May 12, 1942. J. H. WIGGINS 2,282,772

PONTOON TYPE FLOATING ROOFS FOR LIQUID STORAGE TANKS

Filed April 15, 1939 3 Sheets-Sheet 1

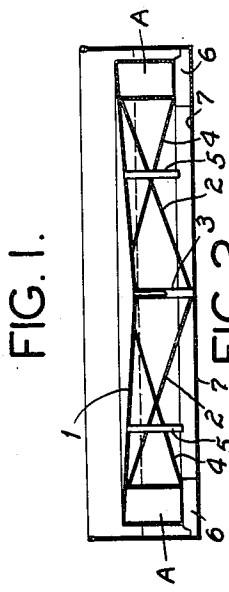

FIG. 1.

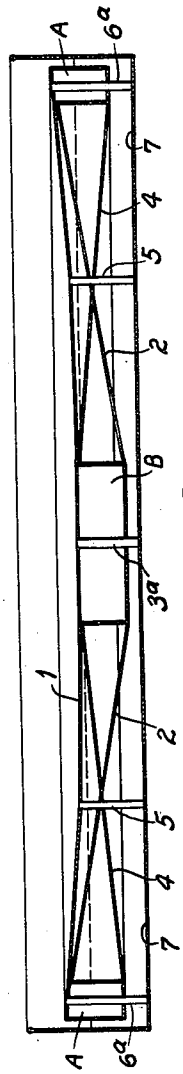

FIG. 2.

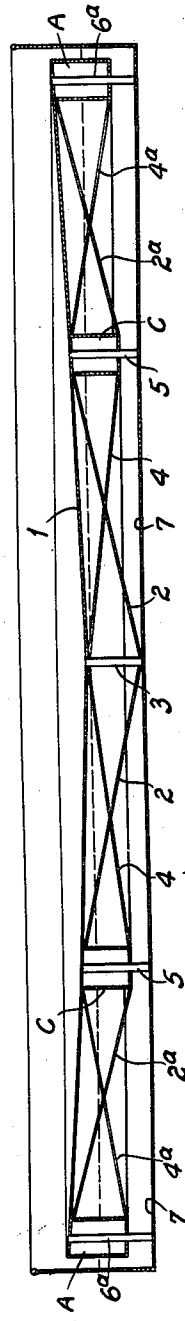

FIG. 3.

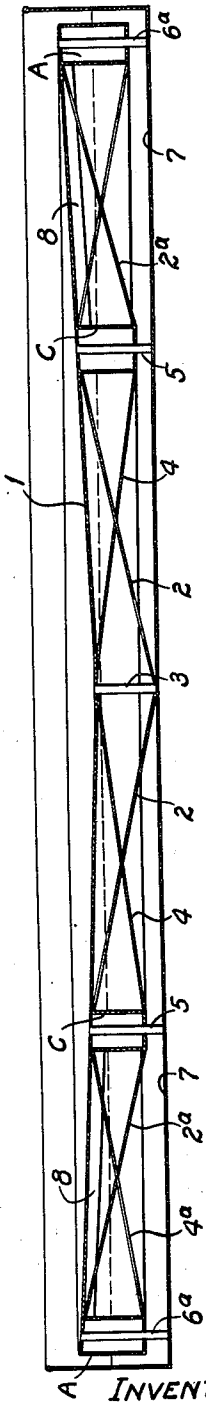

FIG. 4.

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PONTOON TYPE FLOATING ROOFS FOR LIQUID STORAGE TANKS

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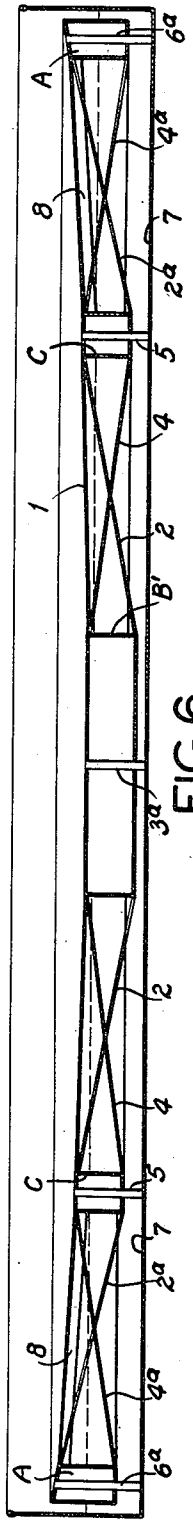

FIG. 5.

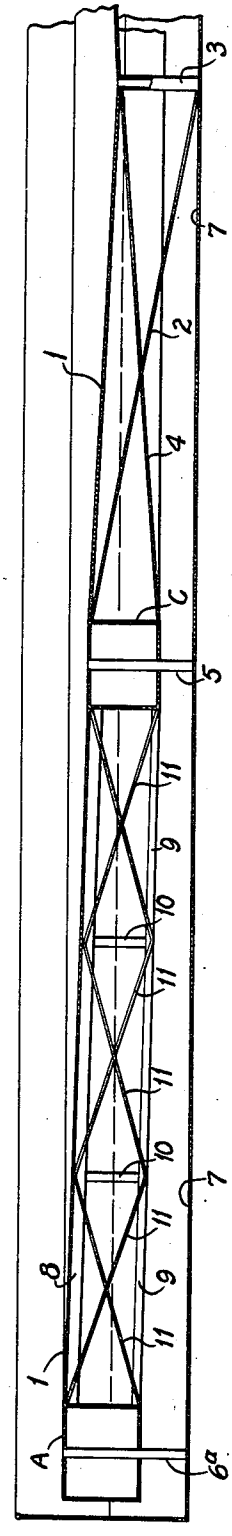

FIG. 6.

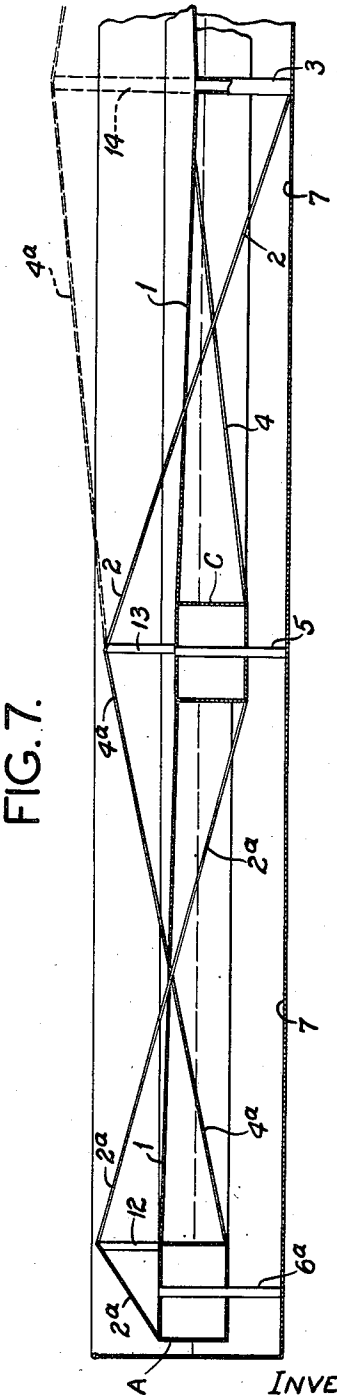

FIG. 7.

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PONTOON TYPE FLOATING ROOFS FOR LIQUID STORAGE TANKS

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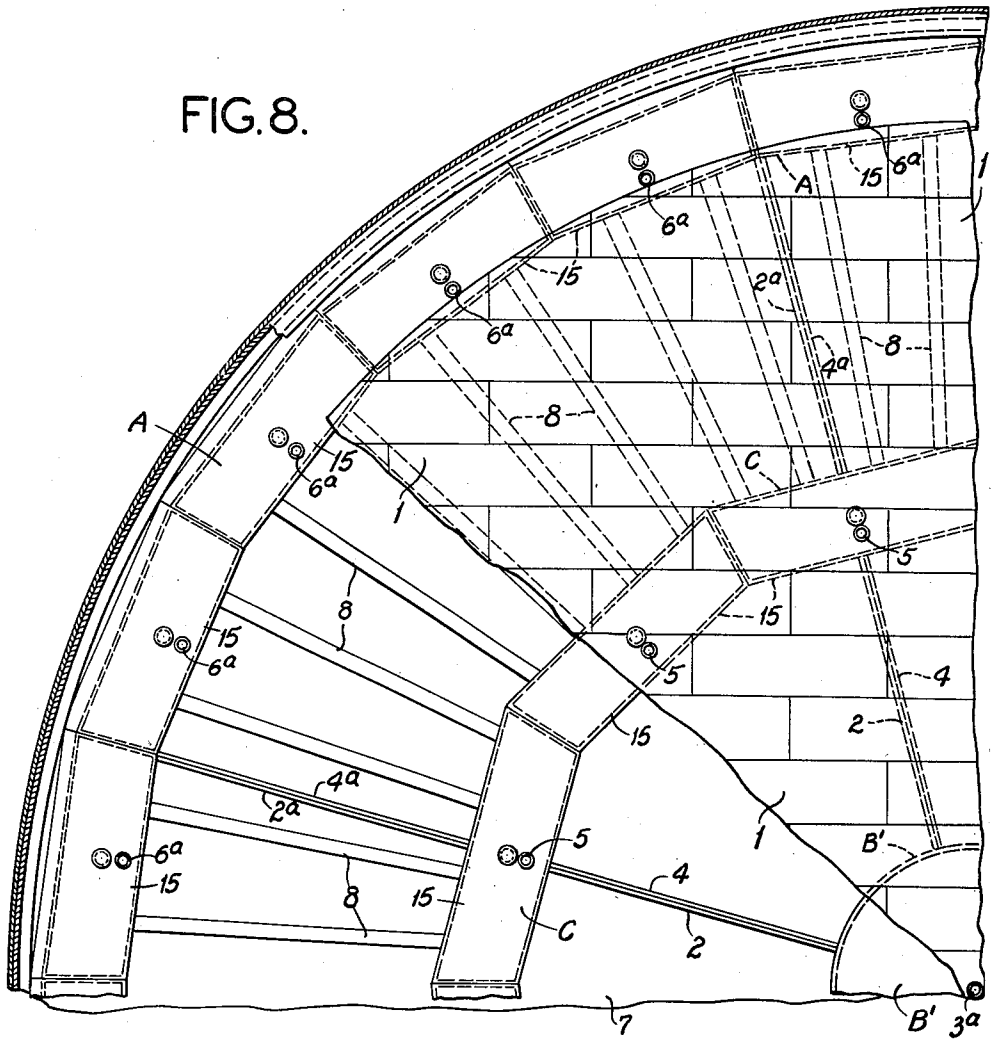
FIG. 8.



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UNITED STATES PATENT OFFICE

2,282,772

PONTOON TYPE FLOATING ROOF FOR LIQUID STORAGE TANKS

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Application April 15, 1939, Serial No. 268,005

1 Claim. (Cl. 220—26)

This invention relates to floating roofs for liquid storage tanks, and particularly floating roofs of the type that are equipped with one or more pontoons for increasing the buoyancy of the roof.

One object of my invention is to provide a floating roof whose component parts are constructed and arranged in a novel manner that attains the following results: (*a*) decreases the weight of the roof; (*b*) reduces the number of parts used in the construction of the roof; (*c*) increases the stability of the roof under all conditions; (*d*) insures efficient drainage of water from the top side of the roof and eliminates the possibility of an excessive quantity of rain water collecting and remaining on the roof; and (*e*) reduces the cost of manufacturing and erecting the roof.

Another object is to provide a floating roof which is equipped with a novel means for preventing the approximate shape of the deck of the roof from being substantially changed or altered by flexing or displacement, resulting from accumulation of gases on the underside of the roof.

Another object of my invention is to provide a floating roof that is equipped with a novel means for preventing the central portion of the roof from sagging disproportionately to the rest of the roof, in the event an abnormally heavy load of rain water or snow is imposed on said central portion.

Another object is to provide a floating roof of the pontoon type, in which the deck and the pontoons are of such construction and arrangement that the roof is capable of successfully carrying a much greater load than pontoon roofs of conventional design, and also has a safety factor far in excess of that required for a commercially acceptable floating roof.

Another object is to provide a floating roof pontoon that weighs less and is cheaper to build than roof pontoons of conventional construction; that can be built and tested in a factory, and thereafter shipped to the place where the roof is being erected; and which is easy to combine with the deck and other component parts of the roof in the operation of erecting the roof.

And still another object of my invention is to provide a floating roof, which, in addition to having a peripheral pontoon, is equipped with a means that prevents the deck of the roof from being substantially distorted by downward and upward forces exerted on said deck, and also carries stresses from eccentric loads directly across the deck from one side to the other. Other objects and desirable features of my invention will be hereinafter pointed out.

To this end I have devised a floating roof that comprises a deck, preferably formed from a metal diaphragm or substantially limber metal sheet structure that constitutes the top surface of the roof, a stiff annular compression member arranged at the periphery of the roof and constructed in the form of a pontoon that projects downwardly from the underside of the deck, a stiff compression member at the center of the roof constructed or arranged so as to comprise a downwardly-projecting portion, and radially-disposed tension members rigidly attached to or combined with said center compression member and said peripheral compression member, for maintaining said compression members in the positions they are intended to occupy relatively to each other, or, in other words, for preventing, or tending to prevent, either of said compression members from moving vertically relatively to the other under the loads or forces which the roof is liable to be subjected to in normal use. To state it in another way, my improved roof is constructed on the same general principle as the conventional wire spoked wheel and comprises two stiff compression elements at the center and at the periphery of the structure that correspond to the hub portion and the rim of the wheel, plus radially-disposed tension members, corresponding to the spokes of the wheel, that cause vertical loads, strains, or forces exerted on the center compression element (either upward or downward forces) to be transmitted to the peripheral compression element in substantially the same way that the side thrusts on a wheel hub are transmitted by the spokes to the rim when the wheel is traveling around a curve.

The number of pontoons with which the roof is equipped may be varied, and the construction and arrangement of the pontoons may be varied, without departing from the spirit of my invention, but in all instances, the roof will be provided with a buoyant means, such as a pontoon or pontoons, that project downwardly from the underside of the deck and which are combined with the deck in such a way as to support and maintain the deck out of contact with the liquid in the tank. Preferably, the roof comprises a substantially annular-shaped, stiff pontoon that constitutes a compression member located at the periphery of the deck and said deck and said peripheral pontoon are designed or arranged

so that under normal conditions the peripheral portion of the deck will be spaced higher above the surface of the liquid than the central portion of the deck, thereby producing a floating roof of substantially dish shape or inverted cone form, whose top surface slopes downwardly to a drain outlet at the center of the deck. The peripheral pontoon above referred to, or any other pontoon of the roof that is of annular form or substantially annular form, is preferably made up of a number of sections or units that can be easily manufactured and tested in a factory and then shipped to the place where the roof is to be erected. The particular cross-sectional shape of said annular pontoon or pontoons is not essential, and may be square, oblong, round, oval, or a modification of any of said shapes. In addition to the peripheral pontoon above mentioned, the roof may also comprise (*a*) a stiff center pontoon that functions as a compression member; (*b*) an intermediate pontoon of substantially annular form, arranged between the center of the roof and the peripheral pontoon; or (*c*) a center pontoon and one or more substantially annular pontoons arranged between the center pontoon and the peripheral pontoon.

The tension members preferably consist of radially-disposed members attached at their inner ends to a stiff compression element comprising a part or member depending from the center of the roof, and attached at their outer ends to the annular compression member formed by the peripheral pontoon, said tension members being so disposed that they act to hold down the central portion of the roof and prevent said central portion from flexing upwardly, due to the accumulation of gases on the underside of the roof, and said tension members also act to prevent the central portion of the roof from sagging disproportionately to the rest of the roof when an abnormally heavy load of snow or rain water is imposed on said central portion.

The roof is preferably equipped with a drainage apparatus that may comprise a center drain, either of the inverted syphon type, or any other preferred type, and one or more annular rows of auxiliary drains arranged between the center drain and the periphery of the roof.

Figures 1 to 7, inclusive, of the drawings are vertical transverse sectional views, illustrating various ways of constructing the floating roof which constitutes my present invention; and

Figure 8 is a fragmentary top plan view of said roof, illustrating the preferable way of constructing the annular pontoons.

The roof illustrated in Figure 1 comprises a stiff annular compression member formed by an annular pontoon A, arranged at the peripheral edge of the roof, a deck 1, constructed from metal plates, and preferably designed so that when the roof is completed, it will be dish-shaped or of substantially inverted cone form, and a means for maintaining the approximate shape of the deck and preventing it from being displaced by upward and downward forces exerted on same, such, for example, as an upward force resulting from accumulation of gases on the underside of the roof, or a downward force caused by an abnormally heavy load of rain water or snow on the central portion of the roof. The buoyant means that sustains the deck projects downwardly from the underside of same and is so designed and combined with the deck as to always maintain the deck at a point considerably above the surface of the liquid. The means that is used to prevent distortion of the deck is herein illustrated as consisting of tension members which, in addition to maintaining the approximate form or shape of the deck, effectively carry eccentric loads from one side of the peripheral pontoon to the other. In Figure 1 I have illustrated my improved roof as being equipped with a set of radially-disposed, inclined tension members 2, attached at their inner ends to a strut 3, which constitutes a rigid compression member that depends from the center of the underside of the deck, and connected at their outer ends to the top edge of the annular compression member or pontoon A, and a separate set of oppositely inclined, radially-disposed tension members 4 attached at their inner ends to the central portion of the deck 1 adjacent the upper end of the member 3, and attached at their outer ends to the bottom edge of the pontoon A. The tension members 2 which extend radially from the center compression element of the roof to the peripheral compression element, effectively prevent the central portion of the deck from sagging disproportionately to the rest of the deck, in the event an abnormally heavy load of rain or snow is imposed upon the roof, and the tension members 4, which lead inwardly from the peripheral compression element, and are attached to the center compression element, hold the deck down, and prevent the central portion of same from flexing upwardly when the gas pressure on the underside of the roof increases. Usually, the tension members 2 and 4 will be formed from metal rods.

Water that falls onto the top surface of the deck 1 is conveyed away from said surface by drains that discharge the drain water downwardly into the body of liquid in the tank on which the roof floats. Preferably, the roof is provided with a primary center drain and a plurality of emergency drains arranged between the center drain and the periphery of the roof. The said drains may be of the inverted syphon type, commonly used in floating tank roofs, or may consist simply of vertically-disposed, tubular members, whose open upper ends terminate in the top surface of the deck. In the roof shown in Figure 1 the tubular member 3 at the center of the roof is used to form the primary drain of the roof, and the emergency drains are formed by an annular row or rows of tubular members 5 arranged between the center drain and the annular pontoon A. Some or all of the drains just mentioned may be made of such length that when the tank is empty, said drains will serve as supporting legs for the center and intermediate portions of the roof. The peripheral portion of the roof may be supported during the operation of erecting the roof, or when the tank is empty, either by supporting legs attached to the peripheral pontoon A, or by roof supports 6 attached to the bottom 7 of the tank in which the floating roof is used.

The floating roof shown in Figure 2 embodies the desirable characteristics and features of the roof shown in Figure 1, and is composed of parts of quite similar construction and arrangement. However, the roof shown in Figure 2 is provided with a stiff or rigid center pontoon B that functions as a compression member, and the tension members 2 and 4 are attached to said center pontoon B. In Figure 2 the reference character 3ª designates a center drain that extends upwardly through the center pontoon B, and the reference character 6ª designates depending legs

or roof supports attached to the peripheral pontoon A.

The roof illustrated in Figure 3 is provided with an intermediate annular pontoon C arranged between the center of the roof and the peripheral pontoon A. Oppositely-inclined tension rods 2 and 4 are combined with a depending rigid center member 3, and with the intermediate annular pontoon C, and additional sets of oppositely inclined, radially-disposed tension members 2a and 4a are combined with the intermediate pontoon C and the annular compression member A at the periphery of the roof.

Figure 4 illustrates an additional feature that may be incorporated in a roof of the kind shown in Figure 3, to wit, radially-disposed deck beams 8 attached to the underside of the portion of the deck 1 which bridges the space between the annular pontoon A and the intermediate pontoon C, so as to impart stiffness to the peripheral portion of the deck.

The roof shown in Figure 5 is similar to the one shown in Figure 4, except that it is provided with a stiff or rigid center pontoon B', to which the inner ends of the tension rods 2 and 4 are attached, the center pontoon B' being equipped with a center drain 3a that also acts as a roof support under certain conditions.

Figure 6 illustrates a roof that differs from the one shown in Figure 5, in that the trussing means arranged between the intermediate pontoon C and the annular pontoon A that constitutes the peripheral compression member, is composed of a plurality of sets of oppositely-inclined, crossed braces 11 combined with vertical struts 10 and with horizontal top and bottom beams 8 and 9 in such a way as to co-act with the tension members 2 and 4 between the center of the roof and the intermediate pontoon C to effectively hold the roof in shape and cause loads or forces thereon to be distributed in the manner previously explained.

It is not essential that all of the tension members be arranged on the underside of the deck. In some instances it may be desirable to arrange some of the tension members on the top side of the deck. Thus, as shown in Figure 7, the roof may comprise a stiff annular compression member formed by a peripheral pontoon A, an intermediate annular pontoon C, a depending center strut 3, and sets of oppositely-inclined tension rods 2, 2a, 4 and 4a, some or all of which may extend through the deck and be attached to struts 12 and 13 that project upwardly from the top side of the deck, said struts 12 and 13 being located intermediate the center of the roof and the peripheral pontoon A. The tension rods 2a that lead upwardly and outwardly from the bottom edge of the intermediate pontoon C extend through the deck, and after passing over the upper ends of the struts 12, are attached to the outer top edge of the peripheral pontoon A. Similarly, the tension rods 2 that extend outwardly and upwardly from the center strut 3 pass through the deck and are attached to the upper end of the struts 13 on the top side of the deck. The tension rods 4a that lead inwardly from the bottom edge of the peripheral pontoon A pass upwardly through the deck and are attached to the struts 13. If desired, said rods 4a may be extended inwardly towards the center of the roof, as shown in broken lines in Figure 7, and can be attached to a strut 14 shown in broken lines, that projects upwardly from the top side of the center of the deck.

In order to reduce the cost of manufacture and erection of the roof, I prefer to construct each of the annular pontoons from a plurality of sections or units that can be manufactured and inspected at a factory and then shipped to the place where the roof is to be erected. This feature of my invention is illustrated in Figure 8 of the drawings, wherein it will be noted that the peripheral pontoon A and the intermediate pontoon C are each made up of a number of small hollow members 15. Said hollow members may be of any preferred cross sectional shape, but each of said members consists of a complete hermetically sealed member provided with a top wall, a bottom wall, side walls, and end walls, joined together by tight joints. Said members 15 are of such form that when a plurality of members are arranged end to end, they cooperate with each other to form a pontoon of substantially annular form. The pontoon sections 15 can be hermetically sealed, because they are of such shape and size that they will stand any possible pressure or vacuum. Also, they are small enough so that they may be shop-welded and tested for leaks under high pressure, and then shipped in lengths of 30 ft. or 40 ft., or more, to the place where the roof is to be installed. By constructing the annular pontoons in the way above described, the cost of fabricating same is materially reduced. As previously explained, the particular cross-sectional shape of the annular pontoons is immaterial, but I prefer to use a peripheral pontoon of such shape and size and combine the deck of the roof with the pontoons in such a way that the roof, after completion, will have a sloping top surface that pitches downwardly to a drain outlet at the center of the roof. The emergency drains, although highly desirable, are not essential to the successful operation of the roof. They are so disposed or located on the surface of the roof that if the center drain becomes stopped up, water can collect on the roof only until it reaches the first row of emergency drains. Preferably, the roof is so designed that the center portion of the deck is normally a few inches (2 inches or 3 inches) above the liquid line, so that with a very small load of water or snow, on the roof, the center of the roof is submerged in the liquid on which the roof floats, and hence, becomes a buoyant means of itself. This fact makes the roof as an entirety capable of carrying a very large snow load, and also decreases the stress in the tension rods that are used to prevent the central portion of the roof from sagging disproportionately to the rest of the roof, in the event of an abnormally heavy load. Whereas, the center of the roof normally may be only 2 or 3 inches above the liquid, the peripheral portion of the roof deck may be from 10 to 18 inches above the liquid line. Thus, an emergency load, which would bring the upper openings of the emergency drains down to the liquid line, would be the complete displacement of all the pontoons, plus the displacement of the cone formed by the roof deck. To submerge the pontoons alone would require a snow load of from 15 inches to 25 inches. To further submerge the deck (assuming that it is constructed in the shape of a cone with a 9 inch pitch to center) would require an additional load of 21 inches of snow. Consequently, a roof constructed in accordance with my invention can be designed to carry from 36 inches to 46 inches of snow, without liability of the liquid stored in the tank finding its way to the top surface of the roof. It

will also be noted that it would be impossible for a rain load of equivalent magnitude to collect on the roof, due to the fact that the roof is provided at numerous points throughout its area with emergency drains arranged in one or more annular rows between the center of the roof and the periphery of the roof.

Ordinarily, when erecting a floating roof, whose co-operating parts are joined together inside of the tank in which the roof is used, it is necessary to build a frame over the whole area of the tank bottom upon which to erect the roof.

With a roof of the design herein illustrated the pontoon sections can be set in place on their fixed supports and welded together so as to form complete pontoons. If the roof is provided with a peripheral pontoon and an intermediate pontoon, said pontoons are joined together by roof beams 8, thus forming a supporting framework that constitutes part of the roof, and which overcomes the necessity of building a temporary framework. In most instances the pontoons will have a depth of about 3 ft. Consequently, if the pontoons are provided with depending portions that constitute legs or roof supports, ample space is provided on the underside of the deck when the tank is empty, to facilitate cleaning of the tank. When liquid is pumped into the tank, during the operation of filling the tank, the roof is effective as a floating roof as soon as the bottom of the peripheral pontoon is sealed by the liquid in the tank. Thus, adjustable legs are eliminated and more of the tank height is used as a floating roof than has been the custom with prior designs of floating roofs. This decreases the cost of the roof and increases the efficiency of the entire structure.

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

A floating roof for liquid storage tanks, comprising a stiff annular peripheral pontoon, a single deck portion constructed in the form of a flexible diaphragm, attached to the said pontoon adjacent the upper edge thereof, and sloped downwardly towards the center of the roof, and radially-arranged tension members, each having one end attached to said single deck portion at a point inwardly spaced from said pontoon and having the other end attached to said pontoon, at a point substantially at the bottom of said pontoon, for maintaining said deck portion in a downwardly sloped position, under all conditions of pressure in the gas space between the roof and the liquid in the tank.

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