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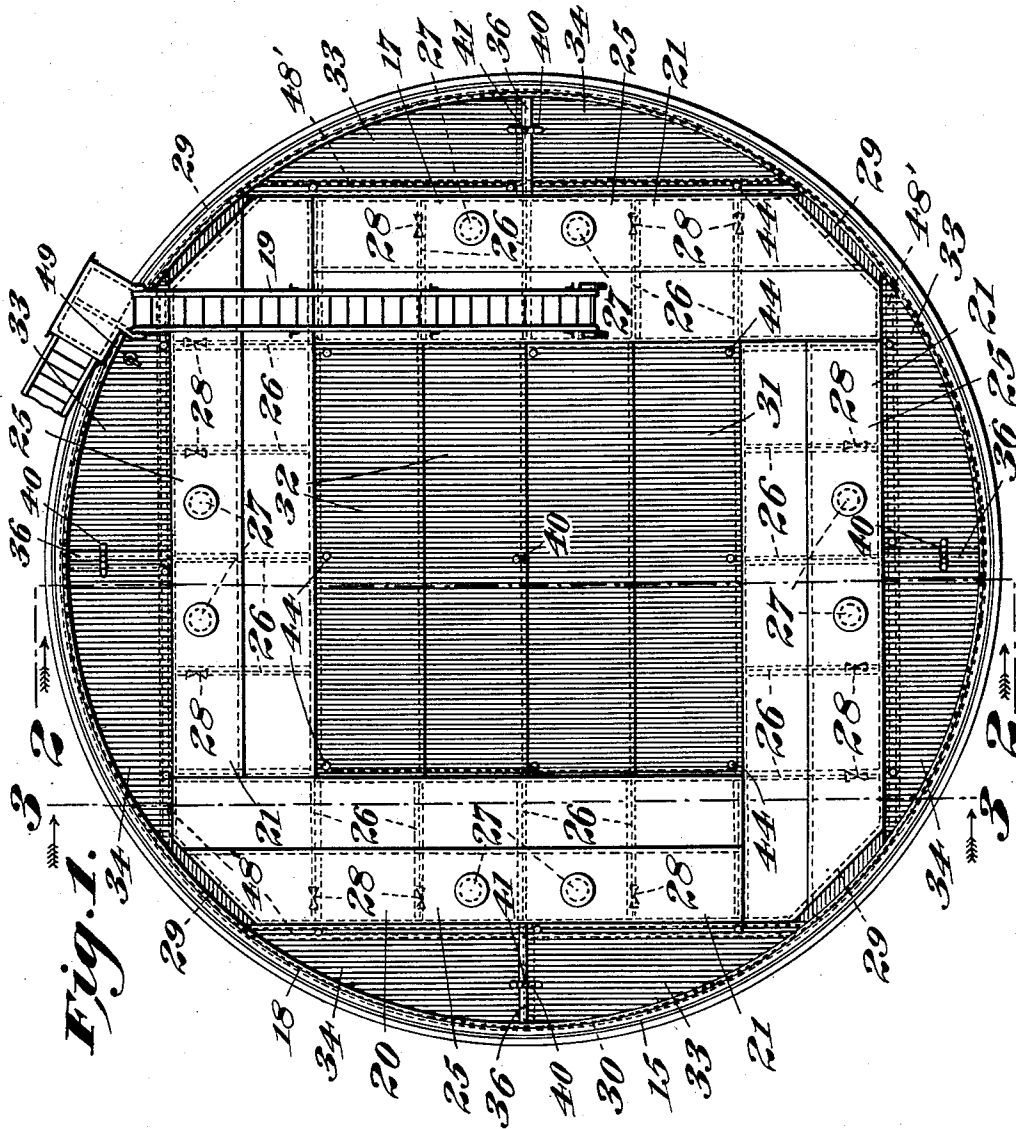
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2,089,645

LIQUID STORAGE TANK

Filed Dec. 13, 1934

8 Sheets-Sheet 1



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8 Sheets-Sheet 2

Fig. 2.

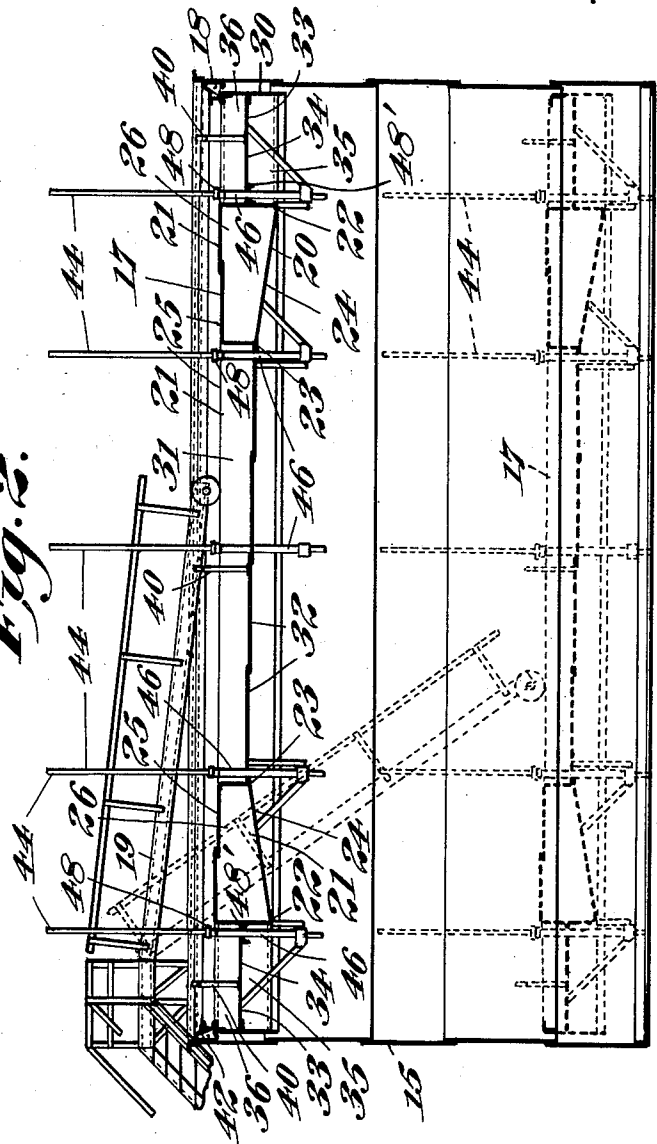
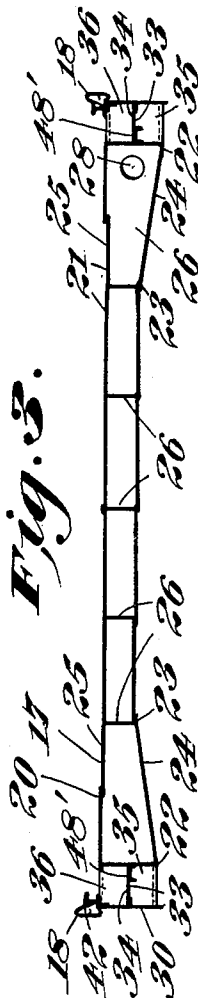


Fig. 3.



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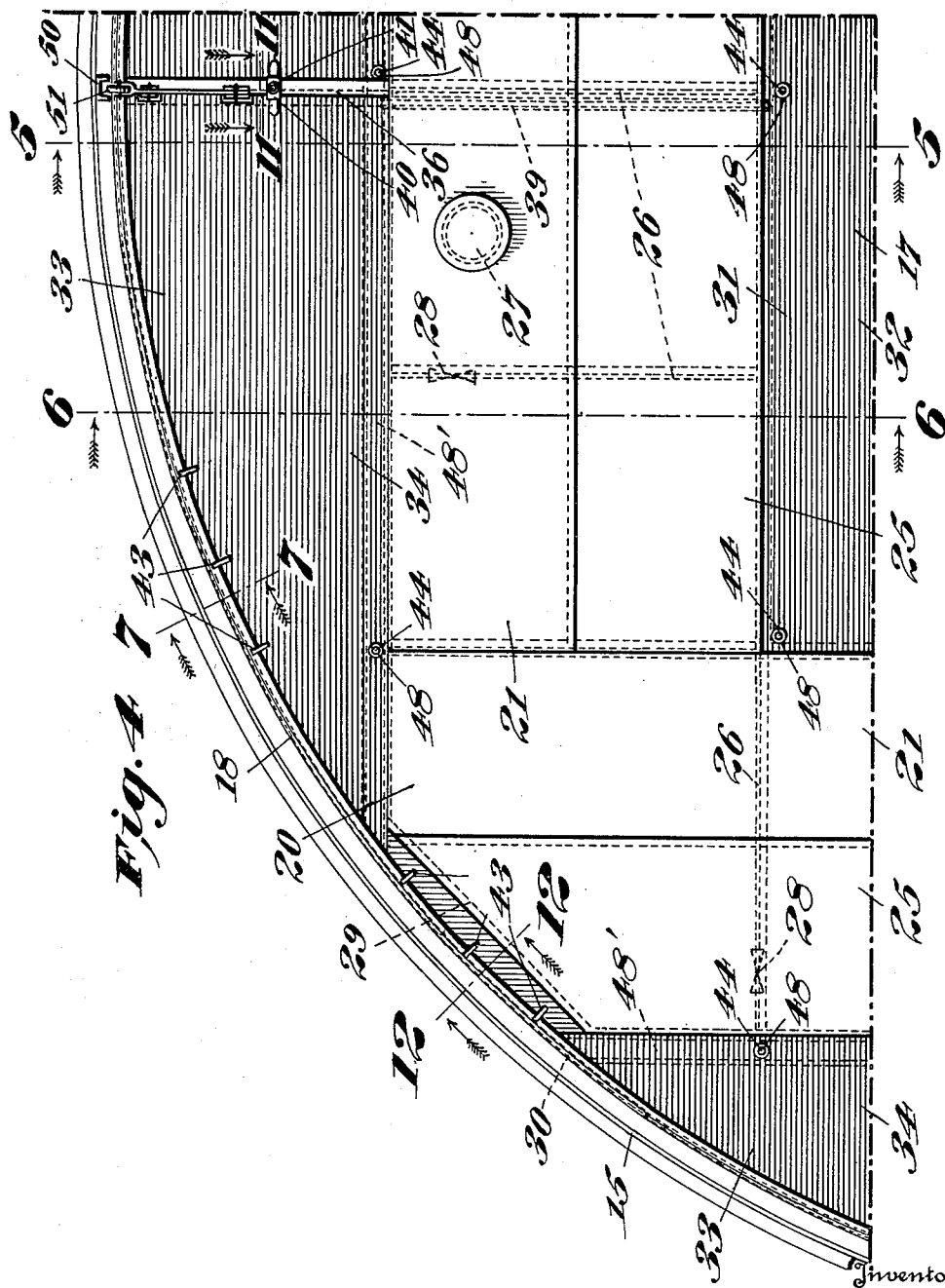
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8 Sheets-Sheet 3



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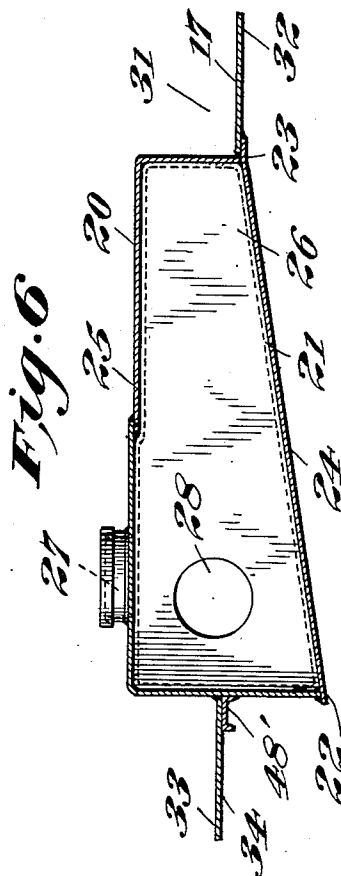
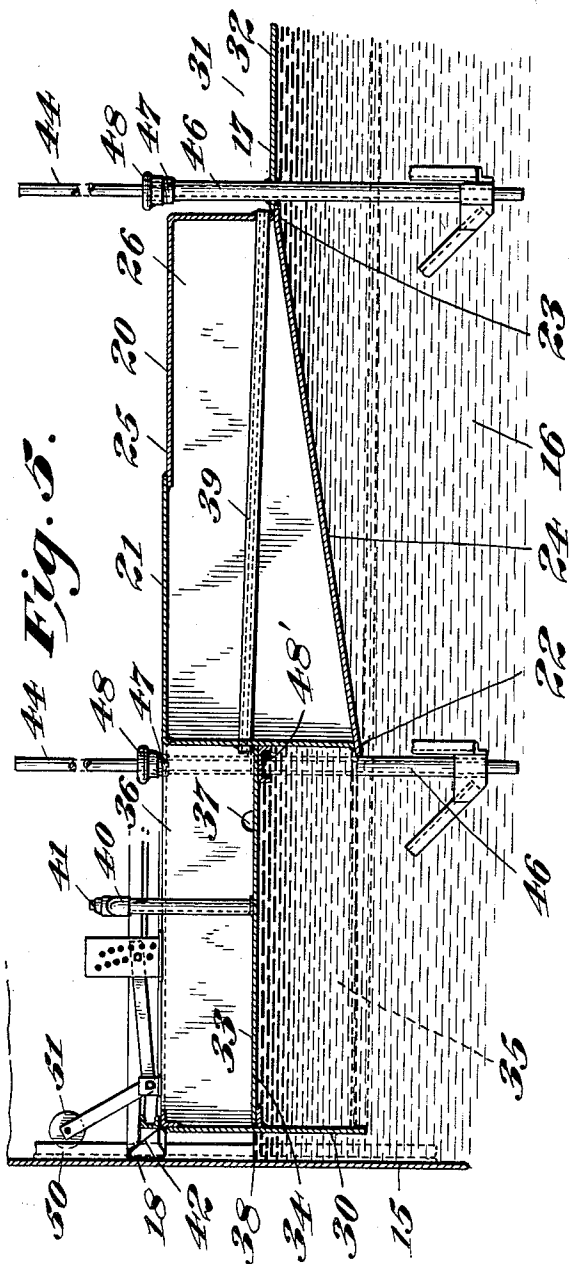
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8 Sheets-Sheet 4



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Fig. 8.

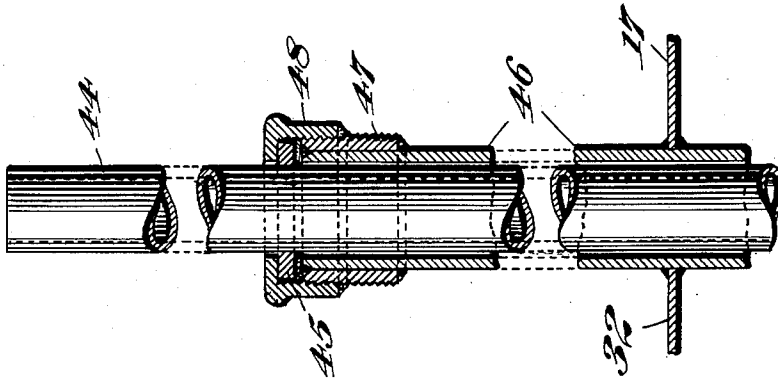
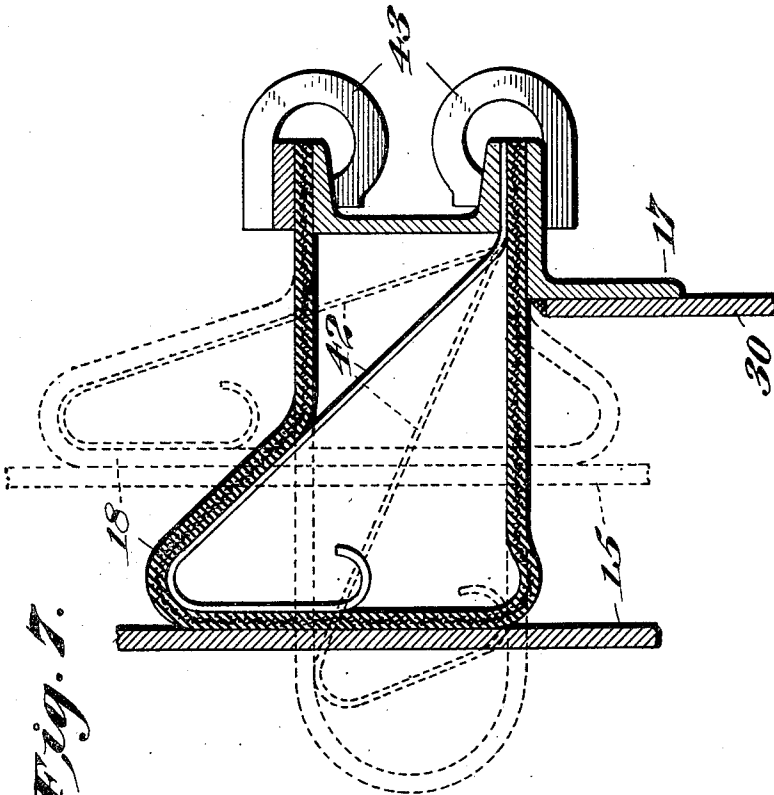


Fig. 7.



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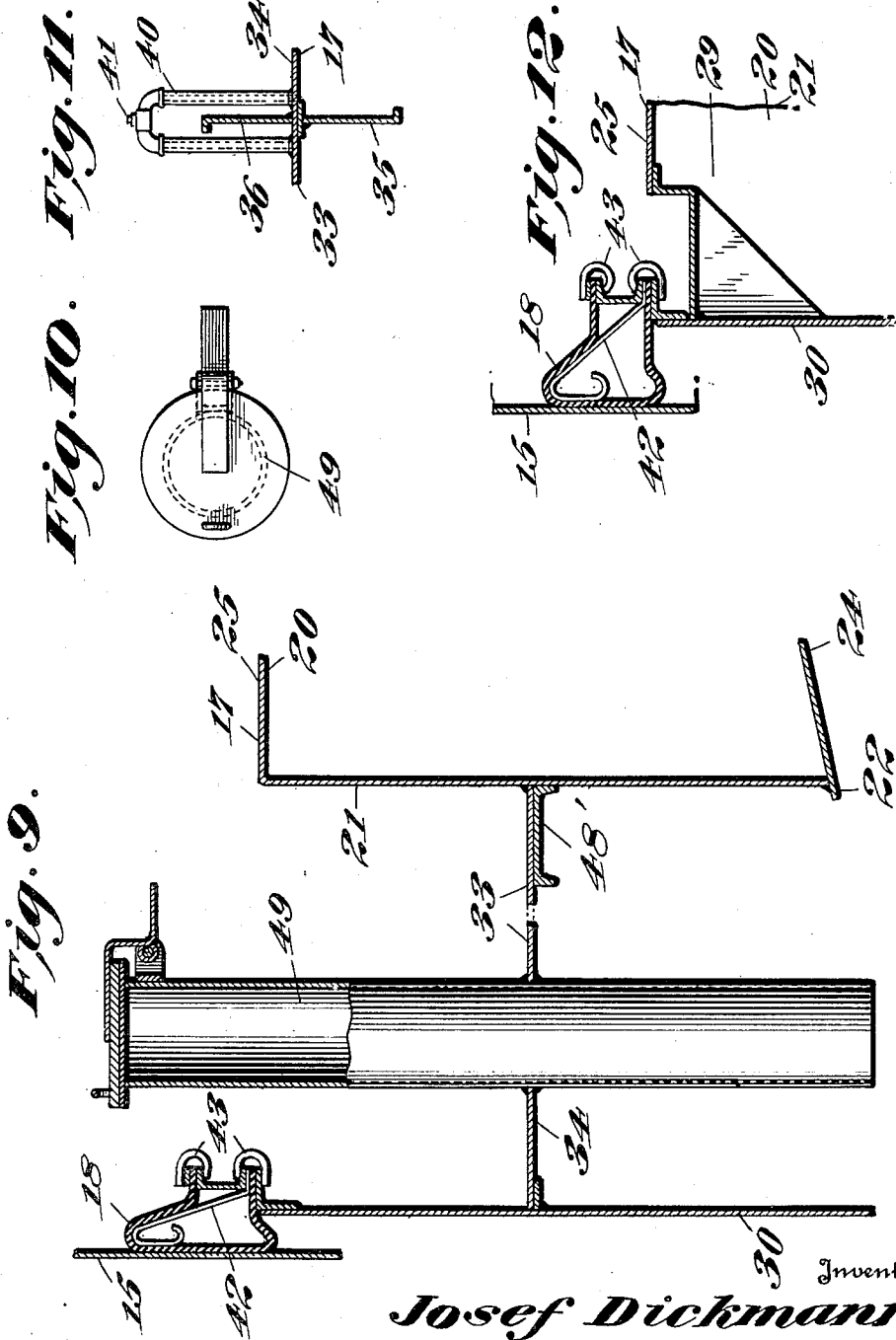
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8 Sheets-Sheet 6



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LIQUID STORAGE TANK

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Fig. 13.

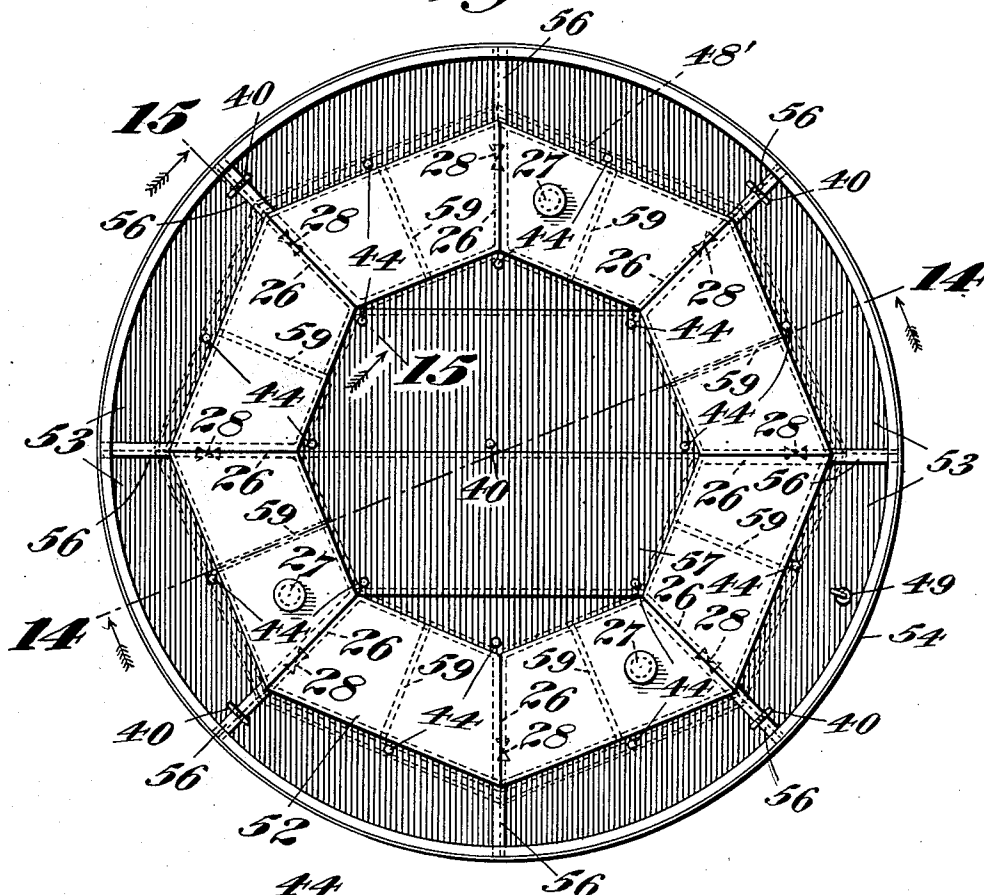


Fig. 14.

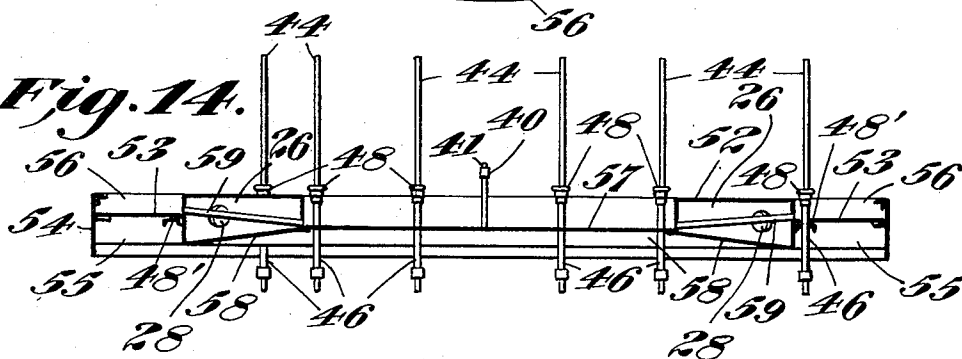
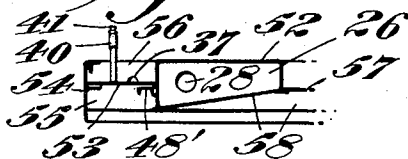


Fig. 15.



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Fig. 16.

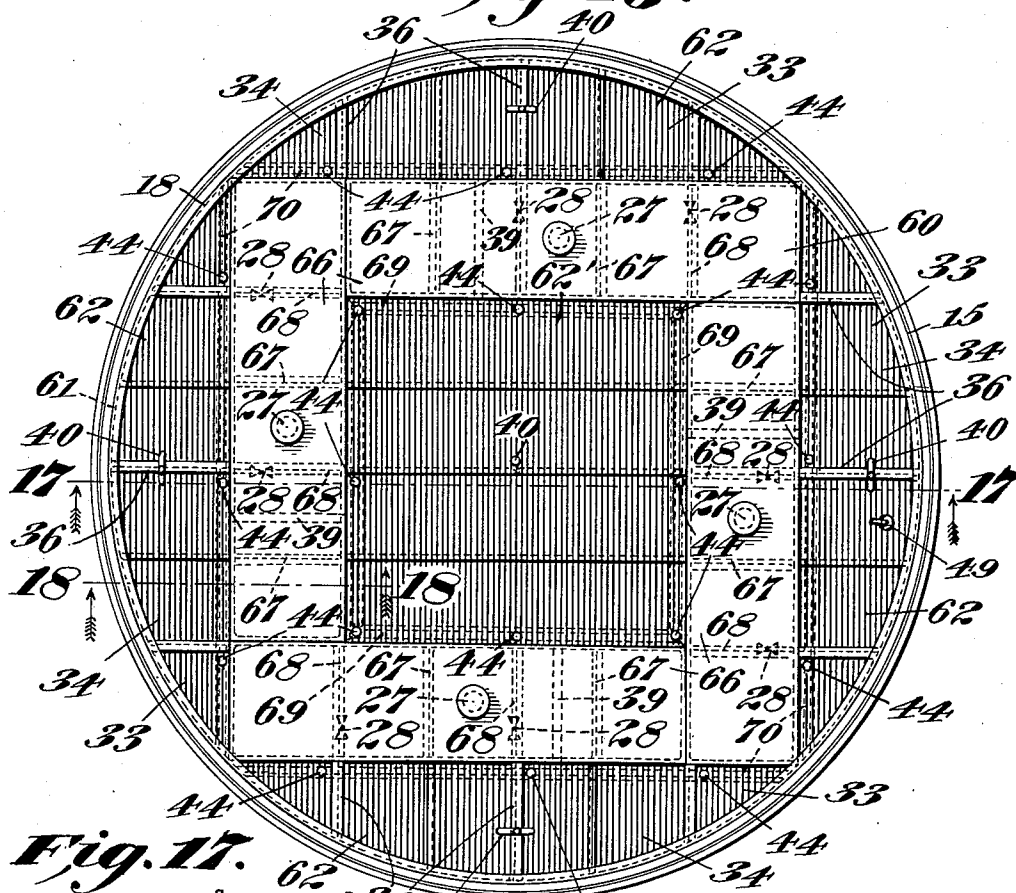
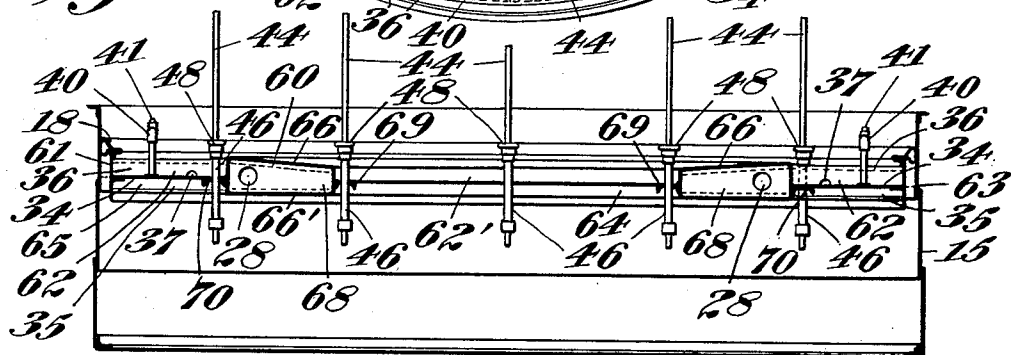
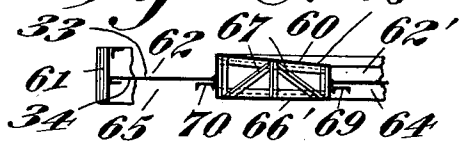


Fig. 17.



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UNITED STATES PATENT OFFICE

2,089,645

LIQUID STORAGE TANK

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Application December 13, 1934, Serial No. 757,256

19 Claims. (Cl. 220—26)

This invention relates to floating roofs for liquid storage tanks.

Among the features of the present invention may be mentioned the following:

5 The roof has a flat deck bounded by a marginal rim forming an upstanding portion projecting above the deck and a downwardly extending portion forming a skirt below the deck. A pontoon of open frame-like formation is embodied in the
10 deck to provide buoyancy for the roof, the cross section of which is substantially rectangular.

The formation of the pontoon provides water compartments between the outside edge of the pontoon and the marginal rim above the deck
15 plating, and gas-tight compartments below the deck. The central portion of the pontoon constitutes a water-tight compartment above the deck and also a gas-tight compartment under the deck.

20 In the preferred form the pontoon is formed of separate shop-welded sections, also the portions outside of the pontoon will be shop assembled. In the open field the pontoon sections may be welded together to form an open frame. Then
25 the outside sections may be welded to the pontoon frame, and the center deck plates welded to the inside bottom edges of the pontoon so as to form an inverted pan having sloping edges.

Each pontoon section is provided with covered manholes for access to the interior thereof.

30 Vents are provided at various points for the escape of gases from the underside of the deck.

Reversible legs are provided for supporting the deck at different elevations when the tank is
35 empty and for cleaning purposes.

Drainage pipes connect the outside water compartments with the center water compartment. Due to the lower elevation of the center compartment, all precipitation collected by the outside
40 compartments will be drained toward the center until the water reaches the elevation of the outside compartments. A flexible drain may be attached to the central compartment for drawing off the water, or a siphon may be used instead.

45 For sealing the annular space between the inside of the tank and the edge of the deck I prefer to use a flexible seal which will resist to a high degree the effects of oil and gasoline vapors. This seal can be readily replaced while the tank is
50 in service, and its cost is comparatively low. This seal will not require vents, as it will open up and relieve any high pressures which may develop within the sealing space. This type of seal requires a smaller opening between roof and tank
55 than required by most other types.

A rolling ladder of standard construction is used for access to the roof. For the purpose of balance, I propose to mount the ladder on top of the northern pontoon section. The weight of the
5 ladder will then tend to counterbalance the tendency of the roof to rise at this side due to gas expansion under the section of the pontoon which receives more sun heat than the southern portion which is protected by the tank shell.

In this design, effort has been made to trap all
10 gases beneath the central inverted disc-like portion and to prevent escape of gases to the annular gas space between the roof and the tank.

The preferred structure has been designed as a water-cooled roof with provision for holding a
15 greater depth of water in the center compartment than in the outside compartments. The layer of water will serve as a cooling agent. The decreased temperature and the increased pressure upon the liquid will check vaporization and
20 aid in the re-condensing process due to temperature changes.

This roof will not sink even when filled with water to the elevation of the seal. There is sufficient free board and the water will run over the
25 rim into the tank. Normal evaporation should be sufficient to remove excess precipitation.

A sudden shifting of the water load to one side which has caused sinking of other water cooled
30 roofs, will not affect this roof. The peripheral water loads on the upper side of the deck and the vacuum effect on the under side of the deck together with the stabilizing effect of the pontoon has the tendency to quickly restore the equilibrium of the roof.

35 Due to the novel shape of the pontoon and the separation of the water load there is a better distribution of the mechanical forces acting on this roof than apply to the annular pontoon type roof having a centralized water load only, whereby a
40 more rigid and stable structure is obtained when floated.

When the tank is being filled with liquid for the first time, the rising liquid level will force all
45 the air from the gas compartments through the air outlets. The outlets will then be tightly closed so as to prevent further escape of gas or intake of air.

50 Considering the fact that the airless gas compartments do not permit any contact between gases and air and also due to the fact that the deck is water-cooled, it is believed that the gas space volume will be more than sufficient to provide for all gases which may be generated during
55 the heat of day.

Escape of gases from the under side of the deck will require tilting the roof to a practically impossible angle. This is due to the relatively narrow, but deep outside compartments and the downwardly extending portion of the rim.

The outside airless gas compartments also provide greater stability in case of a concentrated load acting at the periphery of the deck. This loading is possible during the winter when a heavy snow drift may concentrate the snow load at one side of the drained roof. Under these conditions the ordinary floating roof would be submerged into the liquid at the loaded side and raised above the liquid level at the opposite side. Any attempt to lift the airless gas compartments above the liquid level creates a vacuum within these compartments. The vacuum counteracts the concentrated load which is acting at the opposite side. This results in greater stability of the structure.

The bottom of the center water compartment will deflect under the water load, but if the roof has been drained, the bottom will deflect upwardly due to reaction of the buoyant forces.

The novel features will be more fully understood from the following description and claims taken with the drawings.

Figure 1 is a plan view of the floating roof within the tank; Fig. 2 is a vertical sectional view of the tank and roof when floated at its highest elevation taken on line 2—2 of Fig. 1, and the roof in dotted lines at its lowest position; Fig. 3 is a section of the roof taken on line 3—3 of Fig. 1; Fig. 4 is an enlarged plan view of a corner portion of the deck; Fig. 5 is a vertical sectional view taken on line 5—5 of Fig. 4; Fig. 6 is an enlarged section through the pontoon taken on line 6—6 of Fig. 4; Fig. 7 is an enlarged sectional view of the seal taken on line 7—7 of Fig. 4; Fig. 8 is a vertical sectional view showing the construction of a supporting leg; Fig. 9 shows an enlarged detail of the gauge and thief hatch, together with details of the deck; Fig. 10 is a plan view of the cover shown in Fig. 9; Fig. 11 shows an air outlet for venting air or gas; and, Fig. 12 shows a corner section of a pontoon taken on line 12—12 of Fig. 4.

Fig. 13 shows a modified plan view of Fig. 1.

Fig. 14 is a sectional view taken on line 14—14 of Fig. 13.

Fig. 15 shows a section taken on lines 15—15 of Fig. 13.

Fig. 16 shows a further modified plan view of Fig. 1.

Fig. 17 is a sectional view taken on lines 17—17 of Fig. 16.

Fig. 18 is a sectional view taken on lines 18—18 of Fig. 16.

As shown in the drawings, 15 indicates a cylindrical tank in which is stored oil or other liquid 16. The roof as a whole is represented by the numeral 17, and the sealing means by 18. 19 denotes the rolling stairway.

The pontoon 20 is preferably made of four similar elongated hollow sections 21 in overlapping relation one to the other. The cross-section of the pontoon is substantially rectangular but somewhat deeper at the outer edge 22 than at the inner edge 23. The bottom surface 24 of the pontoon is in sloping relation to the top surface 25. Suitable bulk-heads 26 reinforce the pontoon sections. Each section is provided with covered manholes 27 in the top plating, and open manholes 28 in the bulkheads for access to all parts of the pontoon.

Each pontoon section as fabricated in the shop may have an open end 29 which will be closed by a portion of the rim 30 when the sections are erected in the field, the opposite end being closed by the overlapping adjacent section.

It will be noted that the diagonal distance across the corners of the completed square of the pontoon is greater than the diameter of the rim as illustrated in Fig. 1.

A pontoon shaped after this manner has several advantages over an annular pontoon. In the first place, the pontoon as a whole is square which allows all straight cut plates to be used in its construction. In the second place there is a minimum of waste in cutting straight edged plates as compared to plates having curved edges; and again, a roof of this type having outside water and gas compartments formed by a square pontoon will have greater buoyancy than an annular pontoon of equal section because the square covers a greater area than would a circle of equal breadth. The square pontoon also provides for maximum buoyancy at the four corners which are contiguous to the rim but still allows for deep segmental gas and water pockets outside of the pontoon and inside of the rim.

The center opening 31 between the pontoon sections is closed by rectangular deck plates 32 welded to the lower surfaces of the pontoon, thus forming the center water compartment.

The segmental section 33, including the rim and deck portions, may be shop fabricated and field welded to the pontoon sections to complete the roof. Each of the segmental sections comprises a deck plate 34 welded to the outside of the pontoon and to a section of the rim 30. Each rim plate is supported by a channel like section 35 which is a welded continuation of the pontoon bulkhead 26. Another plate 36 separates the outside water space into two compartments which may be connected by drain holes 37.

The deck plates 34 are secured to the pontoon side walls 22 at a predetermined elevation so as to be at or about the same elevation as the displacement line 38 of the liquid when the roof is floated, due to the dead weight of the roof. In this position the outside deck plating 34 will be higher than the center deck plating 32 by several inches.

Drainage pipes 39 connect each outside water space with the central water compartment. Due to the lower elevation of the central compartment, all precipitation collected by the outside compartments will be drained into the central compartment until the water reaches the elevation of the outside compartments.

Each compartment under the deck plating has an air outlet 40 consisting of a pipe welded to the plating and extending above the maximum water level. A cap or plug 41 is provided to close the vent after floating the roof.

The seal 18, which is the connecting part between the floating roof and the tank provides flexible contact against the tank shell and is adapted to ride over rivet heads and overlapping plates or butt straps. The material forming the seal is preferably rubber reinforced with wire mesh.

Leaf springs 42 support the seal and prevent it from collapsing. The ends of the seal are clamped to the rim of the deck by means of clamps 43 as clearly shown in Fig. 7, each end of the seal being secured by separate clamps.

Each supporting leg 44 is made of pipe having a collar 45 welded thereto so as to form short

and long leg portions. The leg is rigidly connected to the deck by means of the braced pipe 46 having a threaded end portion 47 and the cap 48 which securely clamps the collar 45 of the leg to the braced pipe. The top of the pipe 46 extends above the maximum water line. By reversing the leg from the short position as shown in Fig. 2, a leg of greater length is obtained for supporting the roof at a higher elevation. These legs are placed at selected points in the roof structure so as to cooperate with the main frame members 48 where possible.

The gauge and theft-hatch 49 as shown in Figs. 9 and 10 is of standard construction and needs no further description.

Four guides 50, and adjustably mounted rollers 51 are provided to prevent turning of the roof and to centralize it.

It will be obvious to those skilled in the art that a floating deck constructed with a square pontoon of reinforced box section, provides a very stiff and rigid member for securing thereto the deck plating and for tying up with the rim member. When all of these units have been assembled and welded together as an integral piece, a very serviceable and efficient roof is obtained.

Although I prefer to construct a roof with a square pontoon, it is, nevertheless, within the scope of my invention to build a roof after the manner shown in Figs. 13 and 14, wherein the pontoon is of polygonal shape. Again, I may choose to make the pontoon annular without materially altering the general cross section of the deck or departing from the basic principle of the distributed water loading and the outside gas compartments.

In Figs. 13 and 14, 52 represents the polygonal pontoon as a whole. The pontoon may be constructed of a plurality of straight sided units welded together and properly braced to form a stiff ring to which the outside deck plating 53 is secured. The rim 54 being welded to the deck 53 and provided with supports 55 under the deck which form individual gas-tight compartments. The upper side of the outside deck is divided into water compartments by plates 56. The inside deck 57 is made up of straight sheared plates welded to the bottom members 58 of the pontoon. Drain pipes 59 provide communication between the outside and inside water compartments on the upper side of the deck.

The remaining details and other general features of Figs. 13, 14 and 15 may be similar to those heretofore described with reference to Figs. 1, 2 and 3.

In Figs. 16, 17 and 18 is illustrated a roof generally similar to Figs. 1, 2 and 3, with the exception that the corners of the pontoon 60 are not cut off as shown in Fig. 1. In this case diagonal lines extending through the corners of the pontoon are coincident with the rim 61 so as to form a square bounded by a circle.

With this arrangement it will be obvious that the outside segmental water compartments 62 are larger in proportion than those shown in Fig. 1, and that the central water compartment 62' is relatively smaller, provided the section of the pontoons are equal. Also, in this last modification I have shown the deck plating all on the line of the displaced liquid level 63, with the pontoon embodied in the deck so as to form a gas pocket 64 inside the pontoon section and also gas pockets 65 outside of the pontoon and inside the rim 61. The top 66 of the pontoon in this instance is shown sloping downwardly and in-

wardly while the bottom 66' is horizontal and extending below the deck plating 62.

With reference to Fig. 18 I show internal bracing 67 intermediate the bulkheads 68, and framing members 69 and 70 inside and outside of the pontoon.

The drains, air vents, supporting legs, seal and other details may be similar to those shown in connection with Figs. 1, 2 and 3, and the same reference numerals will apply thereto.

Various modifications obviously may be made in the details of the foregoing structures without departing from the spirit of the invention as embodied in the appended claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. A floating roof for tanks comprising a central deck portion supported by a surrounding pontoon projecting substantially above said deck at its point of attachment, an outside deck portion attached to the outside of the pontoon, and an upstanding rim attached to said outside deck intermediate the edges of the rim.

2. A floating roof for tanks comprising a central deck portion supported by a surrounding pontoon at its inside lower corner, an outside deck portion attached to the outside of the pontoon at a higher level than the central deck portion, and an upstanding rim attached to said outside deck intermediate the edges of the rim.

3. A floating roof for tanks comprising a pontoon of box-like section forming an enclosure and having an outer lower edge projecting below the level of its inner lower edge, deck plating attached to the inner lower edge of the pontoon, deck plating attached to the outside of the pontoon intermediate its edges, and a rim attached to the outside plating projecting above and below said outside plating.

4. A floating roof for tanks comprising a pontoon of box-like section forming an enclosure and having an outer lower edge projecting below the level of its inner lower edge, deck plating attached to the inner lower edge of the pontoon forming a bottom for said enclosure, deck plating attached to the outside of the pontoon at higher level than said inside bottom, and an upstanding rim attached to the outside plating projecting at least to the top level of the pontoon and projecting below the bottom level of the pontoon.

5. A floating roof for liquid storage tanks comprising a frame-like pontoon forming a large central opening, said pontoon being of closed box section having a bottom portion sloping upwardly and inwardly toward the center of the pontoon, inside deck plating attached to the pontoon adjacent the edges of said sloping bottom for closing the opening at the bottom of the frame, deck plating attached to the outside of the pontoon frame at a higher level than the inside deck and secured to an annular rim projecting substantially to the top level of the pontoon and at least to its bottom level, whereby to form a gas-tight collecting space under the whole expanse of the roof and water collecting compartments inside and outside of the pontoon frame above said decks, conduits passing through the pontoon for connecting the water compartments, and means for venting air and gas from the under side of the roof when the roof is floated.

6. A floating roof for liquid storage tanks comprising a frame-like pontoon of box section forming an enclosure, said pontoon having an outer lower edge projecting below the level of its inner

lower edge, deck plating attached to the outside vertical face of the pontoon substantially at the displaced liquid level when the roof is floated, deck plating attached to the pontoon inside of said enclosure and providing a closed bottom therefor at a level lower than the outside deck, an annular rim attached to said outside deck projecting substantially to the top and bottom levels of the pontoon, and vent pipes communicating with the under side of the roof.

7. A floating roof for liquid storage tanks comprising a frame-like pontoon of closed box-section forming an enclosure, said pontoon having an outer lower edge projecting below the level of its inner lower edge, deck plating attached to the outside vertical face of the pontoon substantially at the displaced liquid level when the roof is floated, deck plating attached to the pontoon inside of said enclosure and providing a bottom therefor at a level below that of the outside deck, and an annular rim attached to said outside deck projecting substantially to the top of the pontoon and below the lower level thereof, whereby to form an inverted air-tight compartment under the pontoon and an air-tight pocket between the outside of the pontoon and the inside of said rim, also water collecting compartments inside and outside of the pontoon above the decks, means for venting air and gas from the under side of the decks, and conduits for connecting the inside and outside water compartments.

8. A floating roof for liquid storage tanks comprising a deck having an upstanding rim and a downwardly extending marginal skirt, and a pontoon of hollow-polygonal formation embodied in said deck with vertical partitioning members extending outwardly from the pontoon to said rim and skirt so as to form with the rim water compartments on the upper face of the deck, and with the skirt gas-tight compartments under the deck; the central enclosure formed by the pontoon constituting a water-tight compartment on the upper face of the deck and also a gas-tight compartment under the deck.

9. A floating roof according to claim 8, with conduits extending through the pontoon so as to connect the water compartments outside of the pontoon with the central water compartment, and means for venting air and gas from the under side of the deck when the roof is floated.

10. A floating roof for liquid storage tanks comprising a deck, having an upstanding rim and a downwardly extending marginal skirt, and a pontoon of hollow-square formation embodied in said deck so as to form with the upstanding rim segmental water compartments on the upper face of the deck, and with the skirt gas-tight segmental compartments on the lower face of the deck; the inner square of the pontoon constituting a water-tight compartment on the upper face of the deck and also a gas-tight compartment on the lower face of the deck.

11. A floating roof for liquid storage tanks comprising a flat deck having an upstanding circular rim and a downwardly extending circular skirt, and a pontoon of hollow-square formation embodied in said deck so that diagonal lines joining the outside corners of the pontoon are coincident with the diametrical lines of said rim and skirt, thereby forming with the rim segmental compartments on the upper face of the deck to retain water, and with the skirt gas-tight segmental compartments under the deck; the inner square of the pontoon constituting a water-tight compartment on the upper face of the deck and

also a gas-tight compartment under the deck.

12. A floating roof according to claim 11, with conduits extending through the pontoon so as to connect the segmental water compartments with the inner water compartment, and means for venting air and gas from the under side of the deck when the roof is floated.

13. A floating roof for tanks comprising a deck having a circular rim, and a pontoon of hollow square formation embodied in said deck; the distance across diagonal corners of said pontoon being substantially coincident to the inside diameter of said rim.

14. A floating roof for tanks comprising a deck having a circular rim, and a pontoon of hollow square formation embodied in said deck; the diagonal distance across the intersecting outside lines of the pontoon being greater than the diameter of said rim.

15. A floating roof for tanks comprising a deck having an upstanding rim and a downwardly extending marginal skirt, and a pontoon embodied in said deck; said pontoon being constructed of individual hollow sections welded together so as to form a square enclosure, said sections having straight inside and outside faces with said rim in spaced relation to said outside faces.

16. A floating roof for tanks comprising a deck having a vertical rim and a pontoon of hollow formation embodied in said deck; said pontoon being constructed of four similar sections and welded together in overlapping relation in the form of an open square, said sections having straight inside and outside faces with said rim in spaced relation to said outside faces.

17. A floating roof for tanks comprising a hollow pontoon constructed of four similar sections welded together in the form of a square enclosure, a vertical rim surrounding said pontoon and secured thereto, deck plating inside of said enclosure and welded to said sections, deck plating outside of said pontoon and welded to the pontoon and to said rim so as to form square and segmental water compartments above said plating and similarly shaped gas-tight compartments under said plating.

18. A floating roof for tanks comprising a flat deck having a pontoon embodied therein, a marginal rim surrounding said deck, the top edge of said rim being substantially in the same plane as the top of said pontoon and the bottom edge of the rim extending at least to the bottom of the pontoon, said pontoon being constructed of four straight tubular sections secured together so as to form a square, each pontoon section having a square end and a mitered end, the square end of each section being in abutting relation with an end portion of an adjacent section whereby to close said square end, and the mitered end of each section being closed by a portion of said rim; the remaining portions of the rim being in spaced relation to the pontoon sections so as to form segmental sections outside thereof.

19. A floating roof for liquid storage tanks comprising a central deck portion supported by a surrounding closed pontoon, a depending skirt in spaced relation to the lower portion of said pontoon for effecting a downwardly opening gas collecting chamber, means for closing the upper end of said chamber, the sides of said chamber being formed by depending portions of said pontoon and said skirt, and means for voiding said chamber of all gases when the deck is floated.

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