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2,847,142

FLOATABLE PARTITION FOR LIQUID STORAGE TANKS

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3 Sheets-Sheet 1

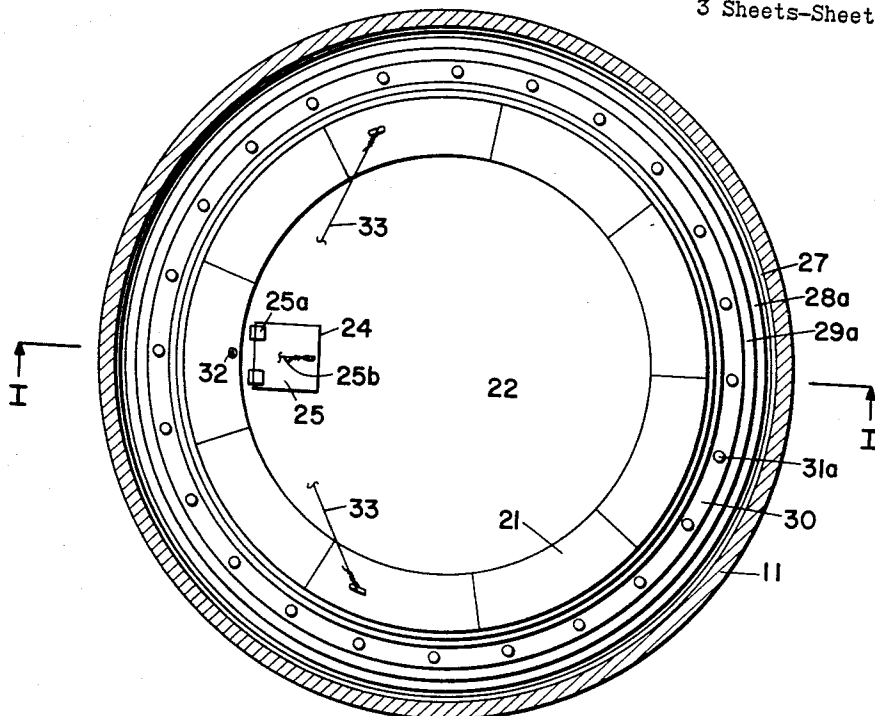


FIG.-2

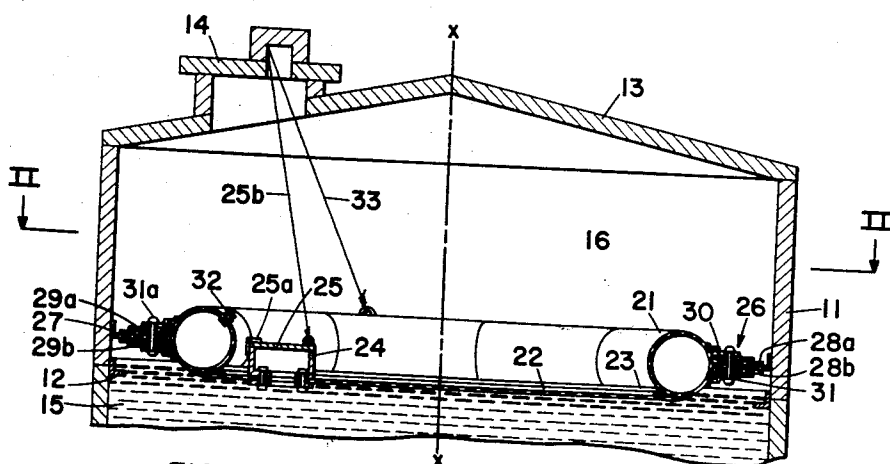


FIG.-1

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3 Sheets-Sheet 3

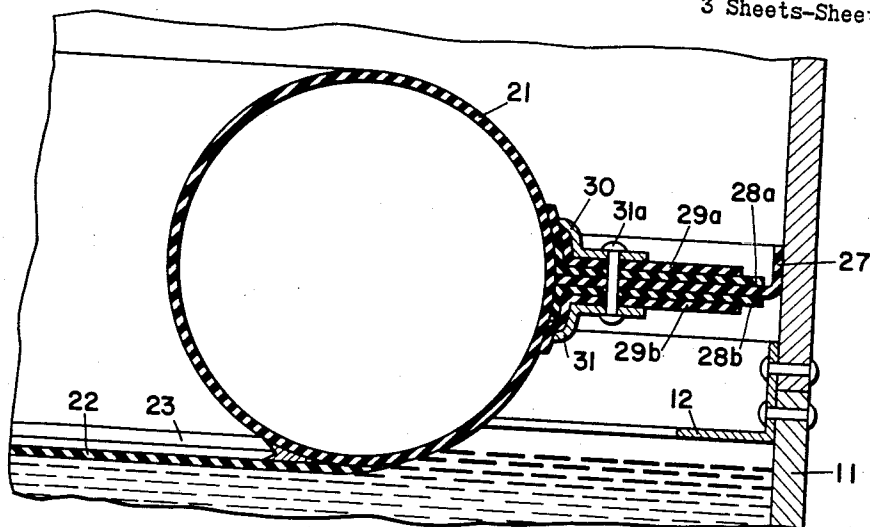


FIG. -3

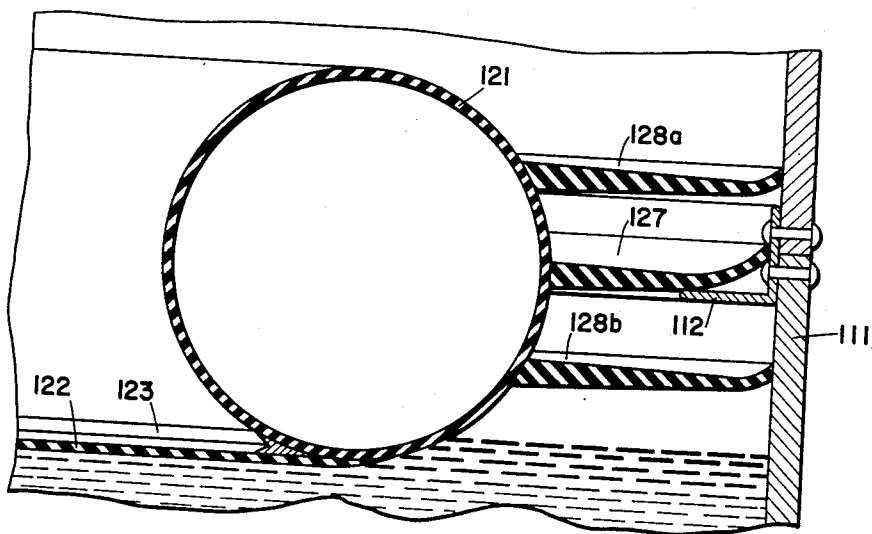


FIG. -6

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FLOATABLE PARTITION FOR LIQUID STORAGE TANKS

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13 Claims. (Cl. 220—26)

The present invention relates to a device for preventing or substantially reducing evaporation losses from stored vaporizable liquids. More particularly the invention relates to a buoyant partition member adapted to separate the liquid contents of a storage tank from a vapor space within said tank above said contents at the normal interface of the liquid and a gaseous atmosphere thereabove. Further, the invention relates to a form of floatable cover for the liquid contents of a storage tank adapted for reciprocally vertical motion within a liquid storage tank, wherein said cover extends transversely of the tank in substantially fluid-tight relation to the tank walls and in supported substantially intimate surface contact with the contained liquid. In addition, the invention relates to an inflatable transverse partition, including means for inflating said partition with a non-inflammable gas and for discharging such gas into the vapor space above the partition.

A continuing problem connected with the storage of volatile liquids is the prevention of evaporation losses occasioned primarily by surface vaporization thereof. These losses are particularly aggravated by convection currents set up in the vapor space of the liquid surface under the influence of the sun's rays striking against the exterior surfaces surrounding the vapor space within the storage tank. Such losses also result not only from the "breathing" losses produced by the expansion and contraction of the vapors above the liquid and of the liquid itself, but also as a result of fluctuations in liquid level produced by the introduction and withdrawal of the liquid contents.

It is an object of the present invention to provide a means whereby the surface of a stored liquid is substantially shielded from interfacial contact with the atmosphere within the tank above the liquid surface. It is a further object of the invention to provide a cover for the normally exposed surface of a body of liquid contained in a storage tank, having rigid sidewalls and a fixed, rigid roof, which cover is inflatable to provide buoyancy, and which when deflated may be collapsed so as to permit introduction into the interior of the tank, as a unit, by way of any ordinarily available manhole or gauging aperture through the fixed roof of the storage tank. In conjunction with a device of the character described, it is an additional object of the invention to provide means whereby the inflated cover may also be employed to introduce an inert gas into the vapor space above the cover and liquid surface to produce a non-explosive atmosphere therein.

The invention and its objects may be more fully understood from the following description when it is read in conjunction with the accompanying drawings, in which:

Fig. 1 is a vertical section through a typical storage tank for liquids with a cover of the character contemplated installed therein, taken along the line I—I of Fig. 2;

Fig. 2 is a view in horizontal section through a storage

tank as shown in Fig. 1, taken along the line II—II of Fig. 1;

Fig. 3 is an enlarged view in vertical section of a portion of a tank wall and of an inflatable cover according to this invention, showing details of construction of the cover and the means provided for establishing a seal between the cover and tank wall as indicated in Figs. 1 and 2;

Fig. 4 is a view similar to that of Fig. 1, taken along the line IV—IV of Fig. 5, illustrating another form of inflatable cover according to the present invention, including means for inflating the cover from a position externally of the tank, and also for introducing inflation gas into the vapor space above the cover;

Fig. 5 is a view in horizontal section through a storage tank as shown in Fig. 4, taken along the line V—V of Fig. 4;

Fig. 6 is an enlarged view in vertical section of a portion of a tank wall and of an inflatable cover according to this invention, showing details of construction of the cover and the means provided for establishing a seal between the cover and tank wall as indicated in Figs. 4 and 5.

In the apparatus illustrated by Figs. 1, 2 and 3, the numeral 11 designates the wall of a conventional bulk storage tank wherein, as shown, the wall consists of a vertical series of circular sections joined by riveting or welding, stiffened internally by a series of vertically spaced arcuately shaped angle iron reinforcing members, such as designated in Fig. 3 by the numeral 12, but otherwise substantially free of internal structural members. Such a tank may be provided with a dome shaped or cone shaped roof 13, including a hatchway or manhole 14 opening through the roof.

Internally of the tank is disposed an inflatable partition which separates the body of liquid 15 contained by the tank from the vapor space 16 thereabove. The inflatable partition as shown includes a hollow, tubular annular pontoon member 21 which is formed of a flexible deformable material such as a rubber or rubber-like material, including nylon cloth impregnated with neoprene. The nature of this material depends primarily on the nature of the materials with which it will come in contact and may include plastics, rubber, neoprene and the like, alone or in combination with textile or other reinforcing fibres imbedded in or otherwise combined with a rubber or rubberlike material to provide a vapor and liquid-tight, flexible and deformable material. The pontoon 21 may be assembled from a number of substantially flat sheets, moulded or otherwise formed in accordance with conventional procedures. As shown, the central, open area of the annular pontoon is closed by means of a substantially, circular sheet of a material similar to that of the pontoon to form a floor or closure portion 22. Preferably this floor portion 22 is attached to the outer surface of the pontoon 21 in substantially tangential relation. Means such as a crotch tape element 23 may be employed to reinforce this attachment of the floor portion to the pontoon, the tape being cemented to adjoining surface portions of both the pontoon and floor. In the apparatus illustrated, the floor portion 22 is formed of three sheets disposed with overlapped edges which are cemented together, and the seam thus formed covered by sealing tape cemented to both upper and lower surfaces of the overlapped sheets.

Where it may be required to provide access to the body of liquid below the floatable partition, as for the purpose of gauging the liquid contained by the tank 1, a hatchway 24 and hatch cover 25 are provided. As shown in Figs. 1 and 2, the hatchway 24 is located astride a radius of the tank and floatable partition in radially

3 spaced relation to the tank axis $x-x$, and the center point of the partition, and at such distance from the axis as to be substantially alignable vertically with reference to the roof hatchway 14. The hatch cover 23 is provided with spring hinges 25a, and may be opened by means of a cable attachment 25b.

The annular pontoon element 21 has an outside diameter somewhat smaller than the internal diameter of the tank at the wall, and also less than that at the innermost edge of the angular reinforcing members 12. For example, in a tank having an internal diameter of about 10 feet 4 inches and with reinforcing members extending horizontally from the wall into the storage space for a distance of about 3 inches, the pontoon element 21 might have an outside diameter of about 9 feet 2 inches. With such dimensions the diameter of pontoon would be about 8 inches less than diameter of the tank at the inner edge of the reinforcing members 12, and about 14 inches less than the diameter of the tank from wall to wall. Thus when centered on the tank axis, the pontoon could be freely and buoyantly supported on the upper surface of the liquid contents of the tank so as to be reciprocally movable vertically in substantially right angular relation to the vertical axis of the tank.

To center the pontoon element in the tank and to provide a substantially fluid-tight seal between the pontoon and tank walls, the outer periphery of the pontoon carries annular sealing means 26 extended radially outward therefrom into frictional contact with the tank walls. As shown in Figs. 1, 2 and 3 of the drawings, the centering and sealing means is a laminated means composed of a vertical series of annular elements each formed of a flexible, deformable material similar to that of the pontoon 21, and membrane 22. In the form shown the number of elements is odd, including a mid-element 27, and successive pairs of elements such as designated by the numerals 28a and 28b, and 29a and 29b, wherein the mid-element has a radial dimension outwardly from the outer periphery of the pontoon which is greater than one-half the difference between the outer diameter of the pontoon and the inner diameter of the tank, and in succeeding pairs the radial dimension of each element is equal to that of the other in that pair but less than that of the mid-element, and wherein from pair to pair the radial dimension of the elements diminishes from pair to pair. In Fig. 3 the paired elements and their relationships to each other and to the mid-element are clearly shown, with one element of each pair disposed above and one below the mid-element in the series. Further, although all the elements 27, 28a, 28b, 29a and 29b are each shown as of a single thickness substantially equal to that of the pontoon and membrane material, these individual elements may be made thinner or thicker as desired and individually also may be laminated. The primary requirement in any event is that they provide a flexible sealing means between the pontoon 21 and tank wall 1 which means is deformable as required to ride over any protruding part of the wall surface, such as angles 12, and yet to provide adequate resistance to horizontal displacement of the floating partition such as to maintain the partition substantially centered on the vertical axis of the tank. Also, although the sealing means may be made to be substantially self-supporting by suitable selection and gradation of the thickness of the laminae, principally the paired elements, it is preferred that they be provided with supplementary annular stiffening means such as the elements 30 and 31. These elements are preferably of a substantially rigid material such as metal or hard rubber, plastic, or other similar materials with or without integral metal reinforcement. Any suitable means may be employed to secure the elements 30 and 31 to the outer surface of the pontoon, or, as shown, to the surface of the sealing means as attached to the pontoon. Further, in the assembled sealing means shown, the surfaces of the several laminae are cemented

together at their inner edges within the outer periphery of the elements 30 and 31, and also to the inner opposed surfaces of these elements, and may be further secured as by means of rivets 31a extending through the elements 30 and 31 as shown. Beyond the outer edge of the elements 30 and 31, the elements 27, 28a, 28b, 29a, and 29b are in free surface contact. Alternately, however, these elements may be cemented together from their roots at the pontoon outer periphery to their outer edges. The annular elements 27, 28a, 28b, 29a, 29b, 30, and 31 may also consist of a plurality of arcuate sections arranged in either overlapping or butt joint relation with the joints of one element in circumferentially staggered relation to those of another.

In addition to the peripheral sealing means and floor closure, described above, the pontoon element as shown is provided with means for inflating and deflating the pontoon, and also supplementary means for retaining the assembly against rotational movement within the tank. In the drawings, the inflation and deflation means is a valve 32, such as a tire valve, opening through the material of the pontoon. As later described this means may include semi-permanent conduit connections to an external source of fluid under pressure, or may include a pressurized fluid container mounted on the pontoon. Also, where desired, the pontoon may be divided internally into a series of fluid-tight compartments with individual valve means for each compartment. Various retainer means may also be provided. A simple form is illustrated, consisting of a pair of guy ropes 33 attached to the pontoon surface at opposite ends of a chordal dimension which is less than the diameter of the pontoon at the level of attachment. Where the change in level of the liquid contents is infrequent, the guy ropes may be belayed on any suitable cleat within the hatchway 14; otherwise a spring actuated tension reel may be employed.

An alternate form of the invention is illustrated in Figs. 4, 5 and 6. In these figures corresponding parts are designated by numerals corresponding to those employed in the description of Figs. 1, 2 and 3. Thus, the numeral 111 designates a tank, 112 angular, annular reinforcing members, 113 a tank roof, and 114 a hatchway. The numeral 115 designates a body of liquid in the tank with a vapor space 116 above it. The numeral 121 designates a pontoon member which differs from that shown in Figs. 1, 2 and 3, in being provided with a series of radial spoke elements such as 121a, 121b, and 121c. These elements are hollow tubular members communicating at their outer ends with the main pontoon member 121. Preferably the inner or hub ends of the spoke elements are sealed one from another, and the pontoon elements are sealed one from another, and the pontoon member divided into three compartments by means of fluid-tight partitions, indicated by dotted lines in Fig. 5, and designated by the numeral 121d, disposed internally and transversely of the tubular pontoon, intermediate the communicating attachment of the spokes with the pontoon. The enclosed area of the annular pontoon 121 is closed by means of a membrane closure or floor portion 122 attached to the pontoon 121 substantially as is the membrane 22 to pontoon 21 of Figs. 1, 2 and 3. The membrane 122 may also be attached to the spoke elements in a similar fashion. A hatchway 124 and hatch cover 125 with spring hinges 125a and cable attachment 125b all correspond to their previously described counterparts 24, 25, 25a and 25b, and are similarly located with reference to the vertical axis $x-x$, of the tank 111 in Figs. 4, 5 and 6.

In the apparatus illustrated by the latter figures, the annular sealing and centering means is provided by a vertical series of annular fin elements, 127, 128a and 128b, each secured at its inner periphery to the outer periphery of the pontoon 121 similarly to the elements 27, 28a and 28b previously described. In the form now contemplated, the elements 127, 128a and 128b are vertically spaced, and each element extends radially outward

from the pontoon into frictional, slidable contact with the inner wall. Preferably the spacing of the layered elements is such as to permit at least two elements to remain in sealing contact with the wall of the tank while a third element may be deformed by passage over an obstruction or projection thereon. In Fig. 6, the element 127 is shown to be deformed by the angle reinforcement member 112, while the elements 128a and 128b are in sealing contact with the tank wall. Also as illustrated, the individual elements 127, 128a and 128b are thicker than the previously described elements 27, 28a and 28b, so as to be substantially self-supporting. The elements 127, 128a and 128b, however, also may be provided with supplementary support means, and/or may be built up of two or more layers or laminations.

In the preferred form of the apparatus referred to, wherein the spoke elements are sealed one from another, separate means for inflating the pontoon compartments are provided. In Figs. 4, 5 and 6 such means include three valve elements 132a, 132b, and 132c open into the interior of the spoke elements 121a, 121b and 121c, respectively. All of these valves are connected to a common inflation system including a flexible conduit 134 connected at one end to each of the valves 132a, 132b, and 132c through branch lines 134a, 134b, and 134c, and at the other end to one end of a rigid conduit 135 supported on the tank roof and wall. The other end of the conduit 135 is connected to a suitable source (not shown) of a gaseous material under pressure. The flexible conduit provided is of a length substantially equal to the height of the tank. If desired, the flexible conduit may be mounted on an automatic, spring operated take-up reel mechanism to avoid kinking or fouling of the conduit when the floatable partition is carried into close proximity to the upper end of the tank. The rigid conduit, as shown, is provided with a control valve 136 and with an adjustable pressure regulator and indicator means 137. By such means, inflation of the pontoon may be maintained at any predetermined pressure desired. By additionally including a flow recorder in the line 135, leakage from the pontoon may be readily discovered from outside the tank.

Another feature of the form of floatable partition, as illustrated in Figs. 4, 5 and 6 resides in the provision of means for discharging the gas used to inflate the pontoon member into the vapor space of the tank. Such means is afforded by a plurality of pressure relief valves 138 opening from the interior of the several pontoon compartments. By adjusting the pressure regulator means 137 to increase the pressure and volume of gas supplied to the pontoon, the relief valves 138 may be actuated so as to discharge the gas into the vapor space above the floatable partition. By using a non-inflammable gas in the system, flammable vapors which may be present in the vapor space can be evacuated and a positive protection against fire or explosion within the vapor space accomplished.

The floatable partition assembly as described above is prepared for use by first rolling and/or folding it, while deflated, to a size such as to permit introduction into a tank such as one designated by the numerals 11 and 111 by insertion through an opening or hatchway such as designated by the numerals 14 and 114. Where conduit means such as 134 and 135 of Figs. 4, 5 and 6 are to be used, in folding the assembly the valves 132a, 132b, and 132c are preferably left exposed so that the flexible conduit 134 may be connected thereto beforehand. Likewise in folding or rolling the assembly as illustrated in Figs. 1, 2 and 3, it is desirable that the valve 32 be available for connection with a detachable pressure conduit means. Of course if the pontoon is provided with automatic self-contained inflation means, no special rolling or folding technique need be employed. Most desirably the assembly will be introduced into the tank at a time when the liquid surface is at an interme-

diate level in the tank, and preferably when the tank is at least half full, in order to facilitate manipulation during or after insertion.

After inserting the assembly through the hatchway or opening in the tank the folds may be shaken out, and while held as by the restraining ropes or cables 33 or 133, the pontoon member is at least partially inflated. The assembly may then be dropped onto the liquid surface and its position adjusted so as to bring the hatch 24 or 124 into alignment with the hatch 14 or 114 as illustrated and described, before complete inflation of the pontoon member forces the sealing means into complete pressure contact with the tank walls. When in position, the inflation of the pontoon member is completed and the assembly is then in service.

In fabricating the assembly, the displacement thereof is gauged so that the membrane closure element or floor portion 22 or 122 is assured of intimate surface contact with the liquid over substantially its entire area. This displacement is also gauged so that displaced liquid will not rise in the annular space between the tank wall and the pontoon to a level high enough to make contact with the sealing means under any normal operating condition. The weight of the assembly and also the resistance of the sealing means is gauged so as to maintain the assembly in substantially free floating relationship to the liquid surface at all times, and to avoid suspension of the assembly by frictional contact of the sealing means with the tank walls.

What is claimed is:

1. A collapsible floating roof assembly comprising a hollow, tubular, annular continuous pontoon element of a substantially fluid-impervious, flexible, deformable material, an annular seal ring of a flexible, deformable material secured at its inner periphery to the outer periphery of said pontoon element, in fluid-tight relation thereto and extending radially outward therefrom, a substantially flat membrane of a flexible, deformable material joined to the outer surface of said pontoon element in substantially fluid-tight tangential relation thereto, and forming a floor for said pontoon extending over the entire area enclosed thereby, and valve means communicating with the interior of said pontoon element adapted to permit inflation and deflation of said pontoon element.

2. A collapsible floating roof assembly comprising a hollow, tubular, annular, continuous pontoon element of a substantially fluid-impervious, flexible, deformable material, an annular seal ring of a flexible, deformable material secured at its inner periphery to the outer periphery of said pontoon element in fluid-tight relation thereto and extended radially outward therefrom, said annular seal ring including a plurality of individual, annular elements disposed in parallel, superposed relation, of which each element is secured at its inner periphery to the outer peripheral surface of said pontoon element, a substantially flat membrane of a flexible, deformable material joined to the outer surface of said pontoon element in substantially fluid-tight, tangential relation thereto, and forming a floor for said pontoon extending over the entire area enclosed thereby, and valve means communicating with the interior of said pontoon element adapted to permit inflation and deflation of said pontoon element.

3. A collapsible floating roof assembly comprising a hollow, tubular, annular, continuous pontoon element of a substantially fluid-impervious, flexible, deformable material, an annular seal ring of a flexible, deformable material secured in its inner periphery to the outer periphery of said pontoon element, in fluid-tight relation thereto and extended radially outward therefrom, said annular seal ring including a plurality of individual, annular elements disposed in parallel, superposed relation, of which each element is secured at its inner periphery to the outer peripheral surface of said pontoon element, wherein the total number of said plurality of individual, annular elements is odd, the outer diameter of said ele-

ments increasing in equal pairs inwardly from the pair of elements forming the upper and lower surfaces of said seal ring, and wherein said odd member of said elements is the middle member and has an outer diameter greater than any other member, a substantially flat membrane of a flexible, deformable material joined to the outer surface of said pontoon element in substantially fluid-tight, tangential relation thereto, and forming a floor for said pontoon extending over the entire area enclosed thereby, and valve means communicating with the interior of said pontoon element adapted to permit inflation of said pontoon element.

4. A collapsible floating roof assembly comprising a hollow, tubular, annular, continuous pontoon element of a substantially fluid-impervious, flexible, deformable material, an annular seal ring of a flexible, deformable material secured in its inner periphery to the outer periphery of said pontoon element in fluid-tight relation thereto and extended radially outward therefrom, said annular seal ring including a plurality of individual, annular elements disposed in parallel, superposed relation, of which each element is secured at its inner periphery to the outer peripheral surface of said pontoon element, a pair of annular support elements secured at their inner peripheries to the outer periphery of said pontoon element, the elements of said pair being disposed respectively above and below said annular seal ring in surface contact therewith, said support elements having an outer diameter smaller than that of any of said individual, annular seal ring elements, a substantially flat membrane of a flexible, deformable material joined to the outer surface of said pontoon element in substantially fluid-tight, tangential relation thereto, and forming a floor for said pontoon extending over the entire area thereby, and valve means communicating with the interior of said pontoon element adapted to permit inflation and deflation of said pontoon element.

5. A collapsible floating roof assembly comprising a hollow, tubular, annular, continuous pontoon element of a substantially fluid-impervious, flexible, deformable material, an annular seal ring of a flexible, deformable material secured at its inner periphery to the outer periphery of said pontoon element in fluid-tight relation thereto and extended radially outward therefrom, said annular seal ring including a plurality of individual, annular elements disposed in parallel, superposed relation, of which each element is secured at its inner periphery to the outer peripheral surface of said pontoon element, a pair of annular semi-rigid support elements of a heavy gauge material similar to that of said annular seal ring secured at their inner peripheries to the outer peripheral surface of said pontoon, the elements of said pair being disposed respectively above and below said annular seal ring in surface contact therewith, said support elements having an outer diameter smaller than that of any said individual, annular seal ring elements, a substantially flat membrane of a flexible, deformable material joined to the outer surface of said pontoon element in substantially fluid-tight, tangential relation thereto, and forming a floor for said pontoon extending over the entire area enclosed thereby, and valve means communicating with the interior of said pontoon element adapted to permit inflation and deflation of said pontoon element.

6. A collapsible floating roof assembly comprising a hollow, tubular, annular, continuous pontoon element of a substantially fluid-impervious, flexible, deformable material, an annular seal ring of a flexible, deformable material secured at its inner periphery to the outer periphery of said pontoon element, in fluid-tight relation thereto and extending radially outward therefrom, a substantially flat membrane of a flexible, deformable material joined to the outer surface of said pontoon element in substantially fluid-tight tangential relation thereto, and forming a floor for said pontoon extending over the entire area enclosed thereby, valve means communicating with

the interior of said pontoon element adapted to permit inflation and deflation of said pontoon element, a series of hollow, tubular, spoke-like flotation elements, formed of said substantially fluid-impervious, flexible, deformable material, disposed radially with relation to said pontoon element, each of said spoke-like flotation elements secured at its outer end to the inner peripheral surface of said pontoon element and in substantially open communication therewith.

7. A collapsible floating roof assembly comprising a hollow, tubular, annular, continuous pontoon element of a substantially fluid-impervious, flexible, deformable material, an annular seal ring of a flexible, deformable material secured at its inner periphery to the outer periphery of said pontoon element, in fluid-tight relation thereto and extending radially outward therefrom, a substantially flat membrane of a flexible, deformable material joined to the outer surface of said pontoon element in substantially fluid-tight tangential relation thereto, and forming a floor for said pontoon extending over the entire area enclosed thereby, valve means communicating with the interior of said pontoon element adapted to permit inflation and deflation of said pontoon element, a series of hollow, tubular, spoke-like flotation elements formed of said substantially fluid-impervious, flexible, deformable material, disposed radially with relation to said pontoon element, each of said spoke-like flotation elements secured at its outer end to the inner peripheral surface of said pontoon element, in substantially open communication therewith, and in substantially tangential surface contact with said membrane.

8. A collapsible floating roof assembly comprising a hollow, tubular, annular, continuous pontoon element of a substantially fluid-impervious, flexible, deformable material, an annular seal ring of a flexible, deformable material secured at its inner periphery to the outer periphery of said pontoon element, in fluid-tight relation thereto and extending radially outward therefrom, a substantially flat membrane of a flexible, deformable material joined to the outer surface of said pontoon element in substantially fluid-tight tangential relation thereto, and forming a floor for said pontoon extending over the entire area enclosed thereby, a series of hollow, tubular, spoke-like flotation elements, formed of said substantially fluid-impervious, flexible, deformable material, disposed radially with relation to said pontoon element, each of said spoke-like flotation elements secured at its outer end to the inner peripheral surface of said pontoon element in substantially open communication therewith, a series of vertical partitions each disposed internally of said pontoon element in fluid-tight relation thereto intermediate the outer ends of an adjacent pair of said flotation elements, said flotation elements each having a sealed junction with said other flotation elements at their inner ends and an individual valve means opening through the wall of each flotation element into communication with the interior of said pontoon element through said flotation element.

9. A collapsible floating roof assembly comprising a hollow, tubular, annular, continuous pontoon element of a substantially fluid-impervious, flexible, deformable material, an annular seal ring of a flexible, deformable material secured in its inner periphery to the outer periphery of said pontoon element in fluid-tight relation thereto and extended radially outward therefrom, said annular seal ring including a vertical series of individual annular elements disposed in vertically spaced parallel relation peripherally of said continuous pontoon element each of said annular elements being attached at its inner edge in fluid-tight relation to said pontoon element, a substantially flat membrane of a flexible, deformable material joined to the outer surface of said pontoon element in substantially fluid-tight tangential relation thereto, and forming a floor for said pontoon extending over the entire area enclosed thereby, and valve means com-

municating with the interior of said pontoon element adapted to permit inflation and deflation of said pontoon element.

10. In a storage tank having substantially vertical walls, a rigid roof supported on said walls and a manhole opening through said roof, said tank adapted to contain a variable volume body of liquid with a vapor space above the surface of said liquid, a means providing a substantially fluid-tight separator seal between said liquid surface and the vapor space thereabove, comprising a hollow, tubular, annular continuous pontoon element of a substantially fluid-impervious, flexible, deformable material having an outer diameter less than the inner diameter of said tank and being floatable in said liquid when inflated, an annular seal ring of a flexible, deformable material having an inner diameter substantially equal to the outer diameter of said pontoon element attached at its inner periphery in fluid-tight relation to the outer periphery of said pontoon element, said ring extending radially outward from said pontoon element into frictional, pressure engagement with the inner wall of said tank, said ring having an outer diameter slightly greater than the inner diameter of said tank, a substantially flat membrane of a substantially fluid-impervious flexible, deformable material joined in fluid-tight relation to the outer surface of said pontoon element so as to extend over the entire area enclosed by said pontoon element and forming a floor adapted to be disposed in intimate surface contact with the body of liquid contained by said tank, and valve means communicating with the interior of said pontoon element whereby said pontoon element may be inflated and deflated, said pontoon element, seal ring, and membrane being adapted for collapsed insertion through the manhole opening through said roof when said pontoon element is deflated.

11. In a storage tank having substantially vertical walls, a rigid roof supported on said walls and a manhole opening through said roof, said tank adapted to contain a variable volume body of liquid with a vapor space above the surface of said liquid, a means providing a substantially fluid-tight separator seal between said liquid surface and the vapor space thereabove, comprising a hollow, tubular, annular continuous pontoon element of a substantially fluid-impervious, flexible, deformable material having an outer diameter less than the inner diameter of said tank and being floatable in said liquid when inflated, an annular seal ring of a flexible, deformable material having an inner diameter substantially equal to the outer diameter of said pontoon element attached at its inner periphery in fluid-tight relation to the outer periphery of said pontoon element, said ring extending radially outward from said pontoon element into frictional, pressure engagement with the inner wall of said tank, said ring having an outer diameter slightly greater than the inner diameter of said tank, a substantially flat membrane of a substantially fluid-impervious, flexible, deformable material joined in fluid-tight relation to the outer surface of said pontoon element so as to extend over the entire area enclosed by said pontoon element and forming a floor adapted to be disposed in intimate surface contact with the body of liquid contained by said tank, a series of vertical partitions internally of said pontoon element disposed in fluid-tight relation thereto and at regular spaced intervals therein to divide the interior thereof into a series of separate compartments of substantially equal volume, a plurality of hollow, tubular flotation elements, each formed of said substantially fluid-impervious, flexible, deformable material and equal in number to the number of said compartments, each of said flotation elements having an inner and an outer end and disposed radially of the area enclosed by said pontoon element with the inner ends of said flotation elements joined in fluid-tight, non-communicating relation substantially at the center of said area and the outer ends extending outward to a

fluid-tight juncture with the inner peripheral surface of said pontoon element, said flotation elements each communicating at its outer end with a separate compartment of said series of compartments, and individual valve means opening into the interior of each said flotation element adjacent the juncture of the inner ends of said flotation elements.

12. In a storage tank having substantially vertical walls, a rigid roof supported on said walls and a manhole opening through said roof, said tank adapted to contain a variable volume body of liquid with a vapor space above the surface of said liquid, a means providing a substantially fluid-tight separator seal between said liquid surface and the vapor space thereabove, comprising a hollow, tubular, annular, continuous pontoon element of a substantially fluid-impervious, flexible, deformable material having an outer diameter less than the inner diameter of said tank and being floatable in said liquid when inflated, an annular seal ring of a flexible, deformable material having an inner diameter substantially equal to the outer diameter of said pontoon element attached at its inner periphery in fluid-tight relation to the outer periphery of said pontoon element, said ring extending radially outward from said pontoon element into frictional, pressure engagement with the inner wall of said tank, said ring having an outer diameter slightly greater than the inner diameter of said tank, a substantially flat membrane of a substantially fluid-impervious, flexible, deformable material joined in fluid-tight relation to the outer surface of said pontoon element so as to extend over the entire area enclosed by said pontoon element and forming a floor adapted to be disposed in intimate surface contact with the body of liquid contained by said tank, a series of vertical partitions internally of said pontoon element disposed in fluid-tight relation thereto and at regular spaced intervals therein to divide the interior thereof into a series of separate compartments of substantially equal volume, a plurality of hollow, tubular flotation elements, each formed of said substantially fluid-impervious, flexible, deformable material and equal in number to the number of said compartments, each of said flotation elements having an inner and an outer end and disposed radially of the area enclosed by said pontoon element with the inner ends of said flotation elements joined in fluid-tight, non-communicating relation substantially at the center of said area and the outer ends extending outward to a fluid-tight juncture with the inner peripheral surface of said pontoon element, said flotation elements each communicating at its outer end with a separate compartment of said series of compartments, individual valve means opening into the interior of each said flotation element adjacent the juncture of the inner ends of said flotation elements, a rigid conduit member mounted on said tank, said conduit having an outer end adapted for connection to a source of a pressurized gaseous medium and an inner end opening into said tank, and a flexible conduit disposed within said tank connected at one end in fluid-tight communication with the inner end of said rigid conduit and at the other end extended into fluid-tight communication with each of said valve means opening into the interiors of said flotation elements.

13. In a storage tank having substantially vertical walls, a rigid roof supported on said walls and a manhole opening through said roof, said tank adapted to contain a variable volume body of liquid with a vapor space above the surface of said liquid, a means providing a substantially fluid-tight separator seal between said liquid surface and the vapor space thereabove, comprising a hollow, tubular, annular, continuous pontoon element of a substantially fluid-impervious, flexible, deformable material having an outer diameter less than the inner diameter of said tank and being floatable in said liquid when inflated, an annular seal ring of a flexible, deformable material having an inner diameter substantially equal to

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the outer diameter of said pontoon element attached at its inner periphery in fluid-tight relation to the outer periphery of said pontoon element, said ring extending radially outward from said pontoon element into frictional, pressure engagement with the inner wall of said tank, said ring having an outer diameter slightly greater than the inner diameter of said tank, a substantially flat membrane of a substantially fluid-impervious, flexible, deformable material joined in fluid-tight relation to the outer surface of said pontoon element so as to extend over the entire area enclosed by said pontoon element and forming a floor adapted to be disposed in intimate surface contact with the body of liquid contained by said tank, a series of vertical partitions internally of said pontoon element disposed in fluid-tight relation thereto and at regular spaced intervals therein to divide the interior thereof into a series of separate compartments of substantially equal volume, a plurality of hollow, tubular flotation elements, each formed of said substantially fluid-impervious, flexible, deformable material and equal in number to the number of said compartments, each of said flotation elements having an inner and an outer end and disposed radially of the area enclosed by said pontoon element with the inner ends of said flotation elements joined in fluid-tight, non-communicating relation substantially at the center of said area and the outer ends extending outward to a fluid-tight juncture with the inner peripheral surface of said pontoon element, said flotation elements each communicating at its outer end with a separate compartment of said series of compartments, individual valve means opening into the interior of each said flotation

tion element adjacent the juncture of the inner ends of said flotation elements, a rigid conduit member mounted on said tank, said conduit having an outer end adapted for connection to a source of a pressurized gaseous medium and an inner end opening into said tank, a flexible conduit disposed within said tank connected at one end in fluid-tight communication with the inner end of said rigid conduit and at the other end extended into fluid-tight communication with each of said valves opening into the interiors of said flotation elements, pressure relief valve means opening from each of said series of separate compartments in said pontoon element, and control valve means connected in said rigid conduit adapted to regulate fluid flow through said rigid and flexible conduits, and pressure in said pontoon element.

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