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2,403,604

STORAGE TANK FOR OILS AND OTHER LIQUIDS

Original Filed April 16, 1940

Fig. 1.

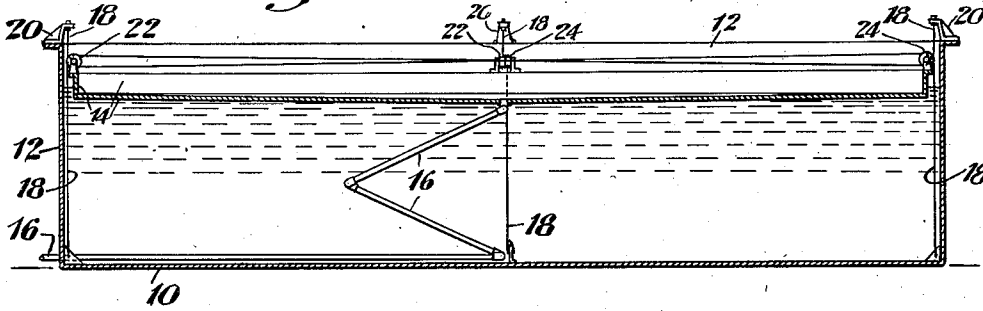


Fig. 2.

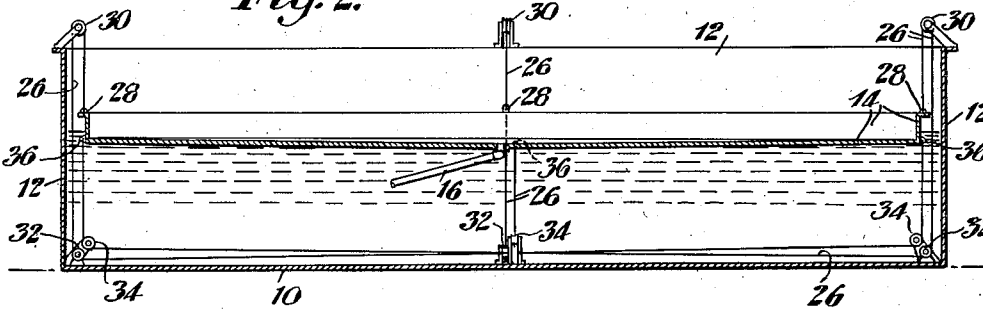


Fig. 3.

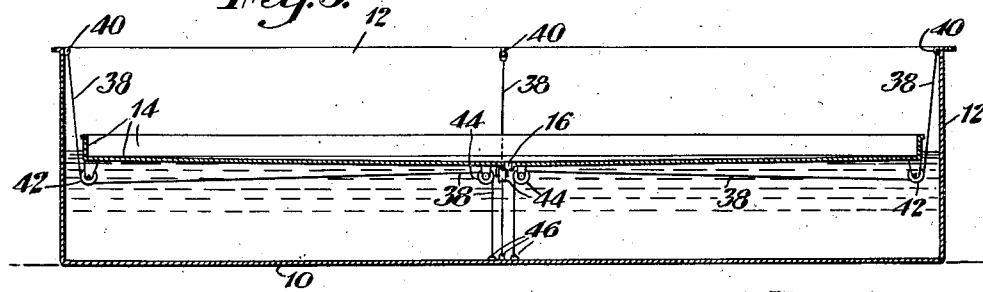


Fig. 4.

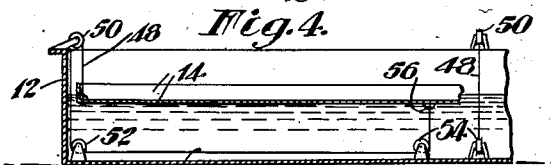


Fig. 5.

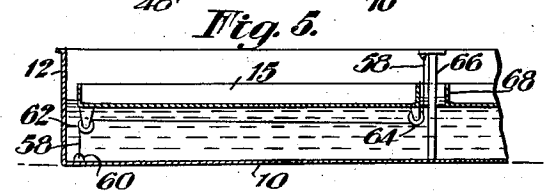
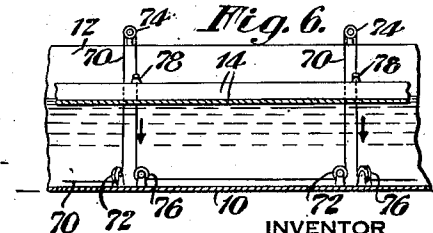


Fig. 6.



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# UNITED STATES PATENT OFFICE

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## STORAGE TANK FOR OILS AND OTHER LIQUIDS

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Continuation of application Serial No. 329,875,  
April 16, 1940. This application May 1, 1943,  
Serial No. 485,310

2 Claims. (Cl. 220—26)

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This invention relates to improvements in apparatus for storing or holding volatile liquids, and more particularly to improvements in means for controlling the operation of floating decks in tanks to prevent such decks from tipping and upsetting and then sinking.

This application is a continuation of pending application Serial No. 329,875, filed April 16, 1940.

Various types of floating roofs, covers or decks have been used in oil storage tanks for reducing the evaporation of the volatile components of the oil, but considerable difficulty and loss has been caused by the sinking and destruction of such decks. Since these decks are normally supported at all points by the oil on which they float, relatively thin sheet steel is employed in their construction. Under usual conditions no great safety factor is necessary to insure rigidity of the structure, but the formation of ice, collection of snow, dust and dirt on one side of a deck is sufficient to cause a deck to tip or tilt, fill with oil and sink. Sometimes one side of the deck will stick to the side of the tank, because of ice or other causes, and sink, with serious consequences.

In the construction of oil tanks of the type illustrated, it is customary to make the rigid portion of the deck considerably smaller in diameter than the normal diameter of the tank. Any slight unequal settlement of the foundation tends to throw the tank out of round, and wind pressure frequently has the same effect. Furthermore, it is customary practice to lap the sheets to form the circumferential seams with the sheet above inside the sheet below, making the top of the tank somewhat smaller in diameter than the bottom. For these and other reasons the diameter of the rigid portion of the deck may be 18" or so less than the diameter of the tank itself; smaller clearance may be used for smaller tanks. The unequal or varying clearances resulting from these conditions makes it impracticable to utilize the walls of the tank as an effective and satisfactory guide for maintaining the deck in a constantly level position in the event of its encountering any obstruction such as ice formation, or any binding action such as might be caused by unequal foundation settlement. Pontoons and sealed-in floats have been used in connection with floating decks in attempts to prevent tipping, but they are very expensive and difficult to make and keep air and liquid-tight.

The primary object of the present invention is therefore to provide other and less expensive means for preventing the tipping and upsetting

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of floating decks in liquid storage tanks, in which the decks are entirely supported by the liquid.

Another object of the invention is to provide positive means for keeping floating decks in a substantially horizontal position on the liquid on which they float, while at the same time allowing such decks to move freely up and down with the level of the liquid.

Accordingly, the improvements of the present invention for preventing the tipping of a floating deck in a storage or other tank for liquids comprise a cable or a plurality of flexible substantially taut metal cables attached to the deck and tank at distributed positions with the ends or selected portion of each cable fixed at predetermined points and with other portions of each cable held in movable relation to the other points by means of sheaves which are fixed to the apparatus at said other points and on which portions of such cable moves, each cable being attached to said deck at two substantially spaced points and arranged to prevent one of said last mentioned points from changing its vertical position in at least one direction with respect to the other point.

The present invention is based on the well-known principle of securing parallel motion by means of rope or other flexible lines arranged to transmit simultaneous and concordant motion to two or more points or parts of an apparatus. The principle has been applied to drawing board instruments and by Pease and Gadd in 1890 to water-sealed bell gas holders, Patent Nos. 435,186 and 433,463. Some 42 years later Pease again applied the principle to the piston of a dry gas holder (Patent No. 2,050,459). This was about two years after applicant had applied it to the same purpose (Patent No. 1,894,535). This invention makes use of the principle in connection with metal cables to prevent the tipping of flat decks which normally float on the liquid in oil storage tanks and the like.

The present invention includes other features and details of the arrangement and functioning of the cables as will be apparent from the following description thereof taken in connection with the accompanying drawing forming a part of this application.

In the drawing:

Fig. 1 is a vertical cross-sectional view of an apparatus for storing or holding liquids in which one form of the present invention is illustrated.

Figs. 2 and 3 are views similar to Fig. 1 showing modified forms of the invention.

Figs. 4, 5 and 6 are broken vertical sectional

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views of liquid storage apparatus on a smaller scale than those shown in Figs. 1 to 3, and illustrating further modifications of the apparatus of the present invention.

While the improvements of the present invention may be applied to floating decks or covers in tanks for storing or holding various liquids, the improvements have particular application and will be described and illustrated in connection with oil storage tanks.

Referring to Fig. 1 of the drawing, the oil storage apparatus illustrated therein comprises a cylindrical steel tank of usual construction including a sheet steel bottom 10 and a sheet steel side wall 12. The apparatus also includes a floating deck 14 of smaller diameter than the tank and which may be of any type of construction, but which, as shown, comprises a pan-like structure having an outside rim or flange extending substantially above the liquid in the tank. The bottom of the deck slopes down toward the center to prevent vapor and gas from being trapped, and for drainage purposes. The deck may be provided with the usual jointed rain water drainage pipe 16 which takes the water from the deck and delivers it to any desirable point, for example, some point outside the tank. A water sealed trap to discharge the water directly into the tank may be used in place of the line 16. And any suitable line or swing-line may be used to supply oil to and draw oil from the tank.

In Fig. 1 the improved arrangement for preventing the deck 14 from tipping and upsetting in the tank, comprises a set of similar cables 18 arranged so that some cables apply opposing stresses to certain points on the deck from those applied by other cables of the set. The cables 18 each have one end fixed to an elevated part of the tank or other stationary part of the storage apparatus, for example, by means of a bracket 20. From that point each of the cables 18 passes under a sheave 22 and over a sheave 24 mounted in fixed position on substantially spaced or opposite portions of the deck 14, and then extends downwardly substantially on the opposite side of the deck, from the bracket 20, to the lower portion of the tank where its other end is fixed to the tank by a lug or other means as shown.

It will be noted that, as shown in Fig. 1, each cable 18 is mounted in a substantially opposite manner to another cable 18 of the set so that the deck must move, if at all, in a horizontal plane which is its normal floating position. This is apparent because, if the right side of the deck 14 is bound on the side of the tank, with ice for example, the end of the cable 18 on the left side will hold up the left side of the deck, which cannot go down without receiving cable slack from the right side of the deck over the sheave 24. The cables have the same constraining action on the deck if the sheaves are fixed in inverted position on the bottom edge of the deck as in Fig. 5.

In Fig. 2 the deck 14 is held in horizontal position and kept from tipping by means of substantially taut cables 26, both ends of each of which are fixed to the deck. Each cable 26 has one end attached to one side or edge part of the deck, for example, at a point 28, and from there passes in succession over sheaves 30, 32, and 34, which are fixed to the tank or other part of the storage apparatus in approximately the relative positions shown, and the other end of the cable is fixed to the opposite side or a remote edge por-

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tion of the deck 14 at a point 36. As shown in this figure, the cables may be regarded as mounted substantially in "pairs," so that the ends of one cable of the pair act on substantially the opposite sides of the deck to that of corresponding ends of the other cable of the pair. The adjacent points 28 and 36 need not be in exact vertical alignment. A pair of cables mounted substantially oppositely, as shown, prevents one side of the deck from changing its vertical position with respect to the other side of the deck, if unevenly loaded with snow, ice, etc. A single cable may take the place of two cables 26, as shown in opposed mountings, by making the fixed points 28 and 36 coincide, or by using an endless cable fixed to the deck at two points such as 28 or 36, but which has the length and mounting of two opposing cables 26.

In Fig. 3, the deck 14 is controlled by a plurality of cables 38 distributed around the tank and deck. One end of each of these cables 38 is fixed with respect to the point 40, at the top of the tank, and from there is mounted around sheaves 42 and 44 set in fixed position, respectively on the outer edge of the bottom of the deck 14 and on the bottom of the deck near its center or at a point a substantial distance from the edge of the deck. From the sheave 44, the other end of each cable is fixed at a point 46 directly below the sheave 44. In this figure, it will be noted that the deck 14 at the points of the sheaves 42 cannot be lowered without pulling the cable over the sheaves 44, and thereby also lowering the center of the deck. Since some decks of this type are substantially rigid in view of the vertical outside rim and the downwardly sloping bottom, it is apparent that the cable arrangement shown in Fig. 3 will cause the deck as a whole to move upwardly or downwardly in substantially horizontal position with the upward or downward movement of any one side of the deck. For large tanks the sheaves 44 may actually be nearer the edge of the deck than the center.

The cable arrangement shown in Fig. 4 is a modification of that shown in Fig. 2, in which a cable 48 has one end fixed to the edge of the deck 14 from which it passes in succession over sheaves 50, 52 and 54 in substantially the relative positions shown, and then has its other end fixed to some point of the deck 56, which is substantially removed from the point of attachment of the other end of the cable 48, but which may be on the edge, middle or any other desired point on the deck. The point 56 corresponds to the point 36 in Fig. 2 which is on the opposite end of a cord or diameter from the point 28. It is apparent that in the apparatus shown in Fig. 4, with a sufficient number of cables 48 distributed around the deck; for example, three or more cables distributed uniformly; one portion of the deck cannot move in a downward direction or sink in the oil without pulling the other portion of the deck down also. Unless the point 56, for example, moves downwardly, it is clearly impossible for the left side of the deck to go down.

Fig. 5 shows a modification of the cable arrangement in which a number of distributed cables such as the cable 58 have their ends fixed to portions of the storage apparatus with the intermediate part of such cable mounted over sheaves fixed to the deck. The cable 58, for example, has one end fixed at a point 60 and from there is mounted over sheaves 62 and 64 respectively at one edge of a deck 15, and at some pre-

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determined point which may be near the center of the deck. In this instance, the other end of the cable 58 is fixed to the top of a post or pillar 66 which extends from the bottom of the tank through an opening 68 in the deck. In the apparatus shown in Fig. 5, it is apparent that the portion of the deck around the pillar 66 cannot move downwardly without at the same time drawing the cable over the sheave 62 and pulling the left edge of the deck down. The sheaves 62 and 64 may be mounted on the top of the deck as in Fig. 1, if desired.

It is to be understood that in Fig. 5 any number of cables 58 may be used, and that in any case at least three cables regularly positioned should be used. Any number of posts or pillars 66 may be used in a tank.

The modification shown in Fig. 6 is a further variation of the form described in connection with Fig. 2, in which a single cable mounted in an endless or series arrangement is used as a safety device for an entire deck. In this figure a continuous cable 70 is mounted in substantially taut condition over a series of regularly spaced groups of sheaves 72, 74 and 76 fixed in the relative positions shown. The cable is clamped or otherwise fixed to the deck at the position of each group of sheaves by means of a series of clamps 78. A deck should have at least three points of attachment 78, to the cable 70; very large tanks may require from 6 to 10 or more for proper protection, depending upon conditions. With the arrangement shown in Fig. 6, all points 78 must move in the same direction at the same time, regardless of a greater load of dirt, etc., on one side.

While individual cables or sets of cables may be mounted in still other ways, all arrangements come within the two general species in which the cable is either fixed with respect to the tank or with respect to the floating deck. The upper and lower sheave mountings (Figs. 2 and 6) may be reversed if desired, but relatively long spans of cable are not so desirable above or at the top of the tank.

If the upper and lower cable mountings are reversed, with the cables fixed to the deck, as in Figs. 2 and 6, the cables may be mounted outside the tank with the use of additional sheaves. For example, a cable such as 26 may be fixed to the deck at 36, pass around a sheave at the bottom of the tank, then over a sheave directly above on top of the tank, down on the outside of the tank to the bottom, over a sheave, then under the tank to the opposite side, over a sheave, up to the top of the tank, over a sheave, and then down to the deck at 28 where the cable is fastened.

In general, a deck should be provided with at least three points of cable engagement. Some of the larger tanks require more for proper protection. Cables of corrosion resistant metals or alloys may be used for particular purposes, and in any case an old or corroded cable may be readily replaced by threading it over the sheaves as the old one is pulled out. Cables indicated as fixed to the bottom of the deck or tank as shown in some of the figures of the drawing are preferably passed over a sheave at the point of attachment and the end of the cable actually fixed to the upper part of the tank or deck structure so that cable replacement will be easy.

The term "cable" as used in the specification and claims is understood to include any type of flexible line suitable for the purpose, metal or wire rope, chain, strap or rod, used in whole or in part, in accordance with the invention, to effect the re-

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straining or stabilizing arrangements for holding a floating deck in horizontal position on a liquid on which it is adapted to float. Hemp rope may be used in any case where suitable or desirable.

Flexible line or cable may be employed for movement over the sheaves while metal rods, straps, chains or other suitable material may be used for the other portions of the restraining or stabilizing means.

Pan-type decks like the deck 14 are used to reduce vaporization by covering most of the surface of the liquid in the tank, and any gas or vapor formed beneath the deck is preferably allowed to escape around the outside of the deck.

The deck must be free to move horizontally to avoid irregularities in the effective tank diameter and wall surface. However, the space between the deck and tank may be covered if desired, by some flexible or variable covering to reduce evaporation losses and to keep out as much rain, dust and dirt as possible.

The cable or cables may be applied to any type of floating deck (pan or covered), cover or other floating buoyant element in a tank containing, or for holding, or storing, liquids of any kind, regardless of the purpose for which the floating deck or buoyant element is employed. It is to be understood that the term "deck" as used in this application includes any form of floating cover or element, unless otherwise limited in the claims.

The cable or rope arrangements of the present invention which merely act as safety devices are well suited to the purpose of preventing floating decks from tipping and being caused to sink in the liquid on which they float, because the normal movements of such decks, up and down and horizontally, are not interfered with. (The cables prevent appreciable rotation of the deck in the tank.) Furthermore, a floating deck equipped with cables as described may be safely walked upon by a repair man, inspector or gauger. In fact, any unequal loading which may result from rain, leakage, snow, ice, sleet, dirt, etc., is carried on the deck as an unbalanced load by the cable or cables which take the strain.

Under normal operating conditions, the deck, which is slightly smaller than the inside diameter of the tank, floats on the liquid in the tank, and except for abnormal influences, is kept in a substantially horizontal position by the liquid, which, unlike a gas, naturally resists deformation of its level surface. The cable arrangements of this invention are installed to protect the deck from the unusual circumstances mentioned, since tanks of this type are large and open to the atmosphere, and are subject to abnormal weather, corrosion, etc. Without the cable safety means, the deck, if unequally loaded for example, may be depressed at one edge below the surface of the liquid and caused to sink. And when an unprotected deck sinks under these conditions, it is almost always crumpled up and destroyed, because of its relatively light construction and because it goes down at a steep angle.

If a deck equipped with the cable arrangement of the present invention should be caused to sink because of leakage or other unavoidable circumstances, the deck as a whole will settle slowly in horizontal position so that it will not be damaged, but will come to rest upon the supporting structure, not shown, which is used in floating deck liquid storage tanks, so that it may be cleaned or repaired when the tank is emptied.

A "tank" is to be understood as including any

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type of storage vessel or reservoir for liquids in which one or more floating decks or deck units are or may be used.

Having described the invention in its preferred form, what is claimed as new is:

1. An apparatus for holding liquids which comprises an upright open-topped cylindrical tank capable of withstanding the hydrostatic head of liquid stored therein, a buoyant floatable sheet metal deck within said tank adapted to be floated by the liquid in the tank in a substantially horizontal position under normal conditions, said deck being of sufficient area to substantially cover the liquid in the tank but of sufficiently smaller diameter than that of the tank to leave a narrow annular space between the outside edge of the deck and the inside of the tank wall in which liquid displaced by the deck may rise freely and by which vapor evolved from the liquid in the tank may escape, the said deck having an outside rim extending substantially above the normal level of the liquid in said annular space when said deck is floating, said deck being normally freely movable vertically in the tank, and safety means for restraining said deck from any substantial tipping from its normal substantially horizontal floating position on the liquid in the tank which may be caused by ice formation, unequal loading of the deck by snow, sleet, dirt, leakage and other abnormal causes, said means comprising flexible cable stabilizing means mounted at distributed positions around said deck and tank with selected cable portions fixed at predetermined points and with other cable portions held in movable relation to other points by means of sheaves attached to the apparatus at said other points and on which portions of cable move, a cable portion associated with each of said distributed positions being attached to said deck at two substantially spaced points and arranged to prevent one of said last-mentioned points from substantially changing its vertical position with respect to the other of said last-mentioned points, said flexible cable stabilizing means being arranged in such a way as to permit the free normal vertical and sidewise movement of the deck on the liquid on which it floats.

2. An apparatus for holding liquids, which

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comprises an upright open-topped cylindrical tank capable of withstanding the hydrostatic head of liquid stored therein, a buoyant floatable sheet metal deck within said tank adapted to be floated by the liquid in the tank in a substantially horizontal position under normal conditions, said deck being of sufficient area to substantially cover the liquid in the tank but of sufficiently smaller diameter than that of the tank to leave a narrow annular space between the outside edge of the deck and the inside of the tank wall in which liquid displaced by the deck may rise freely and by which vapor evolved from the liquid in the tank may escape, the said deck having an outside rim extending substantially above the normal level of the liquid in said annular space when said deck is floating, said deck being normally freely movable vertically in the tank, and safety means for protecting said deck from any substantial tipping from its normal substantially horizontal floating position on the liquid in the tank which may be caused by ice formation, unequal loading of the deck by snow, sleet, dirt, leakage and other abnormal causes, said means comprising flexible cable safety means mounted at distributed positions around said tank and deck, parts of the cable at each position being fixed to the apparatus at predetermined points of attachment and other portions of the cable at each position being held at other points of attachment to the apparatus by at least two sheaves on the intermediate portion of such cable which are fixed to said apparatus at said other points, said points of attachment to the apparatus including the attachment of the cable at each position to said deck at two substantially spaced points which are in substantially vertical alignment with points of attachment to fixed parts of the apparatus, said cable safety means being distributed and arranged around said deck and tank and the cable at each position being attached to the apparatus in such a way as to allow movement of the deck vertically and horizontally on the liquid on which it floats and to prevent the deck from tipping substantially from its normal floating position on the liquid.

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