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(71) Applicant *(for all designated States except US)*: **SINGLE BUOY MOORINGS INC.** [MC/MC]; 24 Avenue de Fontvieille, MC-98007 Monaco Cedex (MC).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **QUEAU, Jean-Pierre** [FR/FR]; 15, rue Deloye, F-06000 Nice (FR). **MAUREL, Walter, Willy** [FR/FR]; 19, boulevard Paul Deroulede, F-06310 Beaulieu Sur Mer (FR). **MENARDO, Philippe, Albert, Christian** [FR/FR]; 63, Chemin du Vinaigrier, F-06300 Nice (FR).

(74) Agent: **VAN WESTENBRUGGE, Andries**; Postbus 29720, NL-2502 LS Den Haag (NL).

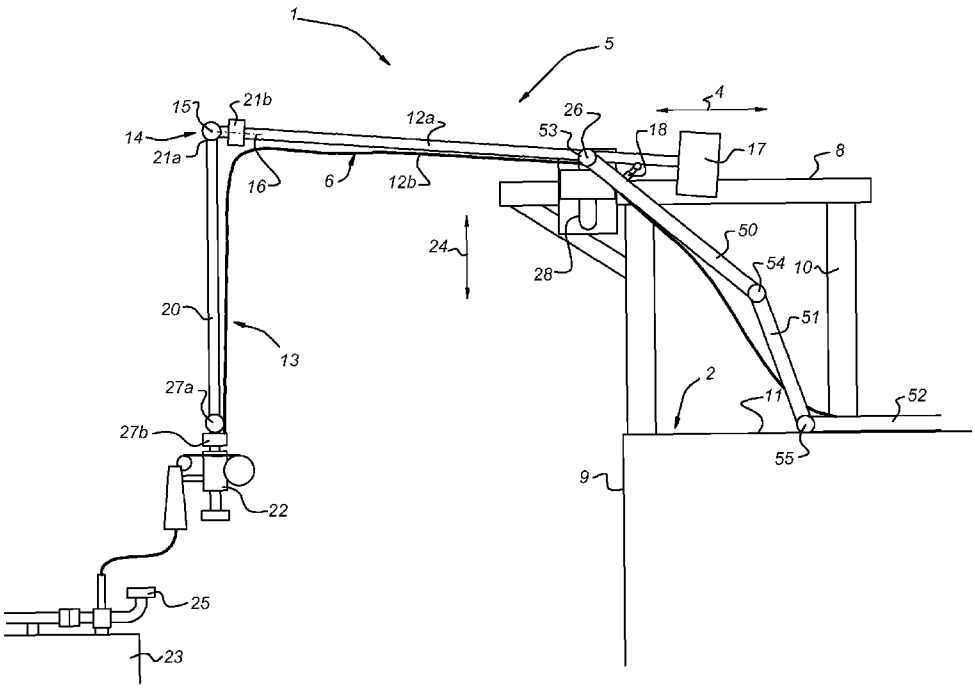
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(54) Title: HYDROCARBON TRANSFER SYSTEM WITH HORIZONTAL DISPLACEMENT



(57) Abstract: A hydrocarbon transfer system comprising a first structure with a length direction and a transverse direction having a frame carrying a fluid transfer duct with at its end a fluid connecting member for connecting to a second structure which is moored alongside the first structure and wherein the fluid transfer duct is placed on a movable frame part which is displaceable in the transverse direction.

WO 2007/113201 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Hydrocarbon transfer system with horizontal displacement

The invention relates to a hydrocarbon transfer system comprising a first structure having a length direction, a width direction and a deck level, a support structure extending upwardly from deck level of the first structure and supporting a track extending in the transverse direction, a movable frame part being connected to the track, a substantially transverse member and a vertical member being attached to the movable frame part, a vertical member extending downwardly from a first end of the transverse member from a movable joint such as to be pivotable around a first axis extending in the length direction and a second axis extending in the transverse direction

Such a hydrocarbon transfer system is known from EP-A-1 389 580. In the known system, a vertical tower is attached to a submerged production/storage vessel. A transverse manipulator arm is attached to the tower and has telescoping arm parts that can move transversely with respect to the vessel. A vertical suspension member extends downwardly from the free end of the manipulator arm and can rotate around an axis extending in the manipulator arm direction and around a second axis extending in a length direction of the vessel. The lower end of the suspension member carries a structural connector for attaching to receiving vessel moored alongside the storage vessel. A flexible hose extends from the tower to the lower end of the suspension member for attaching to fluid transfer ducts on the receiving vessel.

The known transfer system has as a disadvantage that the storage vessel is submerged below water level and that the deck is not accessible. Furthermore, the flexible fluid transfer duct extends across a relatively large distance and occupies the space between the far side of the storage vessel and the receiving vessel, hence hampering deck access even in case the deck level would be raised above water level. The curved flexible transfer duct is furthermore subject to uncontrolled swinging motions caused by wind and by wave movements which may result in undesired forces on the points where the flexible duct is connected to the tower and to the structural connector at the end of the vertical suspension member. The first structure may be a quay, tower, barge, vessel or the like.

Another hydrocarbon transfer system of the above-mentioned type is known from WO 2005/105565 A1 which shows a first vessel for containing hydrocarbons and hydrocarbon transfer means which are connected to a tank on the first vessel. The

hydrocarbon transfer means comprise a connecting member for connecting to a second vessel which is moored at a relative large distance of for example 25m or more alongside the first vessel. The hydrocarbon transfer means bridging the large gap between the two structures comprise a frame for carrying the fluid transfer duct with a connecting member at one of its ends. Such a large distance mooring arrangement between two structures is known from unpublished patent application EP051042182 "Soft quay mooring" in the name of applicant.

The known hydrocarbon transfer system has as a disadvantage that when the connecting member is connected to the second vessel, stress is created in the fluid transfer duct and/or the frame because of movement of the moored second vessel relative to the first vessel. As the transfer ducts need to bridge a large gap of more than 25m between the two structures which are moving relative to each other, large forces and moments are introduced in the transfer system bridging the gap. The end of the transfer ducts will need to follow the movements of the second structure which creates a motion envelope for the connector in which the system must be able to function correctly and safely. The combination of large distance, large dimensions of the transfer system and motion envelope creates inertia related fatigue problems within the transfer system. On top of the motion envelope there will be a relative large draft variation (up to 5m) between the two structures during the offloading off LNG from one structure into the other structure as in the case of two floating structures one will rise from a loaded draft level to an unloaded draft level while the draft level will increase. In addition to this, there are relative movements between the structures even when a vessel is moored alongside a static structure, like a quay. One of the movements of a moored second structure is a sway motion or roll motion in the direction from and towards the first structure alongside which the second structure is moored. The know transfer system compensates that movement by a vertical transfer duct part which is connected to the frame pivotable around an axis extending in the length direction. Because of the pivoting displacements of the vertical transfer duct part, also an additional up and down displacement of the connecting member relative to the first structure is created. This up and down movement of the connection member is in the height direction and creates stress in the fluid transfer duct and/or the frame. Stress in the fluid transfer duct and/or the frame can create leakage of the transferred materials. Because the hydrocarbon transfer system is used for transferring highly inflammable

hydrocarbons, such as LNG, leakage must at all times be avoided. Therefore the stress in the fluid transfer duct and/or the frame of the hydrocarbon system must be brought to a minimum.

A further disadvantage of the known hydrocarbon transfer system is that because of the pivoting movement of the vertical transfer duct around the axis extending in the length direction, large displacements of the moored second structure from and towards the first structure can not be compensated.

Another disadvantage of the known hydrocarbon transfer system is that it cannot function correctly over such a large distance if there is a variation in the position of the connection points or flanges on the second structure, as the motion envelope of the end of the transfer duct will be completely different. Another disadvantage related to the large distance between the two structures and the large variations in draft (up to 5m) between the two structures during offloading of LNG is that the known loading arms can not provide the same motion envelope of the connector at the end of the fluid duct which is needed in all circumstances.

The present invention has as an object to provide a hydrocarbon transfer system in which the above mentioned problems are solved. It is in particular an object of the present invention to provide a hydrocarbon transfer system which leaves a relatively large available deck area and in which the fluid transfer lines take up a relatively small volume of space. It is also an object of the present invention to provide a hydrocarbon transfer system in which the motions imparted to the transfer system can be taken up by a relatively rigid construction. The transfer system should compensate for large draft variations during the offloading of LNG from one structure to the other and be able to bridge varying distances between the moored structures while allowing wave-induced motions which result in relative low stress on the mooring arms. It is again an object to provide a transfer system that bridges a large distance between two structures and which can be adjusted to the different positions of the connection point or connection flanges on the second structure.

Hereto a hydrocarbon transfer system according to the invention is characterised in that

- deck level is situated above water level,
- the transverse member comprising a rigid fluid transfer duct,
- vertical member comprises a fluid transfer duct, wherein

- a second end of the transverse duct is attached to an inboard fluid transfer duct on the first structure situated closer to deck level than the transverse duct, via a length-adjustment fluid transfer member which is can be horizontally displaced upon movement of the second end of the transverse duct relative to the inboard fluid transfer duct. By using rigid piping for the transverse fluid transfer duct, a compact construction is achieved which is not subject to large swinging motions induced by wind and waves. The horizontal displacement of the transverse duct of the invention is compensated for by the length-adjustment fluid transfer duct that is situated for its larger part inboard of the vessel in the region of the support structure, such that the deck space occupied is relatively small. A flexible cryogenic hose may be used as a length-adjustment member.

In another embodiment, the length-adjustment fluid transfer member connects the fluid transfer duct to storage/processing or further transfer elements via a pivoting hard pipe construction and an in-line swivel coupling. The length-adjustment member comprises a first pipe having a first end attached to the transverse duct via a first swivel, a second pipe attached with a first and to the second end of the first pipe via a second swivel and attached with a second end to the inboard duct via a third swivel, the first, second and third swivels each being rotatable around an axis that extends in the length direction . In this construction, the movements of the length-adjustment member are well-defined and are confined to a relatively small space. The rigid pipes are particularly suitable to provide a safe thermally insulated transfer duct for cryogenic hydrocarbons, such as for instance LNG.

Hereby the fluid transfer duct can be correctly positioned for each second structure individually. In the desired position the frame will be locked, so that further movement will not be possible. Its is also possible that the moored second structure can move from and toward the first structure and that this movement is compensated by the moveable frame part without creating additional displacements of the connecting member relative to the first structure.

In an embodiment of the invention, the movable frame part is placed on a track extending in the transverse direction and projecting beyond a perimeter of the first structure, for example by 15m or more. By using a track the displacement of the movable frame part is realised with a simple and durable construction. Because the track projects beyond the perimeter of the first structure, this embodiment is preferably

used to adjust the transfer duct position so that it can be connected to each connection point on the moored second structure in the transverse direction. When no second structure is moored, alongside the first structure the transfer duct can be moved inward from at the first structure into a storage position. The track has preferably a total length of between the 20 and 40 meters.

In a further embodiment of the invention, the first structure comprises a frame part that is displaceable in the height direction as well. An advantage of this embodiment is that the position of the transfer ducts can be adjusted in accordance with the draft variations during offloading or loading LNG from one structure to the other, so to ensure at all times the same motion envelope for the connector end of the transfer duct. Draft variations of the moored second structure in the height direction can be compensated for without creating any additional displacements of the connecting member relative to the first structure. A further advantage is that this allows to first position the connecting member of the hydrocarbon transfer system exactly above the cooperating connecting member of the second vessel and to then lower the connection member of the transfer system in a straight line on the connection member of second structure.

In an embodiment of the invention the movable frame part is placed on a track carried by a support structure extending upwardly from deck level of the first structure, a transverse arm or duct being connected to the movable frame part and a vertical transfer duct part extending downwardly from the transverse arm or duct in a movable joint such as to be pivotable around a first axis extending in the length direction and a second axis extending in the transverse directions. The pivotable vertical transfer duct part is used to compensate small movements of the moored second structure in the transverse and length direction. For adjusting the transfer duct exactly above the connector of each second structure in the transverse direction, the movable frame part will be displaced.

The movable frame can be provided with multiple fluid transfer arms.

In again another embodiment of the invention the transverse arm or duct is pivotably connected to the movable frame part and a counterweight is connected at or near an end of the transverse arm or duct. Hereby movement of the moored second structure in the height direction of the first structure can be compensated. The transverse arm or duct is pivotable around an axis extending in the length direction. The

transverse arm or duct may also be pivotable around an axis extending in the height (vertical) direction. This can be realised by making the frame rotatable around a vertical axis. The hydrocarbon transfer system may comprise an actuator on the movable frame part for pivoting of the transverse arm or duct. The actuator can be used to actively displace the connection member.

Furthermore, the vertical duct transfer part may comprise a rigid arm which is connected to the horizontal duct part via a swivel allowing rotation around an axis extending in the length direction and an axis extending in the transverse direction.

The invention will be discussed in detail with reference to the accompanying drawings, wherein:

Fig. 1 schematically shows a side view of an embodiment of the hydrocarbon transfer system according the invention,

Fig. 2 schematically shows a plan view of the hydrocarbon transfer system of fig. 1. and

Fig. 3 schematically shows a side view of the hydrocarbon transfer system according the invention with a vertical flexible hose part.

Figure 1 shows an embodiment of the hydrocarbon transfer system 1 according the invention. The hydrocarbon transfer system 1 comprises a first structure 2 with a length direction extending perpendicular to the plane of the drawing arrow (3 of fig. 2), transverse direction 4 and height direction 24. The first structure 2 can be a sea-bed supported gravity based structure (GBS), quay, tower or a floating structure like a spread moored or weathervaning FSRU, a gas liquefaction plant or a floating power plant. The first structure 2 has a frame 5 which carries a fluid transfer duct 20,12a. At its free end the fluid transfer duct has a connecting member 22 for connecting to a cooperating connecting member 25 of a second structure 23. The second structure 23 is moored alongside the first structure 2 and can be a shuttle tanker for transporting LNG. The frame 5 has a movable frame part 7 which is displaceable in the transverse direction 4. The frame part 7 moves over a track 8 which is supported by a support structure 10 which extends upwardly from deck level 11 of the first structure 2. The track 8 extends (more than 10 m) in the transverse direction and beyond the perimeter 9 of the first structure 2. A transverse fluid transfer arm 12a is connected to the movable frame part 7. At one end of the transverse arm 12a a counter weight 17 is connected. An actuator 18 is connected to the movable frame part 7 and the transverse arm 12a for

pivoting the transverse fluid transfer arm 12a around a third axis 26 extending in the length direction 3 of the structure 2. The movable frame part 7 is displaceable in the height direction along a height track 28. The fluid transfer arm 12a is connected to a length adjustment member comprising hinging pipes (50, 51 and 52) which comprise pivot joints (53, 54 and 55) to allow the displacement of the frame part (7).

An umbilical line 6(is guided via the fluid transfer arms 12a and 20) such as a hydraulic line to activate the valves and the quick connection-disconnection unit 22 of the first structure 2.

The rigid fluid arm is connected to the transverse arm 12a via a movable joint 14 such as to be pivotable around a first axis 15 extending in the length direction 3 and a second axis 16 extending in the transverse direction 4. Both fluid transfer arms12 a and 20 can be reinforced by an additional rigid support structure (not shown) as for example is known from crane arms. The movable joint comprises a first fluid swivel 21a and a second fluid swivel 21b for allowing rotation respectively around the first axis 15 and second axis 16 while transferring fluids.

For positioning of the connecting member 22 it comprises a swivel 27(a and b) allowing rotation around an axis (not shown) extending respectively in the length direction and an axis extending in the height direction.

Figure 2 shows a plan view of the hydrocarbon transfer system of fig. 1. The parts of the hydrocarbon transfer system 1 shown with dotted lines have the position of the connection member 22 when the vertical duct part 20 is pivoted around the second axis 16 upon movement of the structure 23 in the length direction 3.

It will be clear to the person skilled in the art that many modifications of the embodiments of the present invention are possible without departing from the scope of protection as defined in the accompanying claims.

Figure 3 shows a vertical flexible hose part 60 for the transfer of cryogenic fluid which is connected to the transverse arm 12a. The vertical flexible hose 60 part can be combined with a rigid support arm (not shown) extending downwardly and alongside the vertical hose from the transverse arm 12a.

The invention can also be practised with a completely flexible hydrocarbon transfer duct attached to a in the transverse direction movable frame without departing from the invention.

Claims

1. Hydrocarbon transfer system (1) comprising a first structure (2) having a length direction (3), a width direction (4) and a deck level (11), a support structure (10) extending upwardly from deck level (11) of the first structure and supporting a track (8) extending in the transverse direction (4), a movable frame part (7) being connected to the track (8), a substantially transverse member (12a) 912a) and a vertical member (13,60) being attached to the movable frame part (7), a vertical member extending downwardly from a first end of the transverse member (12a) from a movable joint (14) such as to be pivotable around a first axis (15) extending in the length direction (3) and a second axis (16) extending in the transverse direction (4), Characterised in that

- deck level (11) is situated above water level,
- the transverse member (12a) comprising a rigid fluid transfer duct,
- vertical member (13,60) comprises a fluid transfer duct, wherein
- a second end of the transverse duct (12a) is attached to an inboard fluid transfer duct (52) on the first structure situated closer to deck level (12) than the transverse duct (12a), via a length-adjustment fluid transfer member (50,51) which is can be horizontally displaced upon movement of the second end of the transverse duct (12a) relative to the inboard fluid transfer duct (52).

2. Hydrocarbon transfer system (1) according to claim 1, wherein the length-adjustment fluid transfer member (50,51) comprises a first pipe (50) having a first end attached to the transverse duct (12a) via a first swivel (26), a second pipe (51) attached with a first and to the second end of the first pipe (50) via a second swivel (54) and attached with a second end to the inboard duct (52) via a third swivel (55), the first, second and third swivels (26,54,55) each being rotatable around an axis that extends in the length direction (3).

3. Hydrocarbon transfer system (1) according to claim 1, wherein the track (8) projects beyond a perimeter (9) of the first structure (2).

4. Hydrocarbon transfer system according to one of the claims 2 or 3, wherein the fluid transfer duct (6) is connected to a storage/processing or transfer element on the first structure via a coupling that can accommodate the movement.

5. Hydrocarbon transfer system according to any of the preceding claims, wherein the first structure (2) comprises a height direction (24) and the movable frame part (7) is displaceable in the height direction (24).

6. Hydrocarbon transfer system according to claim 1,2,3 or 4, the vertical duct (13) being connected to the joint (14) such as to be pivotable around a first axis (15) extending in the length direction (3) and a second axis (16) extending in the transverse direction (4).

7. Hydrocarbon transfer system according to claim 6, wherein the transverse arm or duct (12) is pivotably connected to the movable frame part (7) and a counterweight (17) is connected at or near an end of the transverse arm or duct (12).

8. Hydrocarbon transfer system according to claim 6 or 7, comprising an actuator (18) on the movable frame part (7) for pivoting of the transverse arm or duct (12).

9. Hydrocarbon transfer system according to claim 6 - 8, wherein the vertical transfer duct part (13) comprises a flexible hose.

10. Hydrocarbon transfer system according to claim 6 - 8, wherein the vertical transfer duct part comprises a rigid fluid transfer arm (20) which is connected to the transverse arm or duct (12) via a fluid transfer swivel (21) allowing rotation around axis (15) extending in the length direction and an axis (16) extending in the transverse direction.

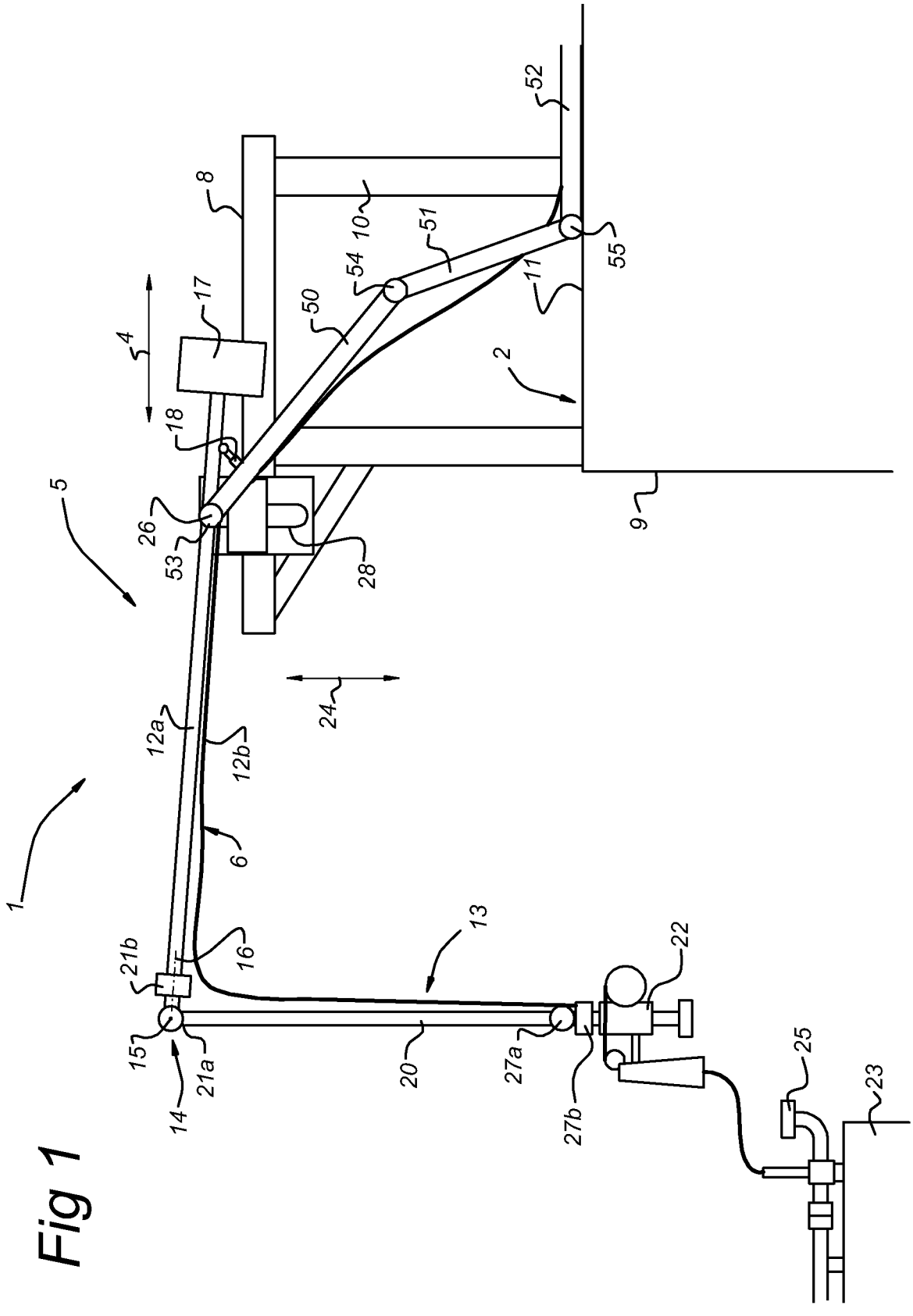

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Fig 1

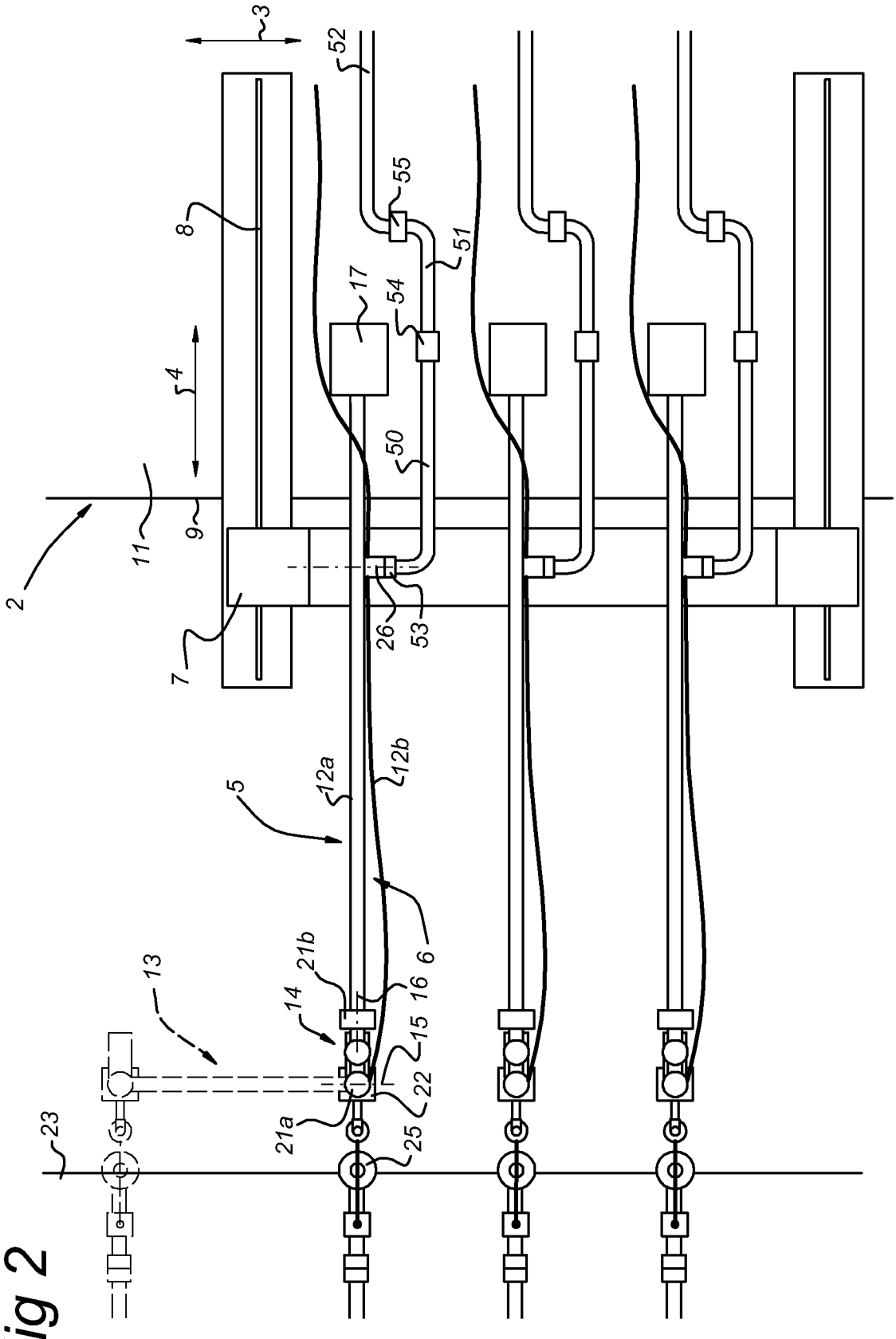

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Fig 2

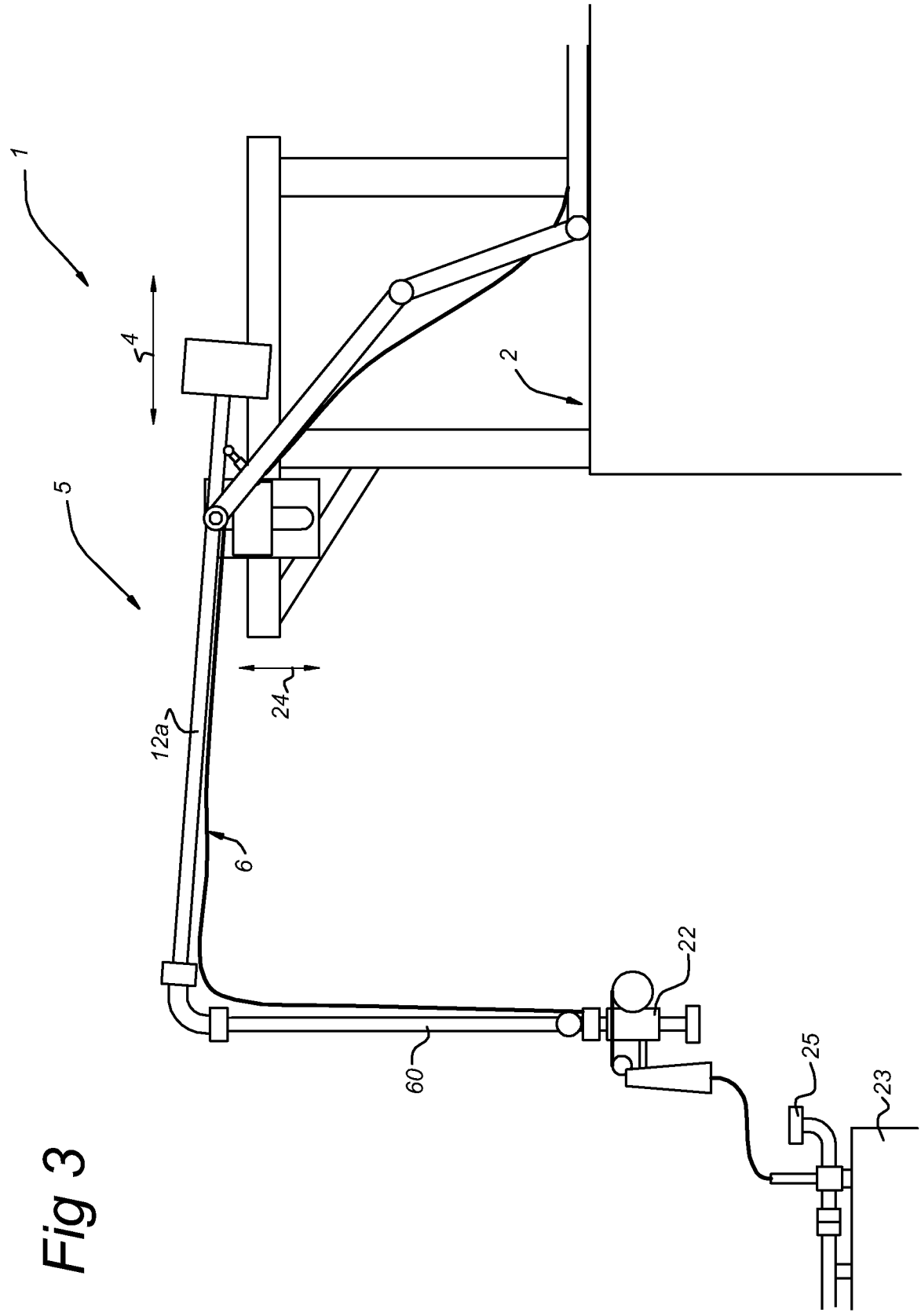


Fig 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/053016

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63B27/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2005/105565 A (SINGLE BUOY MOORINGS [CH]; POLDERVAART LEENDERT [FR]; POLLACK JACK [US) 10 November 2005 (2005-11-10) cited in the application figures 14,15	1
A	EP 1 389 580 A (BLUEWATER ENERGY SERVICES B.V) 18 February 2004 (2004-02-18) figure 1	1
A	GB 2 367 049 A (* OCEAN TECHNOLOGIES LTD) 27 March 2002 (2002-03-27) figures 3,4	1
A	WO 01/81163 A (BLUEWATER TERMINAL SYSTEMS, N.V; DE BAAN, JACOB) 1 November 2001 (2001-11-01) figures 1-4	1

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
31 July 2007	06/08/2007

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	van Rooij, Michael

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2007/053016

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2003/136132 A1 (HARLEY RICHARD B ET AL) 24 July 2003 (2003-07-24) figure 1	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2007/053016

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