

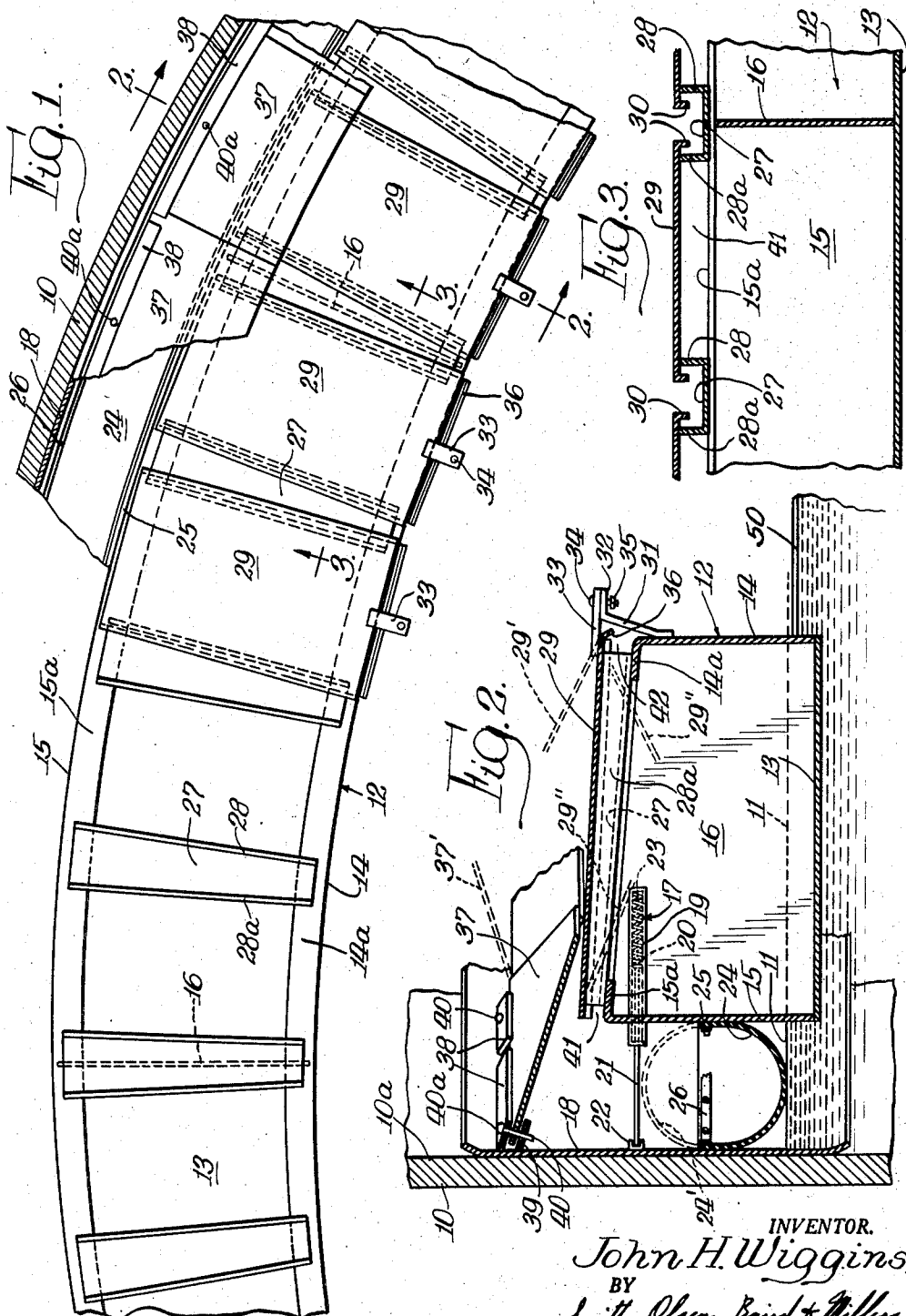
Aug. 13, 1957

J. H. WIGGINS

2,802,591

PONTOON TYPE FLOATING TANK ROOF

Filed May 11, 1956



INVENTOR.
John H. Wiggins,
 BY
Smith, Olsen, Baird & Miller
Attys.

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PONTOON TYPE FLOATING TANK ROOF

John H. Wiggins, Menlo Park, Calif.

Application May 11, 1956, Serial No. 584,291

8 Claims. (Cl. 220—26)

This invention relates to floating roofs for liquid storage tanks of the type employed in the oil industry and elsewhere for the storage of various kinds of liquid products, and is concerned more particularly with a pontoon type floating roof having highly improved implosion and explosion damage minimizing qualities.

It is a well known fact in the petroleum industry that pontoon type floating tank roofs of the ordinary kind have the disadvantage that any leak occurring in the under portion of the pontoon is likely not to be noticed or detected immediately, with the result that explosive vapors may collect in the pontoon and ultimately be ignited, thereby causing an explosion that will severely damage the roof and possibly destroy the entire tank and its contents. Pontoons of the type heretofore known have normally been constructed with a top deck of relatively heavy plating welded securely to the side walls of the pontoon. While some of the pontoons have been provided with small manholes in their tops for inspection purposes, none, insofar as I am aware, has been constructed adequately to ventilate the interior of the pontoon compartments to avoid the accumulation therein of explosive vapors, and none has been devised to avoid extensive damage caused by internal explosions, which often may produce internal pressures as great as forty-five pounds per square inch. Floating tank roofs of the kind heretofore known have also been particularly vulnerable to extensive damage from nearby external explosions and also from more distant catastrophic explosions such as that produced by an atomic bomb. In the latter case it is now known that an atomic bomb produces a pressure or blast shock wave that may be as great as twelve pounds per square inch some distance from the point of detonation, and this pressure shock wave is immediately followed by a negative or reduced pressure wave that sometimes may cause a reduction in atmospheric pressure of as much as five pounds per square inch.

The building of a floating tank roof, in accordance with conventional practices, of such rigidity as to withstand the forces of internal and external explosions of the kind just referred to would be impractical, and I have solved this problem by devising the present structure, which is both relatively easy and inexpensive to construct.

One of the principal objects of the present invention is to provide a floating tank roof of the pontoon type that is adapted very greatly to minimize the explosion damage of internal explosions, and also to minimize the implosion damage caused by heavy explosions occurring exteriorly of the tank but relatively near thereto. Another object of the invention is to provide in a pontoon type roof means for thoroughly ventilating the interior of the pontoon so as to avoid the accumulation therein of explosive vapors and thereby avoid the occurrence of internal explosions. Still another object is to provide a floating tank roof in accordance with the above objects, having the ability automatically to relieve pressure within the roof in case of an explosion in a pontoon thereof and

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also automatically to adapt itself so as to withstand external air shock waves of great magnitude. Still another object of the invention is to provide a floating tank roof having all of the above qualities, but which is substantially less expensive to construct and to maintain than are conventional pontoon type roofs. Yet another object of the invention is to provide a tank roof having the foregoing qualities wherein the pontoon portions of the roof are of the open-boat type and are closed by cover means that are simply and inexpensively constructed and also easily removable so as to open up substantially the entire top of the pontoon portions for easy inspection and maintenance.

These and other objects and advantages of the present invention will be apparent from the following description of a preferred embodiment thereof, taken with the accompanying drawing, wherein:

Fig. 1 is a fragmentary plan view of a peripheral portion of a floating tank roof constructed in accordance with the invention, the tank wall being shown in cross-section, and certain cover members or plates being shown removed from the top of a pontoon that defines the periphery of the roof structure per se;

Fig. 2 is a fragmentary vertical cross-sectional view of the roof and tank taken substantially along the line 2—2 in Fig. 1; and

Fig. 3 is a similar cross sectional view taken substantially along the line 3—3 in Fig. 1.

In the drawing, the numeral 10 designates the upstanding side wall of an open top cylindrical tank of the type commonly used for storing liquids, and particularly liquid petroleum products, of the volatile explosive kind. The liquid level 11 in the tank is expected to rise and fall from time to time, and the roof of the present invention is arranged to float on the liquid and to rise and fall with the changes in the liquid level. The new roof in the present instance comprises an annular peripheral pontoon, designated generally by the numeral 12, having a bottom 13 and upstanding inner and outer walls 14 and 15, the respective upper edge portions 14a and 15a of the latter of which are turned inwardly, as shown in Fig. 1 and 2. At substantially equally spaced intervals, the pontoon may be provided with transversely extending vertical bulkheads 16 which divide the pontoon into separate compartments.

From the drawing it will be noted that the pontoon 12 is of the open-boat type. That is, the pontoon per se has substantially no upper deck and is substantially entirely open at its top. It will also be observed that the pontoon occupies only a fractional portion of the surface area of the liquid in the tank, most of this surface area being covered by a plate-like deck 50 that is buoyantly supported by the pontoon and by its own displacement of liquid in the tank.

The outer wall 15 of the pontoon is spaced radially inwardly from the inner surface 10a of the tank wall 10 and carries a plurality of circumferentially spaced pusher mechanisms, designated generally by the numeral 17, which in turn carry a substantially cylindrical shoe 18 that slidably and intimately engages the inner surface 10a of the tank wall. The pusher mechanisms may be of any suitable construction and in the present instance only one of the mechanisms is shown. It includes a horizontally and radially disposed cylinder 19 that extends through, but is securely welded or otherwise supported in, the outer wall 15 of the pontoon. The cylinder 19 contains a piston 20 provided with a piston rod 21 that extends from the outer end of the cylinder, and the outermost end of this piston rod has a bracket 22 secured thereon, with the bracket, in turn, being welded or otherwise secured to the inner side of the shoe 18. Thus,

it will be understood that the several pusher mechanisms support the cylindrical shoe about the pontoon. The innermost end of the cylinder 19 of each pusher mechanism contains a coiled compression spring 23 which bears upon the piston 20 so as constantly to urge the piston rod 21 outwardly, thereby pressing the cylindrical shoe 18 constantly against the inner surface 10a of the tank wall 10.

The annular toroidal space between the outer upright wall 15 of the pontoon and the shoe 18 is sealed by an annular, gas impervious, flexible boot or sealing member 24. This sealing member, in the embodiment shown, is of rubberized fabric secured at its inner edge to the upright wall 15 of the pontoon by means of a sealing strip 25 secured to the pontoon wall by suitable nuts and bolts. The outer edge of the sealing member is secured to the shoe 18 in a similar manner by a sealing strip 26, the positioning of the edges of the sealing member being such that the member normally drapes loosely downwardly toward the liquid level 11 in the tank, as shown in Fig. 2.

It will be noted that the outer wall 15 of the pontoon extends to a level higher than the inner wall 14 thereof so that the inturned upper edge 15a of the outer wall and the inturned upper edge 14a of the inner wall define a slope with respect to the horizontal. These inturned edges are joined at intervals by circumferentially spaced radially disposed plates 27 which are welded or otherwise secured at their respective opposite ends to the upper surfaces of the inturned edges 14a and 15a to rigidify the pontoon, and the opposite side edge portions of each of the plates 27 have upturned flanges 28 and 28a formed thereon. The upper portion of the pontoon per se, however, is completely open except for the relatively insignificant area thereof occupied by the inturned edges 14a and 15a of the sides of the pontoon and by the plates 27.

A plurality of light-weight easily collapsible cover plate members 29 respectively cover the open spaces between adjacent plates 27 so as to drain to the deck 50 rain and other precipitation that would otherwise fall into the interior of the pontoon. Each of these plates 29 is of generally rectangular shape and has downturned edge flanges 30 formed on its opposite side edges so as to overlap the upturned flanges 28 and 28a of the members 27 in the manner shown in Fig. 3. The coaction between the flanges 30 and the flanges 28 and 28a is thus such as to limit sidewise movement of the plates 29 with respect to the pontoon.

Means are provided for anchoring the radially upwardly directed ends of each of the cover plates 29 to the pontoon and yet permit the plates to be individually pivoted upwardly as shown by the dotted lines 29' in Fig. 2. In the embodiment shown, each of these means comprises an upstanding bracket 31 welded or otherwise secured to the exposed face of the inner wall 14 of the pontoon, the uppermost end of the bracket having a horizontal leg 32 formed thereon to which a lug 33 is removably and rather loosely secured, as by a bolt 34 and a nut 35. As best seen in Fig. 2, the inner end of each lug overlies the inner end of one of the plates 29 a short distance, thereby preventing lifting of the inner end of the plate 29 from the upstanding supporting flanges 28 and 28a of the transverse reinforcing plates 27, but permitting the plate 29 to be pivoted upwardly about its anchored end. Movement of the cover plates 29 radially inwardly and outwardly with respect to the geometric center of the pontoon is also limited by a downwardly directed flange 36 formed on the inner end of each of the plates 29. From Fig. 2, it will be observed that movement of the plates 29 in a radially outward direction will be limited by the engagement of the downturned flange 36 with the inner ends of the supporting flanges 28 and 28a, while movement of the plate in the opposite direction is limited by engagement of the

flange 36 with the adjacent face of the upstanding bracket 31.

The annular space between the outer periphery of the pontoon and the shoe 18 is covered by a plurality of weather plates 37 which are individually pivoted at their outer ends upon the shoe 18 adjacent its upper edge. For this purpose vertically spaced apart short bar members or lugs 38 and 39 may be bolted or otherwise secured in an inwardly and downwardly sloping position about the inner surface of the shoe 18, as shown. These lugs loosely receive therebetween the outer edges of the weather plates 37, these latter plates being loosely secured between the lugs 38 and 39, for example, by plain pins 40 which extend loosely and downwardly through suitable aligned openings in the lugs and the weather plates so as to permit pivoting motion of the plates. If desired, the top of each pin 40 may be provided with a ring 40a so that the pins may be easily installed from the exterior of the structure and may easily be withdrawn when removal of the weather plates is desired. The opposite side edges of each weather plate overlap the side edges of the next adjacent plates, and the innermost ends of the weather plates rest freely upon the upper surfaces of the cover plates 29 so that precipitation that would otherwise fall into the annular space between the pontoon and the shoe 18 is drained downwardly onto the plates 29 or onto the plates 27, and thence downwardly onto the deck 50, from which the precipitation may be disposed of in any of the usual ways well known in the tank art.

Figs. 2 and 3 best show the features of applicant's construction providing for constant ventilation of not only the interior of the compartments of the pontoon, but also the upper portion of the annular space between the pontoon and the shoe 18 above the seal 24. It will be observed that the upstanding flanges 28 and 28a on the transverse plate members 27 are of such height that the body portion of each of the cover plates 29 is elevated well above the inturned edges 14a and 15a of the pontoon side walls, both at the inner and outer ends of the cover plates 29. Thus, each of the cover plates 29, in cooperation with the flanges 28 and 28a of the transverse members 27, provides an inverted channel-shaped venting passage having an unobstructed opening 41 at its outer end and a corresponding unobstructed opening 42 at its inner end through which any vapors that may tend to collect in the annular space between the pontoon and the shoe 18 may freely flow and be expelled to the atmosphere. Likewise, it will be observed that the interior of the pontoon is similarly vented to the atmosphere through the plurality of openings 42 provided under the inner ends of the plates 29. This constant and thorough ventilation of both the pontoon and the space between the pontoon and the shoe 18 prevents the accumulation of explosive vapors therein and thus avoids the occurrence of internal explosions.

The plates 29 are constructed of substantially lighter gauge steel than the remaining portions of the tank roof, including the transverse members 27. For example, the plates 29 in the preferred embodiment are of a gauge and strength such as to be able to withstand only loads that are thirty to forty pounds per square foot or less, whereas the transverse members 27 and the remaining portions of the pontoon and the weather plates 37 are designed to carry loads of one hundred pounds or more per square foot. As a consequence, when the present tank roof is subjected to the initial pressure shock wave of a nearby external catastrophic explosion, such as an atomic bomb explosion, the cover plates 29 are immediately crushed downwardly and inwardly into the interior of the pontoon, as indicated by the broken lines 29', thereby in effect instantaneously opening the pontoon and preventing the pontoon structure per se from being damaged. Furthermore, since the bottom 13 of the pontoon and the main deck 50, as well as the walls

10 of the tank, are in intimate contact with the liquid in the tank, the force of the pressure shock wave striking these surfaces is transmitted immediately to the liquid so that the shock wave pressures, both inside and outside the tank, are equalized practically instantaneously, thereby tending to avoid damage to the roof and tank per se. As previously stated, the pressure wave of such a catastrophic explosion is immediately followed by a vacuum wave of substantial proportions but, inasmuch as the pontoon previously will have been completely opened by the crushing of the plates 29 by the pressure wave, the vacuum wave can do no damage to the pontoon.

Inasmuch as both the interior of the pontoon and the upper portion of the annular space between the pontoon and the shoe 18 are constantly vented, accumulation of excessive vapors in both of these areas is prevented. However, in the event that some such vapors may exist in these areas and are inadvertently ignited, it will be observed that the internal pressures that would normally be created by these explosions are immediately relieved to avoid damage to the structure. The pressure of such explosions pivots the weather plates 37 upwardly to the position indicated by the broken lines 37' in Fig. 2 and simultaneously pivots the plates 29 upwardly about their inner edges to the position indicated by the broken lines 29', thereby instantaneously in effect opening up the entire pontoon and the entire annular space between the pontoon and the shoe 18 and avoiding explosion damage to the pontoon. A similar result will be brought about to a somewhat lesser but adequate extent in the event an explosion should occur in the vapors trapped beneath the flexible seal 24 and the surface of the liquid 11. In this latter event, the seal 24 is reversely ballooned upwardly by the explosion products to the position designated by the broken lines 24' to increase the volume of the space beneath the seal and thus retain the explosion products. This reverse ballooning of the seal 24 quickly displaces air from the area immediately above the seal and the pressure of this displaced air will pivot the weather plates 37 upwardly and possibly also the plates 29 as shown in Fig. 2, thereby again avoiding damage to the heavier structural parts of the pontoon and of the roof.

In all but the most serious types of explosions the only damage done to the roof will be the bending or collapsing of the relatively light-weight plates 29. Replacement of these plates with substitute plates may easily and inexpensively be accomplished and, if the plates are not too seriously wrinkled or bent, they may be easily straightened and replaced.

In addition to the foregoing advantages and features of the present invention, use of the invention very materially reduces the cost of a completed roof assembly. As compared to the conventional pontoon type roof, it will be noted, for example, that the present construction involves far less welding on the top part of the pontoon, and there are no radial welds to make in this area. Instead of welding a relatively heavy steel plate onto the top of the pontoon to enclose the same, as is the case in conventional structures, the light-weight cover plates 29 are simply laid in place. The weather plates 37 also are extremely easy to install and, like the cover plates 29, they may be installed by relatively inexpensive labor. Furthermore, the plates 29 and 37 may be of aluminum or galvanized steel plate material which requires no painting or protective coating, thereby greatly reducing the usual painting costs. The savings in the initial cost of material and in the cost of its transportation is also very substantial. In conventional structures of this general type the fixed top cover plate of a pontoon is normally fabricated of $\frac{3}{16}$ inch steel plate material which weights about 8.1 pounds per square foot and costs approximately 40¢ per square foot. In contrast to such weight and cost, the cover plates 29 in the present construction may be fabricated, for example, of 16 gauge

galvanized steel sheet material which weighs only 2.65 pounds per square foot and costs, on present day markets, only about 18½¢ per square foot. This saving in the cost of construction of a large roof is therefore very substantial, and it also materially reduces the cost of the freight, loading, hauling and the handling involved.

One of the further advantages of the present invention is the ease with which the entire interior of the pontoon may quickly and conveniently be made accessible for inspection, maintenance, painting and the like. By simply loosening the nuts and bolts 34 and 35, if need be, and by turning the lugs 33 about their retaining bolts so as to disengage the plates 29, the plates are prepared to be lifted from the top of the pontoon. This removal of the plates 29 exposes the entire interior of the pontoon, in which condition it may be thoroughly inspected and painted when necessary. By opening the pontoon in this manner, danger of asphyxiation, so common to maintenance personnel during their work on the interiors of ordinary tank roof pontoons, is completely eliminated and the workers are able to carry out their maintenance work in natural light and safety.

The foregoing description of one embodiment of the present invention has been made for clearness of understanding only and no unnecessary limitations are intended thereby, for it will be apparent to those skilled in the art that various modifications may be made in the present roof within the spirit and scope of the appended claims.

I claim:

1. A floating roof for a tank of the liquid storage type having improved implosion and explosion damage minimizing qualities comprising, a hollow, open-boat type pontoon having spaced apart upstanding side walls and adapted to float upon the liquid in the tank so as to occupy a fractional portion of the surface area thereof, a deck secured to said pontoon and buoyantly supported thereby for covering an additional portion of the surface of the liquid, a plurality of relatively lightweight easily collapsible individual plates freely resting in side-by-side position transversely across the open top of said pontoon for closing the same and for normally draining to said deck precipitation that would otherwise fall into said pontoon, said plates being constructed and arranged to collapse inwardly into said pontoon upon impact thereon of a shock wave of a heavy explosion occurring exteriorly of the tank, thereby minimizing implosion damage to said pontoon, and means for loosely and removably anchoring one edge only of each of said plates to said pontoon so that pressure produced by an explosion within said pontoon will cause said plates to pivot upwardly about their respective anchored edges to an open position immediately to relieve said pressure and thereby minimize the damage that would otherwise be produced by said last mentioned explosion.

2. The combination set forth in claim 1, including means for supporting each of said plates transversely across said open top of said pontoon in a position elevated with respect to the upper edge of at least one of said side walls of said pontoon so as to provide an unobstructed opening between each of said plates and said upper edge of said side wall for constant ventilation of the interior of said pontoon, thereby avoiding accumulation of explosive vapors within said pontoon.

3. A floating roof for a tank of the liquid storage type having improved implosion and explosion damage minimizing qualities comprising, a hollow, open-boat type pontoon having spaced apart upstanding side walls and adapted to float upon the liquid in the tank so as to occupy a fractional portion of the surface area thereof, a deck secured to said pontoon and buoyantly supported thereby for covering an additional portion of the surface of the liquid, a plurality of spaced apart channel-shaped structural members extending transversely across the open top of said pontoon and secured to the upper

edges of the side walls thereof to rigidify said pontoon, each of said channel-shaped members having side flanges thereon and being arranged with said side flanges extending upwardly above the upper edges of said side walls of said pontoon, a plurality of relatively light-weight easily collapsible individual plates respectively resting freely upon the upper edges of the flanges of adjacent ones of said channel-shaped members for closing the top of said pontoon between said channel-shaped members and for draining to said deck precipitation that would otherwise fall into said pontoon, said plates being constructed and arranged to collapse inwardly into said pontoon upon impact thereon of a shock wave of a heavy explosion occurring exteriorly of the tank, thereby minimizing implosion damage to said pontoon, said upwardly extending flanges of said channel-shaped members supporting said plates in position elevated with respect to the upper edges of said pontoon so as to provide unobstructed openings beneath each of said plates for constant ventilation of the interior of said pontoon to avoid accumulation of explosive vapors therein, and means for loosely and removably anchoring one edge only of each of said plates to said pontoon so that pressure produced by an explosion within said pontoon will cause said plates to pivot upwardly about their respective anchored edges to an open position immediately to relieve said pressure and thereby minimize the damage that would otherwise be produced by said last mentioned explosion.

4. The combination set forth in claim 3, wherein each of said plates is provided along its opposite side edges with downwardly directed flanges adapted to contact with said upwardly extending flanges on said channel-shaped members to retain said plates on said pontoon.

5. The combination set forth in claim 4, wherein said pontoon is annular in shape and constitutes the peripheral portion of said roof, and wherein said channel-shaped members and said plates are arranged radially upon said pontoon.

6. The combination set forth in claim 5, wherein said plates are respectively loosely and removably anchored to said pontoon only at their radially inwardly directed edges.

7. In combination with an upstanding substantially cylindrical tank for inflammable volatile liquids, a floating roof for the tank having improved implosion and explosion damage minimizing qualities, comprising: an annular, hollow, open-boat type pontoon having spaced apart upstanding concentrically arranged inner and outer cylindrical side walls and adapted to float upon the liquid in the tank with said outer side wall of said pontoon disposed radially inwardly of the inner surface of the side of the tank and in spaced relation with respect thereto; a substantially cylindrical metal shoe carried by said pontoon with its outer periphery in intimate sliding engagement with the inner surface of the side of the tank, said shoe throughout its circumference being spaced radially outwardly with respect to said outer side wall of said pontoon to provide a substantially toroidal chamber therebetween; an annular gas impervious seal extending across the interior of said toroidal chamber between said shoe and said outer side wall of said pontoon; a plurality of spaced apart channel-shaped members extending radially across the open top of said pontoon and secured to the

upper edges of said side walls thereof to rigidify said pontoon, each of said channel-shaped members having side flanges thereon and being arranged with said side flanges extending upwardly above the upper edges of said side walls of said pontoon; a plurality of relatively light-weight easily collapsible individual plates respectively resting freely upon the upper edges of the flanges of adjacent ones of said channel-shaped members for closing the top of said pontoon, said plates being constructed and arranged to collapse inwardly into said pontoon upon impact thereon of a shock wave of a heavy explosion occurring exteriorly of the tank, thereby minimizing implosion damage to said pontoon, said upwardly extending flanges of said channel-shaped members supporting said plates in position elevated with respect to the upper edges of said pontoon so as to provide unobstructed openings beneath each of said plates for constant ventilation of the interior of said pontoon to avoid accumulation of explosive vapors therein; means for loosely and removably anchoring the radially inwardly directed edge only of each of said collapsible plates to said pontoon so that pressure produced by an explosion within said pontoon will cause said plates to pivot upwardly about their respective anchored edges to an open position immediately to relieve said pressure and thereby minimize the damage that might otherwise be produced by said last mentioned explosion; and a plurality of radially arranged overlapping weather plates disposed in side-by-side position for covering said toroidal chamber and said seal therein, said weather plates being pivotally mounted at their outer ends upon said shoe and resting freely at their inner ends upon the upper surfaces of said collapsible plates so that the pressure of an explosion occurring in said toroidal chamber will cause said weather plates to be pivoted upwardly to an open position, the upper interior of said toroidal chamber being constantly vented to the exterior of said tank through said unobstructed openings between said collapsible plates and said upper edges of said side walls of said pontoon.

8. A floating roof for a tank of the liquid storage type having improved implosion and explosion damage minimizing qualities comprising, a hollow, open-boat type relatively rigid pontoon having spaced apart upstanding side walls of relatively heavy gauge metal and adapted to float upon the liquid in the tank so as to occupy a fractional portion of the surface area thereof, a deck secured to said pontoon for covering an additional portion of the surface area of said liquid, a plurality of relatively light-weight thin gauge easily collapsible plates freely resting in side-by-side position transversely across the open top of said pontoon for closing the same and for normally draining to said deck precipitation that would otherwise fall into said pontoon, and means for loosely and removably anchoring said plates to said pontoon to prevent accidental displacement of said plates with respect to said pontoon, said plates being so constructed and arranged as readily to collapse inwardly and downwardly into said pontoon under the impact of a shock wave of a heavy explosion occurring exteriorly of the tank and to be moved upwardly to an open position with respect to said pontoon upon the occurrence of an explosion within said pontoon, thereby minimizing implosion and explosion damage to said pontoon and said roof.

No references cited.