OFFSHORE INSTALLATION FOR PRODUCING, STORING AND LOADING OIL FROM UNDERWATER OIL WELL

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An offshore installation for the production, storage and loading of oil from an underwater source. Installation includes an immersed storage tank, a vertical column connected at its bottom to the tank by a universal joint and having its top above the water surface. Platform is connected to upper end of column. Column is maintained in vertical orientation by circularly arranged distributed buoyancy means connected thereto.

11 Claims, 3 Drawing Figures
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OFFSHORE INSTALLATION FOR PRODUCING, STORING AND LOADING OIL FROM UNDERWATER OIL WELL

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention applies to production, storage and loading installations which permit the exploitation of underwater oil fields in zones where the distance from the shore, the depth of the water and the topography of the bottom of the sea make the construction of an underwater pipeline conducting the crude oil to the shore impossible or unprofitable.

2. DESCRIPTION OF THE PRIOR ART

Offshore installations for exploiting underwater oil are known. These installations comprise in general a platform proper which feeds underwater tanks which are independent of the platform, situated under slight depths of water and comprising an extension in which the production and loading tools can be installed. These known installations are, as a matter of fact, not very compatible with the conditions of operation at great depths and the difficulties in constructing the tanks and platforms equipped in this manner and bringing them to sea seem at the present time clearly to limit the use of such installations.

It is also known that the above described platforms constructed up to the present time have a number of drawbacks related in particular to the effects of wind and the ocean swell, plus difficulties in making the required repair of production and loading tools of the underwater tank which are located in an extension of the tank, and difficulty in maintaining a constant horizontal position of the apparatus and tanks to permit the pretreatment of the crude oils for the removal of sand and gas therefrom prior to their introduction into the tank, and also the problems in mooring tankers at said platforms.

The recent development of so-called super tankers of a capacity in excess of 100,000 tons now requires the creation of loading stations which are capable of withstanding very substantial reactions of the mooring lines of these vessels at open sea. At present there is no device which makes it possible by its flexibility to absorb such stresses and furthermore also to provide a zone of relative calm for the tanker.

SUMMARY

The main object of the present invention is the improvement of offshore oil installations to overcome the drawbacks of previous arrangements.

This main object is accomplished by an installation comprising at least one underwater tank, a column one end of which emerges from the water and an emerged production and loading platform, and it is characterized by the fact that the column is rigidly connected with supporting means formed by floats arranged preferably in a circle concentric to the column and located at a certain distance from it.

Because of these supporting means formed of floats, the column constantly has a tendency to be restored to the vertical position when forces incline the column to the vertical. These floats present a differential righting effect as a function of the inclination. The arrangement of the floats in a circle concentric to the column and located at a preselected distance from the column defines a first zone of relative calm with respect to the condition of the open sea, the said zone being formed by the artificial "lake" located within the circle of the floats.

In accordance with one embodiment of the present invention, floats are formed of tanks having a conical shape towards the top and they are preferably uniformly spaced apart.

In accordance with another embodiment of the invention, the tanks are movably fastened, for instance by universal joints, to an immersed circular element which is itself fastened to the column by means of stiffening tie rods or the like.

Preferably these tie rods have a certain elasticity which confers a certain flexibility to the connection between the circular element and the column. Indeed, the assembly of tanks tends to oppose the inclining of the column on the one hand by the torque which the positive floatability of the assembly of tanks applies to the column as soon as it inclines, and, on the other hand, by the fact that any inclination of the column has a tendency to increase the average immersion of the floats which are located on the side where the column leans to thereby increase the restoring force and at the same time to decrease the average immersion of the diametrically opposite tanks, which result in an increase in the lever arm of the restoring torque.

In accordance with still another embodiment of the present invention, the floats are formed of a plurality of flexible, floating fibers grouped in a bundle and formed of a material which is not adversely affected by prolonged immersion in water and has a density of less than 1.

In accordance with still another embodiment of the present invention, the fibers are bent, for instance at their center, so as to form a loop which, after tying, provides an eyelet serving as point of attachment to an immersed circular element, for instance via an anchor rope, the circular element being in its turn fastened to the column by means of stiffening rods or the like.

These rods preferably also have a certain elasticity which confers a certain flexibility to the connection between the circular element and the column.

Preferably, apart from the tying, the fibers are free over their entire length and float each independently of each other on the water. If the eyelet is urged downward by a pull less than the total floatability of the float thus formed, a part of the bundle of fibers is immersed until this stress is compensated for and the rest spreads out on the surface, generally in the form of a sheet which extends around the central axis of the bundle. This sheet, as well as the rubbing of the water on the immersed parts of the bundle, and the variations in floatability caused by the waves produces a swell-attenuating effect which is greater the longer the float is and the larger its immersed portion. This swell-attenuating effect is increased if several floats attached to anchorings are placed alongside of each other so as to form a more or less tight floating barrier depending upon the number of floats used.

By these means there are obtained floats and an attenuating barrier which have the advantage of never rising above the waves and which may be easily cleared by a vessel without causing damage.
Such a barrier may find industrial application whenever it is necessary to protect a vessel or a stationary installation from the effects of waves or swell. In particular it may make it possible to create at open sea relatively calm zones where a vessel can stay without there being a barrier that must be physically opened and closed to accommodate the passage of a ship therethrough.

Another advantage, in addition to their swell-attenuating effect, which is presented by such floats formed of fibers floating on the surface of the sea is that they do not offer any point of attack to the wind, which further contributes to the stability of the column. Of course, depending on the greater or lesser length of the fibers floating on the surface of the water, the first zone of relative calm has a greater or lesser surface.

In accordance with yet another embodiment of the present invention, the column is fastened by its immersed base to the underwater tank through an articulated joint. This embodiment is applicable to any installation formed of a tank, a column and a platform and is, in particular, applicable to such installations which do not include the supporting means. The underwater tank serves therefore as the base for the column which thus oscillates as a function of the various external stresses which act on it around the articulated joint. The weight of this tank is furthermore such, as compared with the weight of the entire installation, that the external stresses acting on the installation do not jeopardize the permanent seat of the tank on the sea bottom, whatever the conditions of the filing of the tank.

In accordance with a preferred embodiment of the present invention, the articulated joint permits for the passage of the operating conduits, cables connecting the measuring instruments of the tank to the control instruments of the platform and the possible replacement of these measuring instruments. It is thus possible easily to have access to these instruments and possibly readily check or insure their operation.

In accordance with another embodiment of the present invention, the non-immersed production and loading platform is supported by the column in such a manner as to retain at all times a position of horizontal stability.

In accordance with still another embodiment of the present invention, the platform is pivotally fastened on the end of the column emerging from the water, the platform having at its center a flared receptacle serving as housing for the end of the column and having a weight distribution which imparts to it a stable equilibrium within the limits of inclination contemplated for the column.

The advantage of having a platform the horizontal position of which is at all times constant is very particularly felt in connection with the pretreatment of crude oil for the removal of sand and gas and is of very particular advantage to assure the proper operation and reliability of the measuring instruments.

In accordance with still a further embodiment of the present invention, the distribution of weight may be corrected by any means, such as, for instance, by the filling or emptying of ballast tanks, etc.

In accordance with one embodiment of the present invention, the circular element to which the floats are fastened, preferably through a damper, comprises a circular rail supporting two anchoring carriages which are movable on said rail via which the vessels can be moored in loading position.

By means of the dampers, it is possible for the float to oscillate around its point of attachment and for the vibrations transmitted to said circular element by the movements of the floats to be attenuated.

Preferably the ships, when moored, are located in a second zone of relative calm located in the wake of the barrier formed by the floats with respect to the general direction of the stream. In this zone the effects of the wind and of the swell on the vessel are diminished.

**BRIEF DESCRIPTION OF DRAWINGS**

**FIG. 1** is a side elevational view of an offshore oil installation in accordance with the present invention;

**FIG. 2** is a top plan view thereof; and

**FIG. 3** shows another form of float in accordance with the present invention.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Referring now to the drawings in detail, **FIGS. 1 and 2** show an installation in accordance with the present invention composed of an underwater storage tank 1, a column 2 and a platform 5 above the waterline.

The storage tank 1, preferably of pre-stressed concrete, has a generally cylindrical shape and is formed in known manner of a large number of independent compartments. The roof of tank 1 serves as a base for an articulated joint 3 of known type permitting the passage of conduits and cables therethrough, and to which there is fastened a column 2 which swings around joint 3 as a function of the various stresses which act upon it.

The column 2 is such that its upper part emerges sufficiently from the sea to support a platform 5, through a pivot 4 of known type, well above the water surface and thus out of the way of any foreseeable action of the sea. This column 2, which is shown of generally cylindrical shape, may have any cross-sectional shape; in particular, over the entire zone in which it is swept by the waves, it preferably has a more open structure and may be constructed, for instance, of a plurality of spaced apart circularly arranged tubes 9 as shown in **FIG. 1**.

Column 2 is also provided with buoyancy means, having at all times a tendency to return column 2 to its vertical position. As shown in **FIGS. 1 and 2**, the buoyancy means are floats 10 and 26 uniformly spaced on a circle and connected at their respective bases to a circular rail 11 which in its turn is attached to the column 2 by stiffening rods 12 and 13. In accordance with a preferred embodiment of the present invention, rods 12 and 13 are somewhat elastic to confer a slight flexibility to the connection between the rail 11 and the column 2.

Each float 10 is fastened to rail 11 through a shock absorber of known type by a swivel joint 14 which permits the float to swing around its point of attachment and to attenuate the vibrations which the movements of the float might transmit to the rail.

The floats 10 are preferably partitioned and, as shown, preferably have a conically shaped top 15. They extend sufficiently above the water surface to be able to serve as support for a swell-attenuating device 36 of...
known type (FIG. 2). More particularly, the ends 15 of
the floats 10 and the swell-attenuating device 36 which
connects them define two successive zones of relative
calm as compared with the state of the open sea — the
first of these zones is the zone a composed of the artifi-
cial lake within the circle formed by the floats 10 and
the second is the zone b located in the wake of the bar-
rier of floats as compared with the general direction of
bad weather, represented by the arrow 25. It is in this
zone b that the effects of the wind and of the swell have
tendency to maintain the ship moored.

The assembly of floats 10 tends to oppose the inclin-
ing of column 2 on the one hand by the torque which
the positive floatability of the assembly of floats applies
to the column as soon as the latter inclines and, on the
other hand, by the fact that any inclination of the column has a tendency to increase the average immers-
ion of the floats 26 located on the side towards which
the column is leaning, and to decrease, at the same
time, the average immersion of the floats 10 diamet-
rically opposite the preceding ones, which increases the
lever arm of the righting torque.

As best seen in FIG. 1, the platform 5 which has at its
center a flared receptacle 6 serves as the housing of the
pivot 4 and has a distribution of weight which imparts
to it a stable equilibrium and enables it to place itself at
all times in a horizontal position by swinging at point 7
on the pivot 4 within the limits of inclination provided
for the column 2. This distribution of weight may
furthermore be corrected if necessary by the filling or
emptying of ballast tanks 8 on platform 5.

In addition to ballast tanks 8, the production and
loading platform 5 has a story or floor on which there
are arranged the production instruments 16 such as
degasifiers, separators, etc., of known type.

On the same story or floor as instruments 16 there
may also be found the driving groups necessary for the
operation of the various accessories, while in compart-
ments 17 near the top of platform 5 there may be
located control panels and dwelling quarters, as shown.

At the center of the roof of the platform 5 there is ar-
 ranged a cylindrical foot 18 around which a loading
arm 19 can pivot a full 360°. The cylindrical foot 18
may also support at its top a helicopter platform 20.

A circular element comprising the rail 11 is shown in
FIG. 2 as supporting two carriages 21 traveling on the
rail 11 and serving as anchoring for mooring lines 22 by
means of which tankers 23 can moor in loading posi-
tion, in which position a hose 24 attached to the arm 19
can be connected to the tanks of the ship. In this con-
figuration the tanker is free to turn 360° around the
platform as the center of the swing circle as a function
of the composite stresses of the wind and the swell.

During operation, the oil produced by the wells 27 is
conducted by conduits 28, all of which lead to an ar-
rangement of known connectors 29. From which,
without passing through the tank 1, the oil is passed up-
wardly to the production platform 5 through conduits
30 which, although not illustrated, preferably pass
through the joint 3.

After having been treated by the production appa-
tratus 16, the oil is passed downwardly to the tank 1
through hoses 31 which descent within the column and
also pass through the joint 3.

In the tank 1 the oil is stored above water within the
tanks which water enters the tanks through lower
openings 32.

The various measuring instruments necessary for the
operation of the tank, indicated schematically at 33,
can be retracted through the joint 3. They are
preferably connected to transmit their readings to the
control board of the platform 5 via cables 34 passing
through the joint 3.

For loading a ship 23, the oil is taken from the tanks
1 by the conduits 31 through the column 2 to the load-
ning arm 19 where it is passed to piping 35 connected to
conduits 31. Piping 35 is in turn connected to hose 24
which passes the oil to the tanks of the vessel 23.

Referring now to FIG. 3, another embodiment of the
floats is illustrated. The float of FIG. 3 is formed of
smooth or branched fibers 101 of a material which is
unaffected by immersion in water and has a density of
less than 1, the fibers being grouped in bundles. As
shown the fibers are bent over at their center and
bound by a tie 102 alongside of the loop thus formed.
An eyelet 103 is inserted in the loop and serves as a
point for the attachment of the float to its anchoring
by means of an anchor rope 104.

Beyond the tie 102, the fibers are free over their en-
tire length and once immersed in the water, each of
them will float independently of each other.

If the eyelet 103 is urged downwardly by a force
resulting from a pull or tug which is less than the total
buoyancy of the float, a part of the bundle of fibers will
be immersed until this force has been compensated for
and the rest will spread out on the surface in general in
the form of a sheet spread out around the central axis
of the bundle.

Of course, the present invention is not limited to the
embodiments shown but rather is capable of numerous
variations which will readily come to the mind of the
person skilled in the art, depending on the specific ap-
plications in view, without thereby going beyond the
scope of the invention.

What is claimed is:

1. An installation for the exploitation of underwater
oil fields for the production, storage and loading of oil
of underwater origin on to tankers, said installation
comprising:
at least one underwater tank;
a column, the bottom of which is operatively con-
ected to said tank and the upper end of which ex-
tends above the surface of the water;
a production and loading platform on the upper end
of said column;
a plurality of hollow tank floats arranged in a circular
array about said column and in substantially
uniformly spaced apart relation with one another;
means for connecting said floats to said column, said
connecting means including an immersed ring, a
plurality of universal joints, one for each float, for
connecting the bottoms of said floats to said ring,
and a plurality of stiffening rods for connecting
said ring to said column; and
hose means carried by said column and connected to
said tank for supplying oil to said underwater tank
for storage therein.

2. An installation according to claim 19, wherein said
hollow tanks have a conical shape adjacent their tops.
3. The installation according to claim 19, further comprising a platform means for maintaining said platform horizontal, said last mentioned means comprising a flared receptacle in the bottom of said platform, said upper end of said column being disposed within said receptacle for pivotally mounting said platform on said column, said platform having a distribution of weight which imparts to it a stable equilibrium within the limits of inclination defined by the shape of said flared receptacle and said column.

4. An installation according to claim 19, further comprising two anchoring carriages movably mounted on said ring for movably connecting mooring lines from a vessel to said column.

5. An installation for the exploitation of underwater oil fields for the production, storage and loading of oil of underwater origin onto tankers, said installation comprising:
   a column, the bottom of which is operatively connected to said column and the upper end of which extends above the surface of the water;
   a production and loading platform on the upper end of said column;
   a plurality of buoyancy means arranged along a circle concentric to the column and located at a certain distance from the column, each of said buoyancy means including flexible, floating fibers grouped in a bundle, said fibers being formed of a material which is unaffected by immersion in water, and has a density of less than 1; and hose means carried by said column and connected to said tank for supplying oil to said underwater tank for storage therein.

6. An installation according to claim 5, wherein said bundles of fibers are bent over adjacent their centers to form loops, a tie around each of said loops for maintaining same, an eyelet disposed within each of said loops, an immersed circular element, a plurality of anchor ropes, one for each bundle, and extending from said eyelets to said circular element for connecting same, and a plurality of stiffening rods for connecting said circular element to said column.

7. The installation according to claim 5, further comprising a platform, means for maintaining said platform horizontal, said last mentioned means comprising a flared receptacle in the bottom of said platform, said upper end of said column being disposed within said receptacle for pivotally mounting said platform on said column, said platform having a distribution of weight which imparts to it a stable equilibrium within the limits of inclination defined by the shape of said flared receptacle and said column.

8. The installation according to claim 6 further comprising two anchoring carriages movably mounted on said ring for movably connecting mooring lines from a vessel to said column.

9. An installation for the exploitation of underwater oil fields for the production, storage and loading of oil of underwater origin onto tankers, the said installation comprising:
   at least one underwater tank;
   a vertically extending column, the upper end of which extends above the surface of the water;
   a production and loading platform on the upper end of said column;
   an articulated joint for connecting said underwater tank to the bottom of said column;
   a plurality of buoyancy means arranged along a circle concentric to the column and located at a certain distance from the column;
   hose means carried by said column and connected to said tank for supplying oil to said underwater tank for storage therein said hose passing through said articulated joint.

10. The installation according to claim 9, further comprising means for maintaining said platform horizontal, said last mentioned means comprising a flared receptacle in the bottom of said platform, said upper end of said column being disposed within said receptacle for pivotally mounting said platform on said column, said platform having a distribution of weight which imparts to it a stable equilibrium within the limits of inclination defined by the shape of said flared receptacle and said column.

11. An installation according to claim 9, wherein said operative connection between said column and said tank comprises an articulated joint for connecting the lower end of said column to said underwater tank.