July 11, 1961 J. H. WIGGINS 2,991,901

HYDRAULICALLY ACTUATED FABRIC SEAL WITH PULL-DOWN AND PUSH-OUT MECHANISMS

Filed July 10, 1959 3 Sheets-Sheet 1

FIG_1

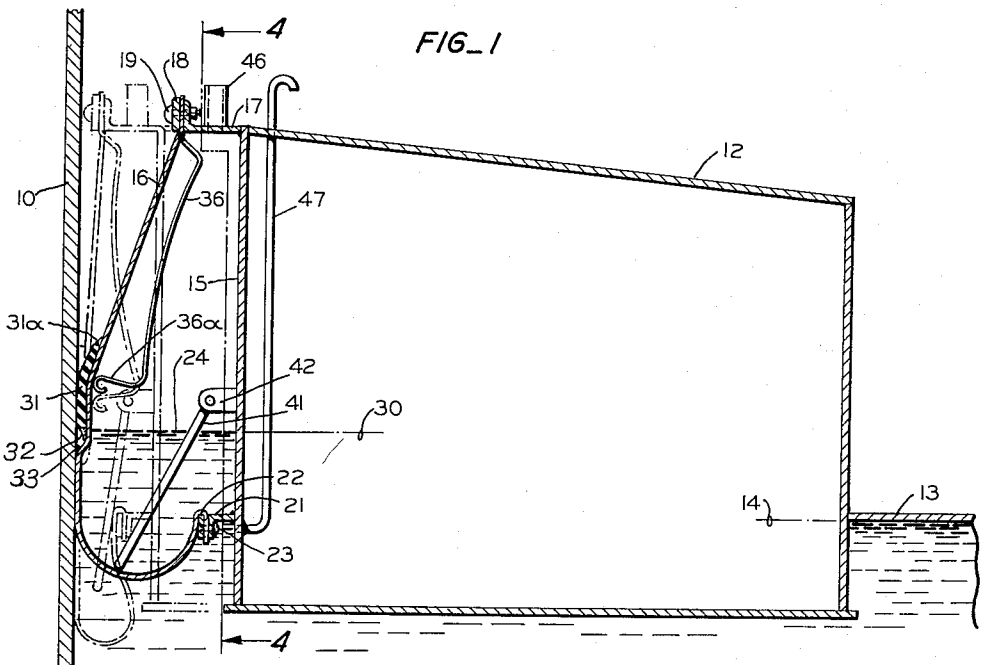


FIG_2

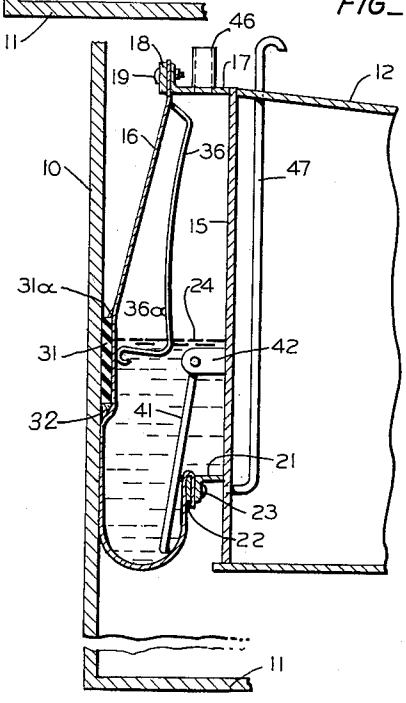
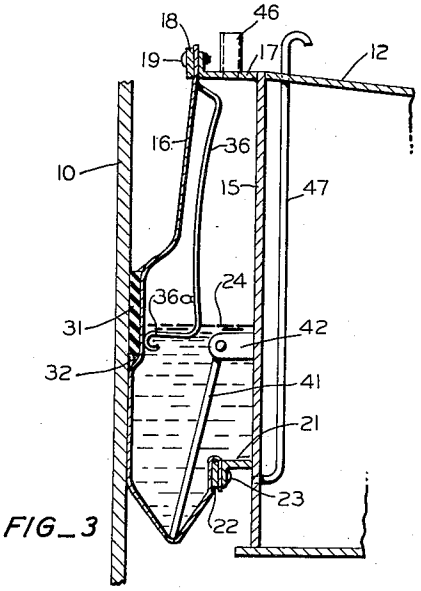


FIG_3



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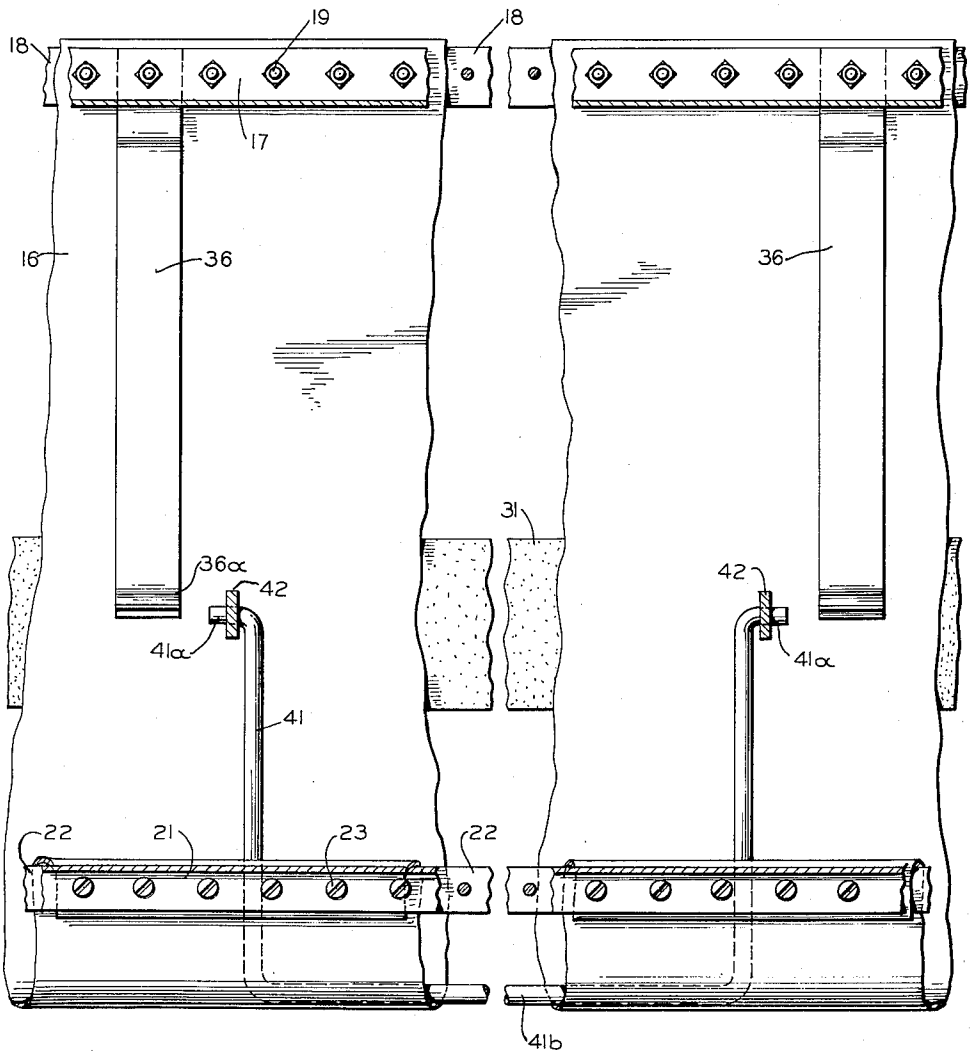
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HYDRAULICALLY ACTUATED FABRIC SEAL WITH PULL-DOWN AND PUSH-OUT MECHANISMS

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FIG_4



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HYDRAULICALLY ACTUATED FABRIC SEAL WITH PULL-DOWN AND PUSH-OUT MECHANISMS

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FIG_5

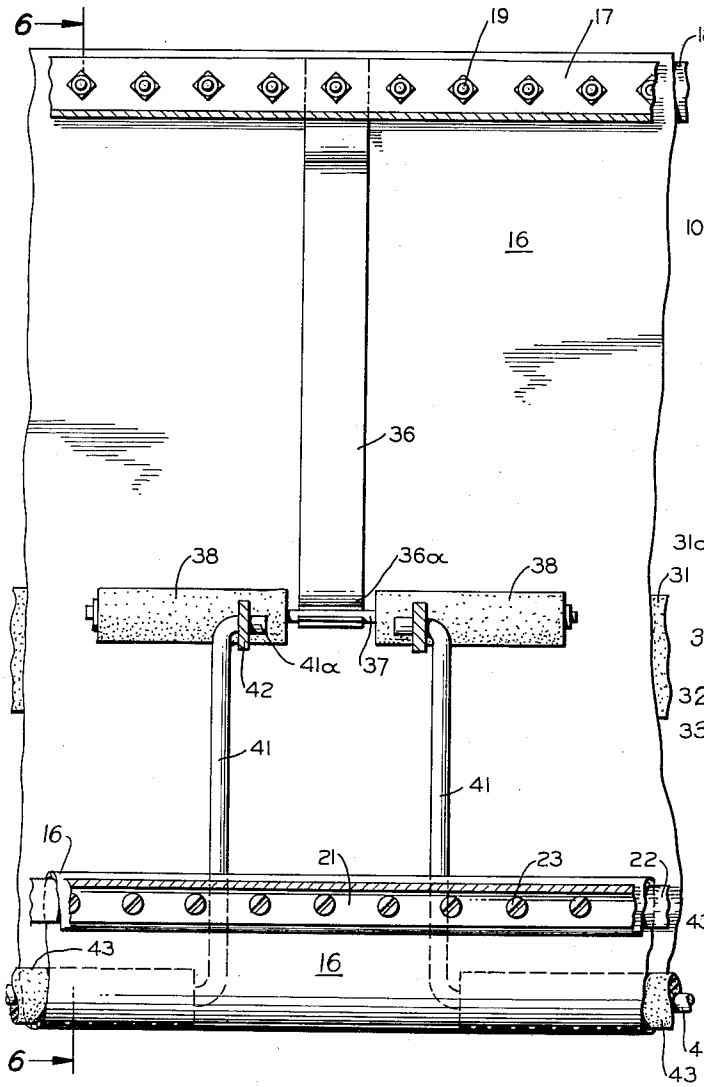
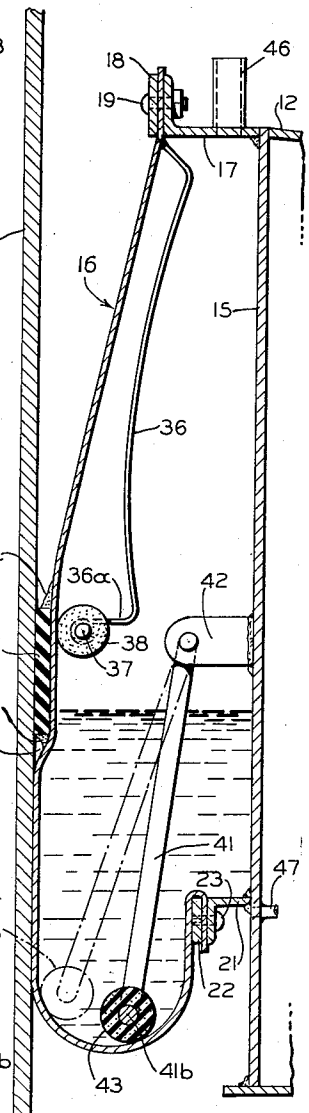


FIG_6



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2,991,901

HYDRAULICALLY ACTUATED FABRIC SEAL WITH PULL-DOWN AND PUSH-OUT MECHANISMS

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9 Claims. (Cl. 220—26)

This invention relates to sealing mechanisms in a cylindrical storage tank for petroleum products, and the like, of the type having a floating roof, and is concerned more particularly with this type of sealing mechanism wherein the seal is suspended or supported on the floating roof to extend into the liquid in the tank and also to contact the side wall of the tank so as to minimize evaporation losses.

It is a general object of the invention to provide an improved sealing mechanism between the side wall and the floating roof of a storage tank for petroleum products and the like.

Another object of the invention is to provide a sealing mechanism of the above type which is of the so-called "wet" type so as to be hydraulically actuated in its sealing action.

A further object of the invention is to provide a sealing mechanism of the above character which is provided with automatically operable means to push the seal out toward the wall of the tank and maintain it in good sealing condition.

Still another object of the invention is to provide sealing mechanism of the above character in which means is provided to break any adherence between the wall and the seal which would interfere with free movement of the seal in response to changes of level of liquid in the tank.

A still further object of the invention is to provide sealing means of the above character in which the seal includes means to prevent capillary lift between the seal and the wall so that loss of liquid from this cause is minimized.

Still another object of the invention is to provide improved sealing means of the above character which is provided with means to insure a desired vertical distance of contact with the seal with the cylindrical tank wall.

Still another object of the invention is to provide a sealing mechanism of the above character in which the area of contact with the wall is made at least in part by a reinforced structure so as to insure long life.

A still further object of the invention is to provide a sealing mechanism of the above character constructed so that no explosive gas pockets can form or collect between the sealing mechanism and the surface of the stored liquid.

Other objects and advantages of the invention will be apparent from the following description of a preferred embodiment thereof, as disclosed in the accompanying description, taken in conjunction with the attached drawings, in which:

FIGURE 1 is a fragmentary vertical sectional view through a storage tank of the floating roof type incorporating the invention as the floating roof floats on the stored liquid. In this figure the full line position of parts shows the widest possible separation of the floating roof from the side wall of the tank, and the dotted line position of the floating roof is at its closest position to the side wall.

FIGURE 2 is a view similar to FIGURE 1 and illustrating the sealing mechanism with a normal gap between the cylindrical side wall of the tank and the side of the floating roof as positioned when the roof and sealing mechanism are ascending.

FIGURE 3 is another view similar to FIGURE 2 but illustrating another condition of the parts.

FIGURE 4 is a fragmentary elevational view taken in a plane indicated by the line 4—4 in FIGURE 1 passing through the sealing mechanism and looking toward the wall of the cylindrical tank, the view being shown as a developed view rather than as a true sectional elevation.

FIGURE 5 is a view similar to FIGURE 4 but illustrating a modified form of the invention.

FIGURE 6 is a sectional view similar to FIGURE 2 illustrating the modified form of the invention.

Referring to FIGURES 1 and 4 there is shown a storage tank for petroleum products or the like having a cylindrical upright side wall **10** and a bottom wall **11**. Within the cylindrical side wall **10** there is provided a roof of the floating type having an outer pontoon **12** of circular outline which occupies the outer fraction of the area of the tank, and is connected to a plate-like deck **13** which may cover the remainder of the surface area of the tank, a center pontoon sometimes also being provided. In this type of tank such as used for storing petroleum products, for example, the liquid level **14** of the tank is expected to rise and fall from time to time as the tank fills and empties and the roof of the present invention is designed to float on the liquid and to rise and to fall with the changes in liquid level. When storage of volatile liquids is contemplated, it is important that there be no escape of this liquid by volatilization and that there be no explosive gases trapped in the gap between the floating roof and the tank wall and it is for this purpose that the sealing mechanism as disclosed herein is provided.

The sealing mechanism of the instant invention is designed to prevent any space above the stored liquid which can trap an explosive mixture of air and vapor, and preferably comprises a hydraulically actuated or "wet" fabric seal which forms a downward loop between the rim **15** and the wall **10** and extends down into the liquid, and the fabric is attached to a side portion or rim of the floating roof and contacts the side wall at respective points which are below the liquid level in the tank. Means are provided within the seal to actuate the seal to insure positive and maximum vertical contact between the seal fabric and the tank wall, and to control the positioning of the seal fabric during the two sliding movements of the fabric relative to the side wall—the upward movement and the downward movement—as the roof moves vertically in response to changes in liquid level in the tank.

Referring to FIGURES 1 and 3, the sealing mechanism comprises generally an annular fabric **16** which has an upper line of attachment at one edge around the upper portion of the roof pontoon **12**, and at the lower edge portion thereof a lower line of attachment around the pontoon **12** so as to drape in proper fashion with reference to the outer wall **10** and the roof **12** and to provide a looped portion which when hydraulically actuated occupies the gap between the roof and the side wall and extends below the liquid level **14** of the tank as stated above. As seen in FIGURE 1, the upper edge portion of the fabric seal **16** is clamped between an angle **17** secured as by welding about the outer pontoon **12** adjacent to the upper edge thereof and extending radially outward to engage the fabric seal **16**, and a circular seal bar **18** secured in place by a plurality of fastening bolts **19**. Also as seen in FIGURE 1, the lower edge portion is clamped between a peripheral angle **21** secured as by welding about the periphery of the pontoon **12** at approximately the level of stored liquid of the tank, and a lower seal bar **22** which is secured and clamped in place by bolts **23**.

It will be noted that the fabric seal **16**, and the pon-

toon **12** form an annular chamber to hold the hydraulic seal actuating liquid **24** which urges the looped portion of the seal **16** yieldably against the side wall **10**.

Means is provided for absorbing the major portion of localized extra heavy wear on the seal **16**, and this means comprises an annular wear or scuff band **31** of fabric and rubber, which is vulcanized to the fabric seal, and is provided with a tapered upper end portion **31***a*. The wear band **31** may be a series of segments but preferably extends continuously about the fabric seal at the location immediately above the liquid level **30** of the hydraulic actuating fluid **24** for the seal. This wear band **31** may also be made of steel plates or a steel strip.

This annular wear band **31** has incorporated therein a means for preventing loss of liquid by capillary action in creeping up between the fabric seal **16** and side wall **10** of the tank; and this means for breaking the capillary lift, comprises a recessed lower portion **32** extending about the entire lower periphery of the wear band **31** and providing an annular recess **33** therein which is of sufficient width and height as to be several times the effective spacing for stopping capillary action.

Means are provided within the sealing chamber for the hydraulic actuating fluid for pressing an upper portion of the fabric seal yieldably against the side wall **10** of the tank. This means may comprise an annular series of spring members **36** (FIGURES 1 and 4) which are secured at their upper ends between the seal bar **18** and the angle **17**, and which extend downwardly and inwardly and then downwardly and outwardly, being provided at their lower ends with an outwardly extending portion **36***a* which contacts the seal **16** behind the wear band **31**. As shown in FIGURE 1 the seal contacting portion **36***a* has its end curved to present a smooth enlarged surface to the seal **16**. In this connection, if desired, the wear strip **31** may comprise a segmental annular series of members, the wear strips coinciding with the spring members **36** and **36***a* which may be spaced, for example, from two to four feet apart about the periphery of the storage tank.

If desired, the spring members **36** (FIGURES 5 and 6) may be provided with transverse rods **37** having respective enlarged portions **38** of synthetic rubber or steel for engaging and urging the fabric seal **16** toward the side wall, thus reducing the unit pressure and distributing the pressure substantially continuously around.

It will be noted that this auxiliary means for urging the fabric out toward the tank wall also tends to hold the floating roof in the tank center, as well as increasing the height of the contact area between the fabric of the seal and the wall of the tank.

The sealing mechanism also includes means for causing the fabric seal to move down with the floating roof when such action occurs, in effect pulling the fabric down at a lower portion thereof, if it should adhere to the tank wall by reason of friction or freezing. This means comprises an annular series of substantially U-shaped stays **41** (FIGURES 1 and 4), having their respective upper ends bent at **41***a* to pivotally engage in brackets **42** attached about the periphery of the pontoon **12**, and having a lower horizontal portion **41***b* disposed within the looped portion of the fabric seal. Upon downward movement of the floating roof, the portion **41***b* will engage the seal **16** as shown in FIGURE 3, and cause it to move downwardly with respect to the side wall breaking it free therefrom if any adherence is present.

If desired the loop or actuating portion **41***b* (FIGURES 5 and 6) of each stay **41**, may be supplied with an enlarged portion **43** of resilient material or of steel to increase the area of contact and to minimize wear on the fabric seal. This enlarged portion **43** may be formed of material of less specific gravity than the specific gravity of the liquid **24** within the seal **16**, and in this event will occupy the position shown in dotted lines in FIGURE 6.

The chamber formed between the fabric seal **16** and the pontoon roof **12** contains a non-explosive petroleum product, such as heavy oil, as the seal actuating liquid, but by virtue of osmosis through the rubber impregnated fabric of the fabric seal **16** certain volatile fractions may be incorporated in this petroleum during operation of the tank in storing such volatile liquid. To avoid the possibility of an explosive mixture being formed in the air space above the liquid level of the hydraulic actuating liquid in the seal, and to accommodate changes in volume of the seal as the volume varies during flexing of the fabric, vents **46** are provided in the angle **17** at the top, being spaced about the periphery of the roof and being protected from the weather by a suitable weather hood.

Referring to FIGURE 1 it will be seen that a vent pipe **47** leads from the space outside the rim **15** and below the angle **21** to the atmosphere above the floating roof **12**, so that any volatile constituents which may tend to accumulate in this annular space will be vented to the atmosphere and prevent the accumulation or trapping of an explosive mixture in this annular space. A suitable number of vents **47** are provided around the periphery of the floating roof **12**.

In operation of the seal, the normal position of the parts is illustrated in FIGURE 4 the full line view of the parts where the actuating liquid **24** is urging the looped portion of the seal, including the lower part of the scuff or wear band **31** against the side wall **10** of the tank. This area of contact is maintained yieldably down to the point of curvature adjacent to the bottom of the fabric seal **16**. The spring members **36** are contacting the fabric seal **16** behind the scuff or wear band **31**, so as to maintain a light sealing engagement at an upper part of the looped portion, the lower part of the looped portion actually entering the stored liquid in the tank **10** so as to prevent any space for accumulation of gas above the surface of the liquid.

The stays **41** normally may hang idly (or be gently held against the fabric) within the chamber formed by the fabric seal **16** and the floating roof **12**. The vents **46** maintain the gas in the space above the liquid **24** below an explosive mixture in content. The recess **32** serves to break up any capillary lifting action between the tank wall **10** and the seal **16**.

The condition of the parts will vary as the position of the floating roof varies with respect to the upright side wall **10**, from a maximum gap spacing as shown in full lines in FIGURE 1 to a minimum gap condition as shown in dotted lines in this figure. The spring members **36** pressing outwardly against the seal **16** tend to keep the floating roof **12** centered.

As the floating roof moves upward, the fabric slides upward along the wall and friction tends to pull the fabric down. This friction plus the weight of the seal is overcome by tension in the upper part of the fabric as shown in FIG. 2. This upper fabric part slants away from the wall and would pull a substantial area of the fabric out of contact with the wall, thereby decreasing the vertical contact of wall and fabric. The springs **36** overcome that slanted pull. The springs **36** also increase the vertical fabric-wall contact. Moreover, the springs **36** hold the entire floating roof in the geometric center of the tank.

As the roof movement changes direction the fabric must slide down the wall. Friction caused by (*a*) the pressure of springs **36** and (*b*) the hydraulic pressure of the liquid **24** inside the seal, tends to hold the fabric momentarily stationary relative to the wall. The weight of the liquid normally may not overcome the above friction until there is a downward pull exerted by the lower part of the fabric. Additionally, as an exaggerated condition, if the upper part of the seal is frozen to the wall by ice, the floating roof will have to descend so far before the lower part of the fabric pulls down, that the oil in the tank is exposed to atmosphere.

It is readily seen that the floating roof would have to descend several inches before it is positively certain that the fabric would pull down under which conditions there would be an air space between the wall at the lower part of the fabric and the surface of the stored petroleum product, for example, gasoline, thereby creating an evaporation and fire hazard.

This is where the swingable members **41** operate. If the fabric remains stationary relative to the wall while the floating roof moves down, say 1", the horizontal runs **41***a* of members **41** contact the fabric **16** at the bottom of the loop, the fabric straightens between that point and the wall and quickly pushes down on the bottom of the loop of the fabric and creates a downward pull to overcome friction or in an emergency to pull the fabric quickly away from ice that may be freezing the upper part of the fabric to the wall. In order to get almost instantaneous action by swingable members **41**, they may be very gently held just in contact with the lower part of the fabric by mechanical means such as springs, floats or counterweights.

Thus friction or freezing is overcome by both upward and downward movement.

The foregoing description of certain embodiments of the present invention has been made for clearness of understanding only and no unnecessary limitations are intended thereby, for it will be apparent to those skilled in the art that various modifications may be made in the present seal structure within the sphere and scope of the appended claims.

What is claimed is:

1. In a tank for storing liquids, such as petroleum products, including an upstanding substantially cylindrical side wall, and a floating roof arranged in said tank and including upstanding substantially cylindrical wall structure spaced radially inwardly from said tank side wall and defining an upstanding substantially annular space therebetween; sealing mechanism for said annular space comprising a substantially annular sealing element arranged in said annular space and carried by said wall structure and movable therewith with respect to said tank side wall, said sealing element being formed of flexible sheet-like material that is highly impervious to the constituents of petroleum products, an upper annular portion of said sealing element being sealed to an upper annular portion of said wall structure and a lower annular portion of said sealing element being sealed to a lower annular portion of said wall structure and an intermediate annular portion of said sealing element being looped between said upper and lower annular portions thereof to define an annular chamber between said sealing element and the adjacent annular portion of said wall structure, a plurality of circumferentially spaced-apart resilient members carried by the upper portion of said wall structure and depending therefrom and disposed in said chamber, the lower portions of said resilient members engaging an intermediate annular sealing section of said sealing element resiliently to urge the same into sliding sealed engagement with said tank side wall, and a plurality of circumferentially spaced-apart stays carried by the intermediate portion of said wall structure and depending therefrom and disposed in said chamber, the lower portions of said stays engaging a lower annular looped section of said sealing element and maintaining the same in submerged position with respect to the liquid stored in said tank and limiting upward relative movement of said sealing element with respect to said wall structure during downward movement of said roof with respect to said tank side wall.

2. In a tank for storing liquids, such as petroleum products, including an upstanding substantially cylindrical side wall, and a floating roof arranged in said tank and including upstanding substantially cylindrical wall structure spaced radially inwardly from said tank side wall and defining an upstanding substantially annular space therebetween; sealing mechanism for said annular space comprising a substantially annular sealing element arranged in said annular space and carried by said wall structure and movable therewith with respect to said tank side wall, said sealing element being formed of flexible sheet-like material that is highly impervious to the constituents of petroleum products, an upper annular portion of said sealing element being sealed to an upper annular portion of said wall structure and a lower annular portion of said sealing element being sealed to a lower annular portion of said wall structure and an intermediate annular portion of said sealing element being looped between said upper and lower annular portions thereof to define an annular chamber between said sealing element and the adjacent annular portion of said wall structure, a plurality of circumferentially spaced-apart resilient members carried by the upper portion of said wall structure and depending therefrom and disposed in said chamber, a plurality of rollers respectively carried by the lower portions of said resilient members and engaging an intermediate annular sealing section of said sealing element to urge the same into sliding sealed engagement with said tank side wall, and a plurality of circumferentially spaced-apart stays carried by the intermediate portion of said wall structure and depending therefrom and disposed in said chamber, the lower portions of said stays engaging a lower annular looped section of said sealing element and maintaining the same in submerged position with respect to the liquid stored in said tank and limiting upward relative movement of said sealing element with respect to said wall structure during downward movement of said roof with respect to said tank side wall.

3. In a tank for storing liquids, such as petroleum products, including an upstanding substantially cylindrical side wall, and a floating roof arranged in said tank and including upstanding substantially cylindrical wall structure spaced radially inwardly from said tank side wall and defining an upstanding substantially annular space therebetween; sealing mechanism for said annular space comprising a substantially annular sealing element arranged in said annular space and carried by said wall structure and movable therewith with respect to said tank side wall, said sealing element being formed of flexible sheet-like material that is highly impervious to the constituents of petroleum products, an upper annular portion of said sealing element being sealed to an upper annular portion of said wall structure and a lower annular portion of said sealing element being sealed to a lower annular portion of said wall structure and an intermediate annular portion of said sealing element being looped between said upper and lower annular portions thereof to define an annular chamber between said sealing element and the adjacent annular portion of said wall structure, a plurality of circumferentially spaced-apart resilient members carried by the upper portion of said wall structure and depending therefrom and disposed in said chamber, the lower portions of said resilient members engaging an intermediate annular sealing section of said sealing element resiliently to urge the same into sliding sealed engagement with said tank side wall, a plurality of circumferentially spaced-apart stays carried by the intermediate portion of said wall structure and depending therefrom and disposed in said chamber, and a plurality of rollers respectively carried by the lower portions of said stays and engaging a lower annular looped section of said sealing element and maintaining the same in submerged position with respect to the liquid stored in said tank and limiting upward relative movement of said sealing element with respect to said wall structure during downward movement of said roof with respect to said tank side wall.

4. In a tank for storing liquids, such as petroleum products, including an upstanding substantially cylindrical side wall, and a floating roof arranged in said

tank and including upstanding substantially cylindrical wall structure spaced radially inwardly from said tank side wall and defining an upstanding substantially annular space therebetween; sealing mechanism for said annular space comprising a substantially annular sealing element arranged in said annular space and carried by said wall structure and movable therewith with respect to said tank side wall, said sealing element being formed of flexible sheet-like material that is highly impervious to the constituents of petroleum products, an upper annular portion of said sealing element being sealed to an upper annular portion of said wall structure and a lower annular portion of said sealing element being sealed to a lower annular portion of said wall structure and an intermediate annular portion of said sealing element being looped between said upper and lower annular portions thereof to define an annular chamber between said sealing element and the adjacent annular portion of said wall structure, a plurality of circumferentially spaced-apart resilient members carried by the upper portion of said wall structure and depending therefrom and disposed in said chamber, the lower portions of said resilient members engaging an intermediate annular sealing section of said sealing element resiliently to urge the same into sliding sealed engagement with said tank side wall, a plurality of circumferentially spaced-apart stays carried by the intermediate portion of said wall structure and depending therefrom and disposed in said chamber, the lower portions of said stays engaging a lower annular looped section of said sealing element and maintaining the same in submerged position with respect to the liquid stored in said tank and limiting upward relative movement of said sealing element with respect to said wall structure during downward movement of said roof with respect to said tank side wall, and a body of seal-actuating liquid contained in the lower portion of said chamber and assisting said stays in maintaining the lower annular looped section of said sealing element in submerged position with respect to the liquid stored in said tank and in limiting upward relative movement of said sealing element with respect to said wall structure during downward movement of said roof with respect to said tank side wall.

5. The sealing mechanism set forth in claim 4, and further comprising means for venting to the atmosphere the upper portion of said chamber disposed above said body of seal-actuating liquid contained therein, so as to prevent the accumulation of any volatile products in the upper portion of said chamber.

6. In a tank for storing liquids, such as petroleum products, including an upstanding substantially cylindrical side wall, and a floating roof arranged in said tank and including upstanding substantially cylindrical wall structure spaced radially inwardly from said tank side wall and defining an upstanding substantially annular space therebetween; sealing mechanism for said annular space comprising a substantially annular sealing element arranged in said annular space and carried by said wall structure and movable therewith with respect to said tank side wall, said sealing element being formed of flexible sheet-like material that is highly impervious to the constituents of petroleum products, an upper annular portion of said sealing element being sealed to an upper annular portion of said wall structure and a lower annular portion of said sealing element being sealed to a lower annular portion of said wall structure and an intermediate annular portion of said sealing element being looped between said upper and lower annular portions thereof to define an annular chamber between said sealing element and the adjacent annular portion of said wall structure, a plurality of circumferentially spaced-apart resilient members carried by the upper portion of said wall structure and depending therefrom and disposed in said chamber, the lower portions of said resilient members engaging an intermediate annular sealing section of said sealing element resiliently to urge the same into sliding sealed engagement with said tank side wall, a plurality of circumferentially spaced-apart stays respectively pivotally connected at the upper portions thereof to the intermediate portion of said wall structure and depending therefrom and disposed in said chamber, so that said stays are mounted for pivotal movements in said chamber in response to sidewise movements of said roof with respect to said tank side wall, a plurality of rollers respectively carried by the lower portions of said stays and disposed in said chamber and engaging a lower annular looped section of said sealing element and maintaining the same in submerged position with respect to the liquid stored in said tank and limiting upward relative movement of said sealing element with respect to said wall structure during downward movement of said roof with respect to said tank side wall, and a body of seal-actuating liquid contained in the lower portion of said chamber and suberging said rollers and assisting said stays in maintaining the lower annular looped section of said sealing element in submerged position with respect to the liquid stored in said tank and in limiting upward relative movement of said sealing element with respect to said wall structure during downward movement of said roof with respect to said tank side wall.

7. The sealing mechanism set forth in claim 6, wherein said seal-actuating liquid has a specific gravity that is higher than that of the material of said rollers, so that said rollers are buoyed upwardly tending to pivot said stays radially outwardly in said chamber toward said tank side wall.

8. In a tank for storing liquids, such as petroleum products, including an upstanding substantially cylindrical side wall, and a floating roof arranged in said tank and including upstanding substantially cylindrical wall structure spaced radially inwardly from said tank side wall and defining an upstanding substantially annular space therebetween; sealing mechanism for said annular space comprising a substantially annular sealing element arranged in said annular space and carried by said wall structure and movable therewith with respect to said tank side wall, said sealing element being formed of flexible sheet-like material that is highly impervious to the constituents of petroleum products, an upper annular portion of said sealing element being sealed to an upper annular portion of said wall structure and a lower annular portion of said sealing element being sealed to a lower annular portion of said wall structure and an intermediate annular portion of said sealing element being looped between said upper and lower annular portions thereof to define an annular chamber between said sealing element and the adjacent annular portion of said wall structure, an annular scuff band carried by the outer surface of an intermediate annular section of said sealing element in facing relation with respect to the inner surface of said tank side wall, a plurality of circumferentially spaced-apart resilient members carried by the upper portion of said wall structure and depending therefrom and disposed in said chamber, the lower portions of said resilient members engaging the inner surface of the intermediate annular section of said sealing element resiliently to urge said scuff band into sliding sealed engagement with said tank side wall, and a plurality of circumferentially spaced-apart stays carried by the intermediate portion of said wall structure and depending therefrom and disposed in said chamber, the lower portions of said stays engaging a lower annular looped section of said sealing element and maintaining the same in submerged position with respect to the liquid stored in said tank and limiting upward relative movement of said sealing element with respect to said wall structure during downward movement of said roof with respect to said tank side wall.

9. The sealing mechanism set forth in claim 8, wherein said scuff band has an annular recess formed therein and disposed above the level of the liquid stored in said

tank, so as to interrupt the capillary lift of the stored liquid between said scuff band and said tank side wall.

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