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(54) SINGLE BUOY MOORING SYSTEM FOR FLUID
 TRANSFER FOR USE AT EXPOSED LOCATIONS

(71) We, SHELL INTERNATIONALE
 RESEARCH MAATSCHAPPIJ N.V. a company
 organized under the laws of the Nether-
 lands, 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 fol-
 lowing statement:—

The invention relates to a single buoy
 mooring system for fluid transfer for use at
 exposed locations.

Nowadays oil is often produced from the
 sea bottom at great distances from the
 shore at locations where the sea-and
 weather conditions are sometimes very
 rough.

It is known to transfer the oil produced
 from the sea bottom to tankers by means
 of the well-known single buoy mooring
 systems. These single buoy mooring
 systems are, for example, described in the
 specification pertaining to Applicant's
 British patents No. 977,451, No. 1,177,908
 and No. 1,281,230.

It is an object of the invention to
 provide a single buoy mooring system for
 transferring fluid to a ship moored thereto,
 which system is particularly suitable for use
 at locations at sea where the expected sea-
 and weather conditions are very rough.

A single buoy mooring system according
 to the present invention comprises an
 elongated buoy body, a part on the buoy
 body which is rotatable around a vertical
 axis; a first fluid conduit on the buoy body
 which is adapted to be connected to a
 pipeline at the bottom of a body of water,
 a hose reel on the rotatable part, a fluid
 hose for making a fluid connection between
 the single buoy mooring system and a ship,
 a pipe swivel rotatable around a vertical
 axis for interconnecting the fluid hose and
 the first fluid conduit, said fluid hose being

[Price 33p]

adapted to be coiled on the hose reel, a
 mooring line reel on the rotatable part, a
 mooring line adapted to be coiled on the
 mooring line reel, and at least one counter-
 weight acting on the hose reel and on the
 mooring line reel.

Since the system according to the in-
 vention comprises an elongated buoy body
 with a small waterline area to restrict mo-
 tions and since the system is not provided
 with a hose and a mooring cable floating
 at the water surface, the risk of damage to
 the system even under the roughest sea-
 and weather conditions is greatly reduced
 as compared with the conventional single
 buoy mooring systems.

Preferably, a single counterweight is pre-
 sent, said counterweight being provided
 with a pulley, a wire running around said
 pulley and the ends of said wire acting re-
 spectively on the hose reel and on the
 mooring line reel. In a suitable em-
 bodiment of the invention the end parts of
 said wire are adapted to be coiled re-
 spectively on a first wire reel which is co-
 axial with the hose reel and on a second
 wire reel which is coaxial with the mooring
 line reel.

In a further attractive embodiment of
 the invention a radial mooring trunk, ad-
 apted to guide the mooring line, is secured
 to the periphery of the rotatable part.
 Preferably, the mooring trunk is provided
 with detectors so arranged that, when the
 mooring line exerts a tangential force of a
 predetermined minimum value on the
 mooring trunk, a signal is produced, and
 wherein means are provided comprising an
 electric motor adapted to be started by
 said signal, said motor being adapted to
 turn the rotatable part and to continue to so
 operate until the tangential force exerted
 on the mooring trunk is reduced to below
 said predetermined minimum value.

The invention will be further explained

with reference to the accompanying drawings wherein,

Figure 1 shows a side view of a single buoy mooring system according to the invention;

Figure 2 shows a side view, in vertical cross-section, of a part of the system above the elongated buoy body;

Figure 3 shows a side view of the rotatable part and of the construction carried by the rotatable part;

Figure 4 shows a side view of the rotatable part and of the construction carried by the rotatable part at an angle perpendicular to the side as shown in figure 3;

Figure 5 shows a side view of a guiding ring for guiding the fluid hose;

Figure 6 shows a side view of the steel construction which carries the fender construction of the single buoy mooring system;

Figure 7 shows a top-plan view A-A of the steel construction according to figure 6.

In Figure 1 a side view is shown of the single point mooring buoy. The buoy comprises a substructure 1 and a superstructure 2. The buoy is shown floating in a body of water 3. The bottom of the water is indicated by reference numeral 4 and the water surface is indicated by reference numeral 5.

The substructure 1 comprises mainly a long relatively slender cylinder 6 and a central column 7 on top of the cylinder 6. The cylinder 6 is provided with a central shaft 8, fixed ballast compartments 9, water ballast compartments 10, trim tanks 11 and buoyancy compartments 12.

The central column 7 is hollow and carries at its upper end the superstructure 2. The central column 7 is surrounded by a fender 13. The buoy is anchored to the bottom by means of a number (for example eight) of anchor chains 14. The superstructure 2 comprises a turntable 18 carrying a space frame 19. The space frame 19 carries a helideck 20 which enables a helicopter 21 to land on the buoy. The space frame 19 carries a hose reel 22. A flexible hose 24 wound on the reel 22 serves for making a fluid connection between the buoy and a ship 25. The turntable 18 carries a mooring rope reel 23. A mooring rope 26 wound on the mooring rope reel 23 and guided by a mooring trunk 27, serves for mooring a ship 25 to the buoy. On the bottom 4 an underwater pipeline 28, for example a pipeline supplying crude oil from a production platform, is present. By means of a pair of flexible hoses 29 the pipeline 28 is connected to two fluid conduits (not shown in Figure 1), which are present within the central shaft 8. Said fluid conduits make a fluid com-

munication between the hose 24 and the hoses 29, so that fluid can flow from the pipeline 28 to the ship 25 moored to the buoy. The hose 29 is provided with buoyancy tanks 30 which maintain the hose 29 in a desired curved shape. A remotely controlled valve 31 enables closure of the fluid supply, if desired.

Figure 2 shows a vertical cross-section of a part of the buoy at the top of the central column 7. The upper part 35 of the central column 7 has a somewhat larger diameter than the remaining part of the central column 7. The upper part 35 carries the turntable 18, the latter being mounted by a means of a large diameter roller bearing 36, in such a manner that the turntable 18 is adapted to rotate around a central vertical axis.

The turntable 18 is provided with a toothed path 37 co-operating with gears 38 mounted in a gear case 39. By driving the gears 38 the turntable 18 can be rotated around its vertical axis, if desired. The gears 38 can be driven by an electric motor 40 via a shaft 41 or by means of a handwheel 42, shaft 43, gears 44, shaft 45 and gears 46.

The central column 7 is provided with a central shaft 47 extending over its whole length, said shaft 37 being aligned with and communicating with the central shaft 8 in cylinder 6.

In the central shafts 8 and 47, two fluid conduits 48 and 49 are present. These conduits 48 and 49 are connected at their lower ends to the hoses 29. At their upper ends the conduits 48 and 49 are connected to a central swivel joint 50. Each conduit 48 and 49 is provided with suitable expansion joints 51.

The central shafts 8 and 47 contain a guiding cage 52 which is provided with holes 53. The central shafts 8 and 47, are each provided with an inner wall 54 dividing the shafts into two separate spaces. The parts of the central shafts 8 and 47 within wall 54 are filled with water. The guiding cage 52 is supported by a roller bearing 55. Guiding rings 56 are present between the cage 52 and the inner wall 54. The purpose of the guiding cage 52 is to guide a counterweight 57 which is present within the guiding cage 52. The counterweight 57 is provided with radial projections 58 which are adapted to co-operate with guiding rails 59 of the cage 52.

The counterweight 57 is suspended by means of a wire 60 running around a pulley 61, the latter being rotatably secured to the counterweight 57. On top of the guiding cage 52 a pair of guiding pulleys 62 for the counterweight wire 60 are present. The guiding cage 52 can be rotated together with the turntable 18 by means of a driver

5 tube 66 which passes through, and is rotatable relative to, the central swivel joint 50. The central swivel joint 50 is carried by the central column 7 and is connected thereto by means of four radial brackets 67. On the driver tube 66 a guiding pulley 68 is rotatably arranged. The two parts of the counterweight wire 60 pass through the driving tube 66. One part of the counterweight wire 60 runs around the pulley 68 and to a reel for the wire 60 which is mounted on the shaft of the hose reel 22. The other part of the counterweight wire 60 runs to a reel 69 for the wire 60 which is mounted on the same shaft as the mooring rope reel 23.

20 The central swivel joint 50 consists of a fixed part 70 in the shape of a large diameter outer pipe, wherein a small diameter coaxial inner pipe 72 is arranged. The radial brackets 67 are fixed to the outer surface of the pipe 70. The driver tube 66 is carried by the inner pipe 72 by suitable roller bearings.

25 A swivel head 73 provided with roller bearings is mounted on the fixed part 70 so that it is rotatable around a central vertical axis. The swivel head 73 is provided with two outlets 74 and with a separate coupling mechanism 75 for turning it round. A coupling mechanism 76 for the driver tube 66 and a coupling mechanism 77 for the guiding cage 52 is present as well.

35 The space frame 19 (see in particular figures 3 and 4) is mounted on the turntable 18 and supports the helideck 20 and the hose equipment. The hose reel construction 22 consists of two hose reels 22a and 22b, each suitable for a flexible oil hose 24a, 40 and 24b, respectively, and a counterweight wire drum 78. The hose reels 22a, 22b and the wire drum 78 are mounted on a hollow shaft 79. The shaft 79 is supported in roller bearings 80 in the joints of the side trusses of the space frame 19. The wire drum or reel 78 is fixed on the shaft 79 and the hose reels 22a and 22b are mounted on shaft 79 by means of roller 50 bearings. Coupling mechanisms 82a and 82b are present on the shaft 79, so that the reels 22a and 22b can be coupled to the shaft 79 as desired. Only one loading hose 24a or 24b can be used at any one 55 time. In other words, there is always one hose reel and one corresponding hose available as a spare.

60 Fluid conduits 83 are connected to the outlets 74 of the central swivel joint 50. The other ends of the fluid conduits 83 are connected to the hollow shaft 79 by means of pipe swivels 84. Communication between the hollow shaft 79 and the hoses 24a and 24b, respectively, is obtained by pipes 85 65 and expansion joints 86.

The free ends of the flexible hoses 24a and 24b are provided with a quick release coupling 87. At one side of the hose reels a lead screw mechanism carrying guiding eyes 88a and 88b is present. A lead screw 70 90 having right-handed screw thread and a lead screw 91 having left-handed screw thread is rotatably arranged in suitable bearings in plates 92. Each hose reel is provided with a chain wheel 93 and each 75 lead screw 90 and 91 is provided with a chain wheel 94. Endless chains (not shown) co-operate with each pair of chain wheels 93 and 94 so that rotation of a hose reel causes rotation of a corresponding lead- 80 screw. The lead screw 90 co-operates with guiding eye 88a and the lead screw 91 co-operates with guiding eye 88b in such a manner that rotation of a lead screw causes displacement of the corresponding 85 guiding eye along the lead screw. Through guiding eye passes a corresponding hose of a corresponding hose reel. The plates 92 are secured to arms 95 which are supported by the shaft 79. At the outer side 90 of each guiding eye 88 a catching house 96 holds the quick release coupling 87 of the hose 24 in a rest position. In the guiding eye 88 lateral rollers 89 are present. This is shown more in detail in Figure 5. 95

Below the heli-deck 20 an emergency cabin 97 for two men is present which can be reached from the deck 20 along a ladder 98. The space frame 19 carries plat- 100 forms 99 and 100 provided with railings 101 and 102. The turntable 18 is provided with a railing 103.

Two mooring rope reels 23a and 23b and a counterweight-wire reel 69 are mounted on a shaft 104. Coupling mechanisms (not shown) are provided so that the reels 23a and 23b can be coupled to the shaft 104 as desired. The shaft 104 is supported by four roller bearings which are mounted on the turntable 18 by means of 110 four supports 105. Each mooring rope reel carries a nylon mooring rope 26. One mooring rope will be used at any one time, the other is always a spare one.

The fender construction is shown more 115 in detail in Figures 6 and 7. It comprises basically a steel structure 113 which is connected to the central column 7 and to the top of the cylinder 6. The steel structure carries the fender 13. The fender 13 120 serves to protect the buoy against collision by tankers to a certain degree and makes berthing of small vessels and barges possible.

The steel structure 103 carries chain guid- 125 ing tubes 114 for the anchor chains 14.

The single-buoy mooring system is built in several separate sections. The sub-structure is towed to the desired location while floating in the water in horizontal 130

position. The superstructure and the fenders are transported to the desired location by ship. At the desired location the substructure is tipped to the vertical position
 5 by ballasting the fixed ballast compartments 9. Then the substructure is anchored to the sea bottom by means of suitable anchors (not shown) and anchor chains or cables 14. Then the super-
 10 structure is installed on the top of the substructure by means of suitable hoisting equipment. For this purpose the substructure is brought to a convenient draft position by means of the buoyancy compartments and the trim tanks. Finally, the
 15 anchor chains 14 are stretched to the desired pre-tension.

By means of a hose 29 a fluid connection is made between the pipeline 28
 20 and the single buoy mooring system. The fender construction 13 is mounted as required.

The water-tight buoyancy compartments 12 provide the buoyancy of the system.
 25 For stability reasons water ballast compartments 10 and fixed ballast compartments 9 are present. The trim tanks 11 serve for correcting the draft and heel of the system.

In the rest position the mooring rope 26
 30 is coiled on the corresponding mooring rope reel 23 and the oil hose 24 is coiled on the corresponding hose reel 22.

When it is desired to moor a tanker 25
 35 to the system, the end of the mooring cable 26 is picked up by a stand-by assistant vessel and the mooring cable 26 is connected to the bow of the tanker 25. The end of hose 24 is picked up as well
 40 by the stand-by assistant vessel and the hose 24 is connected to the tanker 25. During the connecting operation the mooring rope 26 and the hose 24 are partly unrolled from their corresponding reels (see
 45 figure 1). Then loading of the oil can begin. The oil hose 24 and the mooring rope 26 are kept in equilibrium by the counterweight 57. The counterweight 57 serves as well for coiling up the hose 24
 50 and the mooring rope 26 on their corresponding reels after the mooring operation has been completed.

To keep the superstructure 2 in a proper
 55 position in relation to the tanker, the superstructure is rotatable around a vertical axis. Rotation of the superstructure is powered by the electric motor 40 and controlled by signals from the flexible mooring trunk 27. For this purpose the trunk 27 is
 60 provided with detectors (not shown) producing signals when the mooring line 26 exerts a tangential force of at least a predetermined minimum value on the trunk. Means are provided for causing said signal
 65 to start the electric motor 40, the arrange-

ment being such that the motor 40 will continue operation until the tangential force exerted on the mooring trunk 27 is reduced to below said predetermined minimum value. During loading similar signals for the same purpose can be given by detectors (not shown) within the hose guiding eyes 88.

The single buoy mooring system is protected against collision by a fender construction 13. 75

WHAT WE CLAIM IS:—

1. A single buoy mooring system for fluid transfer comprising an elongated buoy body, a part on the buoy body which is
 80 rotatable around a vertical axis, a first fluid conduit on the buoy body which is adapted to be connected to a pipeline at the bottom of a body of water, a hose reel on the rotatable part, a fluid hose for
 85 making a fluid connection between the single buoy mooring system and a ship, a pipe swivel rotatable around a vertical axis for interconnecting the fluid hose and the first fluid conduit, said fluid hose being adapted
 90 to be coiled on the hose reel, a mooring line reel on the rotatable part, a mooring line adapted to be coiled on the mooring line reel, and at least one counterweight acting on the hose reel and on the
 95 mooring line reel.

2. The single buoy mooring system as claimed in claim 1, wherein a single counterweight is present, said counterweight
 100 being provided with a pulley, a wire running around said pulley and the ends of said wire acting respectively on the hose reel and on the mooring line reel.

3. The single buoy mooring system as claimed in claim 2, wherein the end parts
 105 of said wire are adapted to be coiled respectively on a first wire reel which is coaxial with the hose reel and on a second wire reel which is coaxial with the mooring line reel. 110

4. The single buoy mooring system as claimed in claim 3, wherein a first coupling is present which is so constructed that the first wire reel and the hose reel can be
 115 connected and disconnected at will and wherein a second coupling is present which is so constructed that the second wire reel and the mooring line reel can be connected and disconnected at will.

5. The single buoy mooring system as
 120 claimed in claim 4, comprising two separate coaxial hose reels, two of said first couplings, and two separate fluid hoses corresponding to each hose reel.

6. The single buoy mooring system as
 125 claimed in claim 4 or 5, comprising two separate coaxial mooring line reels, two of said second couplings, and two separate mooring lines corresponding to each mooring line reel. 130

(5)

position. The superstructure and the fenders are transported to the desired location by ship. At the desired location the substructure is tipped to the vertical position by ballasting the fixed ballast compartments 9. Then the substructure is anchored to the sea bottom by means of suitable anchors (not shown) and anchor chains or cables 14. Then the superstructure is installed on the top of the substructure by means of suitable hoisting equipment. For this purpose the substructure is brought to a convenient draft position by means of the buoyancy compartments and the trim tanks. Finally, the anchor chains 14 are stretched to the desired pre-tension.

By means of a hose 29 a fluid connection is made between the pipeline 28 and the single buoy mooring system. The fender construction 13 is mounted as required.

The water-tight buoyancy compartments 12 provide the buoyancy of the system. For stability reasons water ballast compartments 10 and fixed ballast compartments 9 are present. The trim tanks 11 serve for correcting the draft and heel of the system.

In the rest position the mooring rope 26 is coiled on the corresponding mooring rope reel 23 and the oil hose 24 is coiled on the corresponding hose reel 22.

When it is desired to moor a tanker 25 to the system, the end of the mooring cable 26 is picked up by a stand-by assistant vessel and the mooring cable 26 is connected to the bow of the tanker 25. The end of hose 24 is picked up as well by the stand-by assistant vessel and the hose 24 is connected to the tanker 25. During the connecting operation the mooring rope 26 and the hose 24 are partly unrolled from their corresponding reels (see figure 1). Then loading of the oil can begin. The oil hose 24 and the mooring rope 26 are kept in equilibrium by the counterweight 57. The counterweight 57 serves as well for coiling up the hose 24 and the mooring rope 26 on their corresponding reels after the mooring operation has been completed.

To keep the superstructure 2 in a proper position in relation to the tanker, the superstructure is rotatable around a vertical axis. Rotation of the superstructure is powered by the electric motor 40 and controlled by signals from the flexible mooring trunk 27. For this purpose the trunk 27 is provided with detectors (not shown) producing signals when the mooring line 26 exerts a tangential force of at least a predetermined minimum value on the trunk. Means are provided for causing said signal to start the electric motor 40, the arrange-

ment being such that the motor 40 will continue operation until the tangential force exerted on the mooring trunk 27 is reduced to below said predetermined minimum value. During loading similar signals for the same purpose can be given by detectors (not shown) within the hose guiding eyes 88.

The single buoy mooring system is protected against collision by a fender construction 13.

WHAT WE CLAIM IS:—

1. A single buoy mooring system for fluid transfer comprising an elongated buoy body, a part on the buoy body which is rotatable around a vertical axis, a first fluid conduit on the buoy body which is adapted to be connected to a pipeline at the bottom of a body of water, a hose reel on the rotatable part, a fluid hose for making a fluid connection between the single buoy mooring system and a ship, a pipe swivel rotatable around a vertical axis for interconnecting the fluid hose and the first fluid conduit, said fluid hose being adapted to be coiled on the hose reel, a mooring line reel on the rotatable part, a mooring line adapted to be coiled on the mooring line reel, and at least one counterweight acting on the hose reel and on the mooring line reel.

2. The single buoy mooring system as claimed in claim 1, wherein a single counterweight is present, said counterweight being provided with a pulley, a wire running around said pulley and the ends of said wire acting respectively on the hose reel and on the mooring line reel.

3. The single buoy mooring system as claimed in claim 2, wherein the end parts of said wire are adapted to be coiled respectively on a first wire reel which is coaxial with the hose reel and on a second wire reel which is coaxial with the mooring line reel.

4. The single buoy mooring system as claimed in claim 3, wherein a first coupling is present which is so constructed that the first wire reel and the hose reel can be connected and disconnected at will and wherein a second coupling is present which is so constructed that the second wire reel and the mooring line reel can be connected and disconnected at will.

5. The single buoy mooring system as claimed in claim 4, comprising two separate coaxial hose reels, two of said first couplings, and two separate fluid hoses corresponding to each hose reel.

6. The single buoy mooring system as claimed in claim 4 or 5, comprising two separate coaxial mooring line reels, two of said second couplings, and two separate mooring lines corresponding to each mooring line reel.



* C L M S *

7. The single buoy mooring system as claimed in any one of the claims 1-6, wherein the counterweight is guided in a shaft within the buoy body.

8. The single buoy mooring system as claimed in any one of the claims 1-7, wherein a fender construction is arranged above the buoy body.

9. The single buoy mooring system as claimed in any one of the claims 1-8, wherein a radial mooring trunk adapted to guide the mooring line, is secured to the periphery of the rotatable part.

10. The single buoy mooring as claimed in claim 9, wherein the mooring trunk is provided with detectors so arranged that, when the mooring line exerts a tangential force of a predetermined minimum value on the mooring trunk, a signal is produced, and wherein means are provided comprising an electric motor adapted to be

started by said signal, said motor being adapted to turn the rotatable part and to continue to so operate until the tangential force exerted on the mooring trunk is reduced to below said predetermined minimum value.

11. A single buoy mooring system as claimed in any one of the claims 1-10, wherein the buoy body comprises fixed ballast compartments, water ballast compartments, trim tanks and buoyancy compartments.

12. A single buoy mooring system for fluid transfer, substantially as described in the specification with particular reference to the accompanying drawings.

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