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(54) MOORING SYSTEM, IN PARTICULAR FOR (UN)LOADING A TANKER

(71) We, SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ B.V., a company organized under the laws of the Netherlands, of 30, Carel van Bylandtlaan, The Hague, the Netherlands, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

The invention relates to a mooring system, in particular for (un)loading a tanker, which system is of the known kind comprising a floating mooring arm, which is adapted to rotate freely around a structure, said structure being secured to the water bottom. In normal use a tanker is moored alongside the floating mooring arm of such a mooring system for loading or unloading.

The invention relates in particular to a new simple and robust construction for connecting the floating mooring arm to the vertical structure.

The mooring system according to the invention comprises a structure secured to the water bottom, an annular element so arranged that it is rotatable around the structure, an annular member arranged around and connected to the annular element, a floating mooring arm secured to, or forming a unit with, the annular member, wherein the annular member is connected to the annular element by means of a suspended weight system comprising a set of weights, each weight being suspended between the annular member and the annular element by means of elongated suspension elements.

Preferably, the elongated suspension elements are connected to the annular member and/or to the annular element via lever arms, each lever arm being rotatable around a horizontal axis and acting against an elastic element.

The main purpose of the last-mentioned embodiment of the invention is that the elastic elements will reduce the stiffness of the suspended weight system at nearly fully stretched positions.

The invention will be further explained with reference to the accompanying drawings, wherein:

Figure 1 shows schematically a top plan view of an embodiment of a mooring system according to the invention;

Figure 2 shows schematically a side view of the embodiment according to Figure 1;

Figure 3 shows schematically a vertical cross-section of the connection between the floating mooring arm and the vertical structure, wherein the mooring arm is in the neutral position relative to the vertical structure;

Figure 4 shows schematically the connection according to Figure 3, wherein the mooring arm is in eccentric position relative to the vertical structure;

Figure 5 shows schematically a top plan view of one of the weights together with the elongated suspension elements.

In Figures 1 and 2, the floating mooring arm, which is in this embodiment of the invention a stationary tanker 1, is secured to a buoyant annular member 2 by means of a frame 3. The frame 3 is

substantially U-shaped and comprises two arms 4 which are rigidly interconnected. The arms 4 are connected to the floating mooring arm 1 by means of hinges 5 having horizontal hinge axes. The arms 4 are furthermore connected to the annular member at 6. The annular member 2 is arranged around and connected to an annular element 7 by means of a suspended weight system which is generally indicated by the reference numeral 8, and which will be discussed in detail with reference to Figures 3 to 5.

The annular element 7 is preferably buoyant and is rotatably arranged around a vertical structure 9. The vertical structure 9 has for example the form of a pile and is secured to the water bottom 10 and extends preferably above the water surface 11.

10 In Figures 1 and 2, a tanker 12 is moored alongside the mooring arm 1 by means of mooring cables 13, conventional fenders 14 being present between the mooring arm or stationary tanker 1 and tanker 12. A loading arm 15 serves to connect the stationary tanker 1 to a fluid discharge or supply conduit (not shown) on or in the vertical structure 9. A loading arm or hose 16 serves to create a fluid communication between the stationary tanker 1 and the tanker 12.

15 The suspended weight system 8 will now be described more in detail with reference to Figures 3, 4 and 5.

Around the vertical structure 9 the annular element 7 is arranged. The annular element 7 is provided with buoyancy chambers 17 and with a number of fender wheels 18 and 19 (for example Firestone Burleigh O.D. 114", respectively O.D. 78"). The fender wheels 18 and 19 are adapted to rotate around vertical axes as shown. Each fender wheel 18, respectively 19, is in contact with the outer surface of the vertical structure 9 in such a manner that when the annular element 7 rotates around the structure 9, the fender wheels 18 and 19 will roll along the outer surface of the structure 9. This construction does not prevent the annular element 7 from sliding in a vertical direction relative to the structure 9.

25 The annular member 2 which surrounds the annular element 7 is provided with a number of lever arms 20. Each arm 20 is secured to the annular member 2 by means of a corresponding hinge 21 having a horizontal axis. Each lever arm 20 is adapted to act against an elastic element 25, which is made of a suitable rubber or plastics material. These elastic elements 25 are, for example, fenders of the type known as 'Krupp-Zellkunststoffpuffer'. Alternatively, metal springs can be used. The chains 22 are secured to the free ends of the lever arms 20. The other ends of the chains 22 are secured to weights 23. Each weight 23 is, for example, a concrete cylinder surrounded by a hollow cast iron or steel cylinder. Furthermore, chains 24 are secured to the annular element 7. The other ends of the said chains 24 are secured to the weights 23. As shown in Figure 1, the number of weights 23 suspended between the annular member 2 and the annular element 7 is six. A wooden fender ring 26 is secured to the annular member 2 in the manner as shown in Figures 3 and 4.

As clearly shown in the figures, the floating mooring arm 1 is connected via the annular member 2 to the annular element 7 via the suspended weight system 8. The suspended weight system 8, when pushed out of the neutral position, absorbs energy by accumulating it in weights 23 which are being lifted. This suspended weight system must provide enough room to the floating mooring arm 1 to move according to the motions of the mooring arm 1 together with a tanker moored to it as a result of the waves, wind, or current or according to the motions of the mooring arm 1 as a result of the waves, wind, or current when no tanker is moored to it. Furthermore, the suspended weight system 8 has to be strong enough to withstand the forces caused by wind, current and waves.

A suitable fender system is present to take up extreme forces. The rubber fender wheels 18 and 19 are adapted to guide motions of the annular element 7 around the structure 9. The upper fender wheels 18 act as a fender work against the wooden fender ring 26 in case of complete stretching of the suspended weight system 8, which situation is shown in Figure 4. Any additional loads will be transferred by solid rubber fender rings 27, respectively 28, arranged respectively on the inner and the outer faces of the annular element 7. To decrease the stiffness of the suspended weight system at nearly fully stretched positions the non-linear gravity spring arrangement 8 is connected in series via the lever arms 20 to the elastic elements or springs 25.

The vertical structure 9 is preferably a hollow steel tube, for example, of steel of quality FE 52, which is secured to the water bottom 10 in a suitable manner, for example by means of a space frame (not shown) which is, for example, anchored to the water bottom 10 by means of a suitable number of piles (not shown).

In the embodiment according to Figures 1 and 2, the floating mooring arm 1 has the form of a stationary tanker. Instead, it is possible to use a mooring arm having the form of a rigid space frame built with steel tubes and preferably provided with a number of flotation tanks, to give the rigid space frame sufficient buoyancy.

5 The operation of the mooring system according to the invention is as follows:

The floating mooring arm 1 is so secured to the structure 9 that the mooring arm is free to rotate around the structure 9. In this manner the mooring arm 1 will offer minimum resistance to waves, winds and currents. When a tanker has to be unloaded or loaded, the tanker 12 is moored alongside the mooring arm 1 by means of mooring lines 13. Then a loading arm 16 is connected to the manifold 10 of the tanker 12. The loading arm 16 is in fluid communication with a pipeline (not shown) on the mooring arm 1 which communicates with a loading arm 15. The loading arm 15 communicates via a fluid swivel with a conduit (not shown) on or within the structure 9. The last-mentioned conduit is in communication with a pipeline on or in the sea bottom 10 leading for example to shore.

When it is desired to load the tanker 12, fluid, for example crude oil, oil products or liquefied gas, 15 is supplied via the pipeline in or on the sea bottom, the conduit in or on the structure 9, the loading arm 15, the pipeline on the mooring arm 1 and the loading arm 16 to the tanker 12. When it is desired to unload the tanker 12, the fluid is pumped through the said various conduits, pipelines and loading arms in the opposite direction.

When the floating mooring arm 1 is a stationary tanker as shown in Figures 1 and 2, it is possible 20 to store the fluid temporarily in the tanks of the stationary tanker 1.

In the embodiment as shown in the drawings, the annular member 2 is secured to the mooring arm 1 by means of the frame 3. Instead, it is possible to secure the mooring arm 1 to the annular member 2 in a rigid manner, for example so that the annular member 2 forms a unit with the mooring arm 1.

25 In the embodiment as shown in the drawings the elongated suspension elements for the weights 23 are chains 22 and 24. Instead it is possible to use cables or metal bars. When metal bars are used as elongated suspension elements, it is necessary to secure the ends of said bars in a hingeable manner respectively to the annular element 7, the annular member 2 and to the weights 23. In the embodiment as shown in the drawings the lever arms 20 are arranged on the annular member 2. If desired, it 30 is possible to arrange such lever arms on the floating annular element 7 or on the annular member 2 and on the floating annular element 7.

In the embodiment as shown in the drawings six weights 23 are used, but any other suitable number of weights can be used, if desired.

WHAT WE CLAIM IS:

35 1. A mooring system, in particular for (un)loading a tanker, comprising a structure secured to the water bottom, an annular element so arranged that it is rotatable around the structure, an annular member arranged around and connected to the annular element, a floating mooring arm secured to, or forming a unit with, the annular member, wherein the annular member is connected to the annular element by means of a suspended weight system comprising a set of weights, each weight being 40 suspended between the annular member and the annular element by means of elongated suspension elements.

2. The mooring system as claimed in claim 1, wherein the elongated suspension elements are chains or cables.

3. The mooring system as claimed in claim 1, wherein the elongated suspension elements are 45 metal bars.

4. The mooring system as claimed in any one of claims 1-3, wherein the connections between the elongated suspension elements and the annular member and/or the annular element are buffered by elastic elements.

5. The mooring system as claimed in claim 4, wherein the elongated suspension elements are 50 connected to the annular member and/or to the annular element via lever arms, each lever arm being rotatable around a horizontal axis and acting against an elastic element.

6. The mooring system as claimed in claim 4 or claim 5, wherein the elastic element is made of rubber.

7. The mooring system as claimed in claim 4 or claim 5, wherein the elastic element is a metal 55 spring.

In the embodiment according to Figures 1 and 2, the floating mooring arm 1 has the form of a stationary tanker. Instead, it is possible to use a mooring arm having the form of a rigid space frame built with steel tubes and preferably provided with a number of flotation tanks, to give the rigid space frame sufficient buoyancy.

5 The operation of the mooring system according to the invention is as follows:

The floating mooring arm 1 is so secured to the structure 9 that the mooring arm is free to rotate around the structure 9. In this manner the mooring arm 1 will offer minimum resistance to waves, winds and currents. When a tanker has to be unloaded or loaded, the tanker 12 is moored alongside the mooring arm 1 by means of mooring lines 13. Then a loading arm 16 is connected to the manifold 10 of the tanker 12. The loading arm 16 is in fluid communication with a pipeline (not shown) on the mooring arm 1 which communicates with a loading arm 15. The loading arm 15 communicates via a fluid swivel with a conduit (not shown) on or within the structure 9. The last-mentioned conduit is in communication with a pipeline on or in the sea bottom 10 leading for example to shore.

When it is desired to load the tanker 12, fluid, for example crude oil, oil products or liquefied gas, 15 is supplied via the pipeline in or on the sea bottom, the conduit in or on the structure 9, the loading arm 15, the pipeline on the mooring arm 1 and the loading arm 16 to the tanker 12. When it is desired to unload the tanker 12, the fluid is pumped through the said various conduits, pipelines and loading arms in the opposite direction.

When the floating mooring arm 1 is a stationary tanker as shown in Figures 1 and 2, it is possible 20 to store the fluid temporarily in the tanks of the stationary tanker 1.

In the embodiment as shown in the drawings, the annular member 2 is secured to the mooring arm 1 by means of the frame 3. Instead, it is possible to secure the mooring arm 1 to the annular member 2 in a rigid manner, for example so that the annular member 2 forms a unit with the mooring arm 1.

25 In the embodiment as shown in the drawings the elongated suspension elements for the weights 23 are chains 22 and 24. Instead it is possible to use cables or metal bars. When metal bars are used as elongated suspension elements, it is necessary to secure the ends of said bars in a hingeable manner respectively to the annular element 7, the annular member 2 and to the weights 23. In the embodiment as shown in the drawings the lever arms 20 are arranged on the annular member 2. If desired, it 30 is possible to arrange such lever arms on the floating annular element 7 or on the annular member 2 and on the floating annular element 7.

In the embodiment as shown in the drawings six weights 23 are used, but any other suitable number of weights can be used, if desired.

WHAT WE CLAIM IS:

35 1. A mooring system, in particular for (un)loading a tanker, comprising a structure secured to the water bottom, an annular element so arranged that it is rotatable around the structure, an annular member arranged around and connected to the annular element, a floating mooring arm secured to, or forming a unit with, the annular member, wherein the annular member is connected to the annular element by means of a suspended weight system comprising a set of weights, each weight being 40 suspended between the annular member and the annular element by means of elongated suspension elements.

2. The mooring system as claimed in claim 1, wherein the elongated suspension elements are chains or cables.

3. The mooring system as claimed in claim 1, wherein the elongated suspension elements are 45 metal bars.

4. The mooring system as claimed in any one of claims 1-3, wherein the connections between the elongated suspension elements and the annular member and/or the annular element are buffered by elastic elements.

5. The mooring system as claimed in claim 4, wherein the elongated suspension elements are 50 connected to the annular member and/or to the annular element via lever arms, each lever arm being rotatable around a horizontal axis and acting against an elastic element.

6. The mooring system as claimed in claim 4 or claim 5, wherein the elastic element is made of rubber.

7. The mooring system as claimed in claim 4 or claim 5, wherein the elastic element is a metal 55 spring.



8. The mooring system as claimed in any one of claims 1-7, wherein the annular member is buoyant.
9. The mooring system as claimed in any one of claims 1-8, wherein the floating mooring arm is a rigid space frame consisting of tubes.
- 5 10. The mooring system as claimed in claim 9, wherein the space frame is provided with flotation tanks.
11. The mooring system as claimed in any one of the claims 1-8, wherein the floating mooring arm is a tanker.
12. The mooring system as claimed in any one of claims 1-11, wherein the floating mooring arm 10 is secured to the annular member by means of a frame, hinges having horizontal axes being provided between the frame and the floating mooring arm.
13. The mooring system as claimed in any one of claims 1-12, wherein the annular element is buoyant and slidable in a vertical direction relative to the structure.
14. A mooring system, in particular for (un)loading a tanker, substantially as hereinbefore 15 described with reference to the accompanying drawings.

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