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3,325,041

LAMINATED SEAL STRUCTURE FOR STORAGE TANKS
EMPLOYING FLOATING ROOFS

Filed Sept. 14, 1964

2 Sheets-Sheet 1

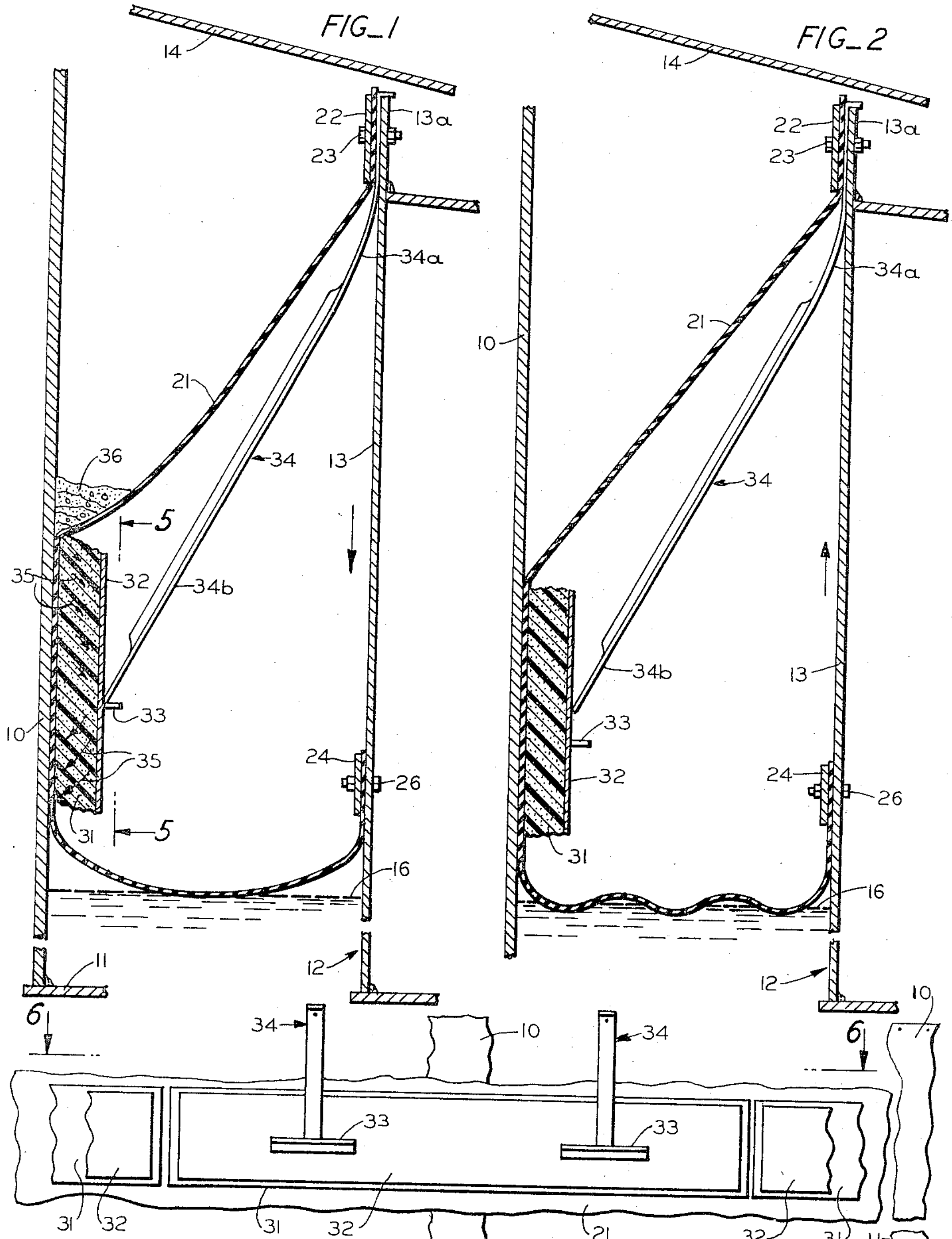

FIG_5

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FIG_3

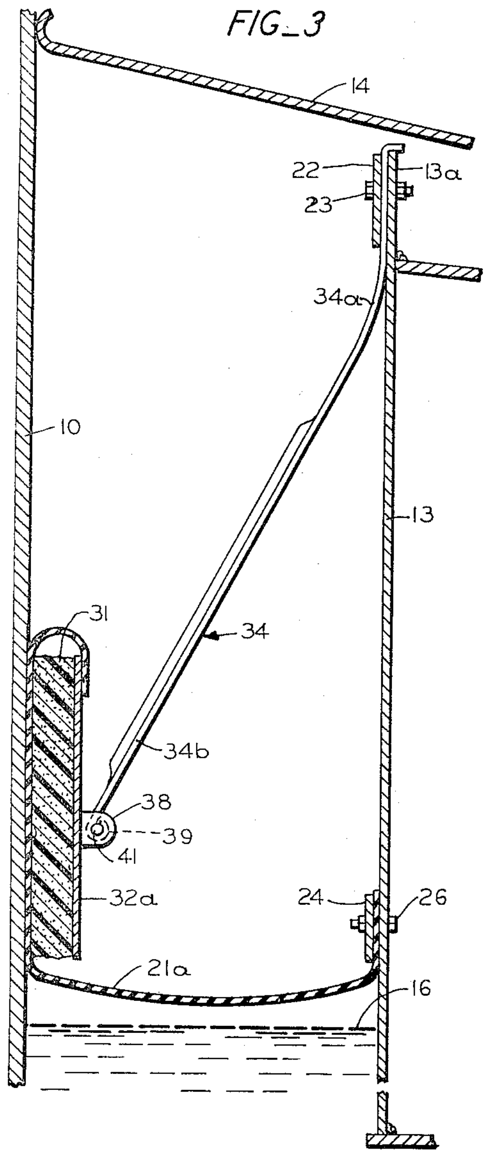


FIG_4

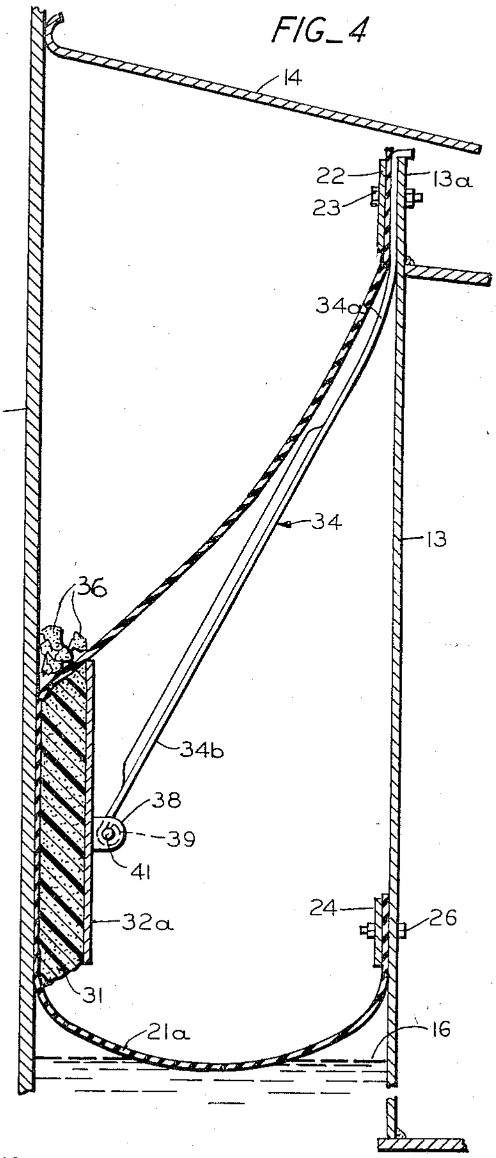


FIG_6

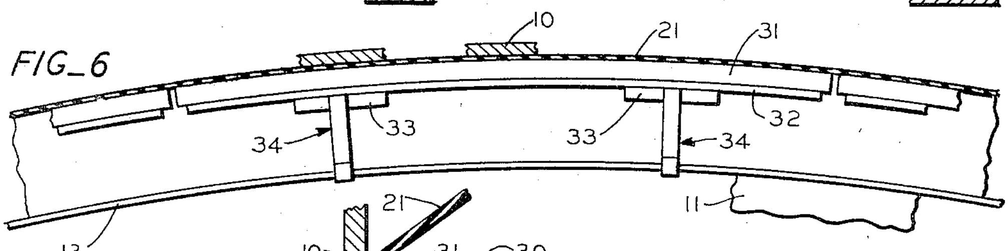
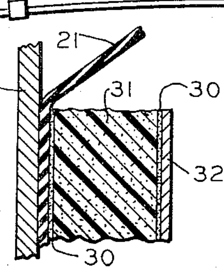


FIG_7



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LAMINATED SEAL STRUCTURE FOR STORAGE TANKS EMPLOYING FLOATING ROOFS

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The present invention relates to cylindrical storage tanks for petroleum products employing a cylindrical floating roof and is concerned more particularly with a sealing mechanism therefor wherein the seal is suspended or supported on the floating roof to extend into the liquid in the tank and to also be maintained in sliding contact with the side wall of the tank to minimize evaporation losses.

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

Another object of the invention is to provide a seal of the above character of low cost yet providing effective sealing action.

A further object of the invention is to provide a sealing mechanism of the above character which has multiple strata laminated construction at the sealing area to provide a yieldable annular sealing structure including a rugged foam stratum, which stratum acts at all times as a horizontal load or bearing distribution member by compression stress and acts intermittently as a vertical load transmission member by shearing stress whenever the floating roof moves up or down in the tank. Special conditions are when ice is broken or when the seal must ride over horizontal or vertical lines of rivets under which conditions the shearing stress may be very great.

Still another object of the invention is to provide a seal of the above character which has a supporting means from the floating roof and which has means for exerting pressure radially outwardly on the seal to urge it into engagement with the cylindrical tank wall, which seal provides for effective ice-breaking action or the like, both during the rising movement of the floating roof and during the lowering movement of the floating roof.

Further objects and advantages of the invention will be apparent from the following description of certain preferred embodiments thereof, as illustrated in the accompanying drawings, in which:

FIG. 1 is a fragmentary vertical sectional view through a storage tank of the floating roof type. In this figure the parts are shown with a wide separation of the floating roof and the side wall of the tank. The parts are also shown in the condition where the floating roof is descending with reference to the side wall of the tank;

FIG. 2 is a view similar to FIG. 1 but showing the parts as positioned when the floating roof is rising with respect to the side wall of the tank.

FIG. 3 is a view similar to FIG. 1 but showing a modified form of the structure wherein springs provide the sole supporting connection of the seal from the floating roof. In this view the seal is shown in stationary relation to the side wall of the tank.

FIG. 4 is a view similar to FIG. 1 but showing a further modified form with the parts positioned with the roof rising with respect to the side wall and with a pivoted spring connection to the shoe.

FIG. 5 is a fragmentary elevational view taken in a plane indicated by the line 5—5 in FIG. 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 true sectional elevation;

FIG. 6 is a fragmentary horizontal sectional view through the sealing mechanism and the wall of the tank with the view being taken as indicated by the lines 6—6 in FIG. 5;

FIG. 7 is a full size fragmentary sectional view of a portion of FIG. 2 illustrating details of the laminated seal construction.

Referring to FIGS. 1, 2 and 5, there is shown a storage tank for petroleum products and the like, including a cylindrical upright side wall **10** and a bottom wall **11** and a conventional floating roof having an outer pontoon **12**, including an outside cylindrical wall structure or rim **13**. The upstanding substantially cylindrical side wall **10** of the tank and the upstanding substantially cylindrical wall structure **13** of the floating roof define between them an upstanding substantially annular space which generally is covered by a conventional weather hood **14**. In this type of tank the liquid level **16** usually rises and falls from time to time as the tank fills and empties, and the roof is designed to float on the liquid and to rise and fall with it. When storing volatile liquids, it is important that the escape of this liquid by volatilization be minimized. Also, certain moisture can collect and freeze within the annular space above the sealing mechanism by condensation or rain leaking past the weather hood, making it necessary that the sealing mechanism break the ice which is formed between the seal and the side wall of the tank, both when the tank is rising and when the tank is falling. The sealing structure is also useful in riveted shells in moving over the lines of rivets and the shoulder formed by the adjacent overlapped plates of the shell.

The sealing mechanism of the instant invention is designed to accomplish the above general objects and also provides a "soft" sealing action by virtue of its bonded laminated or sandwich construction incorporating a resilient annular intermediate upright layer of a foamed plastic so that said construction is capable of transmitting vertical shearing force.

Referring to FIGS. 1 and 2, the sealing mechanism comprises generally an annular fabric **21** which has an upper circular line of attachment to the wall structure or rim **13** of the floating roof by means of a series of clamping plates **22** for securing the upper edge of the annular fabric **21** to an extension **13**a of the annular upright wall structure **13** by means of a series of bolts **23**. The lower edge of the fabric **21** is also secured to the wall structure **13** by a series of clamping plates **24** and clamping bolts **26**.

Referring to FIGS. 1, 2, 5 and 7, it will be seen that the annular fabric **21**, which may be a suitable rubberized fabric, for example, provides a loop between two lines of attachments to the floating roof, and within this loop and combined with the annular fabric **21** there are provided other portions of the annular bonded laminated or sandwich seal construction which provides an integral circumferentially limber structure. This seal includes a series of annular foam segments **31**, each of which is bonded to the fabric **21** by a layer **30** of cement or other suitable glue, as best shown in FIG. 7. Each resilient annular segment **31** is of a strength to transmit stresses therethrough both vertically as a shearing stress, for example, for breaking ice or riding over rivets, and horizontally as a compression stress, for example, to distribute the horizontal outward pressure on the bonded sandwich seal by the combined beam and column and spring and has associated therewith by gluing a flexible or circumferentially limber shoe or backing strip **32** which may be of metal or metal-like construction. Each strip **32**, as seen in FIG. 5, extends substantially throughout the length and height of the associated foam annular segment **31**. The foamed plastic segment **31** is also secured to this annular metal segment or shoe **32** by means of a layer **30** of cement or other appropriate bonding material, as best shown in FIG. 7, so that the three elements of the laminated seal structure, including the annular fabric **21**, a series of annular segments **31** of plastic foam, and a series of annular backing plates **32** for the annular segments **31** provide a bonded laminated seal construction for distributing the horizontal compression load applied to it throughout the surface or area of contact between the fabric **21** and the cylindrical wall **10**, and also for transmitting certain shear stresses vertically during the rising and descending of the seal with the roof.

Each metal backing member **32** (FIGS. 1, 5 and 6) is provided with one or more lips or ledges **33**, each of which is adapted to receive the lower end of a spring beam and column member **34** to provide a one-way drive. The members **34** extends upwardly and is attached to the upper edge of the annular wall structure **13** at its upstanding portion **13***a* by means of the calmping strips **22** and the bolts **23**. It will be seen that the lower end **34***b* of the spring and beam and column member **34** is free to move with respect to the laminated seal structure, both laterally and vertically, it being shown as transmitting downward thrust in FIG. 1 and as being free of its downward thrust transmitting function during rising of the roof, as shown in FIG. 2.

As seen in FIG. 1, moisture can collect and produce ice in cold weather, inside of the tank in the V-shaped crevice between the wall **10** and the fabric **21**, as shown at **36**, for example, and this ice must be broken to allow free movement of the roof and seal structures with respect to the cylindrical outer wall. When the roof is descending, as illustrated in FIG. 1, for example, it will be seen that the downward thrust transmitted by the spring and beam and column member **34** imparts a substantially clockwise moment to the sandwich-type seal structure, as indicated by the arrows **35**, so that the upper portion of the seal structure tends to pull away from the outer wall **10**, and the lower part of the seal structure is pressed more firmly against the outer wall. This action of pulling the upper part of the seal structure away from the wall **10** at the same time that the middle or foam layer of the seal is distorted, as shown in FIG. 1, pulls the fabric **21** downward and away from the ice indicated at **36**, and breaks the ice bond.

When the roof is rising, as shown in FIG. 2, there is no distortion of the seal structure, because there is no vertical shear in the foam at this time, and the ice indicated at **36**, is broken by the stretching of the fabric **21** under tension.

Referring to FIG. 3, there is shown a modified form of the invention wherein the annular fabric **21***a* is attached in the usual manner at its lower edge by means including the plates **24**, but has its upper edge looped over and cemented to the inner side of the backing members **32***a*. The backing members or shoes **32***a* are provided with pivot lugs **38**, which are connected to the spring and beam member **34***a* by a looped lower end **39** and a pin **41**. In FIG. 3 the roof is shown at rest, i.e., neither rising or lowering, and the foam member **31** is relatively undistorted, having no vertical forces applied to it. In this condition the sole forces transmitted through the seal are the outward spring pressures of the springs **34***a* and the plate or shoe **32***a* (as well as the plate or shoe **32** in FIG. 1) which serve to evenly distribute this pressure over the entire area so that the laminated seal construction provides a full distribution of the load or outward spring pressure over the entire sealing area between the fabric **21***a* (or **21**) and the cylindrical side wall **10** of the tank. In the modification shown in FIG. 3, the beam and spring and column member **34***a* transmits the thrust in both rising and descending to break the ice indicated at **36**, which may occur at the crevice between the fabric **21***a* and the cylindrical side wall **10**.

The construction of FIG. 3 presumes the presence of a highly efficient secondary seal or weather hood to minimize the amount of water than can leak past it onto the sealing mechanism.

The FIG. 4 construction is generally similar to the FIG. 1 construction in its action except that the roof in rising and descending controls the sealing structure by means of beam and column and spring member **34** having the spring portion **34***a* and the beam and column portion **34***b*, being attached by a pivot connection **41** to the shoe in the same manner as described in connection with FIG. 3. In this modification the ice breaking functions in rising are effected by the foam stratum and the shoe pressing through the fabric against the ice **36**.

It is to be noted that the invention herein provides in all the modifications a thin annular sealing sandwich which is made up of a bonded radial series of laminae, certain of which lamina are segmental in character, while the outer lamina forms a part of a continuous annular fabric. The thin character of the annular sandwich provides for a minimum radial thickness of the foam stratum or lamina, and usually this will be of about one inch or less in radial thickness while its height will be from 5 to 10 inches. This thin construction provides a desirable soft sealing action while also providing the necessary strength to transmit shearing stresses from the spring and beam and column members **34** in controlling movement of the seal.

It will be apparent from the above description and from the drawings that the vertical shearing stresses in raising and lowering the seal structure and in breaking the ice, when it is applied to the spring and beam and column member **34***a*, is transmitted through the plastic foam layer **31** to the fabric of the annular seal.

It will be noted that the bonded laminated construction provided herein, by virtue of the cementing of the normally limp annular fabric **21***a* to the segmental annulus **31** and its pressure against the outer wall of the tank, converts this portion of the fabric essentially into a rigid layer at the face of contact, so that a foam layer is sandwiched in radial series relation between two rigid layers for effecting a vertical shearing action. To effectively transmit the vertical shearing stress and to provide the desired resilience, the foam employed may be polyether urethane, load deflection 25% at 35 lbs. to 42 lbs. in a 12" x 12" x 2" sampler. Such a foam is sold by the Central Foam Corporation of Chicago, Illinois, as their P–65 "Polyfoam" and also by the American Urethane, Inc., of North Chicago, Illinois, as their F–44 "Everlon." However, any other suitable type of foam plastic may be employed.

While I have shown and described certain preferred embodiments of the invention, it will be apparent that the invention is capable of variation and modification from the form shown, so that the scope thereof should be limited only by the proper scope and interpretation of the claims appended hereto.

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 an 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 radially thin sealing element arranged in said annular space and carried by said wall structure and movable therewith with respect to said tank side wall; said mechanism including a series of upright segmental annular metal-like circumferentially limber shoe members arranged in closely spaced-apart end-to-end relation about a vertical axis, an annular fabric envelope for closing said space and having an intermediate annular strip portion secured to said shoes and engaging said side wall and also having a lower portion looped downwardly and radially inwardly from said annular strip portion and secured to a lower cir-

cumferential portion of said cylindrical wall structure, said annular fabric envelope having an upper portion extending upwardly and radially inwardly from said annular strip portion and secured to an upper circumferential portion of said cylindrical wall structure, and a circumferential series of spring and beam and column members carried by said cylindrical wall structure and extending downwardly and radially outwardly therefrom and having sliding engagements with upper portions of said respective shoe members, each of said shoe members having a ledge disposed below the upper portion thereof for operative one-way driving engagement by the associated one of said spring and beam and column members, said spring and beam and column members sliding upwardly on said shoe members during rising movement of said roof and said fabric drawing taut and serving to lift said sealing mechanism upon such rising movement of said roof, said spring and beam and column members sliding downwardly on said shoe members during falling movement of said roof and serving to press against said ledges to push said sealing mechanism downwardly upon such falling movement of said roof.

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 an 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 comprising a combined bearing distribution and load transmission member of bonded laminated construction for horizontally directed bearing loads and for vertically directed operating loads, said member including a circumferential series of upright segmental annular and circumferentially limber metal shoes, a corresponding circumferential series of upright segmental blocks of foamed plastic material respectively located radially outwardly of and respectively bonded to said shoes, an annular fabric enveloped for closing said annular space and bonded to the adjacent outer surfaces of said series of blocks, and means connecting said sealing element to said wall structure to provide for both raising and lowering movements of said sealing element and also to provide for outwardly pressing of said sealing element against said tank side wall under control of said wall structure, said means connecting said sealing element to said wall structure including a plurality of circumferentially spaced-apart leaf spring and column and beam members carried by said wall structure, each one of said leaf spring and column and beam members having its upper end comprising the leaf spring portion thereof and attached to said wall structure and having its lower end comprising the beam and column portion thereof and connected to a corresponding one of said shoes by abutting the top surface of a ledge provided on said one shoe.

3. In a tank for storing liquids, as recited in claim **2**, in which each of said blocks essentially comprises foamed polyurethane having a load deflection of 25% @ 35 to 42 lbs. on a 12″ x 12″ x 2″ sample.

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 an 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 comprising a combined bearing distribution and load transmission member of bonded laminated construction for horizontally directed bearing loads and for vertically directed operating loads, said member including a circumferential series of upright segmental annular and circumferentially limber metal shoes, a corresponding circumferential series of upright segmental blocks of foamed plastic material respectively located radially outwardly of and respectively bonded to said shoes, an annular fabric envelope for closing said annular space and bonded to the adjacent outer surfaces of said series of blocks, and means connecting said sealing element to said wall structure to provide for both raising and lowering movements of said sealing element and also to provide for outwardly pressing of said sealing element against said tank side wall under control of said wall structure, said means connecting said sealing element to said wall structure including a plurality of circumferentially spaced-apart leaf spring and column and beam members carried by said wall structure, each one of said leaf spring and column and beam members having its upper end comprising the leaf spring portion thereof and attached to said wall structure and having its lower end comprising the beam and column portion thereof and connecting to a corresponding one of said shoes by abutting the top surface of a ledge provided on said one shoe, each one of said ledges being located intermediate the vertical height of the corresponding one of said shoes to impart a twisting movement to said one shoe, thereby to distort the corresponding one of said blocks during downward thrusting movement of the corresponding one of said spring and beam and column members upon lowering of said floating roof in said tank.

5. 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 an 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 radially thin 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 comprising a combined bearing distribution and load transmission member of bonded laminated construction for horizontally directed bearing loads and for vertically directed operating loads, said member including a circumferential series of upright segmental annular metal-like circumferentially limber shoes arranged in closely circumferentially spaced-apart and end-to-end relation and disposed about a vertical axis, a corresponding series of upright segmental blocks of foamed plastic material, each one of said blocks being substantially coextensive with the associated one of said shoes, an annular fabric envelope for closing said annular space and having an annular strip bonded as a lamina to the outer surfaces of said series of blocks, said annular fabric having a lower portion looped downwardly and inwardly from said annular strip of said fabric and secured to a lower circumferential portion of said cylindrical wall structure of said floating roof, said annular fabric having an upper portion extending inwardly and upwardly from said annular strip of said fabric and secured to an upper circumferential portion of said cylindrical wall structure, a corresponding series of spring and beam and column members carried by said cylindrical wall structure and extending downwardly and outwardly therefrom to positions respectively adjacent to said shoes, and a corresponding series of ledges respectively carried by said shoes, each one of said ledges being disposed below and in operative one-way driving relation with a corresponding one of said spring and beam and column members, said fabric serving to lift said sealing mechanism upon rising movement of said roof and said spring and beam and column members serving to lower said sealing mechanism upon descending movement of said roof.

References Cited

UNITED STATES PATENTS

1,513,043	10/1924	Huff	220—26
2,089,645	8/1937	Dickmann	220—26
2,803,371	8/1957	Edens	220—26
2,991,901	7/1961	Wiggins	220—26
3,043,468	7/1962	Harner	220—26
3,119,510	1/1964	Wiggins	220—26
3,185,335	5/1965	Lecler	220—26
3,204,809	9/1965	Cadwell	220—26

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