Sept. 1, 1953 R. C. ULM 2,650,738

FLOATING ROOF

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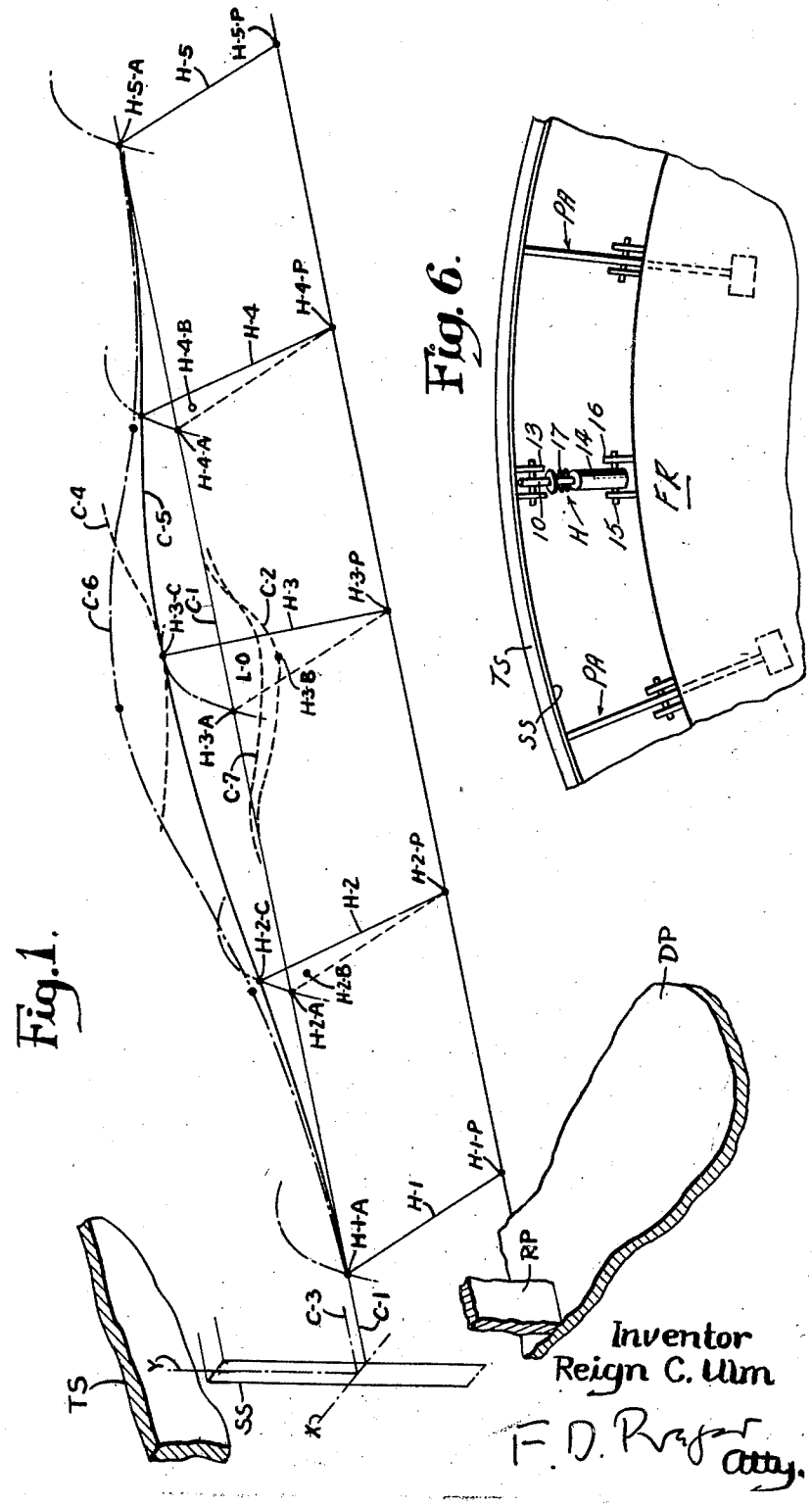


Fig. 1.

Fig. 6.

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Fig.2

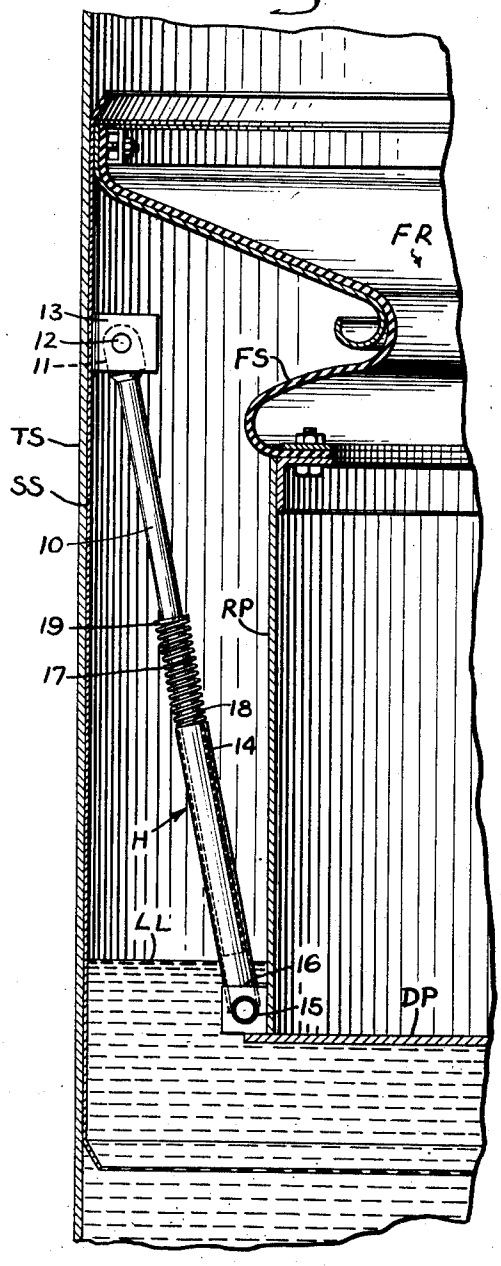
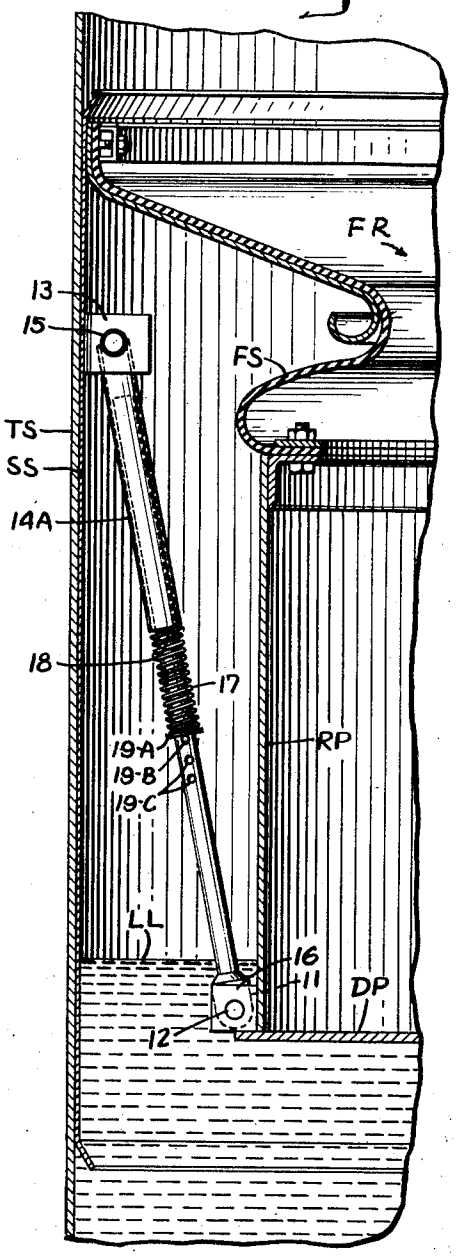


Fig.3



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Fig. 4

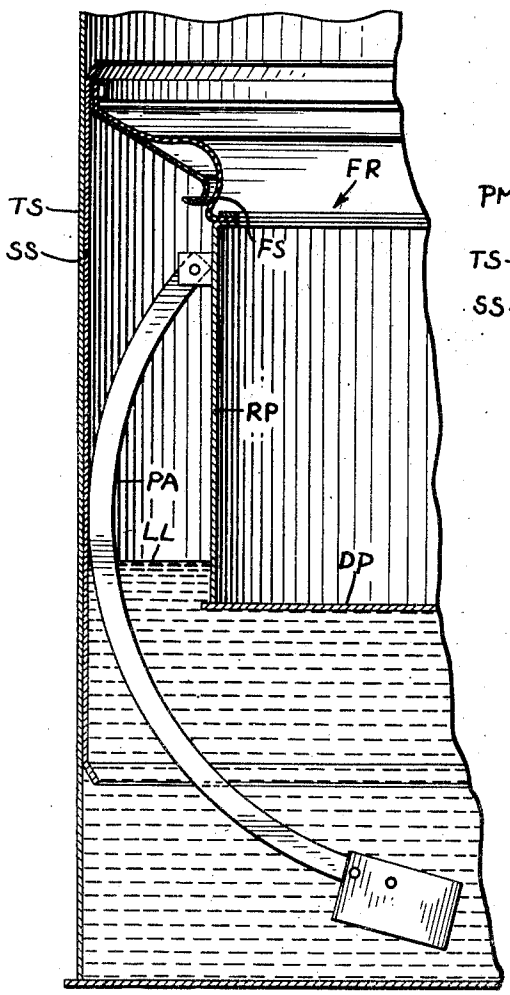
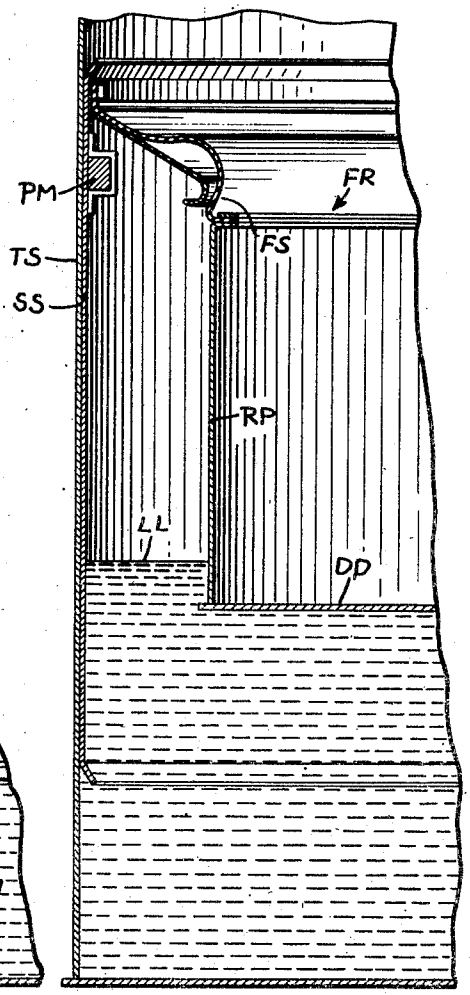


Fig. 5



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Patented Sept. 1, 1953

2,650,738

UNITED STATES PATENT OFFICE

2,650,738

FLOATING ROOF

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Application November 12, 1952, Serial No. 319,806

6 Claims. (Cl. 220—26)

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This invention relates to floating roofs for gasoline storage tanks and the like and particularly to seal hangers for the same. It provides an improved combination of features of economy and efficiency, in such hangers.

Both economy and efficiency are important in these devices. Floating roofs are used for the protection and conservation of valuable liquid products; mainly for vapor conservation and fire protection in gasoline storage tanks subjected to frequent filling and draining operations. The floating roof itself and the annular seals between the floating roof and the tank shell are vital for these purposes.

The floating roof is always surrounded by a clearance space, in order to allow upward and downward movements of the floating roof regardless of local irregularities in the tank shell. In this manner the major cost element, the tank construction itself, is kept within economical limits. A seal is required over the clearance space in order to protect the stored liquid product from evaporation, pollution and other dangers. This seal, in practically all modern and accepted forms thereof, comprises a more or less cylindrical strip or so-called shoe of metal, with one or several expansion joints therein. Flexible fabric strips are commonly attached to the top of the shoe and the floating roof, and sometimes flexible curtains are attached to the bottom of the shoe. Supports are required for the shoe and parts thereon in order to cause upward and downward motion with the floating roof; and holders are required in order to hold the shoe in sliding contact with the tank shell.

These supports and holders as well as the seal shoe itself must be sturdy since they are exposed to corrosive atmospheres and other hard exacting conditions. At the same time they should be simple and economical in order not to destroy the general economy of the tank.

The supports, in modern practice, generally consist in linkage units distributed around the floating roof. They are usually installed below the top edge of the seal shoe, and spaced by distances such as three to six feet. Seal holders usually consist in added linkage, spaced around the floating roof at generally similar or closer distances. Holder magnets, similarly spaced, were introduced a short time ago.

The present invention provides a new seal shoe support linkage with an extremely simple but most effective combination of rigid and yielding parts therein. Earlier hangers of comparable simplicity tended to pull a seal shoe away from

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the tank shell. The new hangers or supports allow the shoe to lie closely against the tank shell.

A primary feature of this new hanger is that due to certain yielding characteristics, it is considerably more efficient than earlier hangers of comparable simplicity and economy. An equally important feature of the new hanger is that due to the small number and simplicity of the parts used therein it is considerably more economical than were the earlier hangers of comparable efficiency.

A great many combinations of rigid and elastic seal support and holder parts have been developed in the past. For instance the art knows plain and rigid, upwardly and outwardly directed hanger arms; horizontally disposed, telescoping, spring-loaded pushers, multiple link hangers or hanger-pusher combinations, and various modifications and combinations of such elements. Said holders of the past were practically unsuitable as hangers and only of limited utility as pushers, according to modern requirements because their horizontal position, either above or below the top surface of the floating roof, interfered with a number of required maintenance operations. Conventional hangers on the other hand were either inefficient when they consisted of simple and inexpensive units such as plain upwardly and outwardly extending arms, or they were highly expensive when being more efficient, such as the well-known pantograph linkages and the like. More and better sealing action is obtained, per cost unit expended for the hangers, by the design disclosed herein.

More specific details about the new hangers are given in the description of preferred embodiments which follows. In the drawing such embodiments are shown diagrammtically. It should be understood that the device can be modified in various respects within the scope of the applicant's claims for the present invention, set forth at the end of this specification.

In the drawing:

Figure 1 is a diagram of motions and deflections occurring in floating roof seals.

Figure 2 is a partial cross sectional view of apparatus according to the present invention, showing one of the new seal supports.

Figure 3 shows a slight modification of the apparatus of Figure 2.

Figure 4 is a view generally similar to Figures 2 and 3, showing one type of seal holder or pusher which can be used together with the new seal supports.

Figure 5 is a similar view showing a different type of seal holder.

Figure 6 is a partial plan view of apparatus according to this invention.

Referring first to Figure 1:

The seal shoe SS is here shown as a flat plate or in other words as a plate curved about a radius of infinite length. This representation is used in order to simplify the showing.

The shoe SS is thin and rather flexible across the plane of the plate material from which it is made. This construction allows a local obstruction LO on the inside surface of the tank shell TS to bend a limited local portion of the seal shoe SS horizontally inward. This limited local portion is located adjacent to the point H–3–A where the shoe contacts the obstruction LO. Said point tends to move horizontally inward to a new position H–3–B. Since the seal shoe SS is rather inflexible in the plane of the plate material from which it is made, an entire segment or vertical portion of the seal shoe, comprising the point H–3–A, moves inward together with said point. By means of suitable seal holders, the various seal shoe portions are urged outwardly to keep them in contact with the tank shell surface TS. Therefore seal shoe segments or portions remote from the local obstruction LO are at least theoretically kept in their original positions.

If no other forces were involved the operation described up to this point would form the center line C–1 of the hanger seal pivots H–1–A, H–2–A, etc. into a generally smooth locally bulging line C–2, extending in a horizontal plane. The centroid C–3 of the seal shoe, being kept parallel with the pivot center line C–1, would follow a similar horizontal course.

Actually, as the rigid hanger H–3 is displaced inwardly by the local obstruction LO from a normal position parallel with other hangers H–1, H–5, etc., this hanger H–3 rotates about its lower pivot H–3–P, anchored on the rigid edge of the floating roof. Due to such rotation of the usual rigid hanger H–3, the outer pivot point H–3–A cannot move horizontally to H–3–B but is forced to move in an arc to a higher point H–3–C, thereby tending to change the original center line C–1 to a locally raised, not only inwardly bulging form C–4. (This also tends to cause some lateral creep of the seal shoe SS along the tank shell TS. This latter tendency is relatively unimportant for present purposes, it being possible to compensate for it, for instance by a slight looseness in the support pivots H–3–A, H–3–P, etc.)

The plate or sheet material of the seal shoe SS resists bending and shearing forces acting in the plane of the plate material. Such forces would be involved in purely local raising of the seal strip near the point H–3–C over the average elevation of the seal shoe. Thus the seal strip actually tends to follow a widely and gradually rising center line, as a joint effect of the local obstruction, of the rigid pivoted hanger construction, and of the seal shoe's high rigidity within its own plane.

Consequently the seal strip SS raises the hangers H–2 and H–4 adjacent the inwardly and upwardly rotated hanger H–3, thereby in turn leading to some inward displacement of the upper pivots H–2–A, H–4–A of these adjacent hangers. These pivots accordingly move upward and inward to positions H–2–C and H–4–C. The center line C–5 passing through these points is bent both inward and upward in a smooth and gradual three-dimensional curve.

Such gradual inward bending can only be counteracted and modified, not eliminated by the application of outward reaction forces of spaced seal holders. For instance, such holders between hangers H–3, H–2, etc., superimpose a wave form (not shown) over the curve C–5.

The essential effect of the forces discussed is that a seal shoe SS supported by rigid hangers H is bent inward over a large area, even by a small local obstruction. This can be visualized when the line C–5 is viewed together with its horizontal projection C–6. Since the seal shoe is urged into locally changing elevations, while inherently resisting such change, the seal shoe is pulled away, inwardly from the tank shell, in a large area between the lines C–5 and C–6. Evaporation and pollution of liquid products tends to occur in this unsealed area.

I have further discovered that such pulling away of the seal shoe SS sometimes occurs even without any apparent local obstructions or buckles in the tank shell TS. It occurs because of unavoidable variations in the width of the clearance space around the floating roof. When a floating roof, due to wind, shifts toward the leeward side of the tank, the hangers on that side rise while those on the windward side are lowered. Adjacent the leeward side, this causes seal shoe distortions, the exact location of which depends largely upon the location of the expansion joints.

Whether distortion and pulling away be caused by local obstructions or by lateral shifting or by both combined, it is always objectionable since it causes loss or pollution of valuable products.

If expansion joints are provided in great number and at close intervals, in the seal shoe, excessive distortion can be avoided. In the past, a multiplicity of such joints has actually been used in certain roofs, for a variety of reasons. However, modern practice is opposed thereto; it favors a minimum number of such joints, as provided for instance by integral, metallic shoes of 50 or 100 feet length. There are several reasons for this preference. The joints form areas of unsealed or poorly sealed construction, all around the tank, even when aiding the seal function locally. They also add to the cost of the construction. They make the seal strip more or less flexible in all directions, but costwise as well as functionally it is preferred to keep the seal strip vertically rigid and self-supporting.

It has occurred to me to combat the pulling away of the seal shoe by an elasticity feature in the seal shoe hangers, not by the use of numerous expansion joints and resulting elasticity in the seal shoe itself. I tested the idea on seal shoes which previously had shown bad pulling away from the shell. I found that the invention practically eliminates pulling away and the unsealed areas caused thereby. It does so by a mechanism of the utmost simplicity and economy.

The new seal hanger links or support arms H, one of which is shown in Figure 2, are of telescoping design. Each arm H comprises (1) an upper, straight, rigid bar 10, with a flattened pivot end 11 pivotally joined to an upper part of the seal shoe SS by means of pivot pin or rod 12 held in bearing members 13 welded to the seal shoe for swinging movement in a vertical plane radial of the tank; and (2) a fitting for the bar 10 provided by a lower, straight, rigid pipe 14 having telescopic fit with the bar or rod 10 and having similar pivotal connection with the lower part of the rim plate RP, by a

hollow rod or pin or pipe member 15. This member 15 is shown as welded to the bottom end of the pipe 14, transversely thereof, and being journaled in a pair of bearing jaws 16 welded to the rim plate RP adjacent the deck plate DP. The linkage is practically completed by (3) a compression spring 17, having an inner diameter slightly greater than the rod 10 and an outer diameter approximately equal that of the pipe 14. This spring surrounds the lower part of the rod 10 and bears with one end against the flat top surface 18 of the pipe 14 and with the opposite end against the flat underside of a stop member or washer 19 secured to the rod 10. A plurality of seal hangers H, comprising the telescoping members 10, 14 and 17, is spaced around a floating roof at suitable intervals; all hangers H extending rather steeply upwards and outwards but being able to find, individually, proper positions and inclinations.

Interspersed with the support hangers H, seal holders or pusher arms PA are spaced around the floating roof, preferably at closer intervals. Such a holder is shown in Figure 4 as comprising a bar pivoted to the top portion of the rim plate RP, extending outward and downward toward the seal shoe SS and then inward and downward to a region below the deck plate DP, where the bar PA is suitably weighted. As an alternate, Figure 5 shows seal holders provided by a series of permanent magnets PM, secured to the seal shoe SS and disposed in magnetic circuit with the steel of the tank shell. In order to seal the tank well, against rain water and evaporation, a series of magnets PM may best be arranged adjacent the upper edge of the seal shoe SS, as shown.

In operation the floating roof FR is supported by and upon the liquid level LL. It supports, by the upwardly directed hangers H, the seal shoe SS, forcing this shoe to rise and fall with the floating roof, as the roof rises and falls with the liquid level. The seal holders PA or PM, or both, keep the outer surface of the seal shoe SS in sliding contact with the inner surface of the tank shell TS. The hangers H contribute to this effect, since they are inclined upwardly and outwardly and apply an outwardly directed pressure to the tank shell due to one of the reactions of the supported weight of the seal shoe SS and of the hangers themselves. However the economical spacing of the hangers H is usually such that their outward pressure contributes but slightly to the desired effect of holding substantially the entire seal shoe in contact with the shell.

The outward actuation of the seal shoe SS by pusher arms PA or hangers H, or both, applies also an inward reaction force to the floating roof FR, tending to center this roof in the tank. Such centering is desirable in order to relieve the flexible seal FS of local stress caused by lateral shifting of the floating roof under the effect of wind pressure. However the uncentering force of the wind is often so great that it would be uneconomical to balance or overbalance its maximum values by the centering effect of the pushers or hangers. Therefore it is usually preferred merely to re-establish centered conditions when extreme wind pressure has subsided. For this purpose the centering effect of the hangers H alone is sufficient at least in a great number of instances. A very adequate seal mechanism can be formed by the telescopic hanger-pushers, interspersed with seal holder magnets PM which are devoid of roof centering effect.

Whenever a local portion of the seal shoe SS, incident to the upward and downward travel of the floating roof, encounters a local obstruction LO, as shown in Figure 1, the present non-rigid, telescoping hangers H are substantially free from the problems explained above with regard to rigid hangers. Inward displacement of a hanger H–3 merely moves a point H–3–A to a new position H–3–B. The rigidity of the seal shoe SS in its vertical plane causes a compression of the spring 17 of the hanger H–3, rather than an upward deflection of the seal shoe between the points H–1 and H–3 and consequent rising and inward displacement of hangers H–2.

Consequently the center line of the upper pivots 12 for the new telescoping hangers H assumes a form rather similar to the horizontal line C–2 which has been shown and explained above. At most, there may be some minor deflection from this relatively ideal form C–2 toward the form C–5 explained above, as shown at C–7. Such deflection, if any, depends upon the exact ratio between the spring characteristics of the various compression springs 17 and of the seal shoe itself.

Considerably better sealing is effected with an elastically supported shoe following the line C–7 than with a shoe supported by rigid hangers, which follows the line C–5. At the same time the expense for pantograph motions and the like is avoided.

Figure 3 shows an embodiment of the new hanger wherein the pipe 14–A is pivoted to the seal shoe and the bar 10–A to the floating roof rather than vice versa. The figure also shows a further modification, according to which the abutment member or washer 19–A for the compression spring 17 is longitudinally adjustable along the bar 10–A, rather than rigidly secured thereto. This can be achieved for instance by supporting this abutment member on a suitable pin 19–B extending through the rod 10–A. A number of holes 19–C are provided for such pins, at different distances from the opposite abutment surface 18. By means of such adjustment, one and the same type of simple telescopic hanger can be adapted to use with seal shoes of very different type and weight, without change in design or material used for the seal shoe hanger.

A number of other modifications will occur to persons skilled in the art, upon a study of this disclosure.

I claim:

1. A seal mechanism for a floating roof tank, comprising a floating roof, a seal shoe surrounding the floating roof and radially spaced therefrom and a plurality of supporting arms for the seal shoe, arranged around the floating roof in circumferentially spaced relation and in upright positions, each of said arms comprising a resiliently extensible and compressible portion, means on a lower portion of the arm to connect it pivotally with the floating roof and means on an upper portion of the arm to connect it pivotally with the seal shoe.

2. A mechanism as described in claim 1 wherein said resiliently extensible and compressible portion forms a telescopic portion of the arm between said lower and upper portions thereof.

3. A mechanism as described in claim 1, additionally comprising a plurality of seal shoe holders arranged around the floating roof in spaced

relation and adapted to apply outward pressure to the seal shoe, sufficient, together with such pressure caused by the weight of the seal shoe connected to said arms, to hold the seal shoe in sliding contact with the shell of the tank.

4. A mechanism as described in claim 3, wherein each holder comprises a magnet secured to the seal shoe in magnetic circuit with the shell of the tank, the shell being made of steel plates.

5. In a tank construction of the type having a floating roof and a sealing shoe, combined shoe supporting and seal maintaining mechanism comprising a plurality of resiliently extensible struts extending upwards from the floating roof to the sealing shoe, pivotally interconnecting the same and arranged in circumferentially spaced relation around the floating roof.

6. A seal mechanism for a floating roof tank, comprising a floating roof, a seal shoe surrounding the floating roof and radially spaced therefrom and a plurality of supporting arms for the seal shoe, distributed around the floating roof in circumferentially spaced relation and extending

upwards and outwards between the floating roof and the seal shoe; each of said arms comprising a lower portion, pivot means thereon to connect it with the floating roof, an upper portion, pivot means thereon to connect it with the seal shoe, the upper and lower portions having telescopically sliding relation with one another, and a compression coilspring coaxial with said arm and resiliently spreading said upper and lower portions apart.

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