

April 11, 1944.

R. W. DE VORE

2,346,129

ELEVATED TANK

Filed July 26, 1941

4 Sheets-Sheet 1

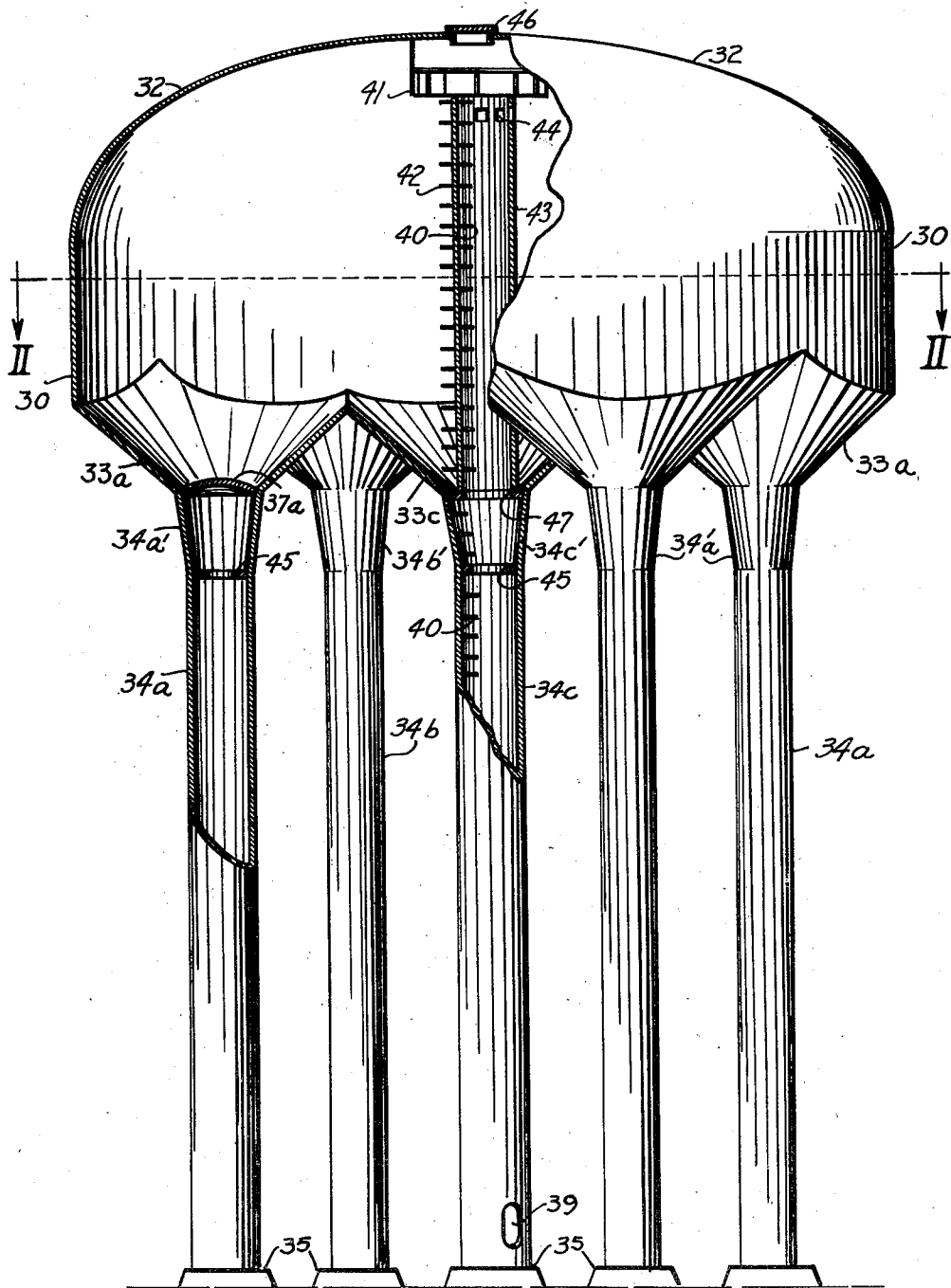


Fig. 1

INVENTOR
Rodney W. DeVore
BY
Green & McCallister
Attorneys

April 11, 1944.

R. W. DE VORE

2,346,129

ELEVATED TANK

Filed July 26, 1941

4 Sheets-Sheet 2

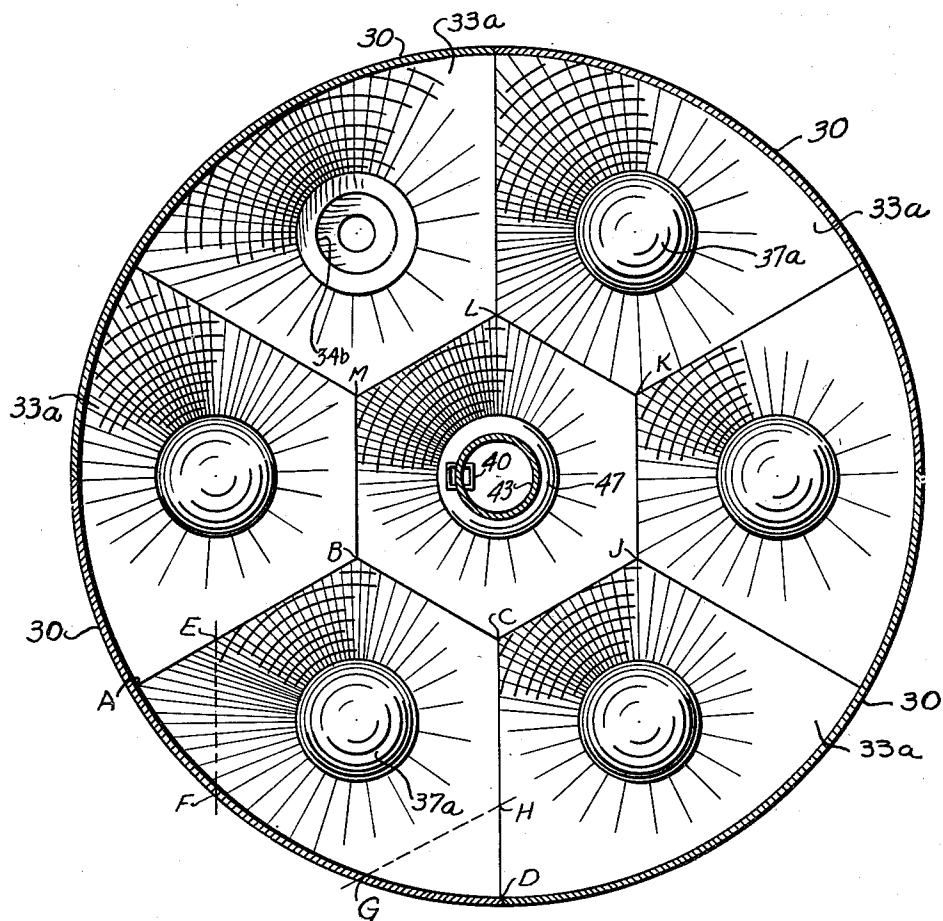


Fig. 2.

INVENTOR
Rodney W. DeVore
BY
Green & McCallister
Attorneys

April 11, 1944.

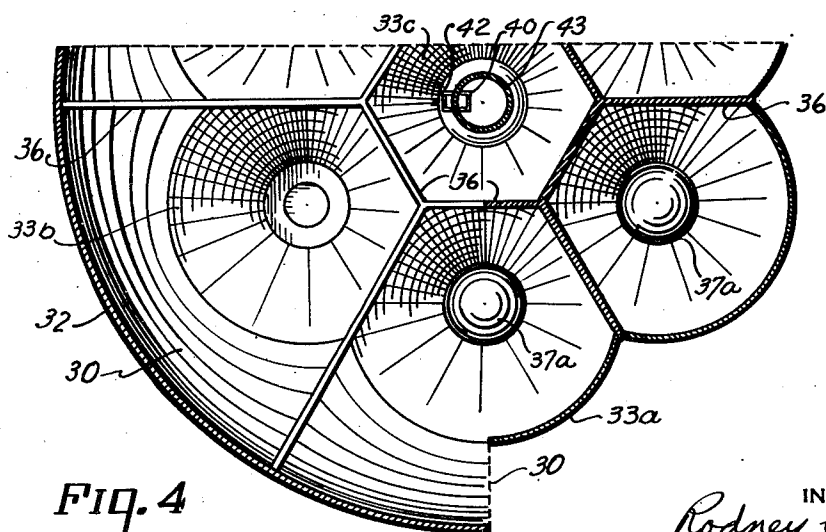
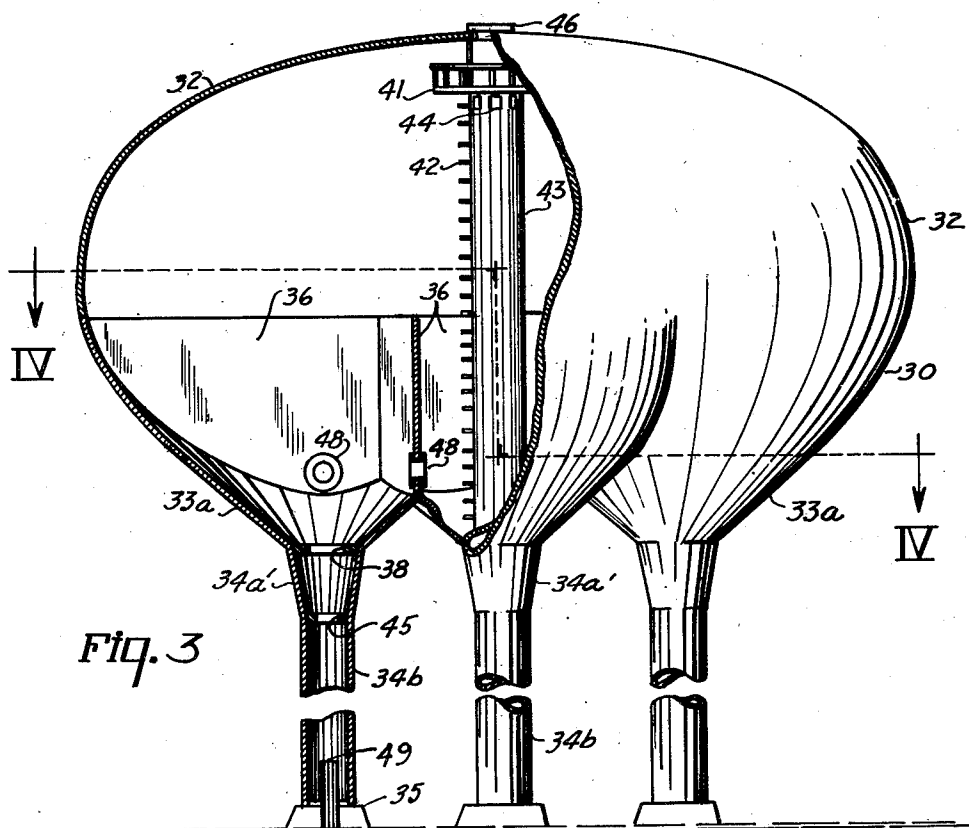
R. W. DE VORE

2,346,129

ELEVATED TANK

Filed July 26, 1941

4 Sheets-Sheet 3



INVENTOR
Rodney W. DeVore
BY
Green & McCallister
Attorneys

April 11, 1944.

R. W. DE VORE

2,346,129

ELEVATED TANK

Filed July 26, 1941

4 Sheets-Sheet 4

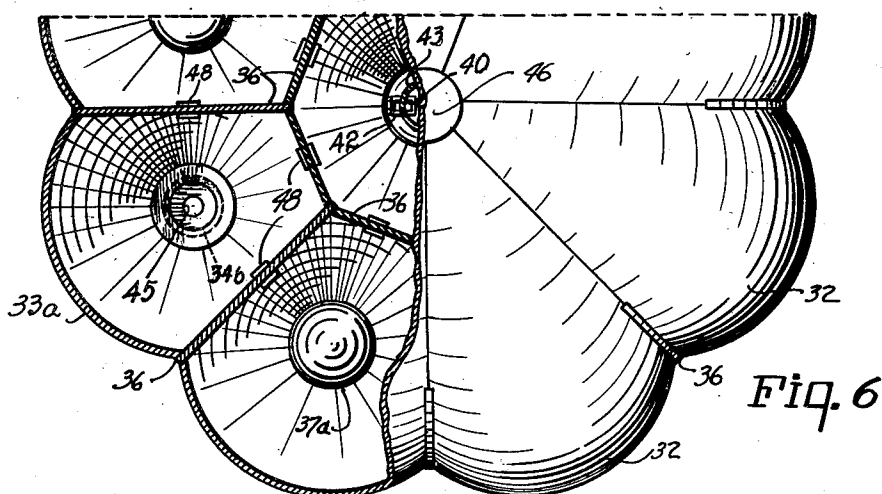


Fig. 6

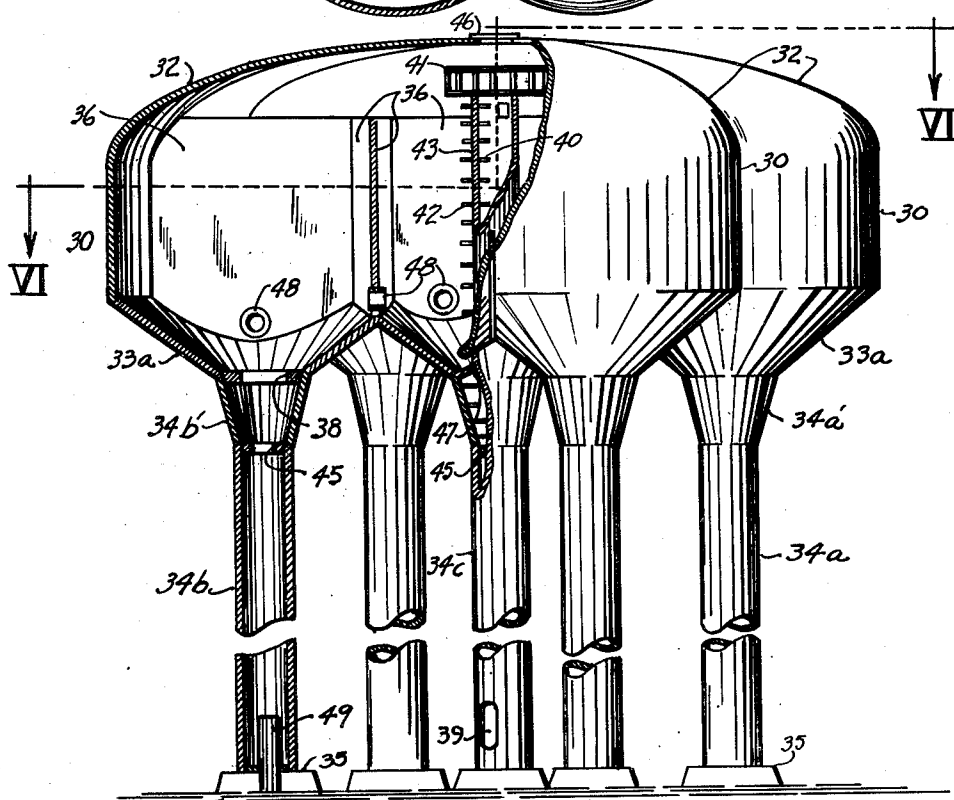


Fig. 5

INVENTOR
Rodney W. DeVore
BY
Green & McCallister
His ATTORNEYS

UNITED STATES PATENT OFFICE

2,346,129

ELEVATED TANK

Rodney W. De Vore, West View, Pa., assignor to
Pittsburgh-Des Moines Company, a corporation
of Pennsylvania

Application July 26, 1941, Serial No. 404,195

10 Claims. (Cl. 220—69)

This invention relates to elevated tanks for the storage of liquids and particularly to tanks of relatively large capacities where it is desirable to have a small range of head, that is, to have a minimum variation between the upper and lower water levels corresponding to a full and an almost empty tank.

Since the weight of the liquid in a tank is supported by the tank bottom, which in turn is held in elevated position by the supporting columns or framework, the construction of the tank bottom is of particular importance. The tank bottom could theoretically be entirely suspended and the tank supported by columns attached to the shell portion of the tank. However, as the diameters of tanks increase, the difficulty and cost of building entirely suspended bottoms also increase, because if the bottom is made to approach the shape of a hemisphere a very large quantity of liquid is contained in the bottom itself which adds to the total weight and cost of the structure, or if the bottom is made more shallow, then, due to the larger radius of curvature the bottom thickness is materially increased, which adds to its weight and cost. It is also obviously uneconomical to transfer the liquid weight for considerable distances laterally into the supporting columns or structure. For the above reasons, large tank bottoms have been made of flat metal sheets supported on a grillage of girders, or girder-supported sag plates or various forms of girder-supported double curved surfaces have been used to overcome the above difficulty.

The primary object of my present invention is to provide a tank bottom and supporting structure which will more economically and more effectively support the weight of the stored liquid than any construction hitherto known.

An additional object of my invention is to provide a tank having a bottom of downwardly sloping sheet metal portions connected to each other and to an upright shell which has a sheet metal roof portion of concavo-convex section secured thereto to form a liquid-tight container of large capacity.

A further object of the invention resides in providing a tank the bottom of which is made up of a number of frusto-conical downwardly tapering portions each of which is supported by a column-like member.

A still further object of the invention is to provide a tank having a plurality of frusto-conical bottom portions each supported by a column-like member and in which at least one such col-

umn-like member is constructed and arranged to give access to the interior of the tank, another to withdraw liquid from such tank and still another is closed by a diaphragm or the like at its upper end.

Other and further objects and advantages reside in the various combinations, sub-combinations and details hereinafter described and claimed and in such other and further matters as will be appreciated by those skilled in this art.

In the accompanying drawings:

Fig. 1 is an elevational view of an elevated tank responding to my invention with parts broken away to disclose the construction thereof;

Fig. 2 is a sectional view taken along the line II—II of Fig. 1 and in the direction of the arrows;

Fig. 3 is an elevational view, partly in section, of a modified form of the invention;

Fig. 4 is a sectional view taken along the line IV—IV of Fig. 3 and in the direction of the arrows;

Fig. 5 is an elevational view, partly in section, of a further modified form of the invention; and

Fig. 6 is a sectional view taken along the line VI—VI of Fig. 5 and in the direction of the arrows.

Similar numerals designate like parts throughout the various views.

Referring now to the drawings in detail, the numeral 30 designates the upright portion of a sheet metal tank shell and is formed of a number of metal sheets attached together in liquid-tight relation, as by welding. The top or roof-like portion 32 of the shell is concavo-convex in section and is also made of metal sheets similarly attached, as by welding. A plurality of downwardly tapering frusto-conical sheet metal shells 33a, 33b and 33c are provided which intersect with each other and with upright shell portion 30 to form a complete bottom for the tank, each such conical shell being formed of metal sheets attached to each other and to the upright portion 30, as by welding. Attached to each of the frusto-conical shells near its lower extremity is a column-like member 34a, 34b or 34c which, in this form of the invention, is a hollow substantially cylindrical tube of sheet metal attached by welding. Members 35 are foundations—usually of concrete—supporting the lower ends of members 34a, 34b and 34c and transmitting the weight of the structure and the stored liquid into the ground.

Column-like members 34a, 34b and 34c have at their upper extremities an outwardly flaring portion 34a', 34b' or 34c' which serves to increase

the diameter of the said column-like members at the point of their connection to frusto-conical shells 33a, 33b and 33c. At the junctions of the column-like members with the flaring portions annular reinforcing members 45 are provided and secured by welding or other suitable attaching medium. At the point of connection an upwardly convexed diaphragm-like member 37a is provided between each column 34a and bottom shell 33a. This upwardly convexed diaphragm serves to prevent the stored liquid from filling the hollow cylindrical column therebelow and also provides a horizontal reaction due to the weight of the water which tends to cancel and, to a certain extent, offset the inward component of force between shells 33a and members 34a due to the angularity of the connection between them. One or more of the columns, e. g., 34b, is so constructed and arranged that the hollow columns may be used as inlet and outlet pipes and these, therefore, have no upwardly convexed diaphragm-like member 37a but instead the forces caused by the angularity of the connection are resisted by a girder ring-like member 38 attached to the outside, as by welding. One or more of the column-like members, e. g. 34c, may be extended to a point above the upper level of liquid where it terminates in a platform 41 and may be provided with vent holes 44. Steps 40 on the interior of this column lead from doorway 39 near the base to the top platform 41 which is accessible to exterior steps 42 leading to the tank bottom. Girder ring-like member 47 is provided to resist the inward stresses at the point of connection between column 34c and shell 33c. In Fig. 2 the lines AB, BC, CD, etc., indicate the intersections between the bottom shells and at which welding or seaming is effected to provide a liquid-tight bottom.

In Figs. 3 and 4 the upright portion 30 extends downwardly and inwardly in curved form to intersect the frusto-conical bottom portions 33a and 33b. In these figures the numerals 36 indicate sheet metal diaphragm-like members which are disposed in the vertical planes of intersection of the various conical surfaces and which extend from such intersection approximately to the elevation of the portion of the upright shell 30 of largest diameter, i. e., the equatorial portion thereof.

In Figs. 5 and 6, which illustrate a further modified form of construction, the upright portion 30 of the tank shell, instead of being a surface of revolution, is formed of a number of curved sheet metal surfaces, which are substantially coaxial with the bottom shell portions 33a. The top portion 32' connects thereto and has a generally scalloped configuration to conform with and intersect the upright shell portions 30. Otherwise the structure is the same as previously described, as will be understood by the use of like numerals.

Referring to Fig. 1 it is apparent that the weight of water above each of the frusto-conical portions of the bottom is supported by that portion, and that the load imposed on each such portion is transmitted to the column-like members and thence to the foundations.

From Fig. 2 it will be apparent that a frusto-conical bottom portion 33a supports the entire weight of the liquid above the section of the tank included between vertical planes delimited by the lines AB, BC, CD and that portion of the upright shell included between the planes AB and CD. The other similar portions 33a likewise support similar volumes and weights of liquid. In the bottom portion 33b the weight of a small cylinder of

water equal to the inside diameter of column-like member 34b will be transmitted directly to the concrete foundations supporting column 34b. Bottom portion 33c supports the weight of all of the liquid between it and the top surface of the liquid in the tank bounded by vertical planes delimited by the lines B—C, C—J, J—K, K—L, L—M and M—B. It is, therefore, clear that the entire weight of the liquid in the tank is divided and is supported by the various bottom portions.

Considering the left front bottom portion 33a of Fig. 2, it is apparent that the weight of liquid on the areas bounded by the lines AEFA and GHDG causes an eccentric loading on said bottom portion. This additional weight produces an eccentric loading on the said conical surfaces, which requires either an increase in the thickness of the metal thereof to compensate for such eccentricity, the use of girder-like members to distribute such loads more uniformly over the said surfaces or the use of diaphragm-like members to offset and equalize the eccentric forces.

It is not necessary in all cases to make special provision for this eccentricity since, if the juncture between bottom portions 33 and the upright portion 30 of the tank shell is made double curved, the additional stiffening effect of the double-curved surfaces may be made to be sufficient to properly distribute the loads over the surfaces in question. This construction is illustrated in Fig. 4.

In designing my new tank I have found it most economical to make the angle of the frusto-conical surfaces with the horizontal between 30° and 60°, although flatter or more upright cones would function properly, but would be excessive in cost. In accordance with my invention each supporting column is substantially vertically under the center of gravity of the liquid supported by that column; thus it is apparent that a minimum weight and cost of structure will have to be provided to transfer the weight of the liquid from each bottom portion into the subjacent column for it is not necessary to transfer such weight laterally by means of girders, etc. The frustocone is in itself a very efficient member for the transmission of compressive forces, for the circular disposition of the metal tends to brace it and to prevent buckling.

At the juncture of each bottom portion 33a and column 34a I provide a diaphragm 37a which resists the horizontal components of the compressions in the conical surfaces and also seals the tops of the columns so that the liquid can not enter them. In at least one of the columns, for example, 34b, Fig. 2, I omit diaphragm 37 and reinforce the connection by means of external circular reinforcing ring 38. Such a column provides a connection to the ground for the water inlet and outlet. In another of the columns 34c, Fig. 1, I provide a tubular vertical extension 43 which rises to a plane above the normal upper water level and, as previously explained, I provide an access door 39 near the ground level. A flight of ladder steps 40 leads to the top of the tube 43 where it terminates in a circular platform 41 connecting to ladder 42, thus providing access to the interior of the tank. Manhole or hatch 46 is provided in the roof-like portion 32 so that access can be had from platform 41 to the exterior of the tank.

Further reference to Figs. 3 and 4 will show that this form of tank is more streamlined in its contours and that the bottom frusto-cones are curved at their upper extremities and warped or

bent so that they are caused to merge smoothly with upright shell portion 30 at about the elevation of the highest point of intersection between adjacent cone portions 33. Sheet metal diaphragm-like members 36 are provided to resist more effectively the eccentric load on the conical surfaces. These diaphragms essentially tie opposite sides of the tank together and, therefore, act in tension to prevent the inwardly intersecting substantially conical surfaces from failing by expanding outwardly.

In Figs. 5 and 6 it will be noted that shell portions 30 and 32 have a scalloped outline or margin so that they intersect smoothly with the bottom conical portions 33. Sheet metal diaphragm-like members 36 are also provided in this form to tie opposite sides of the tank together to prevent the inwardly intersecting surfaces from being pushed outwardly by the weight of the contained liquid. This form of my invention is very economical in its use of metal because, due to the smaller radius of curvature of the sheet metal shell portions, the thicknesses may be proportionately reduced.

The foregoing is intended as illustrative and not as restrictive and, within the terms and scope of the appended claims, I may make other and further additions, omissions, substitutions and modifications without departing from my invention.

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

1. An elevated tank comprising column-like supporting members, a composite bottom portion and an upper portion comprising a shell disposed about a vertical axis; said composite bottom portion comprising inverted conical shells, one of which has its axis coincident with said vertical axis extended, and the others of which are disposed symmetrically about said vertical axis extended; the lower edges of all said conical shells being attached to and supported by said column-like members; said conical shells being extended upwardly to intersect adjoining conical shells; said upper portion being extended downwardly to connect with the upper edges of said conical sections.

2. An elevated tank comprising column-like supporting members, a composite bottom portion and an upper portion comprising a number of partially cylindrical, intersecting shell segments arranged about a vertical axis; said composite bottom portion comprising inverted conical shells one of which has its axis coincident with the said vertical axis extended and the others of which are disposed circumferentially about said vertical axis extended; the lower edges of all said conical shells being attached to and supported by said column-like members, said conical shells being extended upwardly to intersect all adjoining conical shells in vertical planes, and vertical partition-like members of substantial depth with their lower edges terminating along said intersections and their outer edges extending to intersect said upper portion which is extended downwardly and inwardly to connect smoothly to said conical shells and which intersects and is attached to extended portions of said partition-like members.

3. An elevated tank comprising column-like supporting members, a composite bottom portion, an upright shell portion and a roof portion secured to said shell portion; said composite bottom portion comprising a number of inverted frusto-conical shells each supported around its lower

edge by one of said column-like members; said inverted frusto-conical shells extending upwardly until they intersect one another, with those portions thereof lying adjacent to said upright shell portion extending upwardly to intersect such shell portion, and forming a continuous liquid-tight composite bottom portion.

4. An elevated metal tank comprising a partially compound curved body portion which has a materially greater diameter than height, a roof portion joined to the body portion, a bottom portion joined to the body portion and composed of a number of inverted frusto-conical sections symmetrically arranged about the extended vertical axis of the body portion in intersecting relation, vertically extending sheet metal members connected to and extending radially inward from the body portion and above and in alignment with the planes of intersection of said frusto-conical bottom sections, a number of vertically extending sheet metal members which connect the inner edges of said radially extending members and which are so constructed and arranged as to form a central symmetrical compartment, and a vertically extending column-like member supporting each of said bottom sections.

5. An elevated tank comprising a body portion made up of intersecting partially cylindrical sections, a roof portion joined to the body portion, a bottom portion joined to the body portion and composed of a number of inverted frusto-conical sections secured to the lower edges of said body sections and arranged in intersecting relation, vertically extending sheet metal members connected to and extending radially inward from the intersections of said body sections and above and in alignment with the planes of such intersections and the intersections of such frusto-conical bottom sections, a number of vertically extending sheet metal members which connect the inner edges of said radially extending members and which are so constructed and arranged as to form a central symmetrical compartment, and a vertically extending column-like member supporting each of said bottom sections.

6. An elevated tank comprising column-like supporting members, a composite bottom portion, an upright cylindrical shell portion and a roof portion attached to the cylindrical shell portion, said composite bottom portion comprising a plurality of inverted conical shells circumferentially spaced around the extended vertical axis of said cylindrical shell portion, and one inverted conical shell whose axis coincides with the extended vertical axis of said cylindrical shell portion; said inverted conical shells being supported at their lower edges by said column-like supporting members; said inverted conical shells extending upwardly to intersect with one another, with portions thereof extending upwardly to intersect with said upright cylindrical shell portion to form a continuous liquid-tight composite bottom.

7. An elevated tank comprising column-like supporting members, a composite bottom portion, an upright shell portion and a roof portion secured to the shell portion; said composite bottom portion being formed of a number of inverted frusto-conical shells which completely cover the bottom of the tank and each of which is supported around its lower edge by one of said column-like members; said inverted frusto-conical shells being extended upwardly to form intersections with adjacent frusto-conical shells, and with the portions thereof lying adjacent to said upright

shell portion extending upwardly to form intersections therewith.

8. An elevated tank comprising column-like supporting members, a composite bottom portion and an upper portion comprising a shell disposed about a vertical axis; said composite bottom portion comprising inverted conical shells one of which has its axis coincident with said vertical axis extended, and the others of which are disposed circumferentially about said vertical axis extended; the lower edges of all said conical shells being attached to and supported by said column-like members; said conical shells being extended upwardly to intersect all adjoining conical shells in vertical planes, and vertical partition-like members of substantial depth, with their lower edges terminating along said intersections and their outer edges extending to intersect said upper portion which is extended downwardly and inwardly to connect smoothly to said conical shells and which intersects and is attached to extended portions of said partition-like members.

9. An elevated metal tank comprising a bottom formed of a plurality of intersecting inverted

truncated cones, a roof member common to all the cones, a supporting post extending downwardly from each of the truncated vertices, a side wall extending between the roof and bottom and comprising a plurality of intersecting cylindrical segments arranged symmetrically around the vertical axis of the tank and each having a center of curvature substantially in the projected axis of one of said truncated cones; and vertical diaphragms above the lines of intersection of truncated cones adjacent the side wall interconnecting said cones and said side wall segments.

10. An elevated metal tank comprising a bottom formed of a plurality of intersecting inverted truncated cones, a roof member common to all the cones, a supporting post extending downwardly from each of the truncated vertices, a side wall extending between the roof and bottom and comprising a plurality of intersecting cylindrical segments arranged symmetrically around the vertical axis of the tank and each having a center of curvature substantially in the projected axis of one of said truncated cones.

RODNEY W. DE VORE.