a horizontal upright trough and a horizontal inverted trough horizontally adjacent to and having a common wall with said upright trough and having straight hinge lines parallel to the length of the troughs, and corrugated bellows of durable material at the ends of both troughs.

5. In a floating roof tank, the combination of a circular tank, a floating roof, sectional sealing elements closing the space between the tank wall and the roof comprising sealing shoes engaging the tank wall and a compartmented pressure seal connecting said shoe and the roof containing a sealing sheet of substantially rigid material shaped to provide a horizontal upright trough and a horizontal inverted trough horizontally adjacent to said upright trough and having straight hinge lines parallel to the length of the troughs and yieldable closure means at the ends of the troughs, and a vapor pressure equalizer comprising conduit means connecting the inverted troughs of the several sectional sealing elements.

6. The combination according to claim 5 in which the upright trough contains liquid, to a level to wet a substantial portion of the side walls of the trough whereby the liquid exerts an increasing pressure against the walls of the trough tending to urge said walls apart as the distance between said walls is decreased and produces a variable thrust tending to center the roof within the tank.

7. The combination according to claim 5 in which the upright trough contains compression springs arranged to urge the walls of the trough apart, thereby producing a variable thrust tending to center the roof within the tank.

8. In a floating roof tank, a sealing element comprising a curved sealing shoe engaging the tank wall and a pressure seal connecting the sealing shoe and the floating roof, said pressure seal comprising a substantially horizontal, segment-shaped shelf having its curved, outer portion secured and sealed to the inner face of the shoe, a first wall extending downwardly from the inner chord of said shelf and movable about a straight hinge line at said chord to form an inverted trough with said shelve, a second wall rising from a lower portion of said first wall and secured to the floating roof, said second wall being sealed to said first wall to form an upright trough therewith, said troughs being horizontally adjacent, said second wall being movable with respect to said first wall about a straight hinge line to permit the distance between the walls of the troughs to change by movement about said hinge lines, and yieldable means closing the ends of both troughs.

9. The sealing element according to claim 8 in which the shelf and the first wall are made of the same piece of resilient, durable material.

10. In a floating roof tank, a sealing element comprising a sealing shoe engaging the wall of the tank, a compartmented pressure seal connecting said shoe and the roof comprising a sheet of resilient, durable material attached rigidly to the upper part of the shoe and folded downwardly to provide a downwardly extending wall and form an inverted trough between the shoe and the said downwardly extending wall, said sheet being further folded upwardly to provide an upwardly extending wall and form an upright trough between said downwardly and upwardly extending walls, said upwardly extending wall being sealed to the floating roof, and corrugated bellows closing the ends of both troughs.

11. In combination with the sealing element according to claim 10, a beam mounted on the floating roof secured to the sealing shoe to give vertical support thereto.

12. In combination with the sealing element according to claim 10, a pool of liquid in the upright trough, to a level to wet a substantial portion of the side walls of the trough whereby the liquid exerts an increasing pressure against the walls of the trough tending to urge said walls apart as the distance between said walls is decreased, and produces a variable thrust tending to center the roof within the tank.

13. In combination with the sealing element according to claim 10, compression springs in the upright trough arranged to urge said downwardly and upwardly extending walls apart, thereby producing a variable thrust tending to center the roof within the tank.

14. In a floating roof tank, the combination of contact means engaging the tank wall, an upright sectional trough positioned between the tank wall and a peripheral part of the roof, said trough having substantially rigid walls throughout, the side walls being sealed together at the bottom of the trough along a straight hinge line permitting the upper parts of the side walls to move apart, said walls having connections above their bottom portions, one to the roof and the other to said contact means, and at least one of said connections being along a straight hinge line parallel to said hinge line at the bottom of the trough, whereby the upper portions of said walls are movable towards and away from each other by movement about said parallel hinge lines and are arranged to exert an outward thrust from the roof to said contact means when the said walls are forced apart, and means urging said walls apart with a force which increases as the distance between said walls is decreased.

15. The combination according to claim 14 in which the said means urging the walls apart comprises a body of liquid in said trough having a level to wet a substantial portion of the side walls of the trough, whereby the liquid exerts an increasing thrust against the walls of the trough as the distance between said walls is decreased.

ALEXANDER S. FEILD.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,426,998	Leland et al.	Aug. 22, 1922
1,592,244	Wiggins	July 13, 1926
1,775,758	George	Sept. 16, 1930
1,854,535	Wiggins	Apr. 19, 1932
1,930,953	Hampton	Oct. 17, 1933
2,244,782	Jones	June 10, 1941
2,282,772	Wiggins	May 12, 1942
2,314,805	Wiggins	Mar. 23, 1943