IMMERSIBLE TANK WITH BALLAST MEANS FOR TRANSPORT AND IMMERSSION

Jean Courbon, Paris, France, assignor to Société d'Études et d'Équipements d'Entreprises, société anonyme, Paris, France

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ABSTRACT OF THE DISCLOSURE

An immersible tank for the storage of lighter-than-water liquid comprises a tubular peripheral fluid-tight caisson divided into several compartments and a rigid cupola overlying the caisson and firmly connected to it at its perimeter. The caisson may be circular, oval or polygonal in cross section and in plan. The cupola is generally dome shaped. The tank is floated to its location and then immersed. The caisson is preferably supported by legs so as to be spaced from the bottom.

As a consequence of the present trend in the development of submarine oil-fields, the problem of storing raw oil in the vicinity of oil-fields is becoming increasingly important.

To avoid the destructive effects of swell, storage tanks must be immersed at a sufficient depth. Moreover, these tanks must meet the following requirements, for obvious economical grounds:

(1) They must be so designed that their construction can be carried out in the dry, under shelter of a moderate height coffer-dam or in a relatively shallow bed.

(2) When empty, these tanks must have a stable buoyancy sufficient to permit their safe towing to the site of their actual use.

(3) They must be capable of being immersed on sea bottom ranging from 150 to 650 feet in depth.

(4) Possibly, they must be transferable without major difficulties from one site to another.

The present invention relates to a tank for storing lighter-than-water liquids meeting these requirements. It comprises two main components:

(a) A fluid-tight tubular caisson of metal or reinforced or prestressed concrete or, as a rule, any material capable of imparting to the caisson a high resistance to compressive stress and having a weight selected to permit floating the assembled tank to the site of use and thereupon immersing it, with enough negative flotation to resist the buoyancy of the lighter-than-water liquid stored in the tank. In the case of relatively large tanks, it is advantageous to use a caisson of toroidal shape, since it must withstand the water pressure during the immersion operation by charging the caisson with the necessary ballast, this ballast consisting for example of the liquid to be stored. However, in the case of a tank immersed in relatively shallow quiet water the caisson cross-section may be given a shape other than circular, for example a rectangular or triangular shape, in order to facilitate its construction. Under the same conditions, the plan-view contour of the annular caisson may have a shape other than the aforesaid circular shape; thus, an elliptic, rectangular or even polygonal contour may be used.

(b) A metal cupola secured along its outer periphery to the top of said annular caisson. If the caisson has a circular configuration in plan view, this cupola will have a spherical shape. If the caisson has an elliptic configuration in plan view, the cupola is an ellipsoid. Finally, if in plan view the caisson has a rectangular shape, the cupola consists of elements of cylindrical surfaces which are particularly simple to manufacture.

A tank constructed according to these characteristics meets the above-mentioned requirements in a satisfactory manner. In fact, by blowing compressed air into the cupola, it can be extracted from the coffer-dam by floating with a shallow draught. The caisson disposal on the tank periphery imparts an exceptional stability during the towing manoeuvres. Finally, by simply providing a few transverse partitions in the caisson to avoid liquid centers of buoyancy, the tank can be immersed without difficulty by means of low-power winches.

The tank is supported on the sea bottom by means of at least three legs, the space underlying the cupola communicating freely with the sea under the caisson.

At least two alternate forms of embodiment may be contemplated:

(I) In a first form of embodiment, the oil is stored on the one hand in the caisson and on the other hand under the cupola, advantage being taken of the fact that oil be lighter than, and does not mix with sea water. The storage capacity is limited by the requirement that the apparent weight of the tank must be constantly directed downwards.

(II) To increase the tank capacity without incrementing the caisson dimensions and according to another possible form of embodiment, the inner space of the caisson may be filled with ballast; the latter may consist for example of wet sand. In this case raw oil is stored only under the cupola.

In both cases the metal cupula can be constructed under particularly economical conditions. In fact, this cupula is constantly dintended since the resultant of the pressures exerted by the oil retained thereunder and by the external sea water is constantly directed outwards. Therefore, the cupula is free of any risk of instability by general buckling or local blistering.

Although these tanks are usually immersed by virtue of the suitable ballast introduced into the caisson, this ballast consisting if desired of the liquid to be stored, thus increasing inasmuch the tank capacity at a depth sufficient to avoid the destructive effects of swell, the latter is nevertheless likely to exert a detrimental influence on the relatively thin and therefore easily deformable cupula; if these tanks are completely closed either by a bottom wall or by their continuity with the sea bottom, such as a digging Preventor driven through light grounds, this swell creates differences in pressure between the interior and the exterior of the casing whereby costly means must be provided for reinforcing the structure.

These pressure differences may be reduced in practice and to this end a series of direct communication or passage means are created between the interior and the exterior of the tank, in the portion thereof which is constantly filled with sea water, that is, beneath the lower level of the various liquids stored in the tank when the latter is full; thus, a balancing effect is produced in case of sudden pressure variation, without producing any transfer of liquids from the interior to the exterior of the tank.

Of course, these communication or passage means must be disposed in a zone where they are not likely, during their use, to be silted up or produce stirring effects in the sandy bottom on which the tank may be caused to rest.

Several forms of embodiment of the immersed tank according to this invention will now be described by way of example with reference to the accompanying drawing, in which:

FIGURES 1, 2 and 3 are respectively vertical sectional views and a plan view of an immersed tank constructed according to the teachings of this invention, and equipped with a toroidal caisson;
FIGURES 4, 5 and 6 are similar views of a tank equipped with a polygonal-sectioned float;

FIGURES 7 and 8 are views showing a modified form of embodiment with a cupola having a different surface of revolution;

FIGURE 9 is a section showing a modified form of embodiment of the immersed tank.

Referring first to FIGURES 1, 2 and 3 of the drawing, the tank illustrated therein comprises a toroidal caisson 1 carrying a cupola 2 of spherical (FIGURE 2) or ellipsoidal (FIGURE 3) configuration. This caisson bears on the bottom or ground by means of spaced legs 3 so that the internal volume of the tank communicates with the exterior. Due to the difference in density of sea water and oil, the latter does not mix up with sea water and can fill the tank up to the level shown by the chain-dotted line N. Hook means 4 are provided under the cupola 2 for anchoring the winch ropes, and a nozzle 5 is provided for filling the tank with oil or compressed air.

As the metal sheets constituting the cupola are constantly distended as a consequence of the pressure balance between the outside and the inside of the tank, the cupola is connected to the caisson in a tangent direction and therefore no strain is produced in the sheet metal elements.

FIGURE 4 shows a typical form of embodiment comprising an annular caisson having a square cross-sectional contour, and FIGURE 5 illustrates a modified structure comprising a triangular-sectioned float.

FIGURES 7 and 8 illustrate a rectangular caisson 6 having a square cross-sectional contour, the cupola consisting in this case of properly assembled or connected cylindrical surfaces 7 and 8.

Although the figures show closed, possibly ballasted and partitioned floats, it would not constitute a departure from the present invention to cause these caissons to communicate with the tank capacity.

The tank illustrated in FIGURE 9 consists of an annular caisson 9 having secured to its top a cupola 10; this assembly is supported by legs 11 and closed laterally by a digging preventer 12; between the plane 13 tangent to the lower portion of the annular caisson 9 and the lowermost permissible level 14 of the stored liquid when the tank is full is the lower opening 15 of the passages 16 formed through this annular float 9; these passages extend upwards and outwards so that their upper opening 17 lies in the upper portion of the caisson 9.

The dimensions, number, shape and position of these openings are so determined as to remove as completely as possible any stress caused by the action of swell on the tank surface without allowing the stored liquid to escape through its openings.

It will be readily understood that the forms of embodiment of the invention which are described hereinabove with reference to the accompanying drawings should not be construed as limiting this invention since many modifications and variations may be brought about without departing from the spirit and scope of the invention as set forth in the appended claims.

What 1 claim is:

1. An immersible tank for the storage of liquids having a density lower than water and notably hydrocarbons, which consists of a tubular peripheral fluid-tight caisson, means dividing said caisson into several compartments, a rigid cupola overlying and firmly connected at its periphery to said caisson, and means for ballast-sinking said caisson after its transport by floating to the immersion site.

2. A tank as set forth in claim 1, in which the caisson is toroidal and the cupola is generally spherical.

3. A tank as set forth in claim 1, in which the caisson is elliptical and the cupola is generally ellipsoidal.

4. A tank as set forth in claim 1 in which the caisson is of polygonal contour and polygonal cross-sectional shape, and the cupola consists of intersecting surfaces of revolution.

5. A tank as set forth in claim 1, having a series of passages communicating directly between the exterior and the interior of the tank, in the portion thereof which is constantly filled with water, that is, beneath the lowermost level of the liquid stored in the tank when the latter is filled, said passages being disposed in a zone where they are not likely, during their use, to become slitted up or to stir up the bottom on which the tank rests when immersed.

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THERON E. CONDON, Primary Examiner.
GEORGE T. HALL, Examiner.