

June 8, 1943.

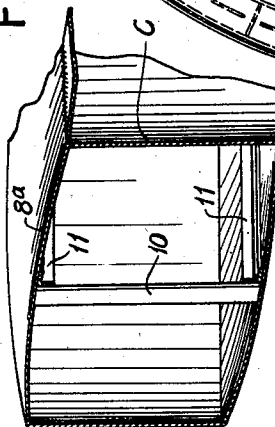
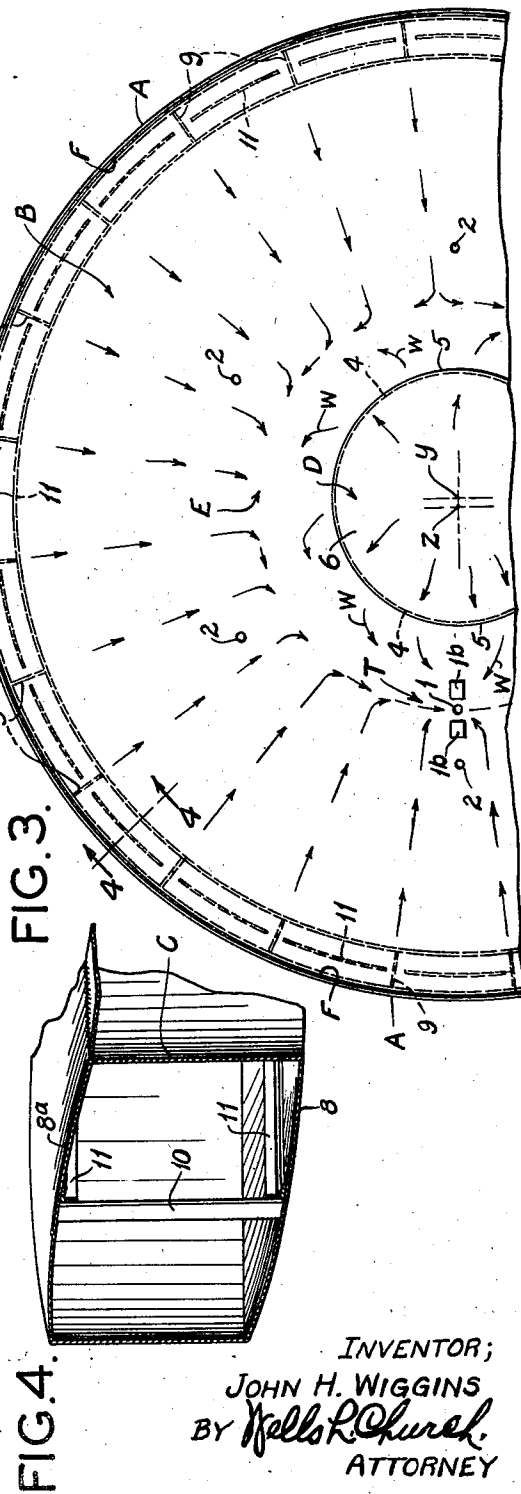
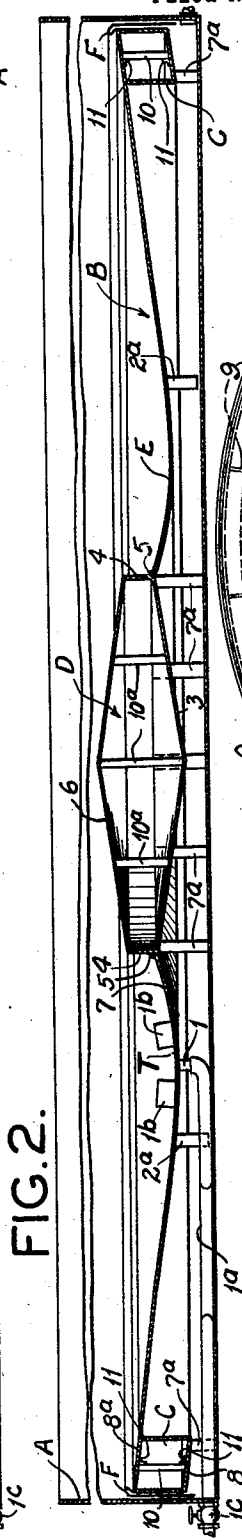
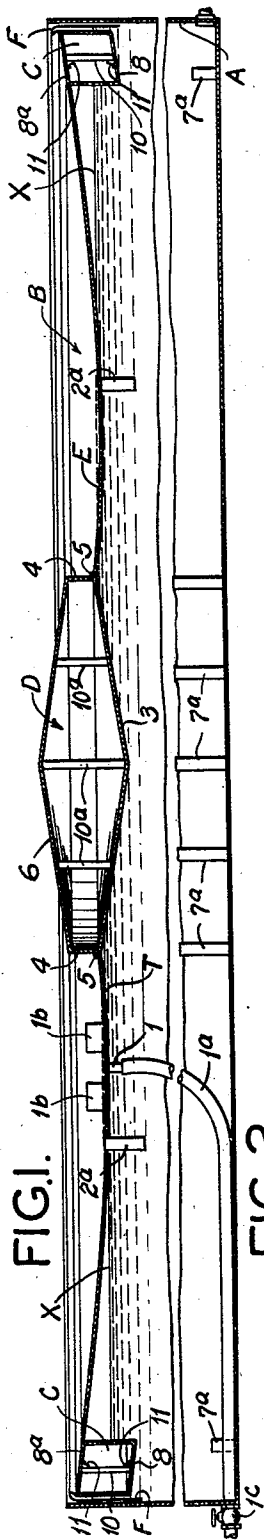
J. H. WIGGINS

2,321,058

FLOATING ROOF FOR LIQUID STORAGE TANKS

Filed Nov. 1, 1940

2 Sheets-Sheet 1



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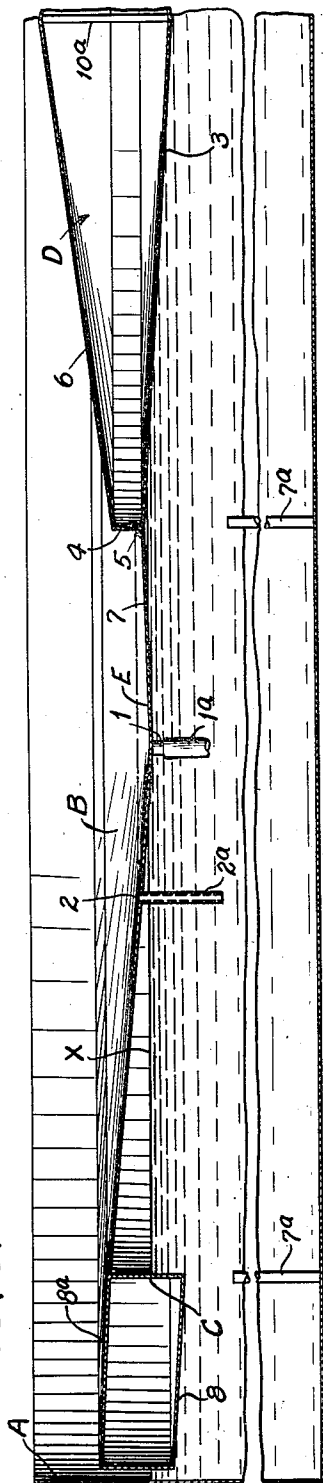
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2 Sheets-Sheet 2

FIG. 5.



UNITED STATES PATENT OFFICE

2,321,058

FLOATING ROOF FOR LIQUID STORAGE TANKS

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Application November 1, 1940, Serial No. 363,837

6 Claims. (Cl. 220—26)

This invention relates to floating roofs for large tanks, in which liquids are stored, and particularly floating roofs of the pontoon type, such as are now used extensively in the oil industry for storing oil.

The main object of my invention is to provide a pontoon type floating roof whose co-operating parts are constructed and combined in a novel manner that produces or attains the following results:

(1) Reduces the cost, simplifies the fabrication and erection, and reduces the weight of the roof;

(2) Increases the buoyancy of the roof without adding to the cost of same;

(3) Makes it impossible for a dangerous water load to collect on the roof either when the roof is floating, or when it is resting on or is supported by the bottom of the tank; and

(4) Reduces the area of the underside of the deck of the roof that is liable to corrode.

Another object of my invention is to provide a pontoon type floating roof that is equipped with a limber or flexible deck, which is of such construction and arrangement that, notwithstanding the fact that it is capable of sagging under an emergency load created by rain water that collects on the top side of the deck, the sagging of the deck can be accurately controlled and the amount of rain water capable of collecting on the roof can be held within sufficiently safe limits to eliminate the possibility of the roof being sunk or thrown out of balance by the collection of an abnormal load of rain water thereon.

Another object of my invention is to provide a floating roof for liquid storage tanks, that is equipped with a means which automatically increases the efficiency of a drainage surface or surfaces on the top side of the roof when the tank is emptied, or when the level of the liquid in the tank drops to such a point that the roof is sustained by the bottom of the tank.

And still another object of my invention is to provide a floating roof of the pontoon type, that is equipped with a peripheral pontoon of novel construction, which insures that the buoyant loads balance the dead loads. Other objects and desirable features of my invention will be hereinafter pointed out.

Briefly described, the preferred form of my improved floating roof comprises or is composed of three main elements, to wit, a peripheral closed pontoon of stiff construction and relatively great

diameter; a peripheral pontoon of stiff construction; and a limber or flexible deck combined with said peripheral and center pontoons in such a way that when the roof is floating on the liquid in the tank, the only area, portion or space on the top side of the roof where rain water can collect is a valley, depression, or collection trough located adjacent the center pontoon.

The particular shape or form of said valley, depression, or collection trough is immaterial, but I prefer to combine the deck with the peripheral pontoon and with the center pontoon in such a manner that when the roof is floating, a portion of the deck lying between said pontoons will sag to a point below the surface of the liquid on which the roof floats, thereby producing an annular valley on the top side of the deck having a bottom or low point disposed below the level of the buoyant liquid and provided with oppositely-inclined surfaces or sides, one of which slopes downwardly and outwardly away from the center pontoon, and the other sloping downwardly and inwardly away from the peripheral pontoon. Generally, the coacting parts of the roof will be so designed and combined that the peripheral portion of the deck adjacent the annular pontoon will be supported above the surface of the buoyant liquid on which the roof floats, and the deck caused to assume a downwardly pitched or sloping position towards the center of the roof, with a considerable radius of said deck submerged in the buoyant liquid. The center pontoon is preferably of such construction and arrangement with relation to the deck that the point at which the deck is attached to or merges into the center pontoon is located in closer proximity to the surface of the buoyant liquid than the point at which the peripheral portion of the deck merges into or is attached to the annular pontoon. It is essential, however, that the deck and center pontoon be combined in such a manner that the portion of the deck that immediately surrounds said pontoon, or which is located in close proximity to the center pontoon, will be self-draining, or provided with an angularly-disposed drainage surface that either forms one wall or surface of the water collection trough or valley, or which discharges into said valley. In the form of my invention herein illustrated the center pontoon is built on the top side of the central portion of the deck and the portion of the deck that constitutes the bottom of said center pontoon is pitched downwardly towards the center of the roof, or is

made of substantially inverted cone shape, so as to increase the lift exerted by the center pontoon on the deck, and in this way increase the buoyancy of the roof or obtain a safe factor of excess buoyancy, without adding to the cost of the roof, or increasing the weight of same. The annular pontoon or peripheral pontoon is also preferably constructed in such a way that its degree of buoyancy is increased without adding to the cost or weight of the roof, for the purpose of causing the buoyant loads to balance the dead loads, as hereinafter explained.

Figure 1 of the drawings is a vertical transverse sectional view of a floating roof embodying my invention, said figure not being drawn to scale, and the angles of the sloping or inclined portions of the structure being exaggerated so as to more clearly illustrate the principle of operation of my invention.

Figure 2 is a view similar to Figure 1, showing the roof resting upon or supported by the bottom of the tank.

Figure 3 is a fragmentary top plan view of the roof.

Figure 4 is an enlarged cross-sectional view of the annular pontoon or peripheral pontoon, taken on the line 4-4 of Figure 3.

Figure 5 is a fragmentary vertical transverse sectional view of a commercial floating roof embodying my invention, but with the side wall seal omitted, showing the roof floating on the liquid in the tank.

Figure 6 is a view similar to Figure 5, showing the roof resting upon or supported by the bottom of the tank and illustrating how the angle of the drainage surface on the top side of the roof is increased automatically when the weight of the roof is transferred from the buoyant liquid to the bottom of the tank; and

Figure 7 is a vertical transverse sectional view, which illustrates diagrammatically a feature of my invention.

Referring to Figures 1, 2, 3 and 4 of the drawings which are intended to illustrate the principle of operation of the preferred form of my invention, rather than the exact shapes and relative sizes of the co-acting parts of the structure, A designates a large oil storage tank, for example, a metal tank, having a diameter in excess of 100 ft., and provided with a relatively high or deep side wall, which is broken away in Figures 1 and 2, so as to save space, and B designates as an entirety a floating roof that is normally sustained by the liquid *x* in the tank, as shown in Figure 1. When the tank is empty, or when there is not sufficient liquid in the tank to float the roof B, said roof is supported by the bottom of the tank, either by supports that project upwardly from the bottom of the tank, as shown in Figure 2, or by depending legs on the underside of the roof. The roof B is constructed principally from metal plates, and comprises or is composed of a closed annular pontoon C of stiff construction arranged at the periphery of the roof, a center closed cylindrical pontoon D of stiff construction, and a flexible or limber deck E made up of metal plates joined together by riveted or welded joints and attached to or combined with the peripheral pontoon C and the center pontoon D in such a way that when the roof is floating, the deck E will slope downwardly and outwardly away from the center pontoon D, and will slope downwardly and inwardly away from the peripheral pontoon C, and thus form a valley, depression or collection trough on the top side

of the deck that is adapted to receive rain water. In order that said valley, depression or collection trough will be the only space or portion on the top side of the deck in which rain water can collect, the top portions or surfaces of the annular pontoon C and the center pontoon D are constructed so that they will shed rain water or will be self-draining. Obviously, the peripheral pontoon may consist of one large annular pontoon or a plurality of small, segmental-shaped pontoons, and the center pontoon may be formed either by a single large pontoon, or a plurality of small pontoons or pontoon sections. In the preferred form of my invention herein illustrated the periphery of the deck E is attached to the annular pontoon C at such a point that it virtually forms a continuation of the top side of said annular pontoon and slopes downwardly and inwardly from same at a sufficiently sharp pitch to cause a considerable area of the deck to be submerged in the buoyant liquid on which the roof floats.

The center pontoon D, which is of relatively great diameter, as compared to the diameter of the roof, is arranged on the top side of the deck, and is combined with or attached to the deck in such a way that the portion of the deck which immediately surrounds the center pontoon D, slopes downwardly and outwardly from the same, preferably at an angle of less pitch than the peripheral portion of the deck which is attached to the annular pontoon C. By constructing the co-acting parts of the roof in the manner above described, I obtain a valley, depression or water collection trough on the top side of the roof whose bottom or low point is below the surface of the buoyant liquid *x* in the tank, as clearly shown in Figure 1 of the drawings. Any suitable means may be used to discharge rain water from said valley or collection trough, but I prefer to equip the roof with a primary drainage means through which the rain water will be discharged to a point preferably on the exterior of the tank A, and an auxiliary drainage means that comes into service when the rain water in said valley or collection trough reaches a certain approximate level, the said auxiliary drainage means being preferably constructed in such a way that the excess rain water not capable of being handled by the primary drainage means, is discharged downwardly into the liquid *x* in the tank A on which the roof floats. Thus, as shown in Figures 1, 2 and 3 of the drawings, the valley or collection trough on the top side of the roof is provided at the lowest point of its bottom surface with one or more primary drain openings or outlets *f* through which rain water is discharged through an eduction pipe or pipes *g* that lead to points on the exterior of the tank, the deck and pontoons of the roof being so constructed and combined that when the roof is floating on the buoyant liquid *x*, said primary drain openings are located in a lower plane than the surface of the buoyant liquid. In order that a single primary drain pipe *g* will suffice to carry off the rain water that collects in the valley or submerged portion of the deck whose top side is disposed below the surface of the liquid on which the roof floats, the roof is built in such a manner that the rain water which drains into said valley will flow to a single discharge opening *h* that constitutes the lowest point of the bottom of said valley or depression. This result can be obtained in various ways, and in the form of my invention herein illustrated, the center pontoon D is arranged slightly off center with rela-

tion to the center of the roof so that the buoyant forces exerted by the center pontoon on the deck E will cause the portion of the deck that constitutes said valley or water collection trough to be maintained in a slightly higher position at one side of the valley than at the point in the valley in which the primary drain outlet 1 is located. For example, if the center of the pontoon D, designated by the reference character y in Figure 3, is located slightly to the right of the center of the roof, designated by the reference character z in Figure 3, the water which finds its way into the valley or collection trough that surrounds the center pontoon D will have a natural tendency to flow from the right hand portion of said valley, looking at Figure 3, to the left hand portion of said valley in which the primary drain opening 1 is formed, as indicated by the arrows w in Figure 3. If desired, weights 1^b can be arranged on the top side of the deck in close proximity to the primary drain opening 1, so as to impose a load on the portion of the deck in which the primary drain outlet is formed, and thus accentuate the flow of the rain water to the primary drain opening, or in other words, increase the pitch or angle of the bottom of the water collection valley or trough towards the primary drain outlet. The auxiliary drainage means is preferably formed by a plurality of auxiliary drain openings or outlets 2 formed in the deck at or adjacent the outer rim or edge of the valley or water collection trough on the deck, each of said auxiliary drain openings 2 communicating with a vertically-disposed, open drain pipe 2^a that projects downwardly from the deck into the buoyant liquid x . Said auxiliary drain openings 2 are located at such points in the deck that under all possible water loads said auxiliary drain openings are located well above the surface of the buoyant liquid x . Under an abnormal load of rain water the portion of the deck that constitutes the outer side of the water collection valley or trough, i. e., the side located nearest the annular pontoon C, will assume a sharper pitch, thus causing the level of the water in said trough or valley to rise rapidly and bring into service the auxiliary drain pipes 2^a through which the excess load of rain water is discharged from the valley. Although the auxiliary drain pipes 2^a consist of open pipes, said pipes are effectively sealed, when the roof is floating, by the buoyant liquid x in which said auxiliary drain pipes 2^a are submerged. A drainage system of the construction above described makes it impossible for rain water to collect on the top side of the deck in a sufficient quantity to create a load that will sink the roof or throw it out of balance, due to the fact that the relatively large center pontoon D prevents rain water from collecting at the center of the deck and creating a load that would sag the center portion of the deck and cause said center portion to continue to sag as rain water continued to build up on same. In my improved roof the only space or portion on the top side of the deck where rain water can collect is an annular portion of relatively slight area as compared to the diameter of the roof, located intermediate the peripheral pontoon C and the center pontoon D, and provided with oppositely-pitched or inclined surfaces that lead to a portion of the deck that is submerged in the buoyant liquid on which the roof floats, and which has a primary drainage means whose outlet or outlets are located below the level of the liquid. Even if the valve 1^c in the primary drain should be

closed, only a relatively small quantity of water could collect on the roof at any one time, due, of course, to the fact that the roof is equipped with emergency drains or auxiliary drain pipes 2^a. The relatively sharp pitch or downward inclination of the portion of the deck that is held above the surface of the buoyant liquid by the annular pontoon C, insures efficient drainage for a large area of the top surface of the deck and causes the level of the water in the collection trough or valley, surrounding the center pontoon, to rise rapidly in the event of an abnormal downfall of rain, with the result that the emergency drains are brought into service before a very large load of rain water can collect on the roof, said auxiliary drains being placed at an elevation which insures rapid discharge of an abnormal rainfall. As previously stated, the auxiliary drain openings 2 are so placed that the surface of the buoyant liquid will normally be below said auxiliary drain openings, but said auxiliary drain openings are located at such a point with relation to the valley or trough that is intended to collect rain-water, that a minimum rain load can collect on the deck, without the possibility, however, of said load being increased to such an extent or degree as to sink the roof or throw it out of balance. Locating the auxiliary drains at a substantial height above the surface of the buoyant liquid, provides a large factor of safety.

In order to increase the buoyancy or lift of the center pontoon D, without adding to the weight or cost of same, the bottom 3 of said pontoon is given a downward pitch from its periphery towards its center, or, in other words, is made of substantially inverted cone shape, as shown in Figures 1 and 2. Preferably, said center pontoon is so proportioned that when the roof is floating on the liquid in the tank, the peripheral edge of said center pontoon will be disposed slightly above the surface of the buoyant liquid, thus insuring that the portion T of the deck which constitutes the inner side or drainage surface of the water collection trough (the side lying nearest to the center pontoon) will be maintained in a downwardly and outwardly sloped position, or, in other words, at an angle that insures the water in said trough draining to the primary drainage means 1 of the roof. So far as my broad idea is concerned, it is immaterial whether the center pontoon D is arranged under the deck or on the top side of the deck. I prefer, however, to erect said center pontoon on the top side of the deck and provide the deck at its center with a downwardly pitched part or a part of inverted cone shape, that constitutes the bottom of the center pontoon. This method of construction simplifies the operation of building the roof, it reduces the cost, and it eliminates a joint in the deck, which, in the event of failure, would permit some of the buoyant liquid to leak upwardly through the deck. Figures 1 and 2 illustrate the preferred method of constructing the center pontoon D, which consists in erecting the rim 4 of said pontoon on the top side of the deck and securing it to the deck plates by a welded joint 5. Failure of said joint 5 would have no effect on the buoyant liquid on which the roof floats, inasmuch as the bottom of the center pontoon D is formed by an integral portion of the deck. Preferably, the center pontoon is provided with a top 6 of such shape or form that rain water which falls onto same will be sure to drain off the center pontoon and enter the water col-

lection valley or trough that surrounds the center pontoon.

One feature of my improved roof that adds greatly to its commercial utility and overcomes the necessity of using adjustable supports for sustaining the roof when the tank A is empty, or when there is not sufficient liquid in the tank to float the roof, is that it is of such construction that when the roof moves downwardly into close proximity to the bottom of the tank, a roof supporting means comes automatically into service to change the position of the drainage surface T of the water collection trough or valley for the purpose of increasing the efficiency of the drainage system of the roof, and eliminating the possibility of a dangerous load of rain water collecting on the roof, even if the primary drainage means is not functioning properly, due to stoppage or to carelessness on the part of the attendant. In the form of my invention herein illustrated the roof supporting means just referred to is so designed that when the weight of the roof is transferred from the buoyant liquid to the bottom of the tank A, the pitch of the portion T of the water collection trough or valley on the top side of the roof that slopes downwardly from the center pontoon is increased automatically, so as to decrease the collectible water load when the roof is not floating on the buoyant liquid and insure rapid discharge of rain water through the emergency drains 2. This eliminates the possibility of a dangerous load of rain water collecting on the roof in the event the control valve 1^c of the primary drain has accidentally closed or through carelessness been left in a closed condition, and it overcomes the necessity of building the roof supporting means strong enough to successfully carry an excessive rain load. Thus, as shown in Figures 1 and 2 of the drawings, the structure is equipped with stationary supports 7 for the peripheral portion of the roof, and stationary supports 7^a for the central portion of the roof, said supports 7 and 7^a being so proportioned or designed that when the roof moves downwardly towards the bottom of the tank, the center supports 7^a come into service before the peripheral supports 7, thereby causing the drainage surface T of the roof to assume a sharper pitch or angle than said drainage surface assumes when the roof is floating on the buoyant liquid. If the center supports 7^a and peripheral supports 7 were made of such relative height that the drainage surface T assumed the same angle when the roof is supported by the bottom of the tank that it assumes when the roof is floating, there would be a danger of an abnormal load of water collecting on the roof when it is supported by the bottom of the tank, in the event the primary drainage means was inoperative, due to the relatively slight pitch or angle of the drainage surface T, but in my improved roof such a contingency cannot occur, due to the fact that the pitch or angle which the drainage surface T automatically assumes when the weight of the roof is transferred from the buoyant liquid to the bottom of the tank, is such as to make it certain that if a load of rain water collects on the roof when the roof is not floating, the level of said collected rain water will rise rapidly, thus bringing the emergency drains 2 into service and insuring the discharge of the excess load through the drain pipes 2a which are always open, or in readiness to permit water to escape from the top side of the roof. No adjustment or manipulation of the said stationary roof supporting

means is required, but instead, said roof supporting means is always in readiness to function in the manner above described when the roof moves downwardly to a certain point in the tank.

Similarly, when liquid is being pumped into the tank to raise the roof, no adjustment or manipulation of the stationary roof supporting means is required to insure proper functioning of same when the roof subsequently moves downwardly to a point in close proximity to the bottom of the tank.

The conventional floating tank roof is provided at its peripheral edge with a seal F that acts on the side wall of the tank so as to produce a tight, or substantially tight, joint between the roof and the tank side wall when the roof rises and falls. Said seal F is of substantial weight and it exerts considerable torsion on the annular pontoon C in a counter-clockwise direction. The weight of the deck and any load thereon exerts torsion on said annular pontoon C in a clockwise direction. In order that the dead loads will be balanced by the buoyant loads, I prefer to construct the annular pontoon C in such a way that when the roof is floating on the liquid x, the torsional effect on the annular pontoon in a counter-clockwise direction is increased, amplified, or made much greater than in floating roof annular pontoons of conventional construction. I attain this highly desirable result in a very simple manner, i. e., by providing the annular pontoon C with a bottom 8, that slopes downwardly and inwardly towards the center of the roof. The buoyancy thus creates a counter-clockwise moment or torsion while the weight of the deck creates a clockwise moment or torsion. In this connection, the maximum live loads applicable to the entire floating structure is a water load or snow load. These also create a clockwise torsion, which may be balanced, or partly balanced, by the eccentric buoyancy. Since the water or snow load causes the maximum torsion in the annular pontoon, this form of annular pontoon which partially balances the water or snow load, is highly desirable and greatly improves the operation of the roof.

The particular construction of the peripheral pontoon is not material, but I prefer to construct it so that its volume is increased without adding to the weight or cost of said pontoon. Briefly described, the peripheral pontoon C herein illustrated, consists of a hollow sheet metal member having walls that are stretched, expanded or dilated in a direction to increase the volume of said member, plus a means for holding said expanded walls under tension or in a stretched or dilated condition. In building the pontoon C, I prefer to incorporate in same a plurality of bulkhead plates or partitions 9 that extend transversely of the pontoon and divide the interior of same into a plurality of compartments, as shown in Figure 3. After the pontoon has been fabricated, the bottom and top walls 8 and 8^a of the various compartments are subjected to pressure that causes said walls to be cambered slightly or placed under tension, as shown in Figure 4. Thereafter, devices are installed inside of the pontoon so as to hold the cambered or expanded top and bottom portions of same in a stretched condition. Manholes are formed in the pontoons so as to make it possible for workmen to enter the various compartments of the pontoon, and after the top and bottom walls have been dilated or expanded outwardly, vertical struts or posts 10 are interposed between the

expanded top and bottom walls and attached to rafters or other suitable reinforcing devices 11 attached to the inner sides of the top and bottom walls of the various compartments and disposed longitudinally of same, as shown in broken lines in Figure 3. Any suitable means may be used to stretch, expand or dilate the top and bottom portions of the annular pontoon C, such as by employing jacks to force the walls of the pontoon outwardly, or by using internal gas pressure to stretch the walls of the pontoon. In addition to increasing the volume of the annular pontoon, the above described method of construction produces a pontoon having an external surface that is free from wrinkles or wavy portions. I prefer to construct the center pontoon D in the same manner as the annular pontoon C, i. e., subject said pontoon to internal pressure so as to stretch or dilate the top and bottom walls of same and then install struts, posts or equivalent devices 10^a inside of the pontoon so as to hold it in a stretched or distended condition.

As previously stated, Figures 1 and 2 of the drawings are intended to illustrate the operation of my invention, whereas, Figures 5 and 6 are intended to illustrate a commercial floating roof embodying my invention, the roof shown in Figures 5 and 6 differing from the roof shown in Figures 1 and 2 only in that the angle, slope or pitch of certain parts of the structure are exaggerated in Figures 1 and 2.

It is believed that the foregoing description, taken in connection with the drawings, clearly discloses the construction and principle of operation of my improved roof and makes it clear that my invention effects a considerable saving in the weight and cost of a floating tank roof and produces a roof that cannot be damaged or injured by excessive rainfall, either when the roof is floating, or when it is supported by the bottom of the tank. In a roof of the design above described the top walls or portions of the center pontoon and peripheral pontoon can be formed from metal of lighter gage than the metal used to construct the deck of the roof, thereby saving weight and cost. No rain water can collect on the central portion of the roof, but instead, practically the only portion or space on the top side of the roof where rain water can collect is a zone lying between the center pontoon and the annular pontoon, and constructed in such a manner that the low point of same, from which the primary drainage means leads, is below the level of the buoyant liquid that sustains the roof. Said zone comprises oppositely-inclined drainage surfaces disposed in such relationship with each other and with the pontoons that when water collects on said zone, the level of said collected water will rise rapidly, whereas, the surface of the buoyant liquid rises very slowly, thus bringing into service an auxiliary drainage means that cannot become stopped up and which insures the discharge of the excess load of rain water from the top side of the roof to a point on the underside of the roof. The surface of the buoyant liquid rises very slowly while the water surface rises very rapidly, because the area of the water surface is very small compared to the area of the roof submerged in the buoyant liquid. Actual calculation on this design shows that the water surface will rise $7\frac{1}{2}$ ", while the liquid surface at T rises only 2 to $2\frac{1}{2}$ ", even though the buoyant liquid is only about 70% as heavy as water. Efficient drainage of the deck is assured when the roof comes to rest on the bottom of the tank,

inasmuch as the roof is provided with a means that is automatically rendered operative to change the shape of the water collection trough or valley on the top side of the roof in a manner to insure the safe discharge of an excess rain load, even though the primary drainage means of the roof fails to function properly. Due to the fact that the major portion of the underside of the roof is submerged in or contacted by the buoyant liquid on which the roof floats, corrosion is reduced to a minimum. Although there is a gas space on the underside of the deck in proximity to the annular peripheral pontoon, the top wall of said gas space is so close to the buoyant liquid that it will be splashed or washed by liquid in the operation of pumping liquid into the tank, thus tending to protect this portion of the underside of the deck from corrosion. By locating said gas space near the annular pontoon, a very small internal gas pressure on the underside of the roof will cause the peripheral portion of the roof to rise, thereby increasing the pitch of the deck and improving the drainage of the roof. As previously explained, the downwardly inclined bottom of the annular pontoon tends to balance the torsion set up in said pontoon at the time of greatest torsion, i. e., when there is an emergency load of rain water or snow on the roof.

While I prefer to equip the roof with a flexible or limber deck that sags between the center pontoon and the peripheral pontoon, as previously described, my invention is not limited to a floating roof provided with a deck of this particular kind. One of the basic features of my invention consists of a floating roof provided with a center pontoon having a portion that projects well above the surface of the buoyant liquid, so as to shed rain water from the center of the roof or prevent rain water from collecting at the center of the roof, and also having a portion that projects well below the surface of the buoyant liquid, so as to cause the point at which the deck is attached to the center pontoon, to normally occupy a position above the surface of the buoyant liquid, thereby producing a structure in which the submerged part of the center pontoon virtually acts as a continuation of the deck as a whole, and still furnishes buoyancy to lift itself and more besides. So far as this feature of my invention is concerned, it is not necessary that the deck be flexible or limber, and in order to make this point clear, I have incorporated in the drawings a figure, numbered 7, which illustrates this feature of my invention more or less diagrammatically, and shows a floating roof composed of any kind of an annular pontoon 100 of stiff construction, any kind of a deck 101 that slopes downwardly from said annular pontoon towards the center of the roof, and a center pontoon 102 provided at its upper end with a rain water shedding portion 103 disposed at a point considerably above the surface of the buoyant liquid and provided at its lower end with a portion 102 submerged in the buoyant liquid, and constructed or designed so that the point 103 at which the deck is attached to the periphery of the center pontoon will normally be located above the surface of the buoyant liquid. In said Figure 7 the hatched portion at the lower end of the center pontoon 102 represents the amount or extent the center pontoon is submerged in the buoyant liquid, and shows that the bottom edge of the center pontoon, i. e., the corner produced by the junction of the bottom of the pontoon

with the rim or side wall portion of the pontoon, is normally disposed above the surface of the buoyant liquid. In such a construction the top 102^a of the center pontoon performs the dual function of a shedding device for rain water and a reinforcing or strengthening device that imparts the required stiffness to the center pontoon, and the bottom 102^b of said center pontoon imparts sufficient additional buoyancy to the center pontoon to insure that the point where the deck is joined to or merges into the periphery of the center pontoon will normally lie above the surface of the buoyant liquid.

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

1. A floating roof for liquid storage tanks, comprising a stiff peripheral pontoon, a stiff center pontoon arranged in spaced relationship with said peripheral pontoon, and a single deck portion attached to said pontoons so as to bridge the space between the same and sloping downwardly and inwardly from the upper end portion of said peripheral pontoon, said deck having an annular trough located adjacent said center pontoon and remote from the peripheral pontoon.

2. A floating roof of the kind described in claim 1, in which the low point of said trough is below the surface of the buoyant liquid, and an emergency drain for said trough having its intake disposed at a level higher than the level of the buoyant liquid.

3. A floating roof of the kind described in claim 1, in which said trough is provided with a radially inclined drainage surface disposed at a sharp

pitch so as to effect a rapid rise in the surface of the liquid that collects in said trough, and an open-ended emergency drain leading from the upper end of said sharply pitched drainage surface and having its outlet discharging into the body of liquid on which the roof floats.

4. A floating roof of the kind described in claim 1, in which the center pontoon is provided with a peripheral rim which constitutes an upwardly-projecting curb at one side of said trough.

5. A floating roof of the kind described in claim 1, provided with means for automatically increasing the pitch or angle of a radially inclined drainage surface of said trough when the weight or load of the roof is transferred to the bottom of the tank.

6. A floating roof for liquid storage tanks, comprising a stiff peripheral pontoon whose bottom slopes downwardly and inwardly towards the center of the roof, a stiff center pontoon arranged in spaced relation with said peripheral pontoon and provided with a bottom of substantially inverted cone shape, a single deck portion attached to said pontoons so as to bridge the space between the same and sloping downwardly and inwardly from the top of the peripheral pontoon, said deck having an annular trough adjacent said center pontoon provided with oppositely-inclined drainage surfaces, a primary drain leading from a low point of said trough that is located below the surface of the buoyant liquid, and an auxiliary open drain leading from said trough and having its inlet located at a level higher than the level of the buoyant liquid.

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