May 30, 1961 E. G. PAULET 2,986,302

SELF-ADJUSTING FLOATING ROOF FOR STORAGE RESERVOIRS

Filed March 3, 1959 3 Sheets-Sheet 1

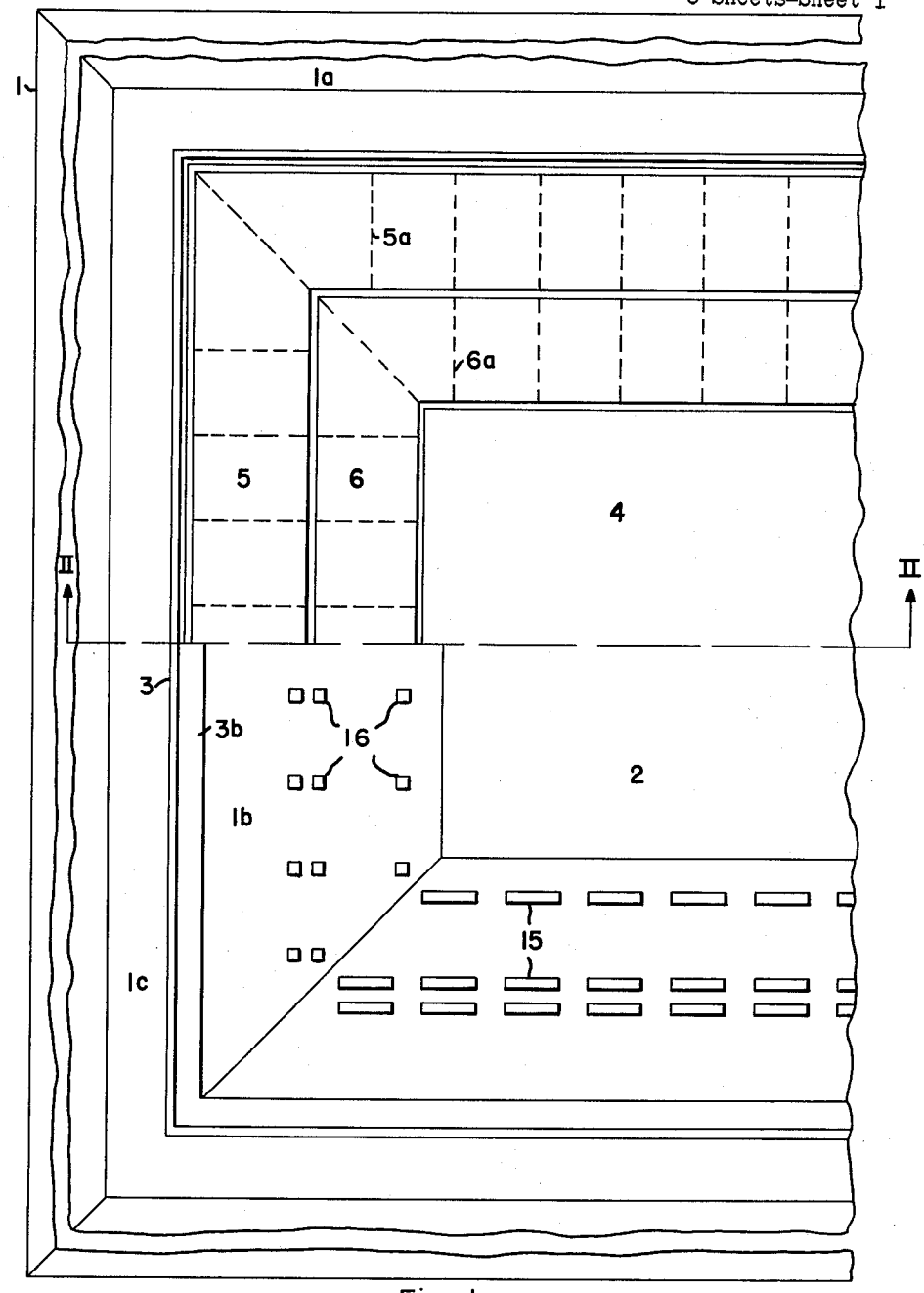


Fig.-1

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Filed March 3, 1959 3 Sheets-Sheet 2

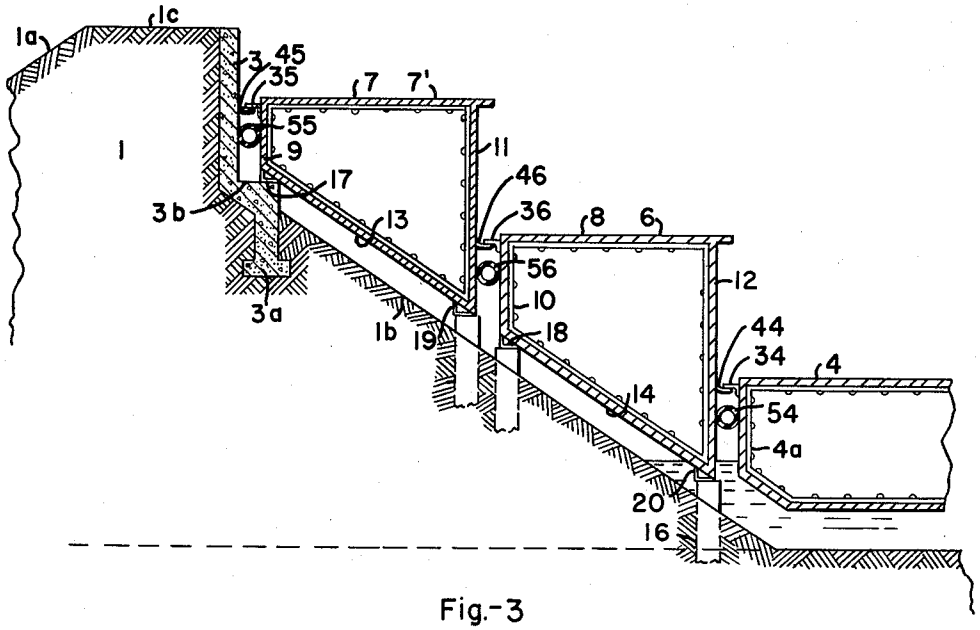


Fig.-3

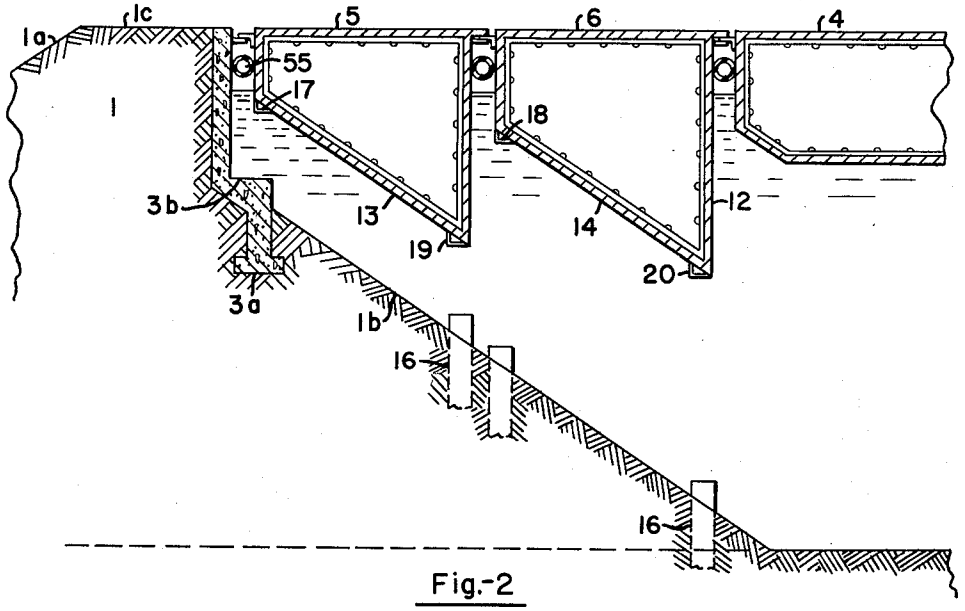


Fig.-2

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Filed March 3, 1959 3 Sheets-Sheet 3

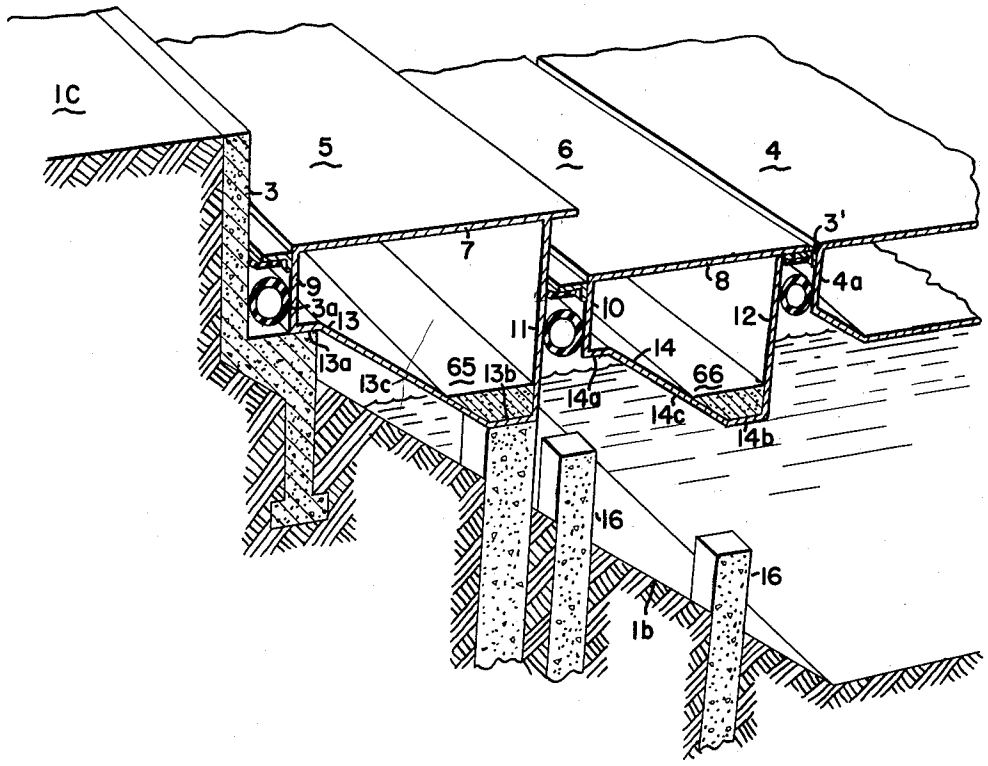


Fig.-4

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United States Patent Office 2,986,302
Patented May 30, 1961

2,986,302

SELF-ADJUSTING FLOATING ROOF FOR STORAGE RESERVOIRS

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Filed Mar. 3, 1959, Ser. No. 796,884

8 Claims. (Cl. 220—26)

The present invention relates to a floating roof structure, and particularly to a floating roof structure adapted for employment in storage reservoirs having banked walls wherein the inner wall surfaces are sloped downwardly and inwardly.

Such reservoir structures are commonly employed for field storage, and may be constructed of tamped earth with or without surface coating. In cross section the reservoir walls have the general contour of an isosceles trapezoid wherein the base and top are parallel and the inner and outer wall portions are inclined toward the top in substantially equiangular relation thereto. A conventional floating roof may not be employed in such a reservoir structure, due to the fact that as the liquid level in the reservoir is reduced, the exposed surface area of the liquid is also reduced, and a roof adapted substantially to cover the entire liquid surface with the reservoir filled, would be "grounded" along its peripheral edge on the sloped reservoir wall surfaces as the level of liquid in the reservoir was reduced. Unless a floating roof structure may be buoyantly supported at all times, by the liquid it covers, it loses its effectiveness in the service for which designed.

The present invention relates to a floating roof structure particularly adapted for employment in a reservoir having sloped walls wherein the roof is adapted substantially to conform its effective peripheral edge to the contour of the reservoir inner wall surface, and to maintain a buoyantly supported relationship to the upper surface area of the liquid contents. More particularly, the invention relates to a sectional floating roof wherein a principal portion of the roof is composed of substantially uniform elements disposed so as to form a series of substantially annular, concentric sections, and a center section substantially matching the conformation of the bottom wall of the reservoir.

It is an object of the present invention to provide a sectional floating roof structure adapted to conform itself to the wall surfaces of a sloped wall reservoir. It is a further object of the invention to provide a floating roof structure wherein the roof is substantially composed of a series of telescopically related, concentric, annulus sections adapted for common buoyant support when immersed in a liquid contained by a reservoir of the character described.

The invention and its objects may be more fully understood from the following description when it is read in conjunction with the accompanying drawings, wherein:

Fig. 1 is a plan view of one half section of a reservoir and roof of the character contemplated, with a portion of the roof cut away to provide a representative showing of support means for the roof according to the present invention;

Fig. 2 is a vertical section taken along the line II—II of Fig. 1 with the reservoir filled substantially to capacity, and the roof structure buoyantly supported in its full floating position;

Fig. 3 is a similar section with the reservoir in a substantially drained condition, and only the roof center section buoyantly supported by the liquid contents remaining in the reservoir; and

Fig. 4 is an enlarged perspective view of a section through three adjoining roof portions, further showing their cooperative relationships, and a typical arrangement for establishing a sealing relationship between roof sections.

In the drawings, the numeral 1 designates a banked wall reservoir for liquids having inner and outer wall surface portions 1*a* and 1*b*, respectively, sloped upwardly from a base to a crest surface portion 1*c* disposed substantially in a plane parallel to the base. As shown, the base is indicated by a dotted line. By suitable disposition of the wall portions, the lower edge of the inner wall surfaces defines a bottom 2 for the reservoir having a peripheral conformation similar to that defined by the upper edge of the inner wall surface portions, wherein the bottom area is substantially concentric with the area defined by the upper edge of the inner wall surface portions. Although in the representation of Figure 1 the reservoir contemplated would be either square or rectangular, and the respectively defined areas of similar conformation, it is contemplated that any desired reservoir shape may be employed without limitation other than that imposed by good engineering practice. In ordinary circumstances, symmetrical shapes including circular, triangular, square, rectangular and the like will be found to be most desirable. Likewise the slope of the inner wall surface portions primarily will be determined by the nature of the materials employed for its construction. In any event, the present invention contemplates an inner wall surface which is related to the reservoir bottom 2 at an angle greater than 90°. Tamped earth walls with a surface finish substantially impervious to the liquid to be contained affords a suitable example of the structural materials contemplated.

In the reservoir structure illustrated by the drawings, the numeral 3 designates an upstanding, vertically disposed, crest wall having a footing portion 3*a* embedded in the inner wall substantially as shown in Figures 2, 3 and 4, and a roof unit support surface designated by the numeral 3*b*. Normally, the angular relationship between the crest wall and the inner wall surface portion will be substantially the same as that between the inner wall surface portion and the bottom of the reservoir, to provide an upstanding wall perpendicular to a horizontal plane through the reservoir. Concrete is a preferred construction material for the crest wall, with or without an applied metal surfacing material for the inner face thereof.

In a reservoir structure substantially as described, provision of a cover or roof is frequently desirable to avoid evaporation or contamination of the liquid which may be stored therein. A fixed roof for a reservoir of this type is unsatisfactory due to the need for an excessive amount of supporting structure. The use of conventional floating roof structures is inhibited by the sloped inner wall surfaces which interfere with the normal rise and fall of such a roof. As shown in the drawings, the interference of the sloped inner wall surfaces is overcome by sectionalization, and by conforming the bottom wall of the roof sections to the angle of inclination of the inner wall surfaces.

In Figure 1 a roof is illustrated which has a center portion 4 and a border portion, including two units 5 and 6 which encompass the center portion substantially as concentric annuli. Dependent upon the dimension of the reservoir, one or more units may provide the roof border portion. Although each unit may be composed of a number of sections, in the finished roof these sections preferably will be joined in permanent relationship. In any event, each unit as well as the center portion preferably should be constructed so as to provide an internal

series of individual liquid-tight compartments. In Figure 1 some of the compartment walls are shown by dotted lines and designated by the numerals 5*a* and 6*a*, respectively. In Figures 2 and 3 the numerals 7, 9, 11, and 13 designate, in order, the top-outerside wall, inner side wall, and bottom of the unit 5, while the numerals 8, 10, 12 and 14 respectively designate similar parts of the unit 6.

In order that the border roof portions may be supported in spaced relation to the inner wall surface at such times as the level of the reservoir contents may be reduced to such extent as to deny buoyant support for these portions, rigid supports are provided to engage exterior support-engaging surfaces on the bottom wall of the respective units. In Figure 1, two forms of such supports are shown. The one form, designated by the numeral 15 is a curb-like support. This form may be continuous, or it may be interrupted at intervals. The other form comprises a spaced series of posts or spiles 16. In either form, the supports are arranged in rows parallel to each other and to the upper and lower peripheral edges of the reservoir inner wall surface portions. In either the form of curbing, or the form of spiles, the support members are disposed in a step-like arrangement substantially as illustrated by Figures 2, 3, and 4, and the bottom wall surfaces of the border portion roof sections are provided with a matching conformation to provide support-engaging surface portions. For each unit the supports are disposed in paired rows wherein the uppermost row in each pair is adapted to support a unit at the outer peripheral edge of the bottom wall thereof, while the lowermost row in each pair is adapted to support that unit at the inner peripheral edge thereof. The support surface 3*a* provided by the crest wall 3 takes the place of the uppermost row of supports in the first pair of support rows.

In order to provide a firm engagement between the units and their respective supports, and to avoid slippage or displacement of the units in a plane parallel to the reservoir inner wall surface, the upper end surfaces of the support members are disposed in a horizontal plane common to all members of a given row. From row to row these planes of reference are spaced vertically so as substantially to locate the downslope and upslope peripheral edges of each support in planes parallel to the reservoir inner wall surface. From row to row in each pair of rows, the support members are disposed in horizontally spaced relation at a distance substantially equal to the width of the unit which they are to support. The respective units forming the roof border portion also are provided with support-engaging surfaces, on or in their bottom walls, which are disposed in horizontal planes spaced vertically to match the corresponding spacing of the opposing support surfaces.

As shown in Figs. 2 and 3, the support-engaging surfaces are provided by means of angular bar elements such as the elements 17 and 19 designated on the unit 5, or those designated by the numerals 18 and 20 on the unit 6. These elements are attached to the respective bottom wall portions 13 and 14, along their peripheral edges, with one angle side aligned with a unit side wall and the other parallel to the top wall. The latter side provides an under surface which is contiguous to and substantially at right angles to an adjacent unit side wall. The side walls of each unit differ in their vertical dimensions by a distance substantially equal to the vertical distance between the horizontal planes common to the support surfaces of the respective support rows in any pair.

In the structural form illustrated by Fig. 4, the support-engaging surfaces of the border portion units are provided by shaping the unit bottom walls 13 and 14 to form opposite peripheral edge portions 13*a* and 13*b*, and 14*a* and 14*b*, wherein the edge portions 13*a* and 14*a*, and 13*b* and 14*b* are inclined downwardly and upwardly respectively relative to the intermediate wall portions 13*c* and 14*c*, and at an angle substantially equal to the angle formed between the reservoir inner wall surface and the bottom thereof.

Although the support-engaging surfaces which may be provided are shown as two separate forms, separately employed, it is intended that these forms may be employed in combination. For example, either of the upper or lower support-engaging surfaces such as 13*a* and 14*a*, and 13*b* and 14*b*, may provide one surface while the angle elements such as 17 and 18, and 19 and 20, may provide the other. Also, the use of other forms of added step or foot portions such as the angle elements 17, 18, 19, and 20, which provide support-engaging surfaces of the character set forth, are contemplated according to the present invention.

As noted above, and shown in Figs. 2, 3 and 4 the several roof units, including the center portion 4, and the border portion units, such as 5 and 6, are disposed and adapted for reciprocal, telescopic movement relative to each other and to the crest wall 3. To permit such movement, the several units or portions are spaced so as to avoid frictional contact between their side walls, and the spaces are sealed by means generally conventional in floating roof structures. A typical seal is illustrated in Figs. 2, 3, and 4, as is also means for preventing the inner units from overriding the outer units due to any relative change in buoyancy.

In the structure as contemplated, the outer side wall of each unit, including the center roof portion, is provided with a lip extension at right angles thereto. For the purpose of distinguishing these extension parts, they are individually designated by the numerals 35, 36, and 34, and in that order are mounted on the outer side walls of the units 5, 6, and the center roof portion 4, respectively. As shown, the respective lip extensions are formed by means of angle iron strips attached to each side wall 9 and 10 of the units 5 and 6, and to all four side walls 4*a* of the center portion 4, one side of the angle forming a means of attachment, as by welding or riveting, and the other side forming the lip extension. The attachment is made so that lip extension is just below the upper edge of the sidewall and/or the top wall of the pontoon unit. The length of the lip extension is determined at somewhat less than the predetermined spacing of one unit from another, and in accordance with conventional practice for the spacing of floating roof structures from a related wall surface.

Immediately below the lip extension element, and preferably secured in contact with the undersurface thereof is a wiper blade element. This element is preferably of a resilient, flexible material having a width greater than the separation space between roof units. It functions as a sealing member between units, and also to inhibit the development of liquid films on the side wall surfaces which may be exposed by telescopic movement of the roof units, as well as to prevent direct access of rain or snow to the interunit space. In the drawings, the wiper blade elements are designated by the numerals 45, 46, and 44 as applied respectively to the units 5, 6, and the center portion 4.

A second seal means, which also functions as a buffer between roof portions, also is disposed in the interunit spaces. As shown, this buffer seal is tubular member of a resilient, flexible material, having an outer diameter not less than the space between units. As shown in each space, the buffer seal is located just below the wiper blade and is attached to the adjacent side wall portions 9, 10, and 4*a*. Other means and places of attachment, and other seal means of similar nature may be employed as may be desired or indicated. In the drawings, the buffer seals are designated by the numerals 55, 56, and 54 with reference to the units 5, 6, and center portion 4.

The top wall of each border roof portion such as the top walls 7 and 8 of units 5 and 6, respectively, is provided to overlap the side walls 10 and 11, respectively.

This overlap or extension of the top wall is of a width less than the predetermined space between units, and is designed to shield the wiper blade on the adjoining unit when the roof is in a full floating position. Contact between the lip extension on one unit with the top wall extension on another unit also prevents any possible overriding of one unit respective to another.

Although when the individual roof portions or units are rigidly assembled, the shape of individual pontoon sections will not appreciably affect the center of buoyancy of the whole unit, it may be desirable to at least partially relieve the unbalance which would be typical of any particular section having a cross-sectional shape such as required to match the slope of the reservoir walls. For this purpose, ballast may be added if desired. In the drawings, such ballast is indicated as sand, and designated in the respective border roof portion units by the numerals **65** and **66**.

Operation of the roof is evident from a comparison of Figs. 2, 3 and 4. As the level of liquid in the reservoir is reduced, each unit loses buoyant support in turn, beginning with the outermost unit **5**. As the level of liquid in the reservoir is raised, the units regain buoyancy in a reverse succession beginning with the center portion **4**. At all times, however, the surface of any liquid remaining in the reservoir is substantially covered by buoyantly supported roof portions, and a substantially fluid-tight seal is maintained between the adjoining portions, and also the crest wall of the reservoir.

What is claimed is:

1. A floating roof for a storage reservoir having a bottom, a lower inner wall surface sloping upwardly and outwardly from said bottom and an upper inner wall surface extending vertically from said lower inner wall surface toward a crest which comprises a buoyant center section substantially conforming in lateral dimensions and contour to said reservoir bottom; a bouyant border section positioned above said lower inner wall surface, said border section having a lateral dimension substantially equal to the horizontal distance between the base of said lower inner wall surface and said upper inner wall surface and having a lower surface substantially conforming to said lower inner wall surface; sealing means between said center section, said border section and said upper inner wall surface of a character to permit vertical movement of said center and border sections independently of one another; and means on the lower surface of said border section for seating said border section upon the lower inner wall surface of said reservoir.

2. A floating roof as defined by claim 1 wherein said border section comprises a plurality of buoyant units of

substantially equal lateral dimensions and each unit is vertically movable with respect to each adjacent unit.

3. A floating roof as defined by claim 1 wherein the lower surface of said border section has a contour which substantially matches the contour of said lower inner wall surface.

4. A floating roof as defined by claim 1 wherein said means for seating said border section comprises a stepped area on the lower surface of said border section substantially conforming in dimensions and contour to a stepped area extending from said lower inner wall surface.

5. A floating roof as defined by claim 1 wherein said border section comprises at least one hollow pontoon structure and said means for seating said border section comprises a stepped area formed integrally with the lower surface of said pontoon structure.

6. A floating roof as defined by claim 1 wherein said sealing means comprises a resilient wiper element having a width greater than the distance separating adjacent sections of said roof.

7. A reservoir for storing liquids comprising in combination a substantially horizontal bottom; a continuous wall surrounding said bottom, said wall having a vertical section at the upper edge thereof and an inclined section which slopes inwardly from a juncture with said vertical section to a juncture with said bottom; a plurality of supports embedded at spaced points in the inclined section of said wall; a bouyant center roof section conforming in dimensions and contour to said bottom; a bouyant border roof section interposed between said center roof section and the vertical section of said wall, said border roof section being movable in a vertical direction independently of said center roof section and the lower surface of said border section being provided with stepped areas for seating said border section in a substantially horizontal position upon said supports; and resilient sealing elements between said border roof section and the vertical section of said wall and between said border roof section and said center roof section.

8. A reservoir as defined by claim 7 wherein said border roof section is provided with ballast in the lower portion thereof.

References Cited in the file of this patent

UNITED STATES PATENTS

1,734,623	Griffin	Nov. 5, 1929
1,902,108	Twogood	Mar. 21, 1933
1,909,484	Bjerregaard	May 16, 1933
2,006,505	Lentschewsky	July 2, 1935
2,735,574	Williams	Feb. 21, 1956