Oct. 16, 1951 E. T. ARMSTRONG 2,571,817

SEAL FOR FLUID CONTAINERS

Filed April 9, 1947 2 SHEETS—SHEET 1

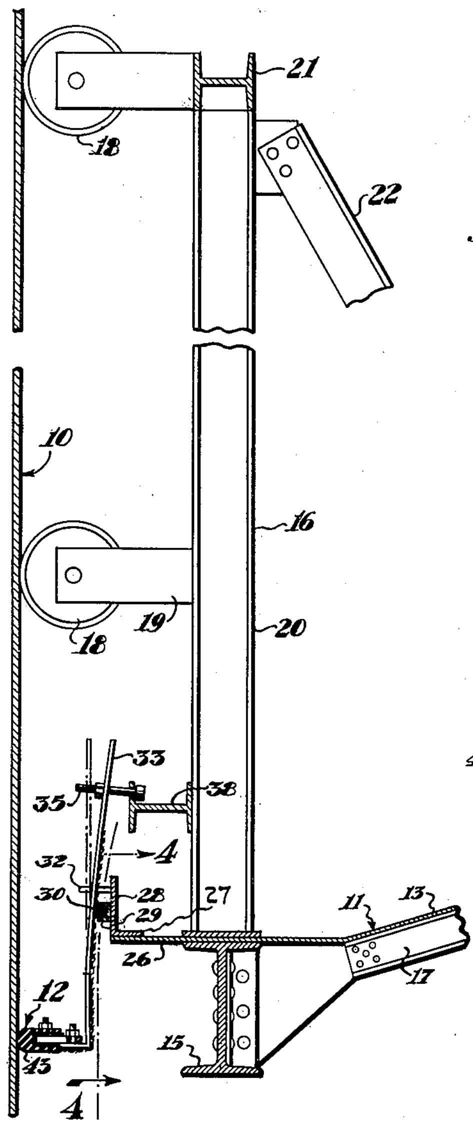

Fig. 1

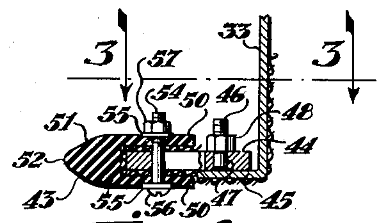

Fig. 2

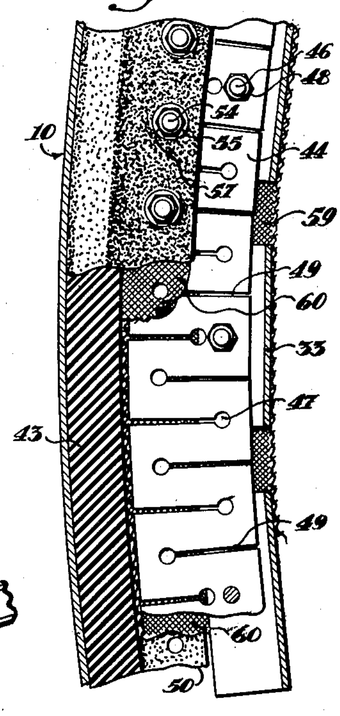

Fig. 3

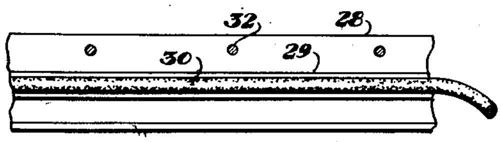

Fig. 4

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SEAL FOR FLUID CONTAINERS

Filed April 9, 1947 2 SHEETS—SHEET 2

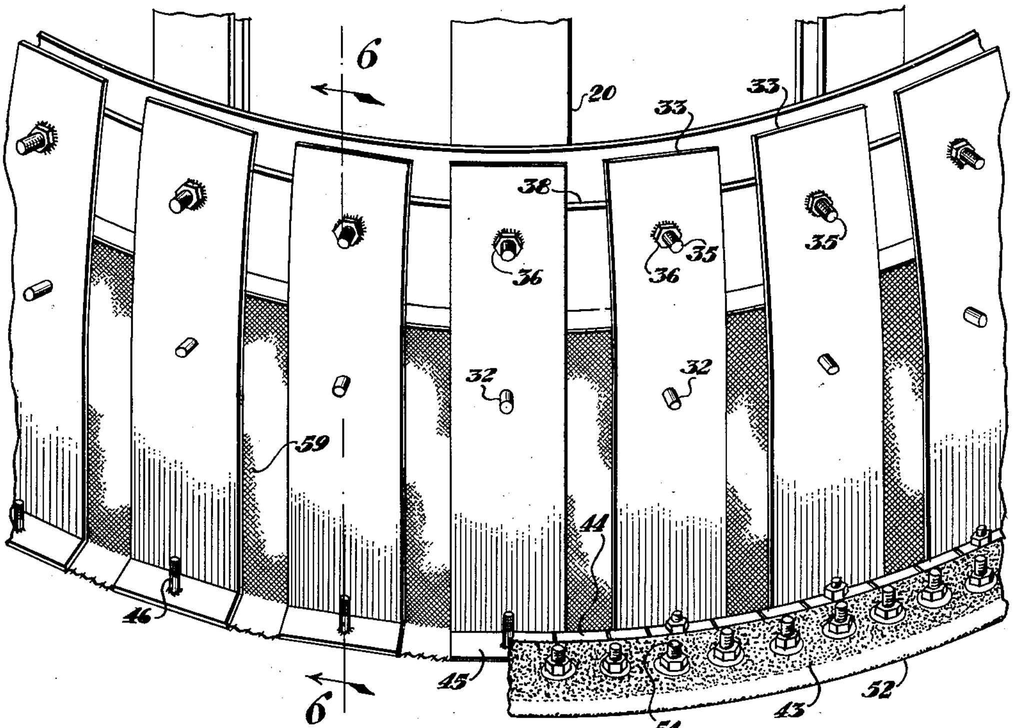


Fig. 5

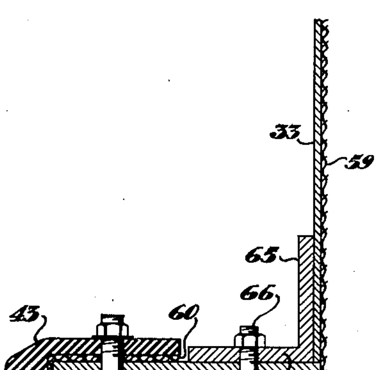


Fig. 7

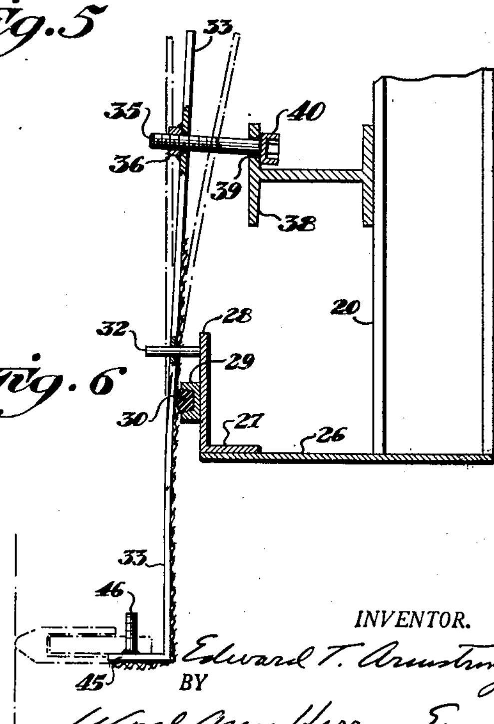


Fig. 6

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# UNITED STATES PATENT OFFICE

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## SEAL FOR FLUID CONTAINERS

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Application April 9, 1947, Serial No. 740,368

16 Claims. (Cl. 48—176)

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This invention relates to fluid storage reservoirs of the class having a floating, vertically translatable piston confined within a cylindrical reservoir, which piston functions as a movable top closure to confine the fluid in the reservoir. Such reservoirs include gas holders of the type wherein the gas is trapped in the reservoir by the piston which, by virtue of its effective weight, maintains the gas under pressure, as well as volatile liquid containers with floating roofs. The present invention is directed to improvements in the sealing apparatus of the piston by means of which a gas-tight seal is established mechanically between the piston and the reservoir or shell.

It has been the practice to utilize, for this purpose, one or more dilatable packing rings forming a part of the piston to establish a mechanical seal with the shell. A series of levers or other means, carried by the piston at spaced intervals, expands the ring outwardly against the shell to establish a seal, in the presence of a suitable lubricant. The United States Patent No. 2,371,966 of H. H. Liese et al., granted March 20, 1945, is representative of this structure. An even earlier example of this general type of holder may be found in the patent to Einbeck et al., 1,924,029, granted August 22, 1933.

The present improvements are directed to this type of dry seal holder as distinguished from the liquid seal type exemplified in the patents to K. Jagschitz, No. 1,275,696, granted August 13, 1918, and No. 1,481,099 granted January 15, 1924.

The liquid seal type holder essentially constitutes a piston disposed within a holder shell and incorporating a trough circumferentially arranged and open to the wall surface of the shell. A viscous sealing liquid is carried in the trough, which liquid leaks through the space between the shell and the piston and in so doing seals the piston relative to the shell. The liquid trickles down the wall of the shell to a collecting trough at the bottom and is returned to the top of the piston by means of an automatic pumping system.

Briefly, it is the concept of the present inventor to provide a simplified piston seal comprised essentially of a continuous, relatively narrow-faced sealing ring or annulus of flexible material, which is supported by a spring loaded support member, the seal being joined to the lower edge of a flexible skirt extending from the piston. The skirt is exposed to the gas trapped under pressure beneath the piston and, therefore, is responsive to pressure changes to vary the sealing pressure of the ring in accordance with gas pressure changes.

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The seal ring may be formed of a continuous plastic extrusion of U-shaped or other cross section to adapt it to be engaged upon a supporting bar of flat cross section, slotted at intervals to impart tangential flexibility. This bar initially may be straight and upon installation be bent to a circular arc conforming to the cylindrical gas holder shell. Together, the elastic seal ring and flexible support bar provide a unit of increased flexibility, which accommodates itself readily to local or general shell irregularities. Friction is reduced and therefore the piston is more, in its movement, responsive to pressure changes and there is less wear.

The support bar is carried by a series of spacing members or staves extending from the piston in the form of flat, springy plates adjustably mounted and arranged to spring load the flexible support bar at a series of points around its periphery. A skirt or apron, of flexible, gas impermeable material extends continuously around the piston, having one edge sealed with the piston or deck, and the other edge joined in sealing relation with the seal ring. This skirt arrangement permits expansive and contractive movements of the seal relative to the piston to accommodate shell irregularities.

Due to the functional limitations of dry or waterless seals constructed in the past, it has been necessary to provide a shell built with greater precision than was necessary for the liquid type seal. Consequently the initial cost of the holder shell has been greater for a dry seal gas holder. On the other hand, maintenance costs are greater for the liquid seal holder than the dry, by reason of the use of sealing liquids and of servicing the holder. Performance of the liquid and dry seal holders is approximately equal if shell diameter, concentricity and vertical alignment of the dry holder shell are held within close limits. Shell fabrication costs, however, increase sharply as the specified tolerances are reduced.

Primarily it has been the object of the inventor to reduce gas storage costs by the provision of a dry piston seal of simplified design, having improved shell accommodation and characterized by reduced friction and minimized wear to permit its application to holder shells fabricated according to lower cost liquid seal standards, as distinguished from dry seal precision practice.

A more specific object has been to provide a narrow-band continuous flexible dry seal by establishing substantially a line contact with the holder wherein the pressure in the narrow contact area is sufficient to completely prohibit the passage of stored gas despite irregularities in the shell surface contour and notwithstanding a certain amount of piston tilt.

It has been a further object to provide a continuous elastomeric sealing ring reinforced by a more generally flexible flat metal support ring, the elasticity of the sealing ring compensating for local irregularities and the metal support ring compensating, by more general deformation, to the overall deviations and eccentricities of the holder shell, the sealing unit being responsive to variations in gas pressure to vary its sealing pressure accordingly.

Undue wear of the seal ring is avoided by holding the mechanical or spring loading of the ring to a minimum and supplementing it with gas developed pressure. This is accomplished by the expansible skirt or diaphragm exposed to the stored gas pressure on one side and to a separate pressure on the other side. Changes in gas pressure induce proportional variations in seal load due to the effect of differential pressure on the skirt. Thus, the seal load is always maintained at the minimum value required to effect sealing resulting in reduced friction and seal wear.

The ring, upon which is engaged the elastic seal section, permits the use of a continuous extruded element of uniform cross-section which may be produced commercially at low cost. Adjustable bending means are provided by means of which the relation between the spring loading and gas pressure loading of the seal ring unit may be varied to suit the required operating conditions.

These and other objects and advantages of the invention not specifically set forth will be more fully disclosed with reference to the accompanying drawings in which:

Figure 1 is a fragmentary sectional view taken radially through one side of a gas holder shell, illustrating a portion of the piston with the improved sealing apparatus in sealing engagement with the shell.

Figure 2 is an enlarged detailed cross sectional view of the seal and its mounting means.

Figure 3 is a sectional plan view taken on line **3—3**, Figure 2 and broken away to further detail the sealing arrangement.

Figure 4 is a sectional view taken on line **4—4**, Figure 1, illustrating the skirt sealing bead which forms also the fulcrum point for the flat loading springs.

Figure 5 is a fragmentary perspective view of a portion of the sealing organization as viewed from the outside of the piston.

Figure 6 is a fragmentary sectional view similar to Figure 1, detailing on an enlarged scale, the adjustable mounting means for the seal ring.

Figure 7 is an enlarged sectional view showing a somewhat modified arrangement for attaching the elastic seal and flexible mounting bar to the piston.

The several views of the drawings are limited to portions of the gas holder sufficient to illustrate fully the environment, construction, and operation of the improved seal. Generally described, the holder shell is indicated at **10**, the piston generally at **11** and the sealing organization generally at **12**.

The vertical cylindrical shell or cylinder is fabricated of steel plates suitably joined together, for example by welding or riveting. These joints may be machined or otherwise dressed to present a relatively smooth, even internal surface contour. Suitable structural steel bracing is applied to the outside of the shell to stabilize and support it according to prevailing commercial practice.

The piston **11** generally comprises a deck **13** formed of steel plates suitably joined together in the form of a dome-like structure disposed within the shell **10**. A series of horizontal beams **15** marginally define the circular contour of the piston, the beams being secured to the underside of the deck and forming the foundation for a superstructure **16** of the piston. A reinforcing structure **17** fabricated of structural steel members is disposed beneath the deck to reinforce and stiffen it.

In its vertical movements relative to the shell, the piston is guided by the superstructure to prevent lateral tilting. For this purpose a series of circumferentially arranged guide rollers disposed in tiers spaced one above the other, is carried by the superstructure. These rollers **18** are journalled in brackets **19**, which brackets are secured upon a series of vertical I beams **20** rising above the piston and forming a part of the superstructure **16**. The lower ends of I beams **20** are supported upon the horizontal I beam **15** and have their upper ends secured together by means of circumferential, horizontally disposed I beams **21**. A bracing structure **22** extends angularly from the piston deck to the upper ends of the vertical I beams to stiffen the superstructure.

By virtue of the guide rollers **18** bearing against and tracking upon the surface contour of the shell, the superstructure **16** and piston deck is caused to follow the shell contour and excessive tilting of the piston relative to the shell is prevented.

Sealing apparatus **12** for the piston is supported in a substantially horizontal plane primarily from a marginal extension **26** of the piston deck. For this purpose an angle iron **27** extends continuously around the marginal edge of extension **26**, being secured thereto preferably by welding to provide a gas-tight connection with the piston deck. Approximately midway of the length of the vertical leg **28** of the angle iron **27**, is secured a continuous circumferential channel iron **29** having seated therein a resilient gasket or bead **30**.

Along the upper portion of leg **28** is located a series of support pins **32** upon each of which is hung one of a series of flexible staves **33**, the lower ends of which carry the seal member as hereinafter described. Each stave is controlled individually by an adjusting screw **35** at the upper end of the plate, which screw engages in a nut **36** welded or otherwise secured to the outside surface of the plate. The opposite end of each of the adjusting screws is anchored in an I beam **38** extending around the superstructure, the I beam being secured to the upright I beams **20**. Each screw passes through one of a series of spaced apertures **39** formed in a web of the I beam **38**, the screw including a head **40** bearing against the web. These screws preferably are of the socket head type having a cylindrical outside diameter and an internal hexagonal or fluted bore, adapted to receive an instrumentality for adjusting them. As viewed in Figures 1 and 6, each stave functions as a lever pivoted upon the annular bead or gasket **30**, the screw **35** drawing the upper end inwardly and bending the lower end outwardly to expand the seal unit against the holder shell wall surface.

Referring to Figures 2 and 3, the piston seal unit consists of a relatively flat elastic band **43** of U-shaped cross-section, engaged upon and carried by a flexible support bar **44**. The support bar in turn is secured to a right-angled end portion **45** formed at the lower end of each of the respective hangers **33**. This attachment is by means of upright studs **46** preferably welded upon the horizontal portions **45** and passing through apertures **47** in the support bar **44**, at suitable spacing. Nuts **48** engaged upon the studs **46** clamp the support bar securely in place on the hangers.

Slots **49** are cut into the flat metal support bar **44** from alternately opposite side edges to render the plate tangentially and radially flexible. This plate is formed preferably from flat steel stock in straight condition, which upon being assembled, follows the circular contour of the holder shell. It is deformable generally, that is, it will accommodate itself to general irregularities encountered in the surface contour of the holder shell, such as eccentricity or general deviations from a plane surface in the vertical direction. It will not as readily accommodate itself to purely local irregularities encountered in its vertical translation, as will the locally resilient sealing band **43**.

Sealing band **43** is formed of a flexible material which may be generally characterized as a synthetic elastomer, although natural rubber also may be used. It is formed preferably as a continuous extrusion of relatively flat configuration, U-shaped in cross-section to provide a pair of limbs **50**, having a wedge-like solid connecting section **51**, with a rounded sealing edge **52**. By virtue of the sealing pressure imposed on the contact surface, this resilient rounded edge which contacts the shell, is deformed or flattened slightly along its line of contact therewith to form a narrow sealing band, closely embracing and establishing a more perfect seal with the shell.

As shown in Figures 2 and 3 the band **43** is slipped over the edge of the flat support bar **44** with its limbs **50** disposed on opposite sides of the bar. A series of bolts **54** pass through the limbs and bar, each bolt having washers **55**, one under the bolt head **56** and the other under the nut **57**. The lower edge of a flexible skirt or apron **59** is doubled over the edge of support bar **44** as at **60** to establish a gas-tight joint with the sealing band **43**.

Thus, the doubled over skirt portion **60** is clamped tightly between the respective upper and lower limbs **50** and bar **44**, and a double seal established between the resilient sealing band **43** and skirt **59**. If desired, a sealing coat of cement or the like may be applied in this area prior to assembly. It will be understood that the skirt and sealing band extend continuously around the circumference of the piston to form an unbroken seal, the adjacent vertical ends of the band and likewise the skirt being joined together in an appropriate manner.

From the sealing band the skirt extends horizontally inwardly along the flanged lower end **45** of hangers **33**, then rises vertically in contact with the inside surface of the hangers, to which surface it may be cemented or otherwise secured. As shown in Figure 6, the skirt passes over the resilient fulcrum bead **30** and is thus pressed between the bead and the hangers **33**. In order to insure a seal between the gasket and the skirt, a coating of flexible cement may be applied therebetween. The skirt may terminate at any desired level above the bead **30**, this portion, of course, being secured to the hangers **33** by a suitable adhesive.

As will be apparent from Figures 1 and 6, the effective portion of the skirt is that area extending between the seal **43** and bead **30**, which area is exposed to the gas pressure under the piston and forms in effect a continuation of the piston deck **13**. Gas pressure thus sets up a diaphragm action upon the skirt and hangers, causing the hangers to transmit the gas pressure to the support bar **44** and sealing band **43**. By this arrangement the spring loading of the bar may be kept at a minimum to avoid unnecessary wear of the seal. This in turn makes the piston more responsive to gas pressure changes since it minimizes mechanical friction between the shell and seal.

The skirt is preferably made from a fabric cloth having a coating of plastic material such as "neoprene" or "Vinylite" to make it gas-tight. Other commercially available diaphragm materials, such as rubber coated fabrics or flexible plastic sheet materials, also may be utilized. By reason of a slight circumferential expansion required of the skirt, it is of course preferable that the material be slightly elastic circumferentially. Also, the material is required to be relatively soft so as not to affect adversely the function of the sealing apparatus.

In the vertical translation of the piston relative to the shell, general shell irregularities encountered by the superstructure guide rollers, are transmitted directly to the piston deck. This tends to cause lateral piston shift and tilt relative to the shell, which action would tend to cause leakage of gas past the sealing band **43**. Also, this tends to produce further tilt due to increased loading induced at a point diametrically opposite the leak. However, the flexible skirt and hangers permit the piston to tilt or shift laterally as a unit relative to the sealing apparatus without causing leakage. There is essentially no change in the seal contact pressure so that leakage is avoided and further tilting due to variation in seal friction is eliminated.

The design of the seal support bar **44** combined with the independently adjustable resilient staves **33** result in increased accommodation to the shell and a minimum of friction between the shell and the sealing band. As viewed in Figure 3, the support bar **44** is spring loaded at equally spaced intervals around its circumference. The design of the bar is such that it distributes uniformly the load between the spring hangers, resulting in a constant uniform pressure about the circumference and permits a minimum number of hangers to be used. Being generally deformable, it is free to deflect and conform to general deviations in the shell structure while the more resilient sealing band **43** is free to accommodate itself to relatively minute inaccuracies in the surface contour of the shell. By reason of the relatively narrow contact area established with the shell by the seal band, the sealing load is concentrated and higher seal contact pressures are attained with reduced seal loads, thereby reducing friction. In addition to this, the increment of seal load induced by gas pressure avoids overloading, permits a very light weight structure, and being uniformly distributed, eliminates uneven wear. By reducing the required sealing loads, the wearing qualities and life of the seal are greatly lengthened.

Lubrication to minimize friction and wear between the holder wall and seal are provided. Supply means for the lubricant is not illustrated since this portion of the structure is not a part of the present invention. While the seal disclosed herein may be lubricated by heavy greases of the type previously used in this type of waterless gas holder, the lubrication necessary may also be accomplished by the use of more fluid lubricants such as mineral oil or antifreeze solutions of the glycerine, or ethylene glycols type.

As shown in Figure 7 a somewhat modified mounting is provided for the support bar and sealing band. In this instance the spacing member or stave **33** has at its lower end, an angle member **65** secured thereto preferably by welding. This member supplants the horizontal flange **45** previously described and provides a mounting surface for the support bar in place of the flange. A bolt and nut **66** extends through the lower flange **67** of the support member, the nut engaging the top surface of the flange to secure the support bar firmly in position.

Referring to Figure 6 of the drawings, the sealing load is developed by drawing the upper end of the flexible hanger inwardly toward the center of the piston, the position of maximum pressure being illustrated in dot-dash lines. By virtue of the lever action of the hangers pivoted upon the bead **30**, the pressure exerted against the seal ring **43** may be greater than that developed at the upper end of the hanger. This of course facilitates adjustment of the hangers and permits the use of relatively simple elements for this purpose. The resiliency of bead **30** additionally supplements the spring action of the hangers. It will be apparent that the leverage of the hangers may be increased or decreased to suit particular conditions by changing the location of the fulcrum bead **30** relative to the seal.

It is desirable to adjust all of the hangers surrounding the piston to a position of approximately equal pressure so that the seal is equally loaded around its entire circumference. When this ideal condition prevails, the piston is in a balanced condition with respect to the seal, there being a minimized variation in seal contact pressure from point to point about the periphery and consequently friction of the seal and wear of the seal is minimized. This uniformity of loading reduces the effect of frictional seal forces in inducing tilting of the piston. It will be apparent, of course, that local deviations in the shell contour will cause localized springing of the seal ring and hangers in that area, but due to the general flexibility of the supporting bar, such deflections are localized to the area affected. Therefore, the tendency to deflect the ring bodily in a lateral direction is kept to a minimum.

Holder shell eccentricities, if general, will cause the sealing apparatus to deflect bodily without excessive resistance and without disturbing the sealing capacity of the apparatus. Irregularities encountered by the guide rollers at times cause a slight general tilting of the superstructure and piston. A face seal having a substantial width dimension, when tilted, tends to leak by reason of the flat face assuming an angular relationship to the wall. As distinguished from this, the contact area and pressure as provided in the present instance are not affected by tilting since no such flat face exists and the ring will simply expand to compensate for the irregularity. This condition obtains since the cylindrical geometry of the seal contact face is insensitive to angular deviation within a fairly large range of angular tilt.



The novel principles and structural improvements embodied in the seal for the fluid storage reservoir specifically disclosed herein are susceptible to individual as well as joint utilization, not only in reservoirs which are geometrically circular, as disclosed, but also which are approximately circular, polygonal, for instance. As disclosed, two superimposed rings, L-shaped in radial cross-section and of dissimilar materials, are attached to the edge of the piston, the one elastomeric to contact the wall of the shell to consummate a gas impermeable seal, the other supporting it mechanically, but characterized by relative flexibility horizontally but not vertically so that the seal travels with the piston but accommodates itself to the contour of the shell.

Preferably, but not necessarily, the shell engaging foot of the elastomeric ring tapers in cross-section toward the shell wall to permit a rocking action and the supporting ring for the elastomer. Specifically the rigid portion of the foot of the support member or ring is relatively thin, substantially perpendicular to the wall, and sufficiently flexible radially to conform to shell irregularity or distortion. Preferably, but not necessarily, the supporting leg of the elastomeric ring depends from the piston so that the gas pressure presses the foot outwardly into engagement with the wall of the shell. Preferably, but not necessarily, this pressure is amplified by spring pressure built into the supporting member to make it self-expanding, and, if desired, this characteristic may be utilized instead of, rather than in addition to, the gas pressure to provide the desired sealing load. Preferably, but not necessarily, the leg of the elastomeric ring is an annulus constituted by the gas impermeable elastomeric membrane vertically stiffened by flat spring spacing members whether mounted on the piston to supplement or oppose the gas pressure.

In summary, the feet of the superimposed rings constitute a reinforced tapering sealing ring and the legs of the superimposed rings constitute a self-expanding, gas impermeable supporting diaphragm which depends from the piston to take advantage of the pressure differential on opposite sides of it. Although each feature of the seal may each be utilized individually in holders of either the approximately or truly circular type, the preferred and disclosed embodiment of the invention incorporates all of them.

Having described my invention, I claim:

1. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising, a plurality of flexible staves supported adjacent the periphery of the piston in closely spaced relationship and extending axially of the shell, a fulcrum ring in a plane between the upper and lower ends of the staves, said fulcrum ring backing the staves, an elastomeric ring supported by the staves in a plane substantially parallel with but spaced from the fulcrum ring, means at the ends of the staves opposite the elastomeric ring flexing said ends inwardly and pressing the staves against the fulcrum ring whereby the elastomeric ring is forced outwardly into sealing contact with the shell, and a gas impermeable skirt joining the elastomeric ring with the piston.

2. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising, a plurality of flexible staves support-

ed adjacent the periphery of the piston in closely spaced relationship, said staves including foot portions turned outwardly toward the shell, an elastomeric ring supported by the foot portions and engaging the shell in a plane substantially parallel with the piston but spaced downwardly therefrom, a gas impermeable skirt joining the elastomeric ring and the piston, a fulcrum ring on the piston in a plane substantially parallel with the elastomeric ring and backing the staves between their upper and lower ends, and adjustable means at the upper end of each stave flexing the stave inwardly against the fulcrum ring whereby the lower end of the stave is forced outwardly pressing the elastomeric ring into sealing contact with the shell.

3. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising, a plurality of flexible staves supported adjacent the periphery of the piston in closely spaced relationship, an elastomeric ring supported by the staves in a plane substantially parallel with the piston but spaced downwardly therefrom, said elastomeric ring disposed to the outside of the staves and in contact with the shell, an elastomeric bead extending around the piston inwardly of the staves and above the elastomeric ring, a flexible gas impermeable skirt having its lower end sealed to the elastomeric ring and extending upwardly along the inner faces of the staves between the staves and the elastomeric bead, and means flexing inwardly the upper ends of the flexible staves whereby said skirt is pressed inwardly into sealing contact with the bead and said elastomeric ring is pressed outwardly into sealing contact with the shell.

4. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising, a plurality of flexible staves supported adjacent the periphery of the piston in closely spaced relationship and depending therefrom, said staves having foot portions extending outwardly toward the shell in a plane substantially parallel with the piston, an elastomeric ring supported by the foot portions and in contact with the shell, a fulcrum ring extending around the piston inwardly of the staves and above the elastomeric ring, said fulcrum ring including an elastomeric bead and means mounting said bead, a flexible gas impermeable skirt having its lower end sealed to the elastomeric ring and extending upwardly along the inner faces of the staves between the staves and the elastomeric bead, and adjustable means flexing inwardly the upper ends of the flexible staves whereby said skirt is pressed inwardly into sealing contact against the bead of the fulcrum ring and said elastomeric ring is pressed outwardly into sealing contact with the shell.

5. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising, a flexible gas impermeable annulus supported adjacent the periphery of the piston and extending axially therefrom, an elastomeric ring carried by the annulus disposed in a plane substantially parallel with the piston but spaced therefrom, said elastomeric ring extending outwardly from the annulus and contacting the shell, means spaced from the elastomeric ring flexing the annulus inwardly and a fulcrum ring extending around the piston inwardly of the annulus and between the elastomeric ring and said means whereby the annulus is pressed inwardly into sealing contact with the fulcrum ring and the elastomeric ring pressed outwardly into sealing contact with the shell.

6. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising; a plurality of vertically disposed flexible staves supported by the piston adjacent to the periphery thereof in closely spaced side by side relationship, each of said staves having one portion thereof connected to said piston and having a free end depending therefrom, a ring of elastomeric material carried by the free ends of said staves in a substantially horizontal plane and a flexible gas impermeable skirt in sealed engagement with the piston and elastomeric ring, said flexible skirt being disposed interiorly of said staves and presenting a surface above said ring and below said piston to the pressure of the contents of said fluid storage reservoir, whereby fluid pressure on the inside of the skirt is transmitted to the staves to urge said ring outwardly into sealing contact with the shell wall.

7. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising, a plurality of vertically disposed resilient staves supported by the piston adjacent to the periphery thereof in closely spaced side by side relationship, each of said staves having one portion thereof connected to said piston and having a free end depending therefrom, a ring of elastomeric material carried by the free ends of said staves in a substantially horizontal plane and a flexible gas impermeable skirt in sealed engagement with the piston and elastomeric ring, said flexible skirt being disposed interiorly of said staves and presenting a surface above said ring and below said piston to the pressure of the contents of said fluid storage reservoir, whereby fluid pressure on the inside of the skirt is transmitted to the staves to urge said ring outwardly, and means carried by said piston and engaging said staves for adjustably bending the resilient staves whereby the elastomeric ring is further spring urged outwardly into sealing contact with the shell wall.

8. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising a plurality of vertically disposed flexible staves supported by the piston adjacent to the periphery thereof in closely spaced side by side relationship, each of said staves having one portion thereof connected to said piston and having a free end depending therefrom, a ring of elastomeric material carried in a horizontal plane below the piston by the free ends of the staves, and a flexible gas impermeable skirt in sealed engagement with the piston and the elastomeric ring, said skirt having an inwardly disposed face exposed to the pressure of the contents of said reservoir, whereby fluid pressure on the inside of the skirt is transmitted to the elastomeric ring to effect a sealing contact between said elastomeric ring and shell wall.

9. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising a flexible gas impermeable skirt in sealed engagement with the piston and depending therefrom, an elastomeric ring joined in sealed relationship with said skirt and engaging said shell wall, a plurality of vertically disposed staves, each supported by the piston adjacent to the periphery thereof and extending below it, each of said staves being pivotally connected to said piston to permit radial movement of the free ends thereof below the piston, said staves supporting said elastomeric ring in a horizontal

plane below said piston and in fixed vertical relationship therewith whereby the fluid pressure on the inside of the skirt tends to expand said elastomeric ring outwardly against the shell wall to effect a sealing contact between said ring and said wall.

10. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising a flexible gas impermeable skirt, a support member including a plurality of vertically disposed staves carried by said piston adjacent to the periphery thereof, a ring of elastomeric material supported by said staves in a substantially horizontal plane, said elastomeric ring being of relatively flat configuration and having a U-shaped cross section, the outer edge of the elastomeric ring constituting a tapered portion adapted to engage the shell in sealing contact, the inner portion of said elastomeric ring having an annular groove therein for mounting said ring upon said support structure, said skirt and said elastomeric ring being in sealed engagement whereby said piston, skirt and elastomeric ring form with the shell a gas-tight enclosure of variable size.

11. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising a flexible gas impermeable skirt secured to the margin of the piston, a plurality of vertically disposed staves carried by said piston, a circular, radially expansible metal ring supported by said staves in a substantially horizontal plane, a ring of elastomeric material supported by the metal ring and having sealed engagement with said skirt, said elastomeric ring having an outer tapered portion engaging the shell in narrow band sealing contact whereby said piston, skirt and elastomeric ring form with the shell a gas-tight enclosure of variable size.

12. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising a flexible gas impermeable skirt secured to the piston, a circular, radially expansible metal ring, a plurality of staves secured to said piston and extending vertically therefrom, said staves supporting said ring in a substantially horizontal plane outwardly of said piston, a ring of elastomeric material having a tapered outer portion, said skirt and said elastomeric ring being in sealed engagement, said elastomeric ring having an inwardly disposed annular groove adapted to receive said metal ring and be outwardly urged thereby into sealing contact with said shell.

13. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising a flexible gas impermeable skirt secured to the margin of the piston, a plurality of staves carried by said piston and extending vertically therefrom, a ring of elastomeric material supported by said staves in a substantially horizontal plane, said elastomeric ring being of relatively flat configuration and having an outer tapered portion engaging the shell whereby the shell compresses said ring to form a narrow sealing contact band, said skirt and said elastomeric ring being in sealed engagement whereby said piston, skirt and elastomeric ring form with the shell a gas-tight enclosure of variable size.



14. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising, a flexible gas impermeable skirt secured to the piston and extending therefrom, a circular, radially expansible metal ring, said metal ring comprising a flat annular plate having radial slots therein, a plurality of vertically disposed staves carried by said piston and supporting said ring in a substantially horizontal plane outwardly of said piston, and a ring of elastomeric material supported by the metal ring in sealing engagement with shell wall, said elastomeric ring being joined to said skirt in gas-tight relationship whereby said piston, skirt and elastomeric ring form with said shell a gas-tight enclosure of variable size.

15. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising a plurality of vertically disposed resilient staves mounted in closely spaced side by side relationship adjacent to the periphery of the piston and supported thereby, each of said staves having a free end spaced from the piston, a ring of elastomeric material supported by the free ends of the staves in a horizontal plane, a gas impermeable skirt joining the ring with the piston and means carried by the piston and engaging each of said staves at a point adjacent said piston for adjustably imposing an outward tension on the resilient staves whereby the elastomeric ring is spring urged outwardly into sealing contact with the shell wall.

16. Sealing means for a fluid storage reservoir of the shell and piston type, said sealing means comprising a gas impermeable skirt secured to the margin of the piston, a plurality of vertically disposed staves carried by said piston, a circular expansible metal ring supported by said staves in a substantially horizontal plane, said metal ring comprising a flat radially expansible member having a plurality of radial slots therein, a ring of elastomeric material having a U-shaped cross section including an annular groove at its inner edge and a tapered portion terminating in a narrow face at its outer edge, said elastomeric ring being mounted circumferentially on the support ring with the support ring engaging said groove and with the narrow face engaging the shell in sealing contact, said gas impermeable skirt and said elastomeric ring being in sealed engagement whereby the piston, skirt and elastomeric ring form with the shell a gas-tight enclosure of variable size.

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