United States Patent

[11] 3,625,415

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[54] **FLOATING ROOF SEAL**
15 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** ..... **222/26 S**
[51] **Int. Cl.** **B65d 45/00**
[50] **Field of Search** ..... 220/26 S, 26 SI

[56] **References Cited**

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ABSTRACT: A floating roof seal includes an annular flexible band, the upper portion of which is connected to the roof and has a gastight seal with respect thereto. The lower portion of the band is connected to an annular ring means. The lower part of the band has hole means formed therethrough for admitting liquid between the ring means and the band from the tank. A plurality of spaced support members are loosely connected at the upper ends thereof to the roof and are loosely connected at the lower ends thereof to the ring means to permit movement of the ring means relative to the roof during use. An annular seal means may be supported by the ring means and engages the inner surface of the band. This annular seal means has hole means formed in the upper and lower parts thereof. The ring means may also be of variable size including a plurality of spring loaded relatively movable portions.

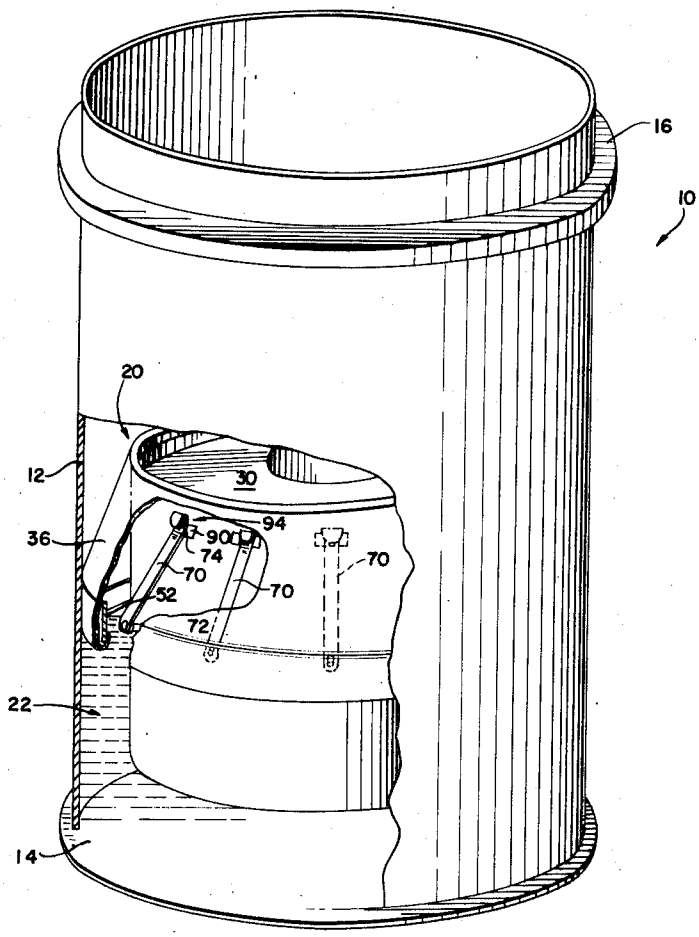
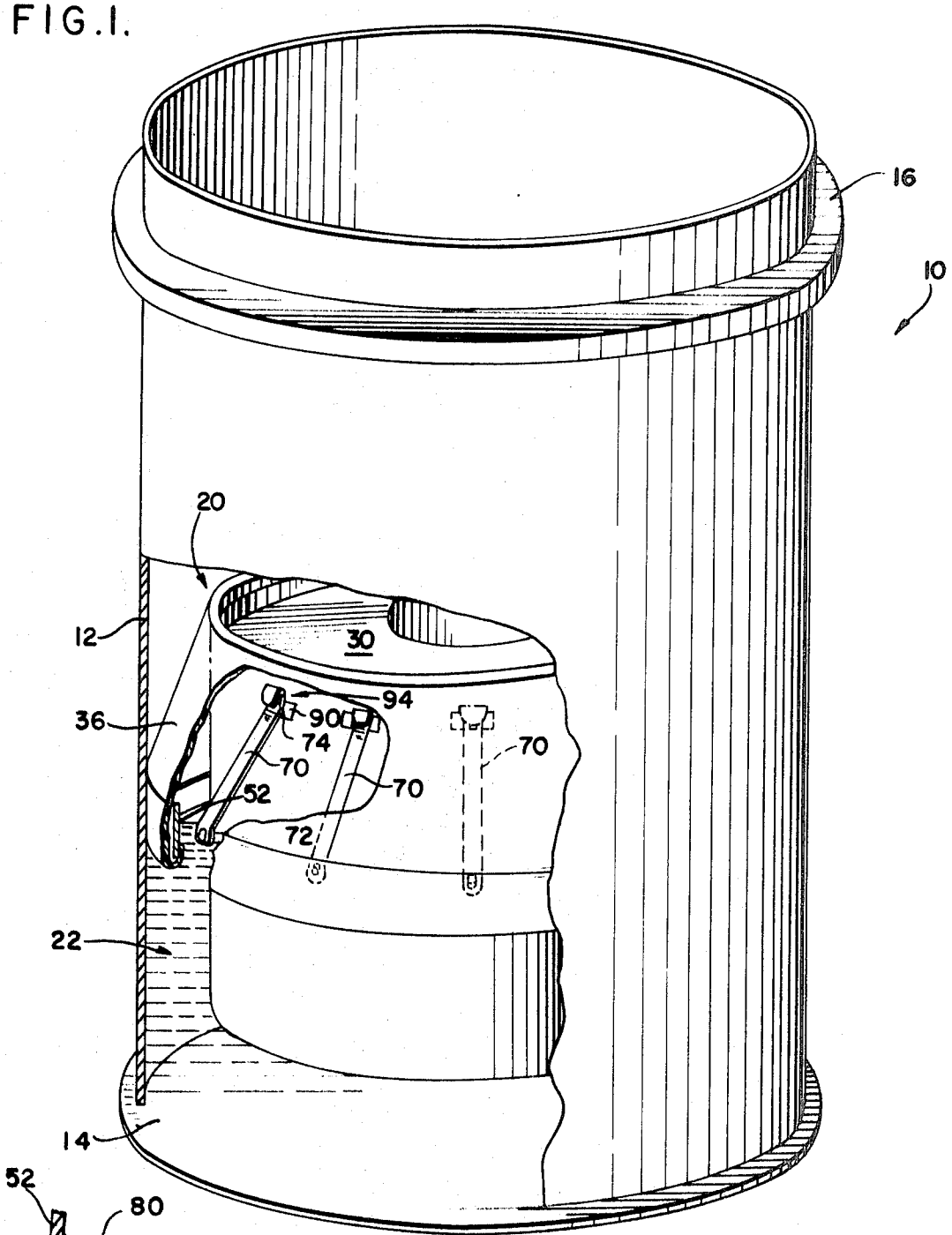


FIG. 1.



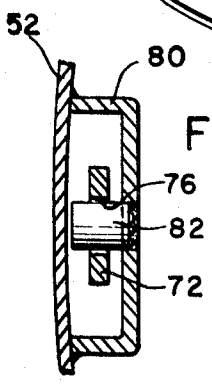


FIG. 4.

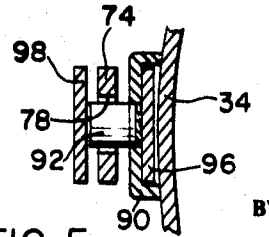


FIG. 5.

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FIG. 2.

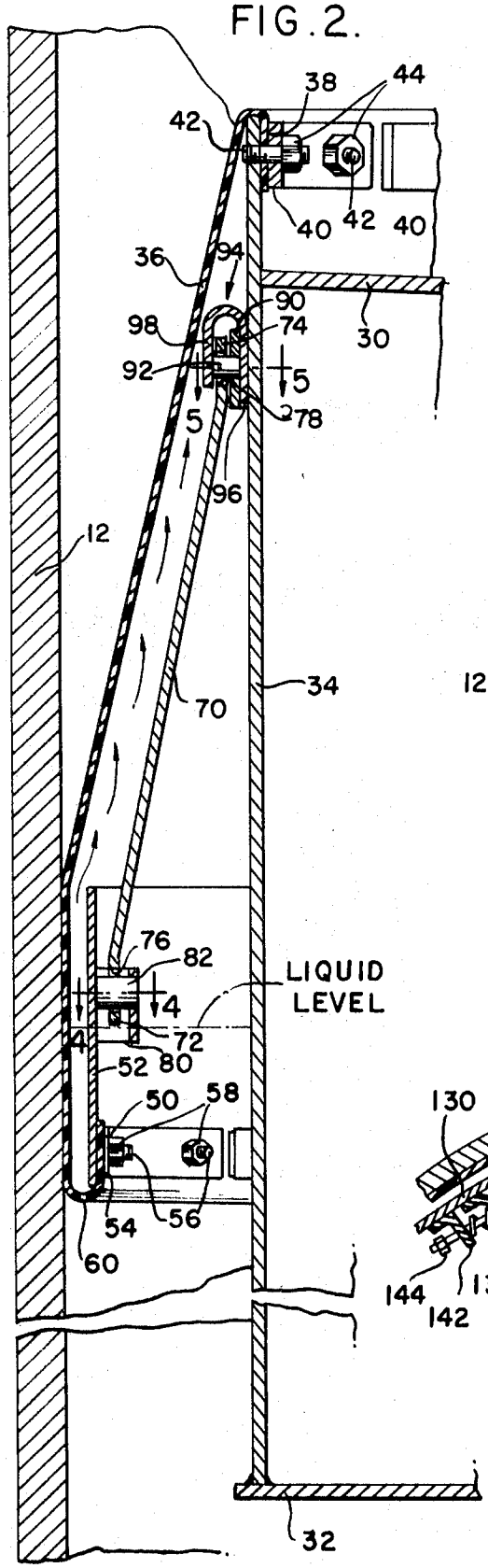


FIG. 3.

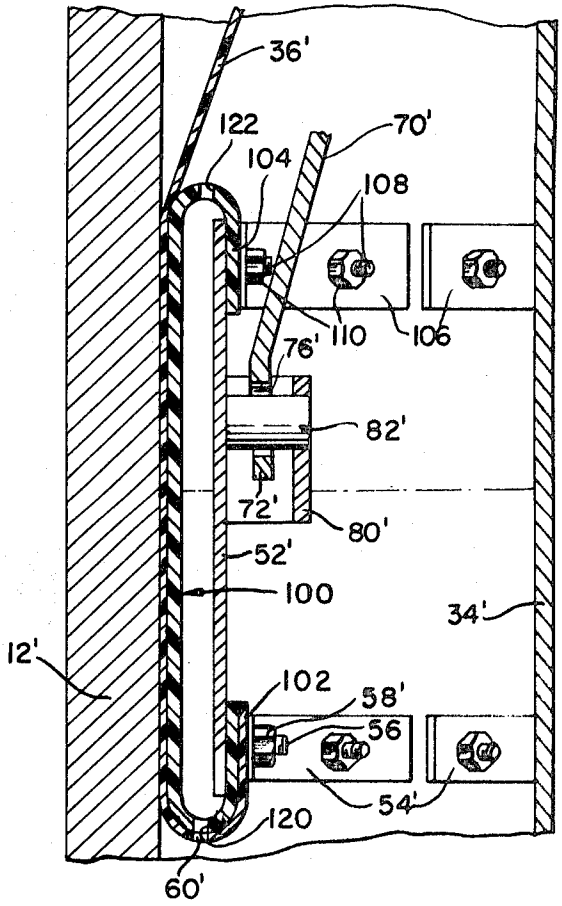
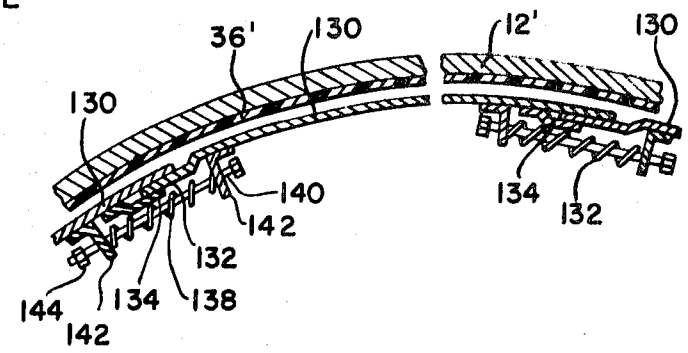


FIG. 6.



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FLOATING ROOF SEAL

BACKGROUND OF THE INVENTION

The present invention relates to liquid storage tanks for such products as oil and the like and which are of the type having a roof which floats on the liquid stored in the tank so that the roof rises and falls with the liquid level in the tank. The present invention is directed to a seal for sealing the annular space between the floating roof and the inner surface of the sidewall of the tank.

Modern day tanks of this type may be 300 to 400 feet or more in diameter, and the size of such tanks is constantly increasing due to the demand for larger capacities. As the diameters of such tanks increase, the required rim space is accordingly increased, and conventional seals are not readily adapted to be utilized in the wider rim spaces of such tanks. Known floating roof seals are of excessive cross-sectional width and permit a greater percentage of the rim space to be utilized, thereby allowing more tolerance of tank construction to compensate for settling of the tank which results in the tank being out of round.

A commonly used seal construction employs a liquid containing flexible hollow member of annular shape as shown, for example, in U.S. Pat. No. 2,735,573. If the liquid containing member should be punctured during use, the entire seal is destroyed, thereby resulting in great evaporation losses. Additionally, repair and replacement of this type of seal is a time consuming and expensive operation.

Other known seal constructions employ flexible open cell absorbent foam materials and the like which after long service usually become saturated with the stored product due to leaks around the connections and by permeating the enclosing membrane. It is necessary to remove the tank from service in order to perform the required maintenance on seals of this type.

In the past, efforts have been made to minimize the amount of gas collecting about the roof above the product which is often of a volatile nature, and many floating roofs employ relatively complex structures for insuring that any accumulated gas is properly vented. This, of course, results in losses of the stored product and increases the expense and maintenance problems associated with the floating roof.

SUMMARY OF THE INVENTION

An annular flexible band has the upper edge thereof connected to the upper part of the roof and forms a gastight seal with respect thereto. The lower edge of the band is connected to a resilient annular ring means which is supported for movement toward and away from the roof by a plurality of spaced support members. Each of these support members is loosely connected at the upper end thereof to the roof and is loosely connected at the lower end thereof to the ring means, each of these connections permitting relative movement between the support members and the roof and the ring means respectively.

The lower part of the flexible band has hole means formed therethrough, whereby liquid is admitted between the ring means and the band. Any gas pressure which builds up due to evaporation of gas from the surface of the stored liquid will be trapped in the space between the roof and the band and further will be disposed in the space between the ring means and the band above the liquid level, whereby the gas pressure acts to maintain the band in contact with the inner surface of the side wall of the tank. Accordingly, there is no necessity in the present invention for venting any collected gas and, in fact, the gas is employed for the useful purpose of maintaining an effective seal at all times during use.

An annular seal means may also be supported by the ring means in engagement with the inner surface of the band. This annular seal means is provided with hole means in the upper and lower parts thereof so that the gas which collects in the space between the roof and the band serves to urge the band into sealing engagement with the tank as discussed hereinabove.

The construction of the present invention enables the seal to automatically adapt itself to wider rim spaces than known devices of a similar nature. The seal of the present invention is of less cross-sectional width than conventional seals due to the unique manner of connecting and supporting the seal with respect to the floating roof. The seal of the present invention takes up only about 2½inches of the rim space, thereby enabling a greater percentage of the rim space to be utilized and allowing more tolerance of tank construction.

The problems encountered with constructions employing liquid containing hollow members or foam materials and the like are completely eliminated with the construction of the present invention.

The seal of the present invention is adapted for use with any size rim space and provides more usable rim space. The seal conforms to tank shells which are out of round, and a particular advantage of the seal of the present invention is the fact that it can be readily removed for replacement or maintenance as required from the top of the roof while the tank is in service. The seal of the present invention also provides a relatively inexpensive arrangement which affords substantial economic advantages over conventional seals.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top perspective view, partly broken away, of a storage tank employing the floating roof seal of the present invention;

FIG. 2 is a sectional view on an enlarged scale through the roof seal as shown in FIG. 1;

FIG. 3 is a sectional view similar to FIG. 2 on still a larger scale, illustrating a modification of the invention;

FIG. 4 is a sectional view taken substantially along line 4—4 of FIG. 2, looking in the direction of the arrows;

FIG. 5 is a sectional view taken substantially along line 5—5 of FIG. 2, looking in the direction of the arrows; and

FIG. 6 is a sectional view through a modified form of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings wherein like reference characters designate corresponding parts throughout the several views, as seen in FIG. 1, a storage tank is indicated generally by reference numeral 10 and includes a cylindrical vertically extending sidewall 12 and a bottom 14. The upper end of the tank is open, and a wind girder 16 is provided around the upper part of the tank. A floating roof generally indicated by reference numeral 20 is supported by a body of liquid 22 in the tank and is adapted to rise and fall with the liquid level in the tank. The roof is of less diameter than the inner surface of the sidewall so as to provide the conventional annular space between the roof and the tank.

As seen in FIG. 2, the roof includes a top deck 30 and a bottom deck 32 rigidly connected with a rim plate 34 of generally cylindrical configuration. The top deck slopes downwardly and inwardly and the bottom deck slopes upwardly and inwardly in the usual manner.

The roof seal includes an annular flexible band 36 formed of a suitable material such as reinforced synthetic rubber, the upper edge 38 of this flexible band extending over the upper edge of rim plate 34 of the roof and being connected thereto in a gastight sealing relationship by means of a plurality of bolting bars 40 suitably clamped in operative position by means of studs 42 secured to the rim plate and extending through holes formed in the band and the bolting bars, nuts 44 being threaded on said studs. It is apparent that the bolting bars may be formed in any suitable length and in any suitable number, or the bolting bar construction may comprise a continuous annular member, although such a construction is generally not practical. In any event, the bolting bar construction serves to clamp the upper edge of the annular flexible band in operative position and provides a gastight seal between the upper edge of the band and the roof.

The lower edge 50 of the band is connected to the lower part of a resilient ring means 52 of annular construction. This ring means is formed of a suitable metallic substance such as carbon steel and may comprise a plurality of sections interconnected with one another to provide a continuous ring means. This ring means may be formed by a plurality of individual sections of any desired length, or may be of integral construction, although the latter is not ordinarily practical. The ring means may also be formed on a nonmetallic substance having the desired resilient properties.

The lower edge of the band is clamped in position relative to the ring means by a plurality of bolting bars 54 which are held in place by studs 56 secured to ring 52 and extending through suitable holes provided in the lower edge of the band and the bolting bars, nuts 58 being threaded on the outer ends of the studs to hold the bolting bars in the operative position illustrated.

The bolting bars may be of any suitable length and number as required, and it is apparent that the bolting bar construction could be formed as a single integral member if so desired.

The lower part of the band has hole means in the form of a plurality of spaced holes 60 formed therethrough. These holes may be provided at any suitable intervals around the bottom part of the band and are disposed in such a position as to admit liquid stored in the tank into the space between the ring means and the band. The liquid level will normally be disposed at the position indicated in FIG. 2, and will partially fill the space defined between the ring means and the band. It is apparent that any liquid disposed in this portion of the space will tend to urge the band outwardly into contact with the inner surface of the side wall of the tank.

Any gas which may evaporate from the surface of the liquid will collect in the area defined between the roof and the band since the band has a gastight seal with the roof. This gas pressure will act outwardly against the band and will be present in that portion of the space between the ring means and the band above the liquid level in such space. Accordingly, the gas pressure produced during use of the apparatus will constantly urge the band outwardly into contact with the inner surface of the sidewall of the tank so as to maintain an effective seal at all times.

The support means for supporting the ring means from the roof comprises a plurality of space support members 70, each of which has a lower end 72 and an upper end 74 disposed at an angle to the main central body portion of the support member. Ends 72 and 74 have centrally disposed holes 76 and 78 formed therethrough respectively.

The means for connecting lower ends of the support members 70 to the ring means includes a plurality of generally U-shaped straps 80, each of which, as seen in FIG. 4, has the opposite legs thereof rigidly secured as by welding to the inner surface of ring means 52. A pin 82 is secured as by welding within a central hole in each of the straps, the pin extending toward the ring means. This pin extends through the hole 76 in the associated support member. It will be noted that each of pins 82 is of less diameter than the hole 76 in the associated support member whereby a loose connection is provided so that the lower end of the support member is adapted to move with respect to the pin to enable swinging movement of the support members as the seal moves relative to the associated roof.

Referring to FIGS. 2 and 5, the means for connecting the upper ends of the support members to the roof comprises a plurality of U-shaped straps 90, each of which has the opposite legs thereof rigidly secured as by welding to the outer surface of the rim plate 34 of the roof. A pin 92 is secured as by welding in a central hole provided in the associated strap and extends radially outwardly therefrom. Each of these pins is received within a hole 78 provided in the upper end of the associated support member.

Each of pins 92 is of less diameter than the hole 78 within which it is received, whereby a loose connection is also provided between the upper end of each of the support members and the roof. This loose connection permits swinging movement of each support member with respect to the roof so that the seal can readily move relative to the roof as required. The connection between the support members and the ring means as well as the roof enables the ring means to move both radially and tangentially with respect to the roof which is necessary in order for the seal to function properly.

The upper ends of the support members are maintained in operative position on pins 92 by clips 94 of generally U-shaped cross-sectional configuration, including a first leg 96 and a second parallel leg 98. Leg 96 is received in the space between the rim plate of the roof and U-shaped bracket 90, while leg 98 of each clip extends downwardly adjacent the outer end of the associated pin 92, whereby the upper end of the associated support member is prevented from coming off of the pin 92 on which it is supported.

When it is desired to remove the seal from the top of the roof while the tank is in service, it is only necessary to remove bolting bars 40 so as to release the upper edge of band 36 from the roof, whereupon clips 94 can be lifted out vertically from the operative position shown, and the upper ends of the support members 70 can be swung off of the supporting pins 92. The entire seal can then be lifted vertically out of the annular space defined between the roof and the tank.

While the support members have been shown as connected to the roof and the ring means by loose connections, other types of generally universal connections, such as ball and socket constructions, may also be employed if so desired.

Referring now to FIG. 3 of the drawings, a modification is illustrated wherein components similar to those of the modification shown in FIG. 2 have been given the same reference numerals primed. The only difference in this form of the invention is the provision of a continuous annular seal means 100 formed of a suitable flexible material such as reinforced synthetic rubber, this annular seal means being supported by the ring means and engaging the inner surface of the band. The annular seal means may be formed of a plurality of sections or may be formed as an integral member.

The lower edge 102 of the annular seal means is clamped in place by the same means employed for clamping the lower edge of band 36' in place. The lower edge of the annular seal means has a plurality of holes formed therethrough which receive studs 56', bolting bars 54' serving to clamp components in the operative position illustrated.

The upper edge of annular seal means 100 is held in place by a plurality of bolting bars 106. These bolting bars as well as the upper edge of the annular seal means have holes receiving studs 108 secured to ring means 52', and nuts 110 are threaded on the outer ends thereof.

The lower part of the annular seal means has a plurality of holes 120 formed therethrough aligned with holes 60' formed in the band, whereby stored liquid is admitted into the space defined between the ring means and the annular seal means.

The upper part of the annular seal means is provided with a plurality of holes 122 formed therethrough providing communication between the space defined between the ring means and annular seal means and the gastight space defined between ring means and annular seal means and the gastight space defined between the roof and the band.

In the construction shown in FIG. 3, annular seal means 100 is of flexible construction so as to assist in urging band 36' outwardly against the inner surface of the sidewall of the tank. Additionally, the gas pressure accumulating above the liquid level will also assist in maintaining sealing engagement since gas pressure will be present in that portion of the space defined between the ring means and the annular seal means which is above the liquid level.

Referring now to FIG. 6, a further modified form of the invention is illustrated wherein the ring means is of a unique construction so as to be a variable size to accommodate tanks of nonuniform circumference. Parts similar to those previously described have been given the same reference numerals primed.

In this form of the invention, the ring means comprises a plurality of relatively movable similar portions **130**, each of which has an offset edge portion **132** slidably disposed within a slot defined by an offset member **134** secured to the adjacent portion of the ring means.

The portions **130** are thereby interengaged with one another and are slidable with respect to one another. These portions are spring loaded by means of compression springs **138**, each of which is mounted on a rod **140** extending through holes provided in brackets **142** secured to adjacent portions of the ring means. A nut **144** is threaded on the outer threaded end of each of rods **140**. It is apparent that the spring means **138** will permit relative sliding movement of the portions with respect to one another, whereby the ring means in this form of the invention is adapted to automatically compensate for changes in circumference of the associated tank.

As this invention may be embodied in several forms without departing from the spirit or essential characteristics thereof, the present embodiment is therefore illustrative and not restrictive.

What is claimed is:

1. A liquid storage tank having a sidewall and a bottom, a floating roof in the tank for support on liquid stored in the tank and adapted to rise and fall with the liquid level in the tank, said roof spaced inwardly from the inner surface of said wall to provide an annular space between the roof and the tank, and a seal for said roof in association with said annular space comprising an annular flexible band, an annular ring means, said band having an upper portion connected to said roof and a lower portion spaced downwardly and outwardly from the upper portion and connected to said ring means in spaced relationship to said roof, said band defining a space therebeneath in communication with the liquid stored in the tank so that gas pressure between the roof and flexible band urges the band outwardly into sealing engagement with the wall, and support means connected at one end to said roof adjacent said upper portion of said band and connected at the other end to said ring means for supporting said ring means from the roof for movement relative to the roof during use, said support means disposed in the space beneath said band, said seal sealing said roof to said tank.

2. Apparatus as defined in claim **1**, including an annular seal means supported by said ring means and engaging the inner surface of said band.

3. Apparatus as defined in claim **2**, wherein said annular seal means has hole means in the lower part thereof, said band also having hole means in the lower part thereof whereby liquid in the tank is admitted between said ring means and said annular seal means.

4. Apparatus as defined in claim **3**, wherein the upper part of said annular seal means also has hole means formed therethrough.

5. Apparatus as defined in claim **1**, wherein said support means comprises a plurality of spaced support members each of which is connected at the upper end thereof to said roof and is connected at the lower end thereof to said ring means.

6. Apparatus as defined in claim **5**, wherein the connections at the upper and lower ends of each of said support members allows relative movement of each of the support members with respect to the roof and the ring means respectively.

7. Apparatus as defined in claim **6**, wherein the connections at the ends of each of said support members are loose connections.

8. Apparatus as defined in claim **6**, wherein the connections at the upper end of each of said support members is readily releasable so as to facilitate removal of the seal from the top of the roof with the tank in service.

9. Apparatus as defined in claim **1**, wherein the upper portion of said band has a gastight seal with said roof the lower part of said band having hole means formed therethrough for admitting liquid between said ring means and said band from the tank, said support means including a plurality of spaced support members each of which is connected at the upper end thereof to said roof and at the lower end thereof to said ring means, the connections at the upper and lower ends of each of said support members allowing relative movement between the ends of the support members and the roof and the ring means respectively.

10. Apparatus as defined in claim **9**, including annular seal means supported by said ring means and engaging the inner surface of said band, said annular seal means having hole means formed in the lower part thereof for admitting liquid between said ring means and said annular seal means from the tank, said annular seal means also having hole means formed in the upper part thereof and being in communication with the gastight space defined between the roof and the band.

11. A liquid storage tank having a sidewall and a bottom, a floating roof in the tank for support on liquid stored in the tank and adapted to rise and fall with the liquid level in the tank, said roof spaced inwardly from the inner surface of said wall to provide an annular space between the roof and the tank, and a seal for sealing said annular spaces comprising an annular flexible band connected at an upper portion thereof to said roof, an annular ring means in said space, the lower portion of said band being connected to said ring means, and support means for supporting said ring means from the roof for movement relative to the roof during use, the upper portion of said annular flexible band having a gastight seal with said roof whereby gas pressure between the roof and the band maintains the band in contact with said inner surface, and the lower part of said band having hole means formed therethrough for admitting liquid between said ring means and said band from the tank.

12. A liquid storage tank having a sidewall and a bottom, a floating roof in the tank for support on liquid stored in the tank and adapted to rise and fall with the liquid level in the tank, said roof spaced inwardly from the inner surface of said wall to provide an annular space between the roof and the tank, and a seal for said roof comprising an annular flexible band in said annular space, an annular ring means in said annular space, the upper portion of said band being connected to said roof adjacent an upper portion thereof, the lower portion of said band being spaced downwardly and outwardly from said upper portion and connected to said ring means, and support means for supporting said ring means from the roof for movement relative to the roof during use, said ring means being of variable size and including a plurality of relatively movable portions.

13. Apparatus as defined in claim **12**, wherein said movable portions are interengaged with one another and are slidable with respect to one another.

14. Apparatus as defined in claim **13**, including spring means connected between adjacent ones of said movable portions of the ring means for normally spring loading said movable portions in one direction with respect to one another.

15. A liquid storage tank having a side wall and a bottom, a floating roof in the tank for support on liquid stored in the tank and adapted to rise and fall with the liquid level in the tank, said roof spaced from the wall of the tank to define an annular space therebetween, a seal for said roof in association with said annular space comprising an annular flexible band connected and sealed at an upper portion thereof to said roof and spaced from said roof at the lower portion thereof, an annular ring means carried by said roof and supported in spaced relationship to said roof, the lower portion of said flexible band connected to said annular ring means, said annular flexible band sealing said roof and defining a space therebeneath in open communication with the stored liquid so that gas pressure between the roof and the band urges the band outwardly; and support means connected at one end to said roof adjacent said upper portion of said band and connected at the other end to said ring means for supporting the ring means from the roof, said support means disposed in the space beneath said band.

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