

[54] COVERED STORAGE TANK WITH MEANS TO SUSPEND FLOATING ROOF WHEN NOT IN USE

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[22] Filed: June 8, 1972

[21] Appl. No.: 260,983

[57] ABSTRACT

An enclosed storage tank having a bottom, side wall and fixed-position roof, a floating-roof in the tank, means to releasably secure the floating-roof, when not in use, in the upper part of the tank near and beneath the fixed-position roof, and access means from above and through the fixed-position roof to provide communication with the means to releasably secure the floating-roof so that the floating-roof can be secured in the upper part of the tank near the fixed-position roof or released to float freely on liquid in the tank.

The access means can be a plurality of closeable ports in the roof.

11 Claims, 13 Drawing Figures

[52] U.S. Cl. .... 220/26 R  
[51] Int. Cl. .... B65d 87/18  
[58] Field of Search ..... 220/26, 22.1, 88, 93

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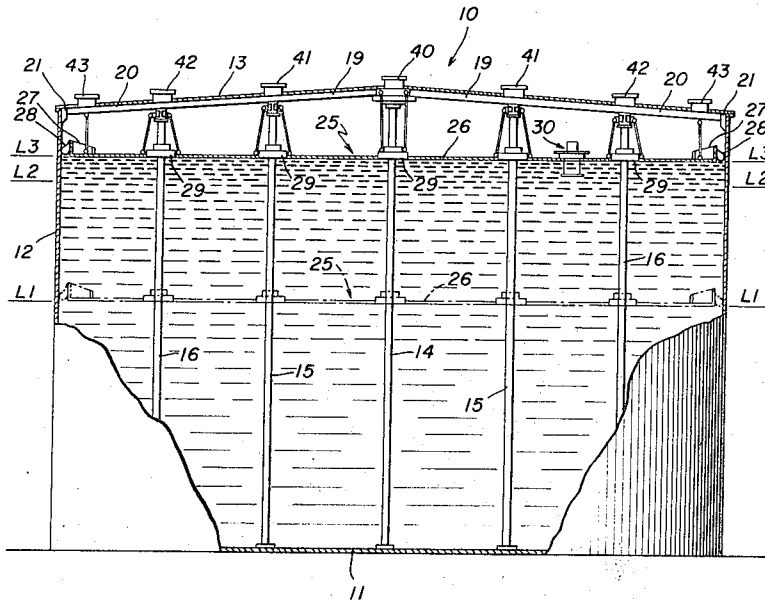


FIG. 1

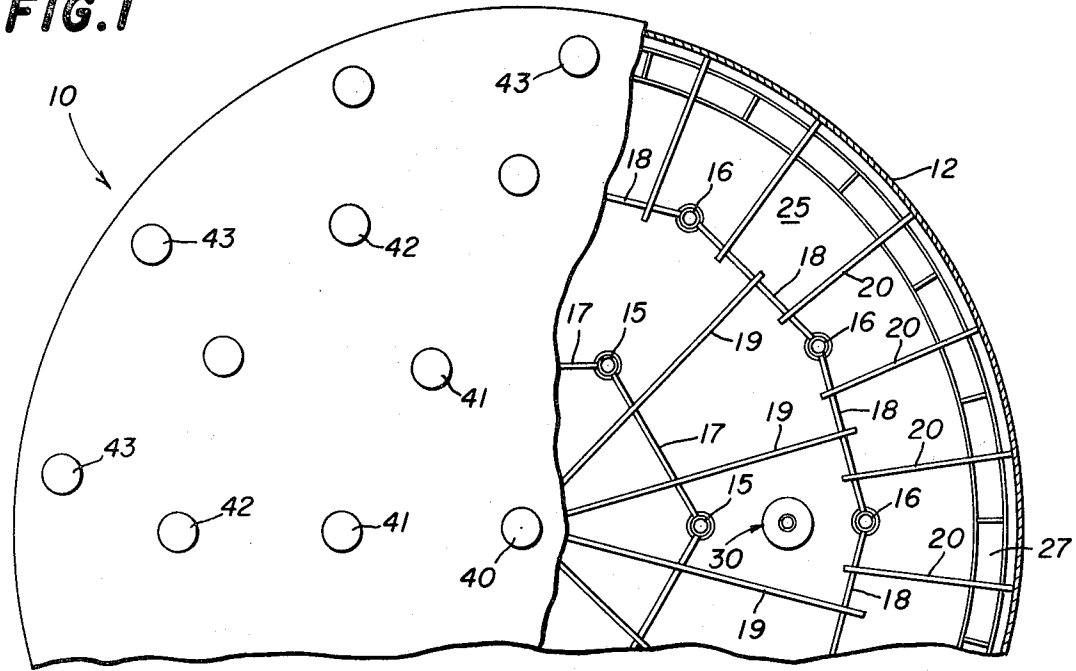
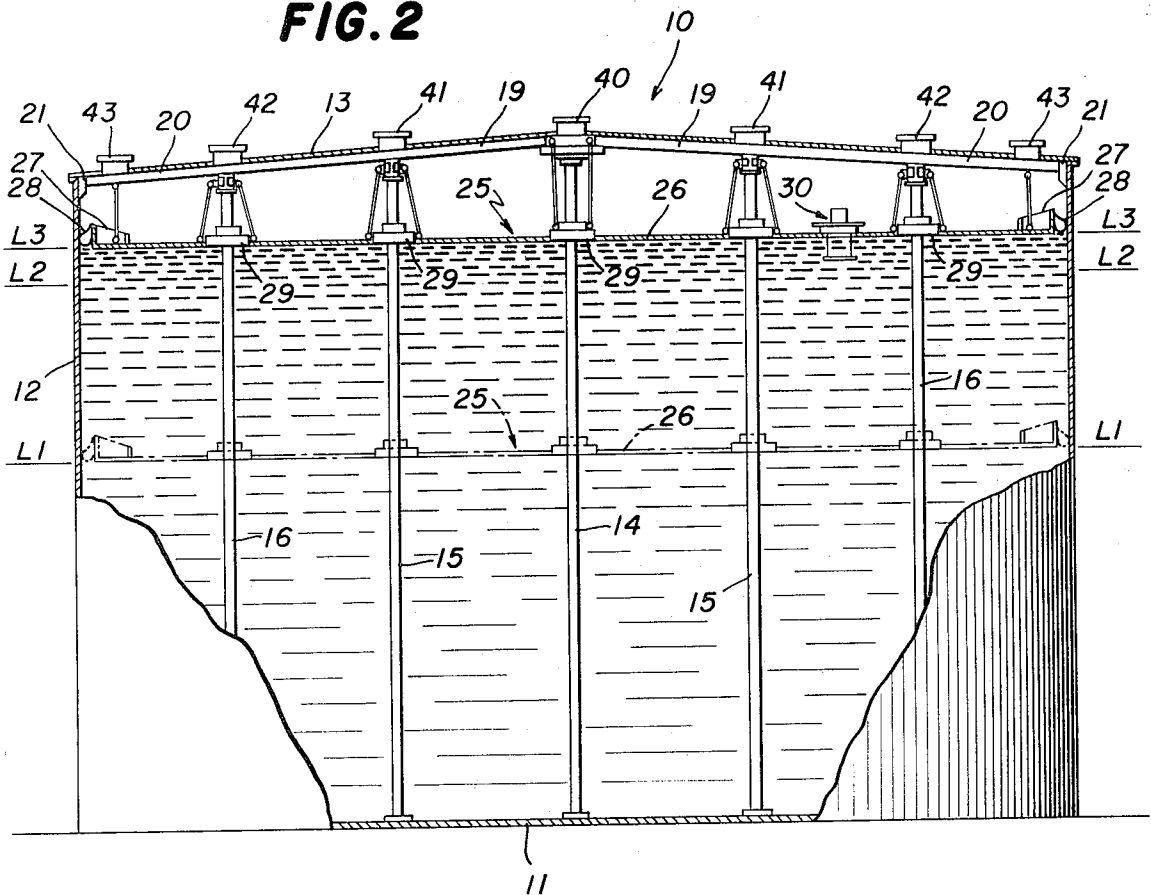
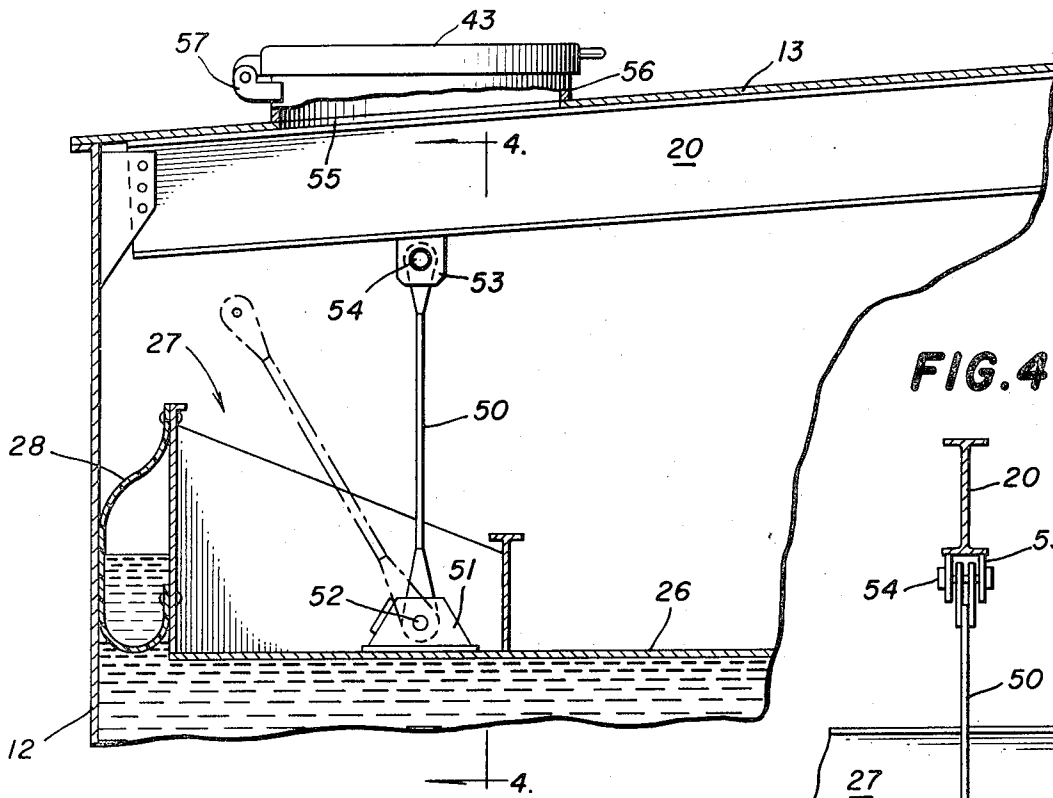


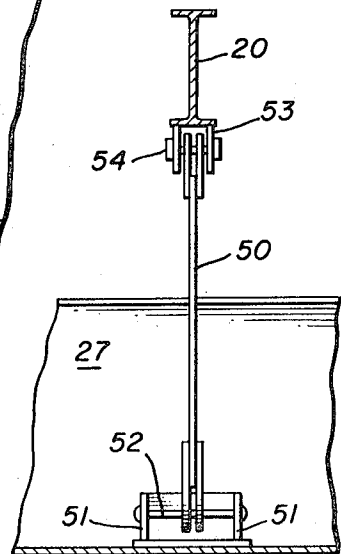
FIG. 2



**FIG. 3**



**FIG. 4**



**FIG. 5**

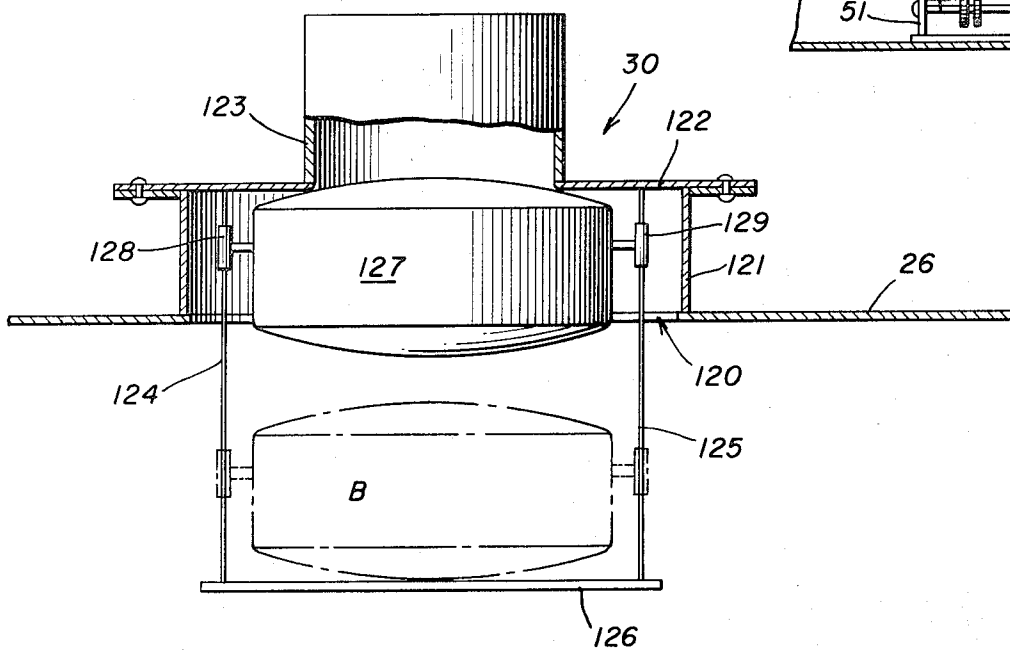


FIG. 6

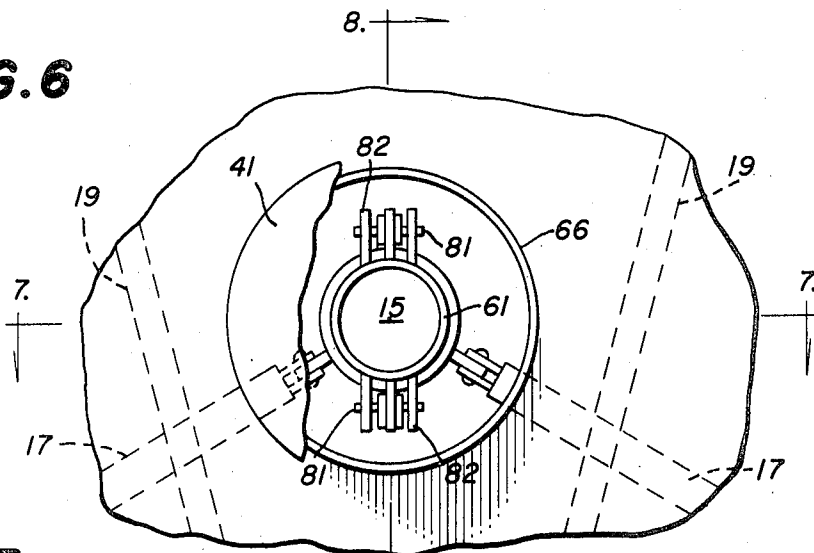


FIG. 7

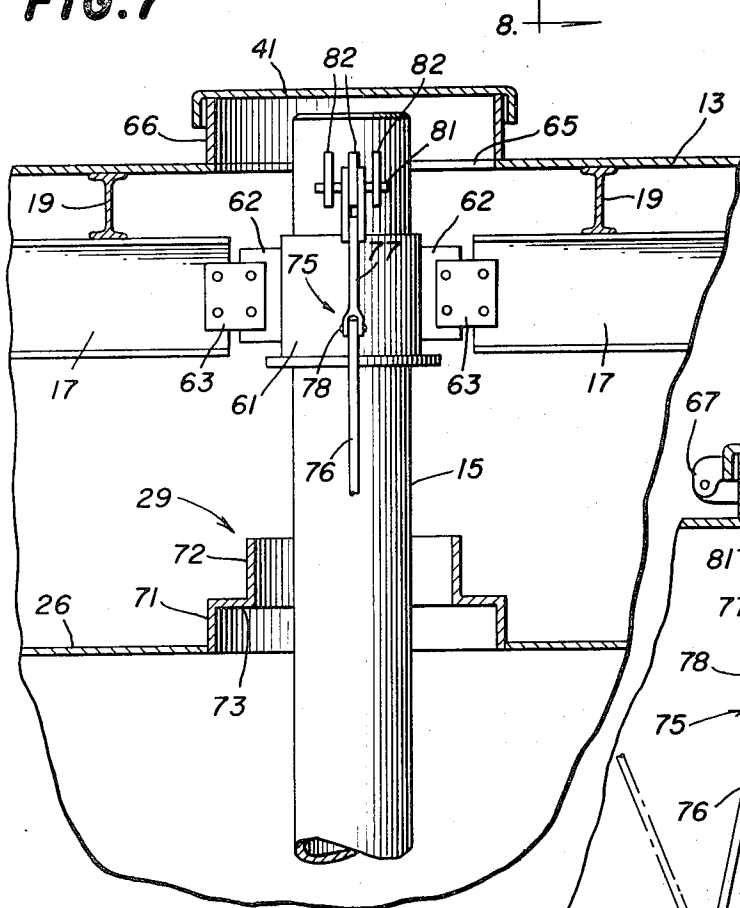


FIG. 8

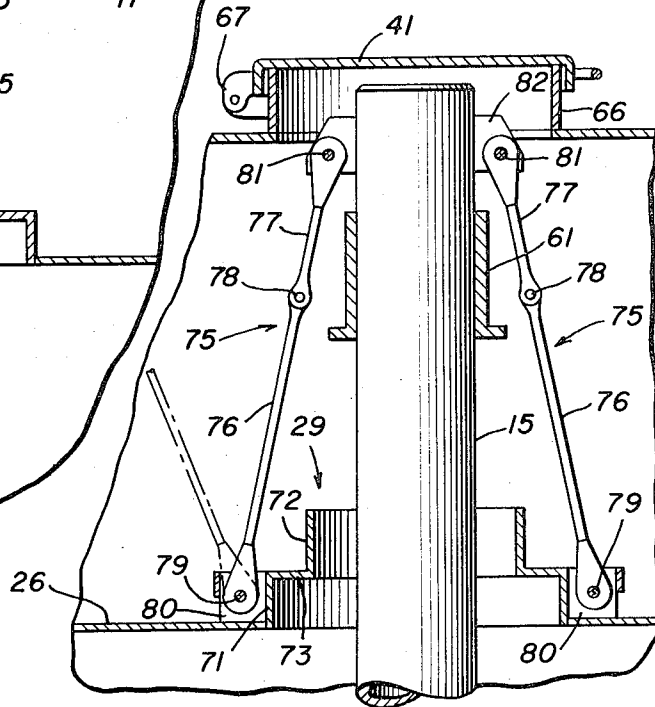


FIG. 9

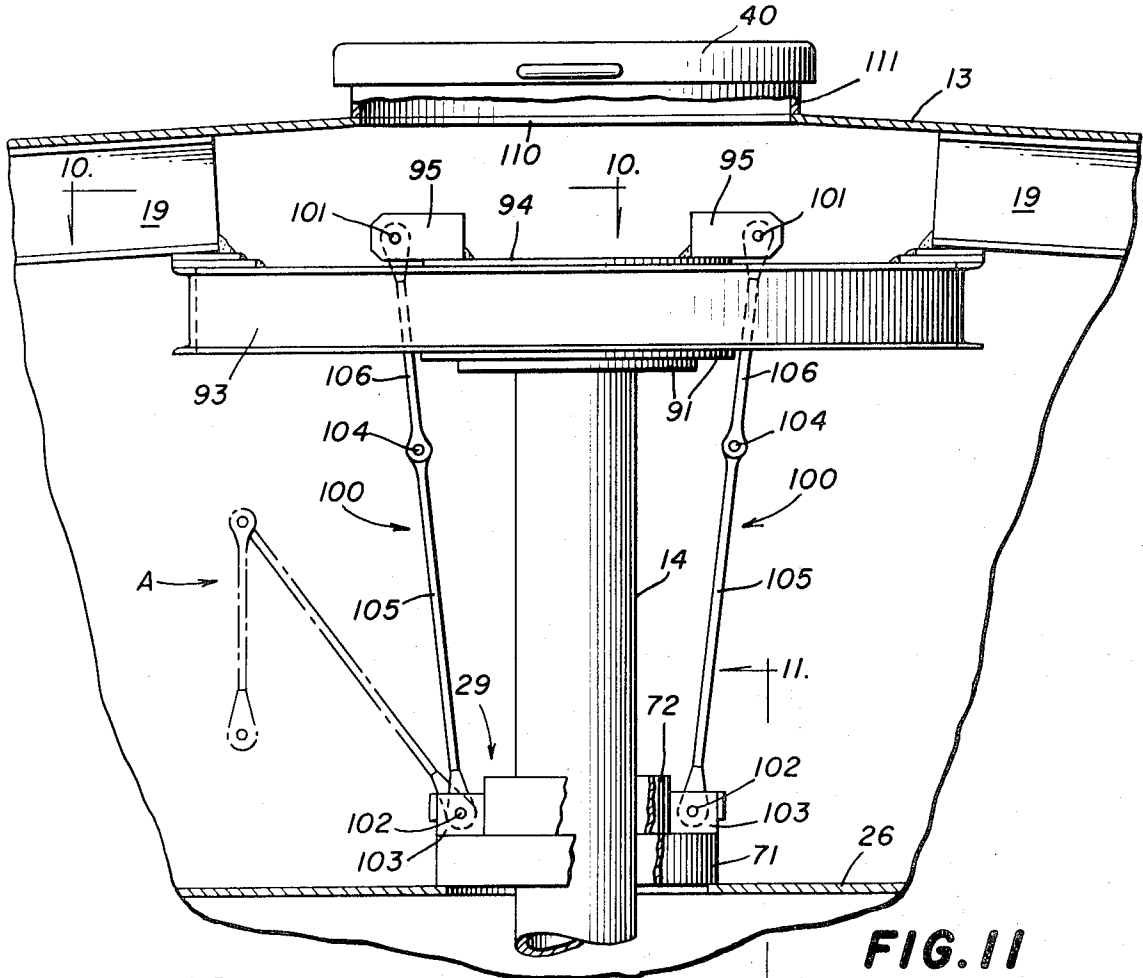


FIG. 10

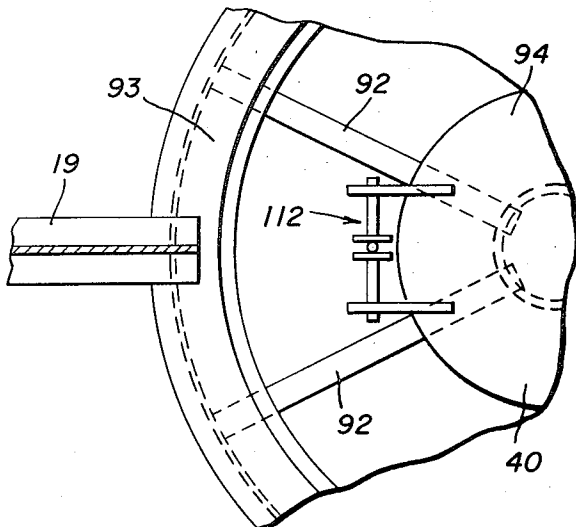
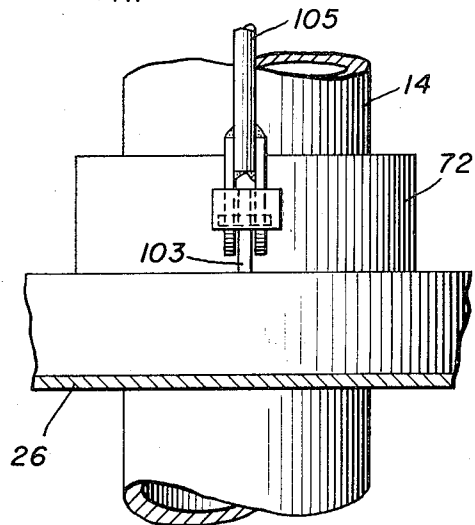
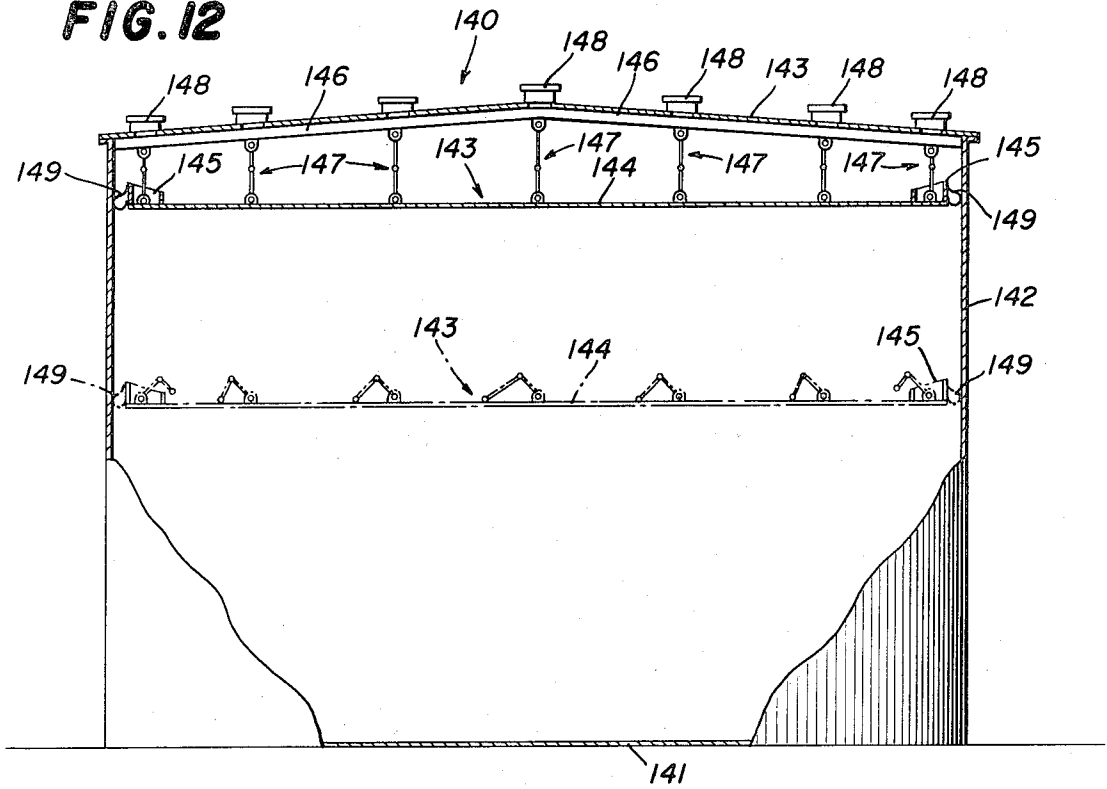


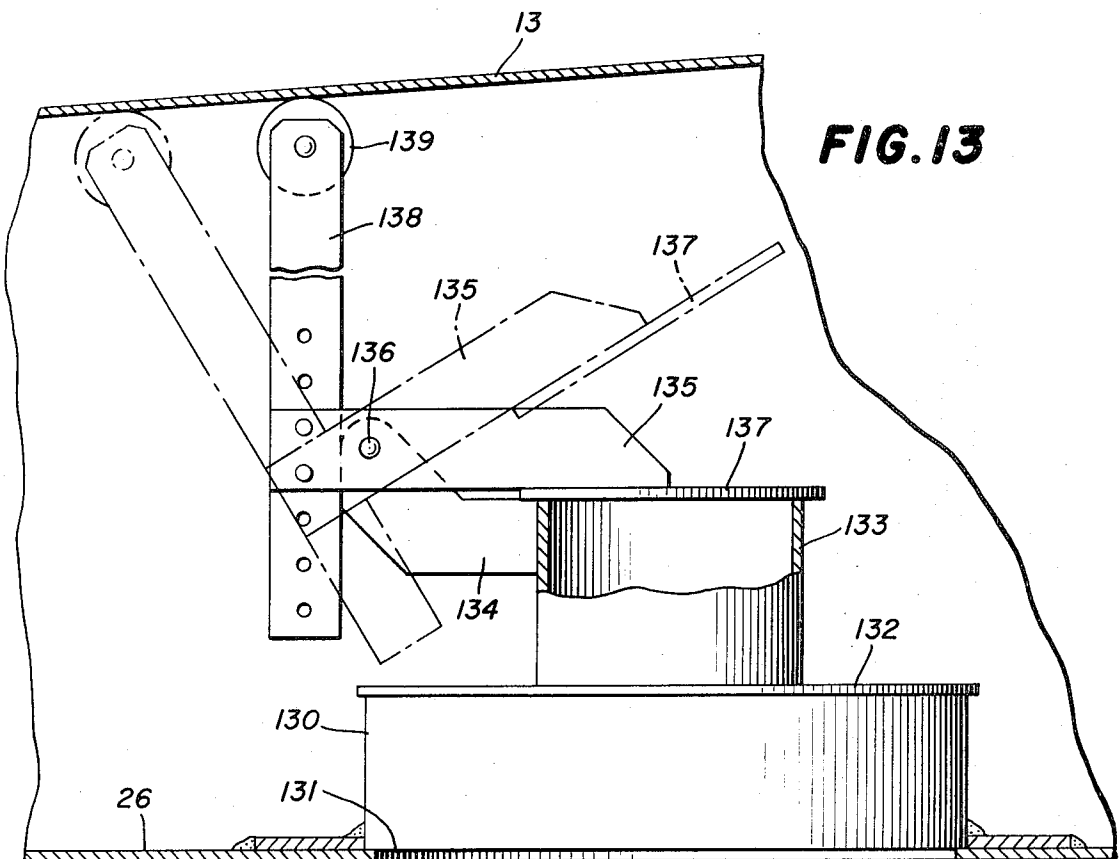
FIG. 11



**FIG. 12**



**FIG. 13**



## COVERED STORAGE TANK WITH MEANS TO SUSPEND FLOATING ROOF WHEN NOT IN USE

This invention relates to storage tanks for liquids. More particularly, this invention is concerned with improvements in enclosed storage tanks for liquids which employ an internal floating roof.

Many kinds of storage tanks are widely used for the storage of liquid products. For reasons of cost and convenience of construction, large size storage tanks are often made with a flat bottom and vertical cylindrical wall. The tank may be fully enclosed such as by the use of a conical or dome fixed-position roof. Alternatively, the tank can be left open at the top and a floating roof positioned inside of the tank to float on the liquid product stored therein.

Although both described types of tanks are widely used, for the storage of liquids having a high volatile content it is beneficial to employ a storage tank which has an external fixed roof, such as of the conical or dome type, and an internal floating roof. The fixed-position roof prevents rain, snow and ice from entering the tank and thereby protects the contents from the weather and the internal floating roof greatly retards the formation of vapor from volatile materials stored in the tank. By suppressing the formation of vapor, there is a greatly reduced need to vent vapor from the tank during atmospheric changes in temperature and pressure. As a result there is a reduction in the amount of product lost through vapor venting.

Although a storage tank having a fixed external roof and an internal floating roof can be used for storing volatile liquid products, it sometimes becomes advisable, and even necessary, for the tank to be used for the storage of a liquid product which is exceedingly low in volatile components and often a product which is very viscous. It is undesirable in many instances to utilize the floating roof with such a product because it can be damaged through failure to operate in the same manner as it would when used in conjunction with the storage of a much more volatile free-flowing liquid stored in the tank. Accordingly, for flexibility in use, there is a need for a storage tank for liquids which contains a floating roof which can be utilized when desired in conjunction with the storage of volatile free-flowing liquids and which floating-roof can be removed from service or use when the tank is employed for the storage of a heavy or viscous liquid, or one low in volatile components.

According to the present invention there is provided an enclosed storage tank comprising a tank having a bottom, side wall and fixed-position external roof, a floating-roof in the tank, means to releasably secure the floating-roof, when not in use, in the upper part of the tank beneath the fixed-position roof, and access means from above and through the fixed-position roof to provide communication with the means to releasably secure the floating-roof so that the floating-roof can be secured beneath the fixed-position external roof or released to float freely on liquid in the tank.

In the enclosed storage tank of this invention, the floating-roof operates in the conventional manner when employed in conjunction with the storage of a volatile free-flowing liquid. However, when the storage tank is to be employed for storing a thick or viscous liquid, and particularly one of low volatility, the floating-roof can be secured below the fixed-position roof

above the usual maximum liquid storage level of product to be placed in the tank so that it thereby is removed from operating cooperation with the storage of the viscous liquid in the storage tank. Securing of the floating roof as described can be achieved according to the invention, without a workman entering the tank, by filling the tank with a liquid product to raise the floating-roof close to the fixed-position roof. Then, by use of the access means, such as openings or ports in the fixed-position roof, suspending means is put in place to secure the floating-roof in nonfloating and nonoperating position.

Various suspending means can be used to secure the floating-roof in nonoperating position. Thus, the suspending means can comprise a plurality of rods, cables or chains connected at various points to the floating-roof and also to the fixed-position roof or to other tank structure above the floating roof. Furthermore, when internal columns are present to support the fixed-position roof, locking means can be positioned on the columns, or the floating-roof, to lock the floating-roof into position relative to the columns so that it can be supported or secured in position. Additional support can be provided by locking means on the tank wall or the periphery of the floating-roof which functions to secure the floating-roof in releasable position relative to the tank wall. Such a wall-floating-roof securement can be the sole means of supporting the floating-roof in nonoperating position if the tank and floating-roof have the necessary strength. The locking means can be positioned to be operable when the floating-roof is high inside of the tank and closely positioned by and beneath the fixed-position roof so as to have it releasably placed in a location high enough so as not to interfere with use of the tank for storage of a viscous or low-volatile liquid.

The invention will be described further in conjunction with the attached drawings, in which:

FIG. 1 is a plan view, partially broken away, of an enclosed storage tank according to the invention;

FIG. 2 is an elevational view, partially broken away and partially in section, of the enclosed storage tank of FIG. 1;

FIG. 3 is an enlarged vertical sectional view of the upper corner of the tank of FIG. 2 showing one part of a mechanism for suspending the floating-roof;

FIG. 4 is an elevational view, partially in section, taken along the line 4—4 of FIG. 3;

FIG. 5 is an elevational view, partially in section, of a vent mechanism located in the floating-roof deck;

FIG. 6 is a plan view, partially broken away, of the top of the columns used to support the fixed-position roof of the tank of FIGS. 1 and 2;

FIG. 7 is an elevational view, partially in section, taken along the lines 7—7 of FIG. 6;

FIG. 8 is an elevational view, partially in section, taken along the line 8—8 of FIG. 6;

FIG. 9 is an elevational view, partially in section, of the upper part of the central column in the tank of FIGS. 1 and 2;

FIG. 10 is a partial plan view taken along the line 10—10 of FIG. 9;

FIG. 11 is an elevational view, partially in section, taken along the line 11—11 of FIG. 9;

FIG. 12 is an elevational view, partially in section, of another embodiment of the invention in which a floating roof is temporarily fixed in position inside of an en-

closed storage tank having a fixed-position roof supported without the use of internal columns; and

FIG. 13 is another embodiment of vent means which can be used in the floating-roof to provide vapor communication from between the top and bottom of the floating-roof when it is placed in releasably fixed position high inside of the tank.

So far as is practical, the same elements or parts which appear in the various views of the drawings, will be identified by the same number.

With reference to FIGS. 1 and 2, the enclosed storage tank 10 has a flat metal bottom 11, a vertical cylindrical side wall 12 and a fixed-position conical roof 13 supported by wall 12 and also supported by internal columns. Central column 14 supports the central area of fixed-position roof 13. A plurality of columns 15, placed more or less in a circular arrangement around central column 14, support an intermediate area of roof 13. Columns 16, also positioned in a generally circular pattern inside of the tank support the roof area between columns 15 and tank side wall 12. Girders 17 are positioned to extend between a pair of adjoining columns 15 and girders 18 are positioned to extend between a pair of adjacent columns 16. Rafters 19 rest on a supporting ring 93 (FIG. 9) on the top of central column 14 and extend to and rest on girders 17 and 18. Rafters 20 rest on girders 18 and extend to and rest on supporting flanges 21 positioned on the inside top edge of tank side wall 12. Roof 13 rests directly on the top of rafters 19 and 20. An enclosed storage tank of the type so far described is conventional in the art of tank construction.

Located inside of tank 10 is a floating-roof 25. Floating-roof 25 has a flat metal deck 26 with a peripheral pontoon 27 located around its outer edge. A flexible seal 28 is located on the outer edge of pontoon 27 to seal the clearance between the pontoon edge and the inside surface of tank side wall 12.

The deck 26 of floating-roof 25 is provided with a plurality of openings or holes through which the columns 14, 15 and 16 extend. Each hole is surrounded by a skirt 29 located on the upper side of deck 26. Each of the skirts 29 located around the holes in the deck extends vertically sufficiently high so that the liquid level therein does not extend above the top of the skirt when the floating-roof is floating on a liquid in the tank.

Vent mechanism 30 (FIGS. 1, 2 and 5) is located in deck 26 of the floating-roof. Vent mechanism 30 is closed when the floating-roof is supported by a liquid in the tank and is open when the floating-roof is suspended or held in fixed position high up inside of the tank when the floating-roof is not to be used. Vent mechanism 30 is further described herein in the discussion of FIG. 5.

Door 40 is positioned over an access opening in roof 13 located above the top of central column 14. Doors 41 are located over access openings in roof 13 above the top of columns 15 and doors 42 are located over access openings in roof 13 above the tops of columns 16. Doors 43 are positioned over access openings in roof 13 positioned in spaced-apart relationship around the peripheral portion of roof 13 to provide access to means to assist in securing the floating roof in position when it is not to be used.

With reference to FIGS. 3 and 4, rod 50 is joined to flange 51 on the floating roof by means of pin 52. The upper end of rod 50 is joined to flange 53 on rafter 20

by means of a bolt or pin 54. A plurality of rods 50 are spaced around the periphery of the floating-roof and fixed-position roof. A plurality of spaced-apart openings 55 in roof 13 are provided so that access to rods 50 can be achieved by a man on the fixed-position roof 13. Generally an opening is provided directly above each rod to make access easy. A vertical wall 56 is positioned around each access opening 55 to keep water from running into the access hole. Door 43 seals off the access area and rests on vertical wall 56 when in closed position. Door 43 is mounted on wall 56 by means of a hinge arrangement 57.

FIGS. 6 to 8 illustrate the construction of and on the upper part of columns 15. As shown in these figures each column 15 projects. Each collar 61 is secured to the upper part of column 15. The ends of girders 17 are joined to flanges 62 on collar 61 by plates 63. Rafters 19 rest on the top of girders 17 and fixed-position roof 13 in part rests on and is supported by rafters 19. An access opening 65 is located in roof 13 above each of the columns 15. Each opening 65 is surrounded by a vertical cylindrical flange or wall 66 which is covered by door 41 movably secured to flange 66 by hinge 67.

Also in reference to FIGS. 6 to 8, a skirt 29 surrounds each opening in floating-roof deck 26 through which each column 15 projects. Each skirt 29 has a stilling well wall 71 and a column well wall 72 which are joined together by horizontal plate ring 73. In practice, when the floating-roof is supported by liquid in the tank, the liquid level should not rise above the horizontal ring 73 at the top of the stilling well space.

As shown in FIGS. 6 to 8, a pair of tension rods 75 in part support the floating-roof on each of columns 15 when the floating-roof is not in use. Each rod 75 has a lower portion 76 and an upper portion 77 with each rod portion being joined together by a pin 78. The lower ends of each rod portion 76 are joined by a pin 79 to flanges 80 joined to floating-roof deck 26 and stilling well wall 71. The upper ends of each upper rod portion 77 are joined by pins or bolts 81 to flanges 82 mounted on the top portion of column 15. The hinge joint or knuckle joint provided by pins 78 in rods 75 facilitates the installation and removal of pins 81 when the floating-roof is to be suspended in the top of the tank or when it is to be removed from such suspension. It is of course obvious that a similar rod construction can be used for rod 50 as illustrated in FIGS. 3 and 4.

Although the construction as illustrated by FIGS. 6 to 8 pertains specifically to the apparatus at the upper part of columns 15, it should be understood that the apparatus at the top of columns 16 is in all respects the same as is shown in FIGS. 6 to 8 and therefore has not been separately illustrated or described.

FIGS. 9 to 11 illustrate the construction at the upper portion of central column 14. Circular plates 91 are secured to the top of column 14. Beams 92 are positioned to rest on the top of plates 91 and to extend radially outwardly therefrom to join with and support rafter ring support 93. The inner ends of rafters 19 rest on rafter ring support 93. Circular plate 94 is joined to the tops of radially positioned beams 92 and is supported thereby. Vertically positioned flanges 95 are secured to plate 94. The upper end of suspension rods 100 are joined by bolts 101 to flanges 95 and the lower end of suspension rods 100 are joined by pins 102 to flanges 103 connected to the skirt 29. Each of the two suspension rods 100 is made in two parts or portions 105 and



106 which are pivotably joined together by pins 104. The phantom view A shown in FIG. 9 illustrates how the suspension rods 100 can be folded out of the way when the floating-roof is not suspended from the upper part of the tank in the manner described.

As shown in FIG. 9, opening 110 is provided in fixed-position roof 13 above the top of column 14. Vertical circular cylindrical wall 111 is located around the opening 110 to prevent water from flowing into the hole. Door 40 is mounted by hinge arrangement 112, as shown in FIG. 10, to cylindrical wall 111 to movably cover the access opening. To obtain access to the upper part of column 14 to position suspension rods 100 in place or to loosen them, door 40 need only be lifted upwardly.

The operation of the enclosed storage tank as described with reference to FIGS. 1 to 11 is conventional except for the means to support the floating-roof high up inside of the tank when the floating-roof is not to be used. As shown in FIG. 2, when the liquid level in the storage tank is at level L1 the floating-roof will be in the position shown in phantom floating on liquid in the tank. The normal maximum height of liquid stored in the tank is at the line L2. The liquid level in the tank is accordingly not raised above the level line L2 when the floating-roof is in use. Of course, when the floating-roof in use the suspension rods 50, 75 and 100 are released at their upper or lower ends or both so that there is unrestricted freedom of movement of the floating-roof with rise and fall of liquid in the storage tank.

When it is desired to take the floating-roof out of use, the liquid in the storage tank is raised to level L3. The liquid is maintained at the level L3 with the floating-roof on top of the liquid. Workmen then mount the fixed-position roof 13, open the doors 40, 41, 42 and 43 and secure the suspension rods 50, 75 and 100 into place. After all of the suspension rods have been secured in place, liquid in the tank is withdrawn and the floating-roof is thereby left in secured position in the upper part of the storage tank. After all of the contents of the tank has been removed, a different liquid can be fed into the tank and stored therein, it being assumed that the liquid fed therein is desirably stored in the tank without use of the floating-roof on the liquid surface. When it is again desirable to place the floating-roof in use, the quantity of liquid in the storage tank is raised to level L3 to place the floating-roof in a slightly floating position on the liquid. Workmen can then release the suspension rods 50, 75 and 100 by opening doors 40, 41, 42 and 43 and releasing the rods from their suspending arrangement without entering the tank.

FIG. 5 illustrates a vent mechanism which can be positioned in deck 26 of floating-roof 25. Opening 120 is provided in floating-roof deck 26. Vertical circular cylindrical wall 121 surrounds opening 120 and supports a horizontally positioned plate ring 122 from which a cylindrical circular collar 123 projects vertically upwardly. A pair of rods 124 and 125 depend downwardly from the bottom of horizontal ring 122. The lower ends of rods 124 and 125 are maintained spaced apart by connecting rod 126. Float 127 is secured on diametrically opposite sides by guides 128 and 129 through which vertical rods 124 and 125 slide in a manner which permits vertical displacement of float 127 up and down. When the floating-roof is supported by a liquid stored in the tank, float 127 is pressed against the lower

internal edge of vertical collar 123 to thereby seal off the passage in collar 123 to prevent flow of vapor from the liquid beneath the floating-roof to the space above the floating-roof. When the floating-roof is not in use and is secured in the upper part of the tank, float 127 drops downwardly to position B shown in phantom in FIG. 5 and thereby opens the passage in collar 123 so that any vapor beneath the suspended floating-roof and above the liquid level in the tank can be vented to the space above the secured floating-roof. The vapor can then be removed from the space above the secured floating-roof by means of a suitable conduit, not illustrated, in fixed-position roof 13.

FIG. 13 illustrates another vent mechanism which can be used to achieve the same results described with respect to the vent mechanism embodiment of FIG. 5. As shown in FIG. 13, vertically-positioned cylindrical stilling well wall 130 is located around opening 131 in floating-roof deck 26. Horizontally positioned ring plate 132, having a central circular hole therein, is mounted on the top of stilling well wall 130. Cylindrical circular wall 133 is mounted on top of horizontal plate 132 with its lower end positioned around the opening in plate 132. Arm 134 extends outwardly and upwardly from the upper part of cylindrical wall 133. Arm 135 is pivotally mounted by pin 136 to arm 134. A circular flat plate 137 is joined to arm 135 in a manner which permits it to cover the top of cylindrical wall 133 to seal off flow of vapors from beneath the floating-roof to the space above the floating-roof when the floating-roof is in use floating on a stored liquid. Vertical leg 138 is joined to arm 135 by suitable pins or bolts placed in holes spaced apart to provide for adjustable positioning. Roller 139 is mounted at the upper end of leg 138. When the floating-roof is raised to level L3, as shown in FIG. 2, roller 139 contacts the bottom surface of fixed-position roof 13 and is caused to roll along such surface to the position shown in phantom in FIG. 13. This results in pivotal movement of leg 138 which causes arm 135 to rotate and to be raised and, in doing so, cover 137 is lifted off of the top of cylindrical wall 133 to thereby provide an open passage for flow of vapor from beneath the secured floating-roof to the space above the said roof. After the floating-roof is released from its secured position and the liquid level in the tank is lowered, the weight of cover 137 causes it to automatically reposition itself on top of cylindrical wall 133 to seal the vapor passage.

FIG. 12 illustrates application of the invention to an enclosed storage tank 140 which has no internal columns supporting the fixed-position roof. The tank 140 has a flat metal circular bottom 141, a vertical circular cylindrical metal side wall 142 and a conical fixed-position metal roof 143 supported by side wall 142 and rafters 146. Inside of the tank is located floating-roof 143 which has a metal deck 144, a peripheral pontoon 145 and a peripheral seal 149. When the floating-roof is not in use, it is suspended from rafters 146 by means of suspension rods 147. Each of the suspension rods 147 is provided with a pivotable connection intermediate its ends in the manner of suspension rods 100 previously described. The lower ends of suspension rods 147 are pivotably joined to connecting flanges mounted on floating-roof 143. The upper ends of suspension rods 147 are removably connected to flanges mounted on rafters 146. An access door 148 is located over an opening, in fixed-position roof 143, above each of the

suspension rods 147. Upon opening of each and every access door, a workman can reach in to connect or disconnect the suspension rod upper end from the connecting means on rafters 146. When the floating-roof is in use floating on a liquid stored in the tank, the suspension rods 147 are left connected thereto by the bottom pivotable connection, as shown in phantom in FIG. 12, so that they can be readily reconnected to secure the floating-roof in position high up in the tank when it is not to be used.

Although the invention has been described with reference to tanks having vertical circular cylindrical walls, it will be obvious that the invention can be utilized in tanks of different shapes including those having polygonal sides. In addition, the fixed-position roof need not be conical but can be any other suitable shape including a domed shaped fixed-position roof. Furthermore, while the invention has been described with reference to tanks made of metal, it should also be understood that the invention can be used in tanks of concrete and plastic construction.

The foregoing detailed description has been given for clearness of understanding only, and no unnecessary limitations should be understood therefrom, as modifications will be obvious to those skilled in the art.

What is claimed is:

1. An enclosed storage tank comprising:

a tank having a bottom, side wall and fixed-position roof,

a floating-roof in the tank,

means to releasably secure the floating roof, when not in use, onto tank structure in the upper part of the tank near and beneath the fixed-position roof, and

access means from above and through the fixed-position roof to provide communication with the means to releasably secure the floating-roof so that the floating-roof can be secured in the upper part of the tank near the fixed-position roof, or released to float freely on liquid in the tank, by a man without him entering the tank.

2. An enclosed storage tank according to claim 1 in which the access means comprises a plurality of closeable ports in the roof.

3. An enclosed storage tank according to claim 1 in which the fixed-position roof is supported by a plurality of columns extending from the tank bottom to the fixed-position roof, and the floating-roof has an opening therein for each column, each opening having a vertical skirt extending above the level of any liquid upon which the floating-roof floats.

4. An enclosed storage tank comprising:

a tank having a bottom, side wall and fixed-position roof,

a plurality of vertical columns extending from the tank bottom to the roof to support the fixed-position roof,

a floating-roof in the tank,

an opening in the floating-roof for each column to extend therethrough,

a vertical skirt above each opening extending above the level of any liquid upon which the floating-roof

floats,

means to suspend the floating-roof, when not in use, from fixed-position tank structure above the floating-roof,

access means from above and through the fixed position roof providing communication with the means to suspend the floating-roof so that the floating-roof can be so suspended or released from such suspension by a man without him entering the tank.

5. An enclosed storage tank according to claim 4 in which the means to suspend the floating-roof is located at least in part in close proximity to the top of some of the columns.

6. An enclosed storage tank according to claim 5 in which the access means includes at least in part closeable openings adjacent the tops of columns having suspending means for the floating-roof.

7. An enclosed storage tank according to claim 4 in which the means to suspend the floating-roof comprises elongated tension members.

8. An enclosed storage tank comprising:

a tank having a bottom, side wall and fixed-position roof,

a floating-roof in the tank,

a plurality of spaced-apart rods extending from the floating-roof to tank structure above the floating-roof to releasably secure the floating roof, when not in use, in the upper part of the tank near and beneath the fixed-position roof, and

access means from above and through the fixed-position roof to provide communication with the rods to releasably secure the floating-roof in the upper part of the tank near the fixed-position roof or to release it to float freely on liquid in the tank.

9. An enclosed storage tank according to claim 8 in which the rods are detachably connected at at least one end to the floating-roof or to tank structure above the floating-roof.

10. An enclosed storage tank according to claim 8 in which at least some of the rods are of variable length.

11. An enclosed storage tank comprising:

a tank having a bottom, side wall and fixed-position roof,

a floating-roof in the tank,

means to releasably secure the floating-roof, when not in use, in the upper part of the tank near and beneath the fixed-position roof,

access means from above and through the fixed-position roof to provide communication with the means to releasably secure the floating-roof so that the floating-roof can be secured in the upper part of the tank near the fixed-position roof or released to float freely on liquid in the tank, and

a vent in the floating-roof which is closed when the floating-roof floats on liquid in the tank and is open when the floating-roof is releasably secured onto tank structure so that vapor can flow from one side of the floating-roof to the other side.

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