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M. K. ALLEN ET AL
FLOATING ROOF

2,669,372

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2 Sheets-Sheet 1

Fig. 1

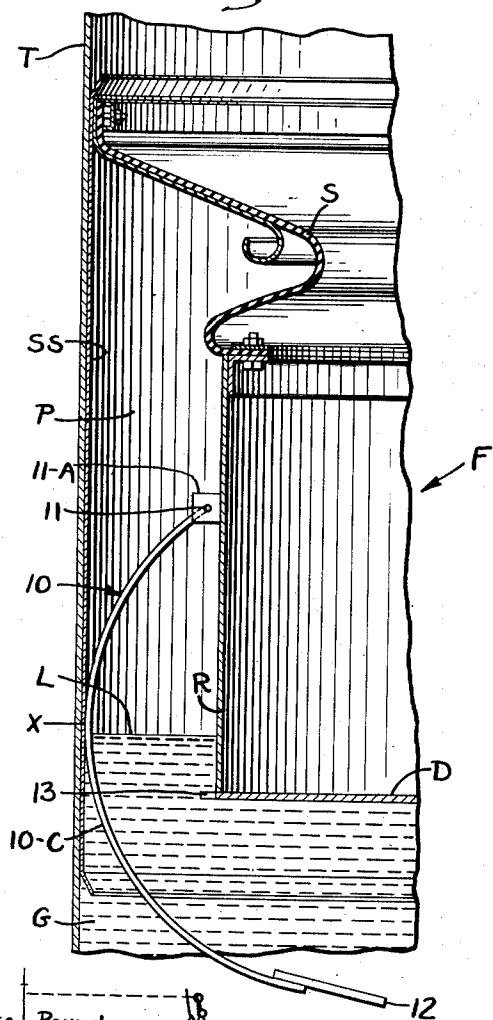


Fig. 2

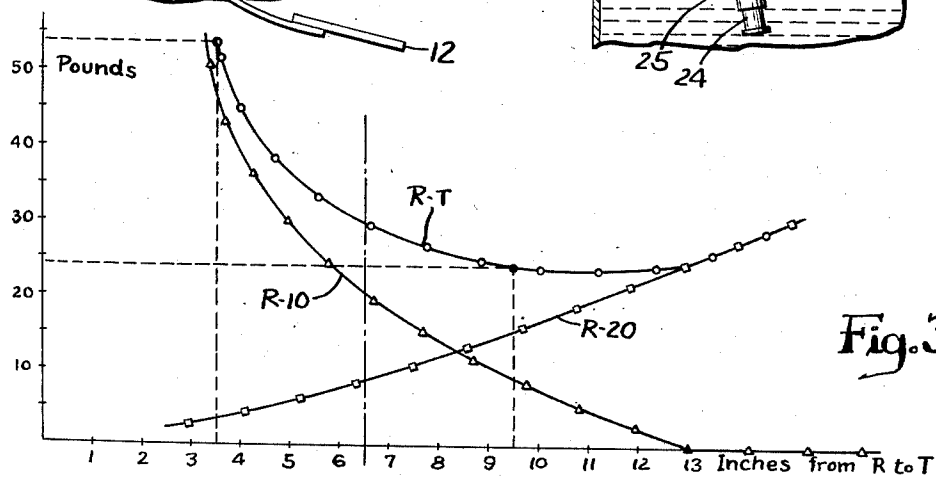
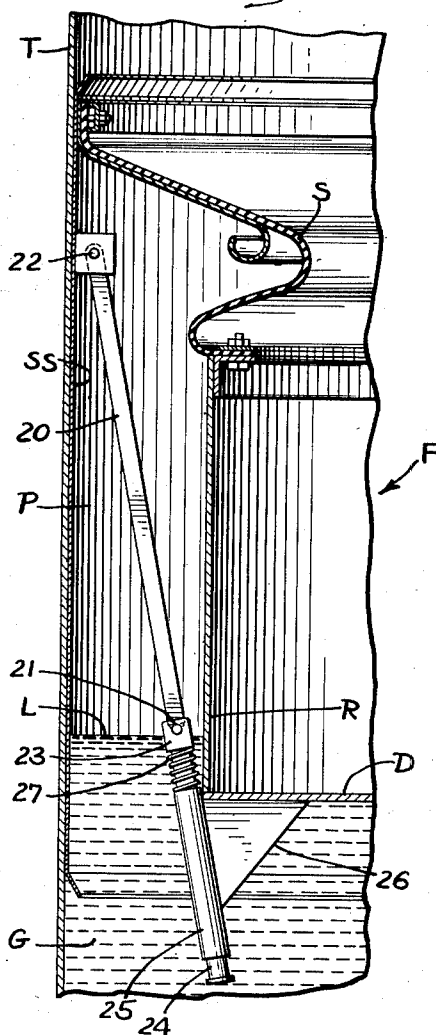


Fig. 3

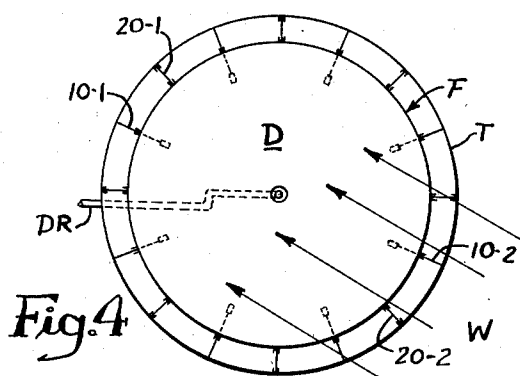
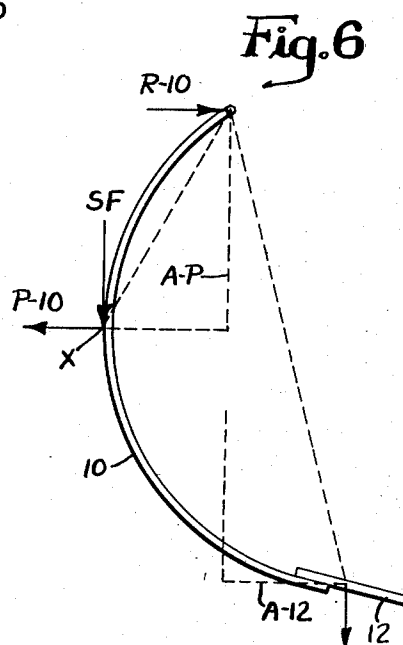
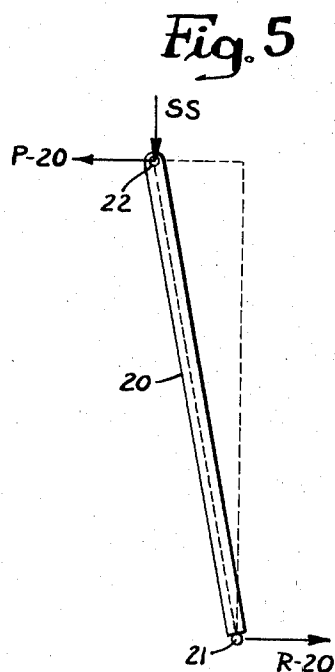
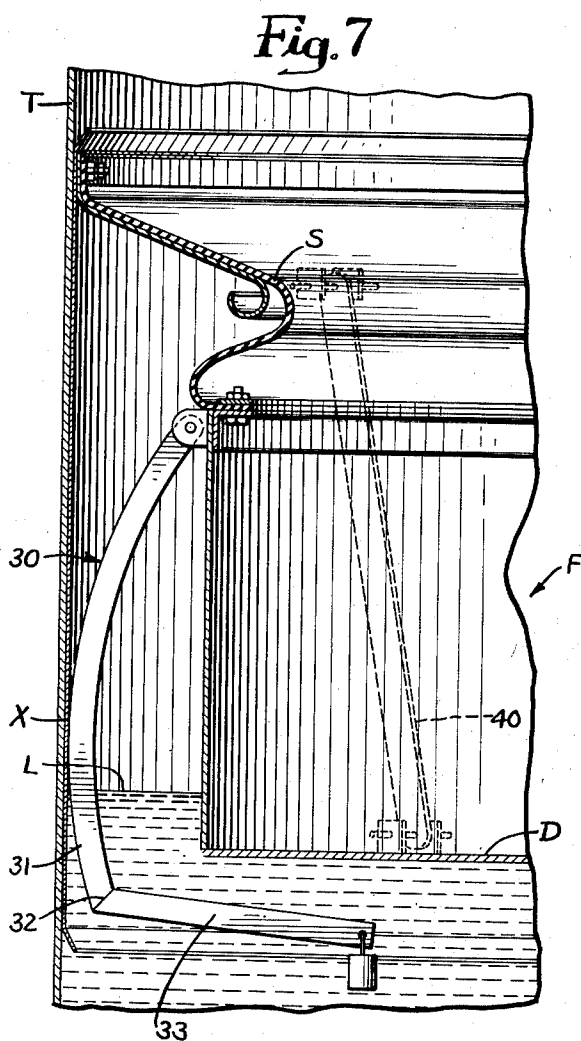
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,669,372

FLOATING ROOF

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4 Claims. (Cl. 220-26)

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This invention relates to the sealing and centering mechanism of a floating roof for the protection of gasoline and the like.

It is known that sealing means must be applied to the peripheral space around a floating roof in order to avoid vapor losses and that the roof must be kept substantially centered against wind pressure and the like in order to avoid injury to the seal and other parts of the installation. It is also known to apply both sealing and roof centering forces by a series of suitable levers. Each of these levers usually has one end pivoted to the floating roof, the opposite end weighted below the floating roof, and an intermediate portion acting upon the seal, either directly like a crowbar or indirectly through additional linkage which may also serve to support the weight of the seal.

According to the present invention the intermediate portion of such a lever acting like a crowbar is curved to provide a seal contacting, load absorbing cam or rocker surface in order to produce a variable load arm. More particularly the cam varies the load arm so that as the floating roof approaches the seal, a more than proportionally increased net force is derived from the uniform weight attached to the lever. In this manner the new weight and lever system produces sealing and centering effects which are superior to those obtainable from the earlier weighted levers and also superior to those of the resilient spring pushers, known to the art. The construction and maintenance cost of the new device is at most equal to that of the earlier weighted levers and considerably less than that of the earlier spring pushers.

These and other features of the new mechanism will be understood more clearly from the description of preferred embodiments which follows.

In the drawing:

Figure 1 is a partial cross-sectional view of a floating roof utilizing the present invention.

Figure 2 is a similar view of another part of the same floating roof.

Figure 3 is a graph of forces utilized in the new mechanism.

Figure 4 is a diagrammatic plan view of a floating roof using the new mechanism.

Figure 5 is a free-body diagram of a hanger lever from Figure 2, showing some of the forces summarized in Figure 3.

Figure 6 is a similar diagram of a pusher lever from Figure 1, showing additional forces summarized in Figure 3.

Figure 7 is a view generally similar to Figures

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1 and 2 but showing modified pusher and hanger levers.

Referring first to Figures 1 to 6:

The floating roof F, comprising a deck D and rim R, floats on a volatile liquid such as gasoline G, stored in the tank T. The deck D covers the liquid surface L except a narrow, annular, peripheral space P. The clearance provided by this space allows slightly irregular, basically economical construction of the tank T and roof F. In order to avoid vapor loss the space P is covered by a flexible seal S formed by an annular strip of rubberized fabric or the like, the inner edge of which is secured to the top of the rim R. The outer edge of this seal S is attached to the upper edge of a seal shoe SS contacting the inside of the tank T and forming an annular ring of thin metallic material such as 16-gauge steel.

A series of rigid pusher levers 10 are pivoted to and peripherally spaced around the rim R of the floating roof F, desirably at peripheral distances such as about 3 to 6 ft. from one another. Each pusher lever preferably consists in an elongated steel bar rolled into a continuous, circular, outwardly convex arc. It has an upper end portion connected with the floating roof rim R by a pivot pin 11; such pin being transversely welded to the bar 10 and pivoted in a pair of pivot clips 11A welded to the rim R. The attachment and orientation of the pivot clips 11A is such that the pusher 10 is swingable in a substantially vertical plane, substantially radial of the floating roof. A weight 12 is secured to the free end portion of each pusher 10, below the deck D and inwardly of the rim R. Throughout its length between the pivot 11 and weight 12 each bar 10 has an outwardly convex, preferably arcuate cam or rocker surface 10C, which contacts the seal shoe SS at a point X, the position of which depends on the local width of the space P. The bar 10 contacts the seal shoe SS with outward pressure, due to the weight 12 which tends to pry the floating roof away from the tank shell.

The arcuate pushers are formed very simply by cold rolling plain bars of predetermined length to a predetermined radius. An arc of about 135 degrees with a radius of about twenty-four inches is preferred when it is desired to keep the width of the space P within a range of about three to ten inches.

The cold rolling operation mentioned is simpler and safer than is the formation of a sharp bend of predetermined location and angularity as used

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in some of the earlier pusher levers. Likewise the new pusher lever 10 is of extreme simplicity, economy and reliability as a moving element, being equipped only with a single pivot 11.

Hanger arms or support links 20 are provided in addition to the pushers 10 in order to support the weight of the seal assembly S, SS. These additional links or levers are spaced around the floating roof at peripheral distances such as about 3 to 6 ft. from one another, suitably interspersed with the pushers 10. As shown in Figure 2 each hanger extends from an inner, lower pivot 21, suitably secured to the floating roof F, through the space P to an outer, upper pivot 22, secured to the steel shoe SS. Preferably each being slidable in an upstanding guide sleeve 25 inner, lower pivot 21 is formed in a clip 23 secured to a slide member 24; the slide member secured to the underside of the deck D by a gusset 26. A compression spring 27 surrounding the slide 24 bears against the top end of the sleeve 25 and the underside of the clip 23, in order to make the support of the seal shoe vertically resilient and thereby to avoid deformation of the shoe and partial loss of sealing efficiency incident to the required pivoting movements of the hanger link 20.

In order to minimize interference of the parts 10, 25 with a close approach of the floating roof F to the tank wall T, whenever such an approach is required, it may be desirable to cut notches 13 into the outermost edge portion of the deck D, outside the rim R, at positions in register with said parts 10, 25.

The sleeve 25 may be installed in an upright but slightly inclined position as shown in order to minimize the side thrust which tends to occur due to the eccentric column loading of the hangers 20. However, this inclined arrangement is subject to modification. In fact it is sometimes possible to omit the entire resilient slide mechanism. In that event, as shown in Figure 7, the hangers 40 can be plain, rigid bars, interconnecting pivots which are rigid with the floating roof F and seal shoe SS.

Figure 7 is also modified as to the pusher 30 which in this case comprises an upper, outwardly curved portion 31, extending from adjacent the rim R to and slightly beyond the seal shoe SS; an intermediate elbow 32; and a lower, straight, more or less horizontal portion 33, extending from this elbow to the region below the deck end within the rim, where said portion is suitably weighted. This modified pusher design is suitable mainly when the radius of curvature in the upper or cam portion 31 is relatively long; and this again may be desirable in order to apply the sealing pressure in predetermined regions of the seal. However, a pusher lever forming an unbroken, short radius arc, as used in Figure 1, is very satisfactory in most cases; certainly more so than is the application of pressure with a fixed load arm as used up to now.

This latter point will become clearer from a description of the operation of the preferred device which follows:

Referring to Figure 4, the action of wind W tends to uncenter the floating roof relative to the tank. This tends to interfere with the most efficient arrangement of the seal S. It also tends to loosen drain pipes DR and to jeopardize other parts. Therefore uncentering must be counteracted and mainly the seal action maintained.

The maintenance of seal action is effected, to

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some extent, by the hangers 20 alone, but these hangers tend to uncenter rather than center the floating roof. Due to its outwardly inclined position, and the weight of the parts 20, S, SS, each hanger 20 applies by the upper pivot 22, an outward pressure P20 to the seal SS, with an inward pressure reaction, applied to the hanger itself (see Fig. 5). An inward pressure reaction R20, equal in magnitude to the outward pressure P20, is applied to the floating roof by the inner pivot 21. These pressures P20, R20 increase, about proportionally, with increasing distance between the floating roof and the tank shell. However, for the purpose of centering the floating roof they would have to increase as the distances are reduced.

In order to make this last point quite clear, reference should be had to Figure 4 again. When the wind, acting in direction W, urges the floating roof F toward the hangers 20-1 at one side of the tank, these hangers turn into more upright positions, causing local reduction of pressures P20, R20. The opposite hangers 20-2 cause the opposite effect by turning into more inclined positions. Therefore, as soon as the wind has moved the floating roof in direction W beyond the centered position the pressure reactions R20 of the hangers 20-1 are less than those of the hangers 20-2. Thus the hangers actually aid the wind pressure in uncentering the floating roof.

These uncentering effects are most efficiently and economically counteracted by the new pushers 10. When the floating roof is uncentered as described, this causes certain shifts in the positions of these pushers. Referring again to Figure 4, the pushers 10-1 adjacent the hangers 20-1 have their weights raised and their contact points X brought closer to their pivots. At the same time the opposite pushers 10-2 have their weights lowered and their contact points X brought further away from their pivot.

The raising and lowering of the weights, which is known to the art, has a useful effect in counteracting the uncentering forces. This effect however, is at most approximately proportional to the lateral displacement of the floating roof, since it is derived from a mere increase of the weight arm A-12 of a swinging pusher lever. In the present mechanism this effect is greatly augmented, since the load arm AP of each pusher lever is reduced while its weight arm A-12 is extended, and vice versa. In this manner the increase in the pressure reaction R10, produced by each pusher 10 can be made more than proportional to the degree of approach to the tank shell.

By varying the profile of the cam 10C the load arms AP can be varied in different, predetermined manners. In practice, the circularly arcuate cam profile is most simply produced; and this profile has ample effect for the purpose of counteracting the uncentering forces with efficiency and safety (even in the event that some pushers become "frozen" or otherwise inoperable upon prolonged use).

It may be well to point out at this point that, when the floating roof moves horizontally, shifting the weight arm A-12 and load arm AP, some sliding friction may take place between the cam surface 10C and the seal SS, depending on the type of hanger 20 or 40 that is used. A starting friction SF, acting either upwards or downwards (depending upon the direction of the floating roof's motion), may have to be overcome before the position of the pusher lever 10 is actually

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changed. In practice this involves no very serious problem. The pusher lever 10 can contact the seal SS with a relatively wide surface, thereby distributing the frictional load adequately.

A summary of the essential pressure reactions obtained by the levers 10 and 20 is shown in Figure 3, for a typical floating roof embodying the present invention.

The curve R20 shows the pressure reactions of the same designation which are caused by the hangers 20 and the weights supported thereby (Fig. 5). The curve R10 shows the pressure reactions of the same designation which are caused by the pushers 10 due to their aforementioned changes of weight and load arms; consideration being given also to incidental matters such as variations in the distribution of weight of the pusher lever itself. The curve RT shows the sum of R-10 and R-20. It is assumed that the floating roof is centered at the distance of six and a half inches from the tank shell. As shown by the graph, the pressures R-T of all pusher-hanger combinations, when the roof is so centered, are slightly more than 30 lbs. Assuming now that the floating roof is driven toward one side by wind pressure and that accordingly the width of the space P on that side is reduced to three and a half inches, adjacent the hangers and pushers 10-1, 20-1, the width of the space is accordingly increased to about nine and a half inches adjacent the opposite pushers and hangers 10-2, 20-2. At the first mentioned points the floating roof is exposed to inwardly acting forces R10 plus R20, the sum of which as shown by the curve RT is in excess of 50 lbs., that is, sharply increased. At the corresponding opposite point the curve RT shows an inward, opposite pressure of less than 25 lbs., that is, less than the pressures in centered position and only slightly more than the minimum pressures shown. Thus there exists a centering force in excess of 25 lbs. for the first mentioned points. This force is multiplied by the number of linkage elements effectively lying in the line of action of the wind pressure; and this number, again, depends upon the size of the tank, as does the effect of the wind pressure itself. The more than proportional outward increase of the pusher pressure is reflected by the pronounced downwardly convexity of the curve R10 and the similar form of the curve RT.

As a result of this new and advantageous arrangement of pressure conditions the total amount of weights 12, required with a given seal S, SS and hanger system 20, is considerably less than in earlier designs. This feature reduces the cost of the mechanism, directly and indirectly.

This is a continuation in part of the copending

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ing applications S. N. 149,956, filed by the undersigned, on March 15, 1950, now abandoned, S. N. 200,713, filed on December 14, 1950, by Reign C. Ulm, now abandoned. The first copending application showed a pusher lever similar to that of the present Figure 7. The second copending application showed a pusher lever similar to that of the present Figure 1. The hanger arms shown in both copending cases were similar to those of the present Figure 7.

We claim:

1. A floating roof comprising in combination with a peripheral rim and a seal ring supported therefrom, a series of rigid pushers distributed around the rim, each pusher having an upper end portion forming a pivot and connected with the rim for swinging motion in a substantially vertical plane substantially radial of the floating roof, a weighted lower end below the floating roof, inwardly of the pivot, and an intermediate cam and rocker portion extending from adjacent the pivot at least over a major portion of the pusher toward the weighted end, with pronounced, arcuate, outward, substantially uniform curvature in the outer surface of the entire cam and rocker portion, with steep downward and outward extension in the cam and rocker portion adjacent the pivot and with progressively steep downward and outward extension to a point of tangential contact between the cam and rocker portion and the seal ring, so that the location of the said point of contact is vertically variable to a substantial extent as compared with the displacement of the weighted end of the pusher, in response to horizontal movements of the floating roof relative to the seal ring.

2. A floating roof as described in claim 1 wherein said curvature in said outer surface of the cam and rocker portion is circular.

3. A floating roof as described in claim 2 wherein the circular curvature extends throughout the entire extension of the pusher from the pivot to the weighted end.

4. A floating roof as described in claim 3 wherein the outer surface of the cam and rocker portion of each pusher forms an arc of about 135°.

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REIGN C. ULM.

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