This invention concerns a fabric type seal for use in floating roof tanks such as those designed and built for storing volatile petroleum products, and more particularly a novel and improved means for supporting the fabric seal.

Floating roof tanks have been in use in the petroleum industry for a long time. They have achieved widespread acceptance throughout the industry on account of their ability to prevent significant vapor loss of volatile petroleum products and also to reduce the hazard from fires and explosions. In such tanks the roof floats on the surface of the liquid thus eliminating any significant air or vapor space between the liquid and the roof in which petroleum vapors may accumulate. Such tanks are of large size, ranging from less than 60 feet to 120 feet or more in diameter, and are generally cylindrical in shape. It is not practicable or economical to make a tank shell of these dimensions perfectly round and for that reason the floating roof for such a tank cannot be constructed as a tight fitting piston but rather it must have a smaller diameter than the internal diameter of the tank shell.

For example, even though a carefully constructed tank shell of the size contemplated can be substantially circular at its base where it attaches to the tank bottom, there is a tendency for it to become out of round at higher parts of the shell because of uneven foundation settlement or other factors. This out of roundness commonly causes the tank shell to differ as much as 16 inches between its major and minor diameters at a given elevation. Since the floating roof remains truly circular this difference must be accommodated by the mechanism closing the space between the floating roof and the tank shell. A flexible sealing device is customarily inserted in the annular space between the outer rim of the floating roof and the inner surface of the tank shell.

Most of the floating roof tanks that have been built in the past have utilized sealing devices largely mechanical in nature. In general, they have consisted of cylindrical or segmental metal shoes supported by the roof and held in contact with the tank shell by springs or levers in combination with a sealing fabric extending across the annular space between the rim of the floating roof and the shoes to effect the seal. In such an arrangement, the seal was only as effective as the effectiveness of the metal to metal contact between the outer surface of the shoes and the irregular inner surface of the tank shell.

Another method of sealing the annular space between a floating roof and a tank shell was by means of a vapor-tight fabric attached to the rim of the floating roof and forced outwardly against the inner surface of the tank shell by means of an inner tube, thus taking on the appearance of a pneumatic automobile tube and tire. The inner tube was ordinarily filled with a liquid.

Still another and more recent development of the vapor-tight fabric seal accomplishes the desired purpose without the use of an inner tube.

Present fabric type seals are not effective in accommodating shell out of roundness exceeding approximately 8 inches between the major and minor diameters. They are therefore unsuitable for use on floating roof tanks on usual foundations which may cause out of roundness in excess of 8 inches. According to this invention there is provided an automatically adjusting supporting means for the fabric type flexible seal which enables it effectively to accommodate differences approaching 16 inches between the major and minor diameters of the tank shell. In addition, the invention provides, where desirable, a centering force for the roof which will counteract the wind forces tending to drive the roof off center. Novel features of the invention will become apparent in the detailed description which follows.

The invention will be described by reference to the attached drawings from which a more complete understanding may be obtained and in which:

Fig. 1 is a plan view of a floating roof storage tank employing the sealing device of this invention;

Fig. 2 is a vertical cross sectional view taken in the plane 2—2 of Fig. 1;

Fig. 3 is an enlarged partial vertical cross sectional view of the roof with the seal in place;

Fig. 4 is a partial vertical cross sectional view of a modification of the roof shown in Fig. 3, which modification is particularly well adapted for use in tanks of relatively small diameters; and

Fig. 5 is a partial isometric view of another embodiment of the sealing device;

Fig. 6 is a partial isometric view of still another embodiment showing an upper annular support and a lower support suspended therefrom.

As shown in Figs. 1 and 2, a floating roof 10 is positioned within a cylindrical storage tank shell 11, the roof being somewhat smaller in diameter than the inside diameter of the storage tank, thus leaving an annular space between the rim 12 of the roof and the tank wall 11 in which space the annular sealing device 13 in the nature of a vapor-tight fabric pocket is located. An interleafing metal weather shield 14 of conventional design is usually provided to protect the sealing device 13 from the elements.

The sealing device 13 is shown in more detail in Fig. 3. A vapor-tight flexible fabric seal material, formed somewhat into a pocket and consisting of a sealing band 15 and a rim band 17, is suspended from an annular angle 19 by means of bolts 21 and an annular clamping ring 23. Angle 19 is attached as by welding to the top of the floating roof 10. The lower portions 25 of the fabric seal material are clamped between an annular bar 27 and a second annular angle 29 by bolts 31. The rim band 17 and sealing band 15 are held in intimate relationship at the bottom supports, so as to form a fluid-tight annular pocket to hold the sealing fluid 33. The hydrostatic pressure of the sealing fluid 33 tends to press the rim band 17 snugly against the rim 12 of the floating roof 10 and to press the sealing band 15 snugly against the interior surface of the tank shell 11, thus forming a barrier or seal which prevents vapors from the stored product 35 from escaping through the annular space between the floating roof 10 and the tank shell 11.

As shown in Fig. 3, the lower supporting member 29 is supported in the rim space by means of a plurality of vertical bars 40, attached by means of sleeve 41 to corresponding horizontal support arms 42 which are suspended from the lower portion of the floating roof 10 by inclined parallel hanger bars 43A and 43B, connected by pins 47A and 47B to the arms 42, and also by pins 47C and 47D to a gusset plate 46 which is connected as by welding to the lower portion of the floating roof 10. The combination of the gusset plate 46, inclined hangers 43A and 43B, horizontal arms 42 and pins 47A, 47B, 47C and 47D thus forms a parallelogram, making it pos-

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sible for the lower angular support 29 to be moved laterally with respect to the floating roof while retained in vertical position when external forces are applied to it.

In order to prevent the annular bar 27 or the heads of the bolts 31 from pinching or abrading the sealing band 15 in an indented area of the tank shell 11 or when the lower support 29 has been moved laterally because of the application of external forces, a bumper 48 may be attached to each of the vertical support bars 40 and are positioned so as to bear against the interior surface of the tank shell 11 in an extreme position of the support member 29. If desired, additional bumpers (not shown) may be attached to the support member 29 at intervals intermediate of the vertical support bars 40.

When a floating roof having the sealing device described above is placed into service the roof is at its bottom position where the tank shell is substantially truly cylindrical. In this position the various parts are all symmetrically aligned as described and the lower supporting member 29 is a circular ring evenly spaced from the tank shell. For purposes of illustration it will be assumed that the tank shell tends to be elliptical with the amount of departure from the circular shape increasing to a maximum at the top of the tank. As the roof floats upward with the filling of the tank, the tank shell will approach the bumpers 48 at the small diameter until contact is made. Simultaneously, the distance between the bumpers 48 and the tank shell will have increased at the major diameter.

The continued upward movement of the floating roof will cause the tank shell to distort the lower supporting member 29 inwardly at the minor diameter and, since it has a fixed circumference, it must also distort outwardly at another point which tends to be at the major diameter. Consequently, the shape of the lower supporting member will follow the shape of the tank shell, thereby always maintaining the lower portion of the sealing band 15 near the tank shell where it can form an effective seal.

The distortion of the lower supporting member 29 is resisted to some extent by its own spring action. The lateral movements of the supporting mechanism bring supplementary forces into play since the weight of the fabric seal assembly is lifted by the local inward movement of the lower supporting member 29 and is lowered by the local outward movement. Since the lower supporting member 29 is relatively flexible, particularly in the diameters here used, the hanger bars 43A and 43B are initially inclined at a small angle to the vertical so as to pre-tension member 29. The existence of this pre-tensioned stress tends to carry the member outwardly at the major diameter.

The spring-like action of the lower supporting member together with the action of the weight of the fabric seal assembly to counteract inward movement of the roof also give the floating roof a centering force which tends to resist external forces, such as wind. As external forces are applied against the support member, thus distorting it, the counteracting centering force increases proportionately. This tends to maintain the roof in a centered position within the tank and improves the ability of the fabric seal effectively to close the space between the floating roof and the tank shell.

The parallelogram type of supporting device has been found to be desirable to insure sufficient rigidity of the support ring and connecting bars in tanks of large diameter. However, when the supporting device is to be used on relatively smaller diameter tanks than those mentioned, a simpler design such as that shown in Fig. 4 may be used. In this construction, an angle hanger bar 43A, connected to a base plate 46 by a pin 47C at its upper end, and at its lower end by a pin 47A to a horizontal arm 42, will ordinarily be adequate. This is true because the smaller diameter of the angular support 29 provides sufficient torsional rigidity to the assembly to overcome the moment which otherwise would tend to cause the vertical bars 40 to rotate out of vertical position, thus reducing the effectiveness of bumpers 48.

On some occasions it may be desirable to provide a similar parallelogram support assembly to support the upper portions of the rim band 17 and sealing band 15. Such an assembly, shown in Fig. 5, where the angle hanger bars 43A and 43B are joined by pins 63A and 63B to a second horizontal arm 42 at the outer end of which is attached the annular angle ring or support 65, to which is attached the sealing band 15. In Figure 5 the sealing band 15 has been provided with an upstanding loop 66 above the support 65, being clamped thereon by an annular bar ring 65A, to form a secondary seal which under normal operating conditions can be maintained in contact with tank shell 11, and the upper edge of the sealing band 15, after being looped as mentioned above, is brought over to the upper edge of the floating roof rim 12 and attached by suitable bars 67 to the rim 12 which also serve to secure the upper end of the rim band 17. It should be understood, however, that in cases where the secondary seal is not considered necessary, the rim band 17 might be connected at its upper edge to the annular support 65, in a manner similar to that shown in Fig. 4.

The parallelogram type of upper support device as shown in Fig. 5 operates in essentially the same manner as does the lower support device shown in Figs. 3 and 4. A bumper is not required, however, for the upper support device because there is no likelihood for the fabric seal material to be caught between the bar 65A and the tank shell 11 in cases of extreme lateral movement of the support 65. The lower portions 25 of the sealing band 15 and the rim band 17 are clamped between a ring clamping band 70 and an angle ring 71, supported upon the upper ends of vertical angle bars 72. The lower ends of bars 72 are secured to horizontal arms 73 extending outwardly from the bottom wall 74 of the roof 10.

While the lower support devices as shown in Figs. 3 and 4 and the upper support device as shown in Fig. 5 have been shown separately, it should be clearly understood that a combination of such devices may be used in the same floating roof installation, so that both the upper and lower supports are able to accommodate themselves to shell irregularities or to lateral movement of the tank roof.

This might be accomplished by combining the structures shown in Figs. 3 and 5, for example, or by a modification as shown in Fig. 6, where the annular support which holds up the bottom portion of the fabric pocket is suspended from the upper annular support. In this form the upper portions of the sealing band 15 and the rim band 17 are supported as shown in Fig. 5. The lower portions 25 are clamped between ring 70 and angle ring 71 but the latter is supported from angle ring 65 by suspension wires 75. In this construction it is desirable to have a bumper 48 on the inner face of the angle ring 71. The use of the support devices shown in this application permits a greater utilization of the annular space between the floating roof rim 12 and the interior surface of the tank 11 for accommodation to external loads and to variation in roundness tolerances of the tank shell, then is the case when support members are rigidly attached to the roof so as not to permit lateral movement with respect to the floating roof.

It is generally recognized that when fabric type seals such as shown in this application are placed in the annular space between the floating roof and tank shell, some sort of support of the lower portions 25 of the fabric seal is required intermediate of the rim 12 and the tank shell 11. If such a support is immovably fixed to the floating roof then only that portion of the annular space between the floating roof and tank shell which is...
located between the outer limit of the rigid support and the tank shell is available for lateral adjustments as described in more detail above. Since the supports shown in Figs. 3 and 4 are capable of moving laterally with respect to the floating roof, a greater proportion of the annular space is available for such adjustment. Thus, in any floating roof tank embodying this invention and having the same size annular space, there is more usable space for lateral adjustment; or, in other words, a greater tolerance for irregularities than is the case in conventional designs. Moreover, if the designer chooses, he may narrow the annular space by using the design shown in Figs. 3 and 4 without adversely affecting the tolerance. Thus, he may choose to make the diameter of the floating roof somewhat greater than would be the case were he to use the conventional type of fabric support which is rigidly attached to the roof and which, therefore, has no provision for lateral movement with respect to the roof.

While a great variety of construction details might be employed to achieve the same results shown and described in this application, it should be understood that the intent of this application is to demonstrate support members for fabric type seals which are capable of accommodating themselves to operating conditions by lateral movement with respect to the floating roof to which they are attached.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

We claim:

1. In a floating roof storage tank, a flexible seal located in the annular space between the floating roof and the tank shell comprising, a fabric pocket between said floating roof and said shell, means for supporting said fabric pocket from the floating roof, said means comprising, an upper annular ring support fixedly carried by said roof and to which the upper end of said pocket is secured, a lower annular supporting ring to which the lower end of said pocket is secured, means for supporting said lower ring from said horizontal bar whereby said lower ring may move laterally with respect to said roof, and a fluid within said pocket and in direct contact therewith to maintain the sides of said pocket in sealing relationship to the roof and shell.

2. In a floating roof storage tank, a flexible seal located in the annular space between the floating roof and tank shell comprising, a fabric pocket between said floating roof and said shell, means for supporting said pocket from said floating roof, said means comprising, an upper annular ring support fixedly carried by said roof and to which the upper end of said pocket is secured, a lower annular supporting ring to which the lower end of said pocket is secured, a single inclined bar pivotally connected at one end to said roof, a horizontal bar pivotally connected to the other end of said inclined bar, and means for supporting said ring from said horizontal bar whereby said lower ring may move laterally with respect to said roof, and fluid within said pocket and in direct contact therewith to maintain the sides of said pocket in sealing relationship to the roof and shell.

3. In a floating roof storage tank, a flexible seal located in the annular space between the floating roof and the tank shell comprising a fabric pocket between said floating roof and said shell, means for supporting said fabric pocket from the floating roof, said means comprising, an upper annular ring support fixedly carried by said roof and to which the upper end of said pocket is secured, a lower annular supporting ring to which the lower end of said pocket is secured, means for supporting said lower ring from said roof permitting substantial lateral movement thereof with relation to said floating roof, and a fluid within said pocket and in direct contact therewith to maintain the sides of said pocket in sealing relationship to the roof and shell.

4. The seal of claim 3 wherein said supporting means tend to create a tensile stress in said lower ring.

5. The seal of claim 3 wherein said supporting means has attached thereto a plurality of spaced bumpers adapted to bear against the interior of the tank shell at points of inward shell distortion and when said roof is floating off-center.

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