Sept. 10, 1935. J. C. PATRICK 2,014,264

SEALING DEVICE FOR STORAGE TANKS

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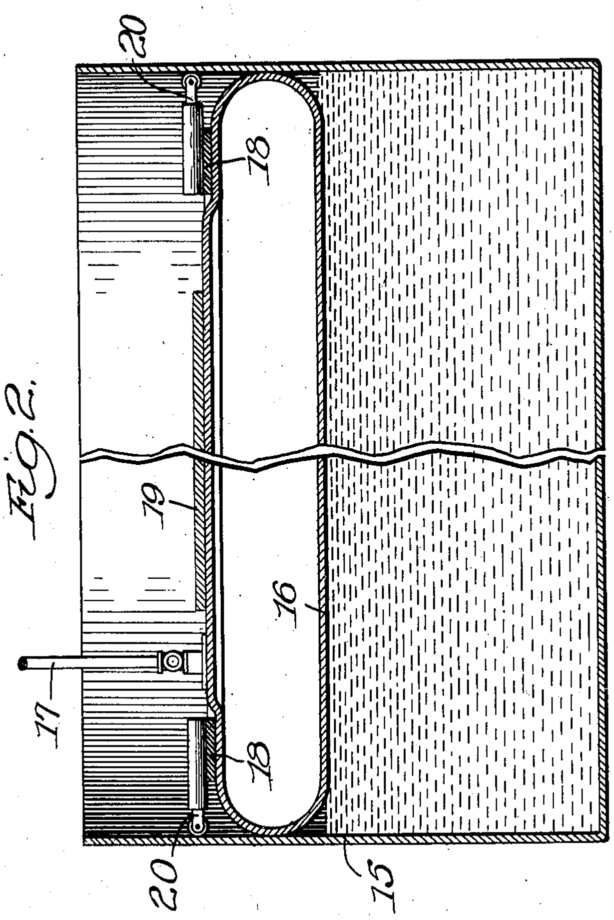

Fig. 2.

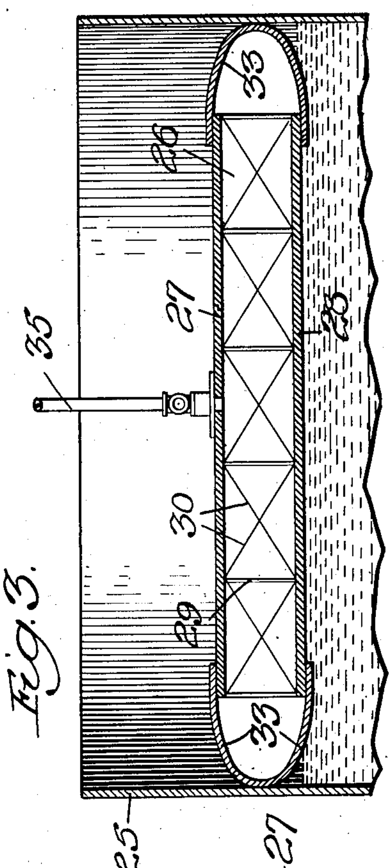

Fig. 3.

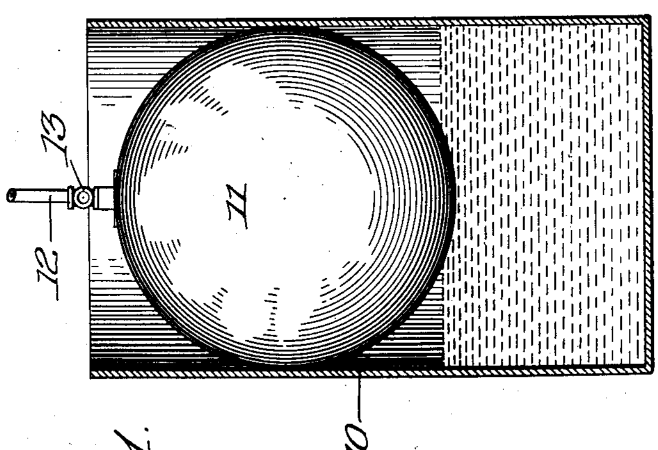

Fig. 1.

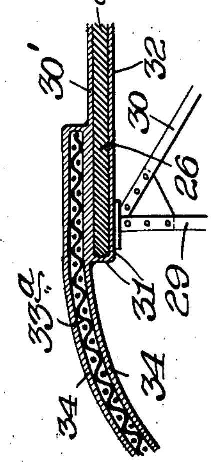

Fig. 4.

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Fig. 5.

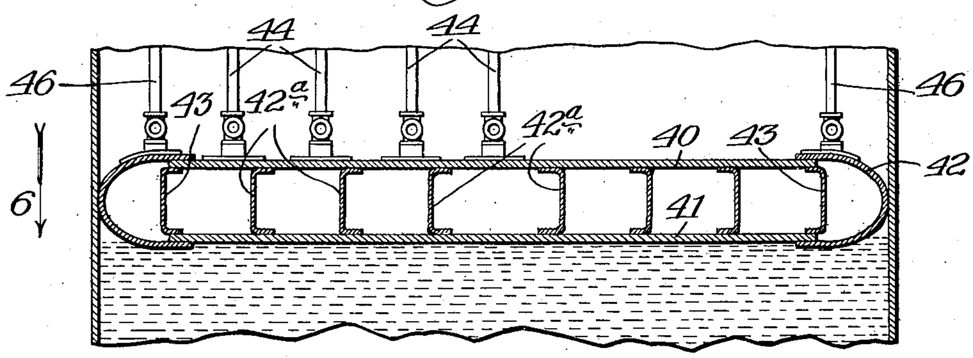
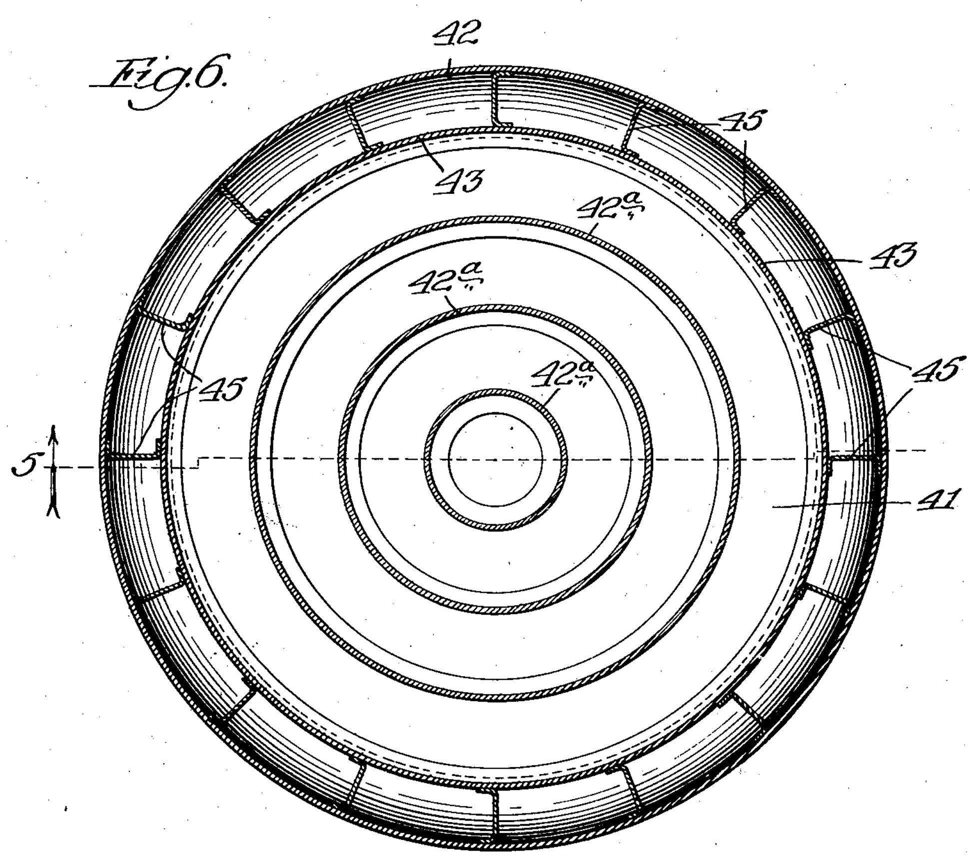


Fig. 6.



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Patented Sept. 10, 1935

2,014,264

UNITED STATES PATENT OFFICE

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SEALING DEVICE FOR STORAGE TANKS

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Application September 29, 1930, Serial No. 485,231

10 Claims. (Cl. 220—26)

The present invention relates to improvements in sealing devices, more particularly intended for use with storage tanks for volatile liquids such as petroleum oils, solvent liquids, and the like, and for materials for use in the construction of such seals.

In order that the invention may be fully understood, it is described herein in connection with certain specific embodiments thereof, illustrated by the accompanying drawings, in which:

Figure 1 is a sectional view of a tank or container provided with a form of sealing device in accordance with the present invention;

Fig. 2 is a broken sectional view through a storage tank provided with a modified form of sealing device in accordance with the present invention; and

Fig. 3 is a broken section view through a modified, semi-rigid form of construction in accordance with the present invention; and

Fig. 4 is an enlarged sectional view of a portion of the construction shown in Fig. 3;

Fig. 5 is a sectional view through a further modification of a semi-rigid embodiment of my invention; and

Fig. 6 is a horizontal sectional view of the form of construction shown in Fig. 5.

A sealing device in accordance with the present invention is illustrated in a simple form in Fig. 1 of the drawings. As shown in this figure, the numeral 10 designates a tank or container in which a supply of a volatile liquid, such as gasoline, crude petroleum, benzol, alcohol, or other volatile solvent is stored. A movable seal or diaphragm for the tank or container is provided by the gas-filled, laterally expansible chamber or balloon 11, suitably formed of a flexible, impervious and chemically resistant material, preferably of the character hereinafter more fully set forth. The balloon or chamber 11 is provided with an inflation pipe 12 having a suitable valve 13, through which the flexible container can be filled with gas. Although air may be employed, I prefer to use an inert gas which does not burn or support combustion, such as carbon dioxide, nitrogen, helium or the like. Ordinarily, I prefer to use a gas, such as carbon dioxide, heavier than air so that in the event of leakage, or of breakage of the sealing chamber in case of fire or the like, the inert gas will settle and form a fire damping or extinguishing blanket upon the surface of the material in the tank.

In the preparation of the flexible material for the construction of the sealing member, it is necessary to employ a flexible material which will adequately satisfy the very severe requirements of continuous use. It must be impervious to the gases or vapors of the materials contained in the tank, as well as to moisture and other constituents of the atmosphere. It must be substantially wholly unaffected by the liquid in the tank and by the gases and vapors given off thereby, both chemically and physically. It must be ductile, laterally extensible, resistant to abrasion, and highly flexible, so as to be capable of an almost indefinite amount of flexure. It must not age or become brittle on the one hand, or soften and swell on the other hand. Materials proposed hitherto for the surface, such as rubber, hardened or tanned gelatin, casein compounds, bituminous or resinous mixtures or the like have been found entirely inadequate, as they fail to satisfy a considerable number or all of the essential requirements.

For example, the use of rubber or rubber-impregnated fabrics has been suggested. However, rubber or fabrics impregnated with rubber or compounds consisting predominantly of rubber are rapidly attacked by many liquids and by gases or vapors given off by them, being dissolved or caused to swell with a marked deterioration in their physical properties. Thus, when used in connection with oils or petroleum products, particularly those containing volatile constituents such as crude oil, gasoline and the like, the rubber is rapidly attacked, partially dissolved and caused to swell and rapidly loses its sealing capacity, its resistance to flexure and to abrasion. Furthermore, when used with many petroleum products which contain sulfur compounds or which evolve sulfur-containing vapors of hydrogen sulfide, sulfur-dioxide, or the like, the rubber is attacked and caused to age and crack. Other solvent liquids and their vapors likewise vigorously attack rubber and compounds consisting predominantly thereof.

I have found that the requirements for the material of a seal of the character described are fully satisfied by the use of a plastic material hereinafter described, as a film or sheet-forming material or as an impregnating material for a fabric to be used in the construction thereof. This plastic is preferably formed of an organic compound consisting mainly of sulfur combined with organic radicals of the general formula C_nH_{2n}, and which may be suitably produced by the reaction of polysulfides on derivatives of methylene and various olefins such as the dihalides of methylene, ethylene, propylene, butylene and the like, formaldehyde and the homologous aldehydes, or mixtures thereof. In general, I prefer to use such polysulfide compounds having a soft, rubbery character, these being in general those in which the polysulfide sulfur is present in proportion corresponding to at least S_2 and preferably to S_3 or higher.

In preparing the material for the production of the seal, I prefer to employ a plastic material of the character hereinbefore set forth, or a compound consisting predominantly thereof. In forming such a compound, I may employ various softening agents such as fatty acids and their metallic soaps, small quantities of rubber, of organic sulfur compounds such as a phenol sulfur compound, elemental sulfur, organic nitrogenous compounds, waxes, sulfur carriers, such as lead oxide, zinc oxide and the like together with fillers or pigments such as carbon black, whiting, clay and the like, or mixtures thereof. The compound is prepared in any suitable mixing device, preferably on rubber milling rolls, and is formed into a sheet or film or preferably rolled or "frictioned" into the body of a suitable fabric or textile, and is subsequently stabilized by heating to a temperature above 200° F. and preferably of about 287° F.

A suitable compound for the preparation of the sealing material in accordance with the present invention may be prepared as follows:

50 parts of a soft ethylene polysulfide plastic is broken down and softened on mill rolls of the type ordinarily used in mixing rubber. To this is added 1 part by weight of the phenol-sulfur compound above referred to; 3 parts rubber, 2.5 parts zinc oxide; 0.125 parts diphenylguanidine; 1 part stearic acid; 0.5 parts paraffin wax; 0.125 parts sulfur and 5 parts carbon black. The compound is milled until thoroughly mixed and forms a smooth, black, highly ductile, plastic mass, which is then sheeted or rolled into a thin film on a fabric by suitable calendering or frictioning rolls, impregnating and coating the fabric and forming a smooth, impervious and highly flexible sheet. The film or coated fabric is stabilized by heat treatment, for example, by heating to a temperature of 287° F. for a period of 40 to 60 minutes. The finished material is cut and united to form a container or balloon of the desired shape in any suitable manner. For example, in case a sheet or film of the material is employed, the edges of the properly cut sheets may be lapped and pressed together in a heated press at say 250 to 287° F. to form an impervious union. In the case of a coated or impregnated fabric, the cut fabric is preferably lapped and sewn together and the lapped edges subjected to similar treatment in order to cause an impervious union between the films of plastic material on the fabric. In this way, a completely impervious, tight sealing bag or container may be prepared.

A sealing member thus formed, with a continuous film or skin of the organic polysulfide plastic as hereinbefore described, is substantially completely impervious to gases and vapors and is unaffected physically or chemically by the vapors or gases with which it is likely to come in contact in use in connection with the storage thereof. Thus it is unaffected by hydrocarbon vapors or gases, such as those from crude petroleum, volatile petroleum distillates, coal tar products, benzols, toluols and organic solvent liquids in general. It is likewise unaffected by, and impermeable to, water, water vapor, oxygen, carbon dioxide, hydrogen sulfide, and to acid vapors in general.

The composition described in the specific example above given may be modified, it being desired, however, to retain the olefin polysulfide plastic as the predominant constituent thereof. Thus, if a black composition is not desired, the carbon black may be omitted, and other fillers, such as zinc oxide, whiting, barium sulfate, kaolin and the like may be substituted therefor. In some cases, it may be desirable to wholly omit the rubber from the composition, particularly when vapors of very powerful solvents of rubber are likely to be encountered, such as in the storage of carbon disulfide. The fabric or textile to which the compound is applied may be a cotton, linen or other textile fabric; but in circumstances under which fire danger is likely to be encountered, I prefer to employ woven asbestos fabric, upon which the plastic compound is milled or sheeted as hereinbefore described, or a suitable fire-proofed textile. I may likewise use a composite protective coating or film; for example, a fabric having the olefin polysulfide plastic sheeted or frictioned upon one side thereof and a rubber compound applied to the opposite side, preferably to the side which is to be on the interior of the sealing member. Rubber is particularly adaptable for such use when the interior of the sealing member is to be charged with carbon dioxide, nitrogen or other inert gases, by which the rubber is protected from oxidation.

The sealing member, formed as hereinbefore described, is inflated with an interior superatmospheric pressure of the selected gas sufficient to distend it to the desired extent, so that it will contact with the side walls of the tank 10, and in moving up and down in the tank in accordance with changes of level therein, or in accordance with expansion or contraction of the vapors on the surface of the liquid, will adjust itself automatically to irregularities in the side walls of the tank and maintain an adequate sealing contact therewith. In case other means of inflation of the sealing member are not available, sufficient quantities of a solution of a suitable carbonate, such as sodium or potassium carbonate or bicarbonate, and of a dilute acid such as dilute sulfuric or dilute hydrochloric acid may be charged into the interior of the sealing member 11 through the conduit 12 to produce the necessary quantity of carbon dioxide gas for inflation by their reaction within the sealing member.

Although the form of sealing member shown in Fig. 1 is satisfactory, particularly in smaller tanks, say up to 4 feet in diameter, for larger tanks, I prefer to modify the form of sealing member, preferably flattening it so that it assumes an approximately elliptical cross section. A simple form of construction of this type is illustrated in Fig. 2, in which the numeral 15 indicates the tank, and numeral 16 the sealing member, formed as an inflated bag or balloon of approximately elliptical cross section, provided with a valved inflating tube 17. In order that the sealing member 16 may be caused to maintain the desired shape and to follow changes in volume of the liquid and vapors in the tank 15, a metallic ring 18 is placed upon it, the outer diameter of the ring being somewhat less than the inner diameter of the tank. In addition, if desired, a metallic disk 19 is placed on the upper surface of the sealing member 16, approximately centrally thereof. The ring 18, and the disk 19, when the latter is employed, may be made of suitable weight, depending upon the diameter of the tank, to insure the sealing and following action of the member 16. If desired, the ring 18 may be provided with spring-pressed pusher rods **20**, contacting with the interior walls of the tank, by which undue lateral displacement of the ring is avoided.

In place of a completely flexible distended sealing member, I may, particularly in very large tanks such as those used for storage of crude petroleum, gasoline and the like, employ a semi-rigid construction, in which the central or body portion of the sealing member is of rigid construction, provided marginally at its contacting surfaces with a laterally expansible, flexible sealing portion. Such a form of construction is shown in Figs. 3 and 4. In this form of construction the numeral **25** designates the side walls of the tank and the numeral **26** the sealing member. The body portion of the sealing member is formed of an upper plate **27** and a lower plate **28**, held rigidly in the desired relative position by the vertical supporting members **29** and cross braces **30**.

The upper and lower plates **27** and **28** may be constructed of any suitable material, such as metal, lumber or the like, but preferably of light, fibrous board, such as the products commercially known as celotex, masonite, insulite, and the like. When used in connection with storage of combustible liquids, the material of the plates may be fire-proofed to a greater or less extent by impregnation with suitable materials, such as alkali metal silicates, ammonium salts, such as ammonium phosphate, ammonium sulfate and the like, soluble tungstates, such as ammonium or sodium tungstate, borates, or other fire-proofing agents. I may likewise employ porous asbestos boards for the construction of these plates. The plates are then impregnated, or preferably coated, with a continuous film of a suitable plastic material, preferably one such as the organic polysulfide material hereinbefore described for use in the treatment of the sealing member as shown in Figs. 1 and 2. A continuous coating of such material is applied as a sealing coating to the exterior surfaces of the plates **27** and **28**, and as shown in enlarged sectional view in Fig. 4, in connection with the upper sealing plate **27**. The sheath or coating of the organic polysulfide plastic material, designated by the numeral **30'**, is continued around the edges of the plates as at **31** and the inner side as at **32**.

Around the marginal edges of the plates, the expansible sealing member **33** is secured thereto, forming with the plates **27** and **28** a completely enclosed chamber. The expansible sealing member **33** is suitably formed of textile material impregnated or coated with olefin polysulfide plastic, of the same character as that hereinbefore described for use in connection with the sealing member shown in Fig. 1. In securing the marginal sealing member to the outer edges of the plates, it is preferably lapped over the exterior surfaces of the plates, as shown on enlarged scale in Fig. 4 in connection with the upper plate **27**, in which numeral **33**ᵃ indicates the body material of the sealing member and **34** the coatings of plastic material on each side thereof. By the application of a suitable heating means, the coating on the outer surface of the plate and on the surfaces of the fabric forming the sealing member **33** are completely united to form an impervious seal.

It is apparent that the plates **27** and **28**, with the marginal sealing member **33** constitute an enclosed, laterally expansible chamber, and a suitable means, such as the valved pipe **35** is provided for filling this chamber and inflating the sealing member **33**, causing it to contact with the seal and the walls of the chamber, in the same manner as in the forms of construction previously set forth.

Figs. 5 and 6 illustrate a further modified form of construction of cellular type, having a central rigid portion formed by the upper plate **40** and lower plate **41**, to which is marginally secured the expansible sealing member **42**. In this form of construction, the upper and lower sealing plates of the central rigid portion are similar to the upper and lower sealing plates of the form of construction shown in Fig. 3, and in addition, partitions **42**ᵃ of similar material are provided between the plates **40** and **41** to divide the space into cells. As illustrated, these partitions are circular in section, although any suitable arrangement to divide the space within the sealing member into cells may be employed. An outer wall or partition **43** may be provided between the outer edges of the plates **40** and **41**. The partitions **42**ᵃ and the outer wall **43**, as well as the plates **40** and **41** are coated with the olefin polysulfide plastic material hereinbefore referred to, so that the cells within the sealing member are substantially impervious and may be individually filled with a suitable gas, preferably carbon dioxide, under pressure by means of the inflation pipes **44**.

The marginal sealing member **42**, which is formed and applied to the plates **40** and **41** in a manner similar to the application of the marginal sealing member in the construction shown in Figs. 3 and 4, may likewise be divided into cells by partitions **45** of impregnated fabric similar to that employed in the construction of the marginal sealing member itself and individual inflation pipes **46** are provided for each of the cells so formed in the marginal sealing member.

With the cellular construction of the device, as shown in Figs. 5 and 6, in the event of the rupture of one of the cells of either of the expansible marginal sealing member or of the rigid center portion, the remaining cells continue to function and the efficiency of the device as a whole can be substantially maintained.

In the operation of the laterally expansible, gas filled sealing members as hereinbefore described, the outer edges of the sealing member, by reason of their flexibility, and of the internal pressure of the gas with which they are inflated, tend to follow the irregularities in the wall of the tank both when stationary and in motion. The sealing member is of high buoyancy, and consequently there is no difficulty in floating it on even the lightest liquids.

The seal of my invention is particularly advantageous in connection with the storage of highly volatile liquids under conditions in which a vapor tends to form and overlie the surface of the liquid. This vapor tends to expand and contract with increase or decrease in temperature, to a very substantial extent, producing the phenomenon known as "breathing". When a sealing member constructed in accordance with the present invention is used in such a case, on increase in temperature, the expansion of the gas within the seal tends to force it more firmly against the side walls of the tank, thus providing a better seal and at the same time a greater resistance to upward movement of the sealing member. On the other hand, on reduction of general atmospheric temperature, the contraction of the gas within the sealing member somewhat decreases the force with which it is held against the side walls of the tank and permits a greater facility of movement of the sealing member downwardly in accordance with the contraction of the vapors within the tank itself.

I clam:

1. In storage means, a storage tank and a closure member therefor, said closure member being formed of a central portion comprising spaced upper and lower plates, a laterally expansible, flexible membrane secured marginally to said plates and closing the space therebetween, and means for forcing gas into the closure member to expand said membrane laterally and force it into contact with the walls of the tank.

2. In storage means, a tank and a closure member therefor, said closure member being formed with a central portion comprising spaced plates and a flexible diaphragm secured marginally to said plates and closing the space therebetween, a continuous sheathing of inert plastic material comprising olefin-polysulfide plastic being provided on said membrane and spaced plates, and means for forcing gas into the space between said plates to force said membrane outwardly into contact with the walls of the tank.

3. In storage means, a tank, a container formed of a flexible membrane comprising a continuous film of olefin-polysulfide plastic adapted to overlie the contents of the tank, and means for forcing gas into said flexible container to expand it laterally against the walls of the tank.

4. In storage means, a tank, a flexible-walled container within said tank and adapted to overlie the contents thereof, the walls of said flexible container comprising a continuous sheathing of inert polysulfide plastic, means for inflating said flexible container to cause it to expand laterally and force it against the walls of the tank, and a weight disposed on the upper surface of said flexible container.

5. In storage means, a tank, a laterally expansible container within said tank adapted to overlie the contents thereof, said container having flexible walls comprising a continuous sheathing of inert polysulfide plastic, means for forcing gas into the expansible container to cause it to expand laterally and engage the side walls of the tank, and a weight on the upper surface of said expansible container, said weight being formed as a ring of smaller diameter than the interior of the tank.

6. Storage means comprising a tank, a closure member for said tank, spaced therefrom, and flexible resilient material that is unaffected by solvents and impermeable to gases closing the space between said tank and said member, said flexible resilient material having its exposed portions composed mainly of a polymethylene-polysulfide reaction product of the general formula $C_nH_{2n}S_x$ wherein x is more than 2.

7. Storage means comprising a tank, a closure member for said tank, spaced therefrom, and flexible resilient material that is unaffected by solvents and impermeable to gases closing the space between said tank and said member, said flexible resilient material having its exposed portions composed mainly of a polymethylene-polysulfide reaction product of the general formula $C_nH_{2n}S_x$ wherein x is more than 2, and being pressed against the inner surfaces of the walls of said tank.

8. Storage means comprising a tank, a closure member for said tank, spaced therefrom, and flexible resilient material that is unaffected by solvents and impermeable to gases attached to said closure member and closing the space between said tank and said member, said flexible resilient material having its exposed portions composed mainly of a polymethylene-polysulfide reaction product of the general formula $C_nH_{2n}S_x$ wherein x is more than 2.

9. Storage means comprising a tank, a closure for said tank having flexible resilient material on the surfaces thereof that contact with the inner walls of said tank and also on the surfaces thereof that are exposed to gases that may arise from the contents of said tank, said flexible resilient material having its exposed portions composed mainly of a polymethylene-polysulfide reaction product of the general formua $C_nH_{2n}S_x$ wherein x is more than 2.

10. Storage means comprising a tank, a closure for said tank having flexible resilient material on the surfaces thereof that contact with the inner walls of said tank, said flexible resilient material having its exposed portions composed mainly of a polymethylene-polysulfide reaction product of the general formula $C_nH_{2n}S_x$ wherein x is more than 2.

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