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(71) **Applicant** *(for all designated States except US)*: **SINGLE BUOY MOORINGS INC.** [CH/CH]; Route de Fribourg 5, CH-1723 Marly (CH).

(72) **Inventors; and**
(75) **Inventors/Applicants** *(for US only)*: **BAUDIN, Christian** [FR/FR]; Villa Miradou 2, escalier du Chateau d'eau, F-06360 Eze (FR). **BRAUD, Jean** [FR/FR]; 3 Chemin des Oliviers, F-06320 La Turbie (FR). **BENOIT, Jean Pierre** [FR/FR]; Residence Le Saint Francois, 19 Av Cyrille Besset, F-06800 Cagnes Sur Mer (FR).

(74) **Agent: KETELAARS, Maarten**; J.W. Frisolaan 13, NL-2517 JS The Hague (NL).

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(54) **Title:** HYDROCARBON TRANSFER SYSTEM WITH A PIVOTAL BOOM

(57) **Abstract:** The invention relates to a hydrocarbon transfer system comprising an offshore structure, a support member extending upward from deck level of the structure, a hydrocarbon transfer duct comprising a transfer duct section extending from a free end of the support member, which free end is located outboard of the structure, to a hydrocarbon storage and/or processing unit on the structure and a connecting duct section in fluid communication with the transfer duct section and connected with a first end to the free end of the support member, a second end of the connecting duct section having a connector and being attachable to a hydrocarbon vessel, characterised in that, the support member comprises a displacement device, connected to the first end of the connecting duct section, which displacement device is movable between a connect and a disconnect position while the support member remains substantially stationary, a vertical distance from deck level of the displacement device being larger for the disconnect position than for the connect position, a horizontal distance from the side of the structure being larger for the connect position than for the disconnect position, wherein in the disconnect position, the connecting duct section in its vertical orientation is situated with its connector at a predetermined distance above sea level.

Hydrocarbon transfer system with a pivotal boom.

The invention relates to a hydrocarbon transfer system comprising an offshore structure with a support member extending upward from deck level of the structure, a hydrocarbon transfer duct comprising a transfer duct section extending from a free end of the support member, which free end is located outboard of the structure, to a hydrocarbon storage and/or processing unit on the structure and a connecting duct section in fluid communication with the transfer duct section and connected with a first end to the free end of the support member, a second end of the connecting duct section having a connector and being attachable to a hydrocarbon structure.

Liquefied Natural Gas (LNG) may be produced at seabed-supported platforms or spread moored or turret moored LNG liquefaction barges (FLNG) and is transferred from the production/processing site to cryogenic carriers. The LNG carriers may be vessels that are moored to an offshore liquefaction barge in a tandem configuration, via hawsers connecting the bow of the LNG carrier to the stern of the liquefaction barge and that are kept in position by dynamic positioning and the use of their thrusters. A flexible cryogenic hose connects at one end to a manifold at the bow of the carrier and at another end to a crane boom on the barge.

In US patent no. 6,434,948 a LNG transfer system is described in which a flexible LNG pipe is arranged at the end of a crane or boom which crane is rotatable around a horizontal axis. A connector in the LNG tank vessel's bow is connected to a pipe manifold leading further to the LNG tanks on the vessel. The crane, which may be an A-frame crane, supports the flexible hose from rigid pipe swivel ducts and gives the flexible LNG pipe in its lowest point sufficient clearance above the sea to avoid being hit by waves. Also, the movable crane frame compensates for slow changes in draught during the LNG transfer. The known crane has a relatively large footprint on the LNG barge when the crane is pivoted inboard of the vessel and the flexible hose is stored on deck. In order to raise the cryogenic hose above sea level when it is disconnected from the LNG tanker, the known crane must pivot around the horizontal axis. The drive mechanism for the crane is relatively complex and large in order to drive the large boom, and raising the cryogenic hose is therefore relatively slow. In case of an emergency quick disconnect procedure, the known crane may not be able to raise the cryogenic hose in a sufficiently rapid manner. Furthermore, in its retracted position, the crane extends above deck level of the LNG barge and has a relatively large footprint, occupying an area in which no further activities can be carried out.

It is an object of the present invention to provide a hydrocarbon transfer system for an offshore structure in which a hydrocarbon duct can be easily and rapidly connected to a tanker vessel. It is a further object to provide a hydrocarbon transfer system which maintains a safe clearance of the transfer duct above sea level in the disconnected state and which has a relatively small footprint on the structure. It is again an object to provide a hydrocarbon transfer system which is easy to operate and which can be rapidly connected and disconnected in a safe manner. It is another object to provide a hydrocarbon transfer system which allows rapid and space-efficient storage of the disconnected hydrocarbon transfer duct on the structure.

Hereto a hydrocarbon transfer system in accordance with the present invention is characterised in that the support member comprises a displacement device, connected to the first end of the connecting duct section, which displacement device is movable between a connect and a disconnect position while the support member remains substantially stationary, a vertical distance from deck level of the displacement device being larger for the disconnect position than for the connect position, a horizontal distance from the side of the structure being larger for the connect position than for the disconnect position. In the disconnect position, the connecting duct section in its vertical orientation is situated with its connector at a predetermined distance above sea level.

By providing a displacement device at the top end of the connecting duct section, the connecting duct section may while it is vertically depending from the support structure, be raised relatively high above seal level by movement of the displacement device only, such as at for instance a distance of between 1m and 15m, preferably about 5m. The support structure, which may comprise a crane or boom, remains substantially stationary. The vertically supported connecting duct section, which preferably comprises a flexible cryogenic transfer hose, may next be connected to a manifold of a tanker vessel, by pulling in a cable connected to the free end of the duct section, via a winch on the tanker vessel. The connecting duct section thereby assumes a more horizontal position and the displacement device may be moved towards the tanker vessel to provide additional length of the transfer duct section bridging the distance between the tanker vessel and the structure. In this way, clearance of the connecting duct section above seal level can, in case of a quick release of the duct from the tanker vessel, be achieved rapidly via the displacement member while only driving the relatively small displacement member, which can be effected rapidly with a relatively simple and light drive member. As the support structure can remain stationary, the footprint of the support structure on the offshore structure can be small.

The connecting duct section is preferably formed by a flexible hose, such as a cryogenic transfer hose that is described in US patent no. 4,445,543, which assumes a curved configuration when connected to the tanker vessel. The offshore structure carrying the support member may rest on the sea bed and may comprise a column-supported platform. The offshore structure can also be a floating structure such as a semi-submersible structure or a turret or spread moored barge.

In one embodiment, the displacement device comprises an arm which is with a base end hingingly connected to the free end of the support member, a support end of the arm carrying the connecting duct section, a force member being connected to the arm for pivoting the arm between a substantially vertical disconnect position and a substantially horizontal connect position. Via the arm, the connecting duct section can be displaced along a circular trajectory from the disconnect position in which the arm extends in a generally vertical direction, to a connect position in which the arm extends in a generally horizontal direction. The force member can be formed by one or more hydraulic cylinders connected on one side to the support structure and on the other side to the arm of the displacement device. Actuation of the cylinders may be controlled by an computerised connect-release system with an emergency actuation to raise the displacement member in case of quick release of the connectors.

The support member may comprise a frame that extends at an angle, a support surface being situated along at least a part of the length of the support member. The connecting duct section can be placed on the support surface to extend along the support member in the disconnected state. In the storage position, the connecting duct can remain attached to the transfer duct that is connected to a hydrocarbon storage and/or processing unit on the LNG barge. The transfer duct section may comprise a rigid duct which is attached at the free end of the support member to a displacement duct via a fluid swivel rotatable around a horizontal axis, a second end of the displacement duct being connected to the connecting duct section via a second swivel rotatable around a horizontal axis.

In one embodiment, the displacement device is in its lowest and most forward position - the connect position- while the connecting duct section is situated on the support surface. By raising the displacement device to the disconnect position, the connecting duct section is lifted from the support surface to become vertically oriented and depend from the raised displacement device.

An embodiment of a cryogenic LNG transfer system according to the present invention will by way of example be described in detail with reference to the accompanying drawings. In the drawings:

Fig. 1 shows a side view of an LNG barge being moored with its stern to the bow of an LNG carrier, and connected to the carrier via a flexible cryogenic hose with the displacement device in the connect position,

Figs. 2a and 2b show an enlarged detail of a hammerhead manifold at the bow of the LNG tanker, coupled to the connector of the flexible cryogenic hose, and the displacement device, respectively,

Fig. 3 shows a side view of the LNG barge and LNG carrier of Fig. 1 while the flexible hose is disconnected, and raised above sea level via the displacement device,

Fig. 4 shows an enlarged detail of the displacement device in the disconnect position,

Figs. 5a and 5b show an enlarged detail of the lower end and the upper end of the cryogenic hose respectively while extending on a support surface along the support member on the LNG barge,

Fig. 6 shows another view of the displacement device in the disconnect position while the flexible hose extends along the support member, and

Figs. 7 and 8 show different stages of the connection process of the flexible hose.

Fig. 1 shows a hydrocarbon transfer system comprising an offshore structure in the form of a floating LNG liquefaction barge 1. The barge 1 is at its stern 2 provided with a support frame 3 extending upward from deck level 11 at an angle α of about 45°, outboard from the barge 1. A LNG carrier 4 is moored with its bow 5 to the stern 2 via hawsers 6, 7. Instead of, or in addition to the hawsers 6, 7, the carrier may be moored, i.e. kept of at a defined position, by one of its thrusters, so called dynamic positioning. For applications where the carrier is equipped with dynamic positioning (DP) the hawsers 6, 7 are installed as a backup safety mooring system which maintains the carrier 4 close to the LNG barge in case of failure of the DP system of the carrier. A connecting duct section in the form of a flexible cryogenic hose 8 is with its upper end 9 attached to a displacement device 10. A lower connector end 12 of the hose 8 carries a connector 13 which is attached to a manifold 15 on the carrier 4. The manifold 15 comprises a plurality of connectors, such as a connector 17 for a liquid LNG line, a connector 18 for a hybrid line and a connector 19 for a vapour return line, such as shown in fig. 2a. The connector 13 and each complementary connector 17-19 are provided with a quick connect/disconnect system (QC/DC), an emergency release system (ERS) and a Break Away Connector System (BAC). On the hammerhead bow structure, the manifold 15 is supported on a hinged articulation, such that it can be rotated to be in line with the hose 8.

In fig. 1 it can be seen that a second flexible hose 20 is with an upper end connected to a respective displacement device for the hose 20. The hose rests on a support surface 25 on the support frame 3, such that the lower end 21, at which the connector 23 is provided, is situated near a lower part of the support frame 3 near deck level 11 of the barge 1. In this way, the hose 20 can be moved between a connect position and a storage position while minimising hose fatigue and reducing the footprint of the hose on the deck of the barge 1. Stairs are provided on the support structure 3 to allow access to the hose 20 for inspection, testing, repair and maintenance.

Along the support frame 3, a rigid cryogenic transfer duct 27 is provided that extends to a LNG storage or processing unit 28, such as a cryogenic tank, on the barge 1. At its upper end 29, the transfer duct 27 is connected to a displacement duct 30 that interconnects the rigid transfer duct 27 and the flexible connecting duct 8 via swivels 38, 39. The displacement duct 30 extends along the displacement device 10, as shown in fig. 2b. The displacement device 10 comprises a frame 33 which is with a base end 36 connected to the free end 35 of the support structure 3, via a pivot joint 34. The free end 35 of the frame 33 carries the flexible hose 8, which is via the swivel 39 connected to the displacement duct 30 which is attached to the frame 33 and which can pivot together with the frame from the horizontal connect position, as shown in fig. 1, to a vertical disconnect position as shown in fig. 3.

In the connect position such as shown in fig. 1, the height H_3 of the displacement device 10 above deck level 11 can be for instance about 40m. The distance D1 of the upper end 9 of the connecting duct 8 from the side of the barge 1 is for instance 50 m.

In the disconnect position that is shown in figure 3, the frame 33 of the displacement device 10 is placed in the vertically upright opposition such that the free end 35 is raised by a height H_2 of about 10 m and the connector 13 at the end of the flexible hose 8, comprising the complex QC/DC, ERS and BAC components, is positioned well above sea level by a height H_1 of for instance about 3-7 m. The distance H_4 above deck level 11 is for instance about 50 m and the distance D_2 of the vertical hose 8 from the side of the barge 1 is for instance 40 m.

As can be seen from fig. 4, several flexible hoses 8′, 8′′are supported along the support frame 3, with their respective displacement devices 10′, 10′′ in a horizontal position. The hoses 8′, 8′′ are supported on a surface on the support frame 3 and are accessible for inspection, maintenance or repair via stairs 40. The connector ends 12′, 12′′ of the hoses 8′, 8′′ are supported on a substantially horizontal platform 42 and are fixed in place by U-shaped brackets 43, which may be provided with a clamping device.

Fig. 5b shows the displacement device 10 of the flexible hose 8 in the vertical position, while the hose is supported along the support frame 3. In this position of the hose 8, the

U-shaped brackets 43 on the lower platform 42 may be opened and the hose 8 may be pushed from the support surface by personnel, such that the hose 8 becomes vertically oriented, depending from the displacement device 10. The frame 33 of the displacement device 10 can be seen to comprise a transverse reinforcing member 45 for carrying the weight of the flexible duct 8.

Fig. 6 shows the displacement 10 form the stern looking towards the bow of the barge 1. At the suspension end, the flexible duct is connected to a hinge articulation integrated in the boom extremity 46 which is adapted for suspending the flexible duct from the frame 33 and which interconnects the duct in a fluid transport manner to the displacement duct 30 via the cryogenic swivel 39. A force member 41 is provided, such as for instance one or more hydraulic cylinders, for pivoting the frame 33 around the pivot joint 34 from a horizontal connect position to a vertical disconnect position. The force member 41 may be driven by an emergency control system for rapidly raising the frame 33 upon occurrence of an emergency in order to keep the connector end 12 clear from the water at all times upon quick release or break away of the connector 13.

Fig. 7 shows the flexible hose 8 being connected via a cable 50 at its connecter end 13 to a winch 51 on the bow of the vessel. The connector end 12 of the hose 8 is pulled towards the vessel 5 until the connector 13 is in line with the connectors 17-19 of the manifold 15 on the bow of the vessel 5. When the connector 13 is aligned with the manifold, the displacement device 10 is lowered as shown in figure 8, and the connector 13 on the flexible hose 8 is pulled inboard of vessel 5 via the winch 51 and is connected to the manifold. In case of a required quick release, the connector 13 can be disengaged while the displacement device 10 is quickly up righted so that the connector 13 at the free end of the hose 8 remains well above water level.

Claims

1. Hydrocarbon transfer system comprising an offshore structure (1), a support member (3) extending upward from deck level (11) of the structure, a hydrocarbon transfer duct comprising a transfer (27) duct section extending from a free end (29) of the support member (3), which free end is located outboard of the structure (1), to a hydrocarbon storage and/or processing unit (28) on the structure and a connecting duct section (8) in fluid communication with the transfer duct section (27) and connected with a first end (9) to the free end of the support member, a second end (12) of the connecting duct section (8) having a connector (13) and being attachable to a hydrocarbon vessel (4), characterised in that, the support member comprises a displacement device (10), connected to the first end (9) of the connecting duct section (8), which displacement device is movable between a connect and a disconnect position while the support member (3) remains substantially stationary, a vertical distance from deck level (11) of the displacement device being larger for the disconnect position (H4) than for the connect position (H3), a horizontal distance from the side of the structure being larger for the connect position (D1) than for the disconnect position (D2), wherein in the disconnect position, the connecting duct section in its vertical orientation is situated with its connector at a predetermined distance (H1) above sea level.

2. Hydrocarbon transfer system according to claim 1, the displacement device (10) comprising an arm which is with a base end (36) hingingly connected to the support member (3), a support end (35) of the arm carrying the connecting duct section (8), a force member (41) being connected to the arm for pivoting the arm between a substantially vertical disconnect position and a substantially horizontal connect position.

3. Hydrocarbon transfer structure according to claim 1 or 2, wherein the support member (3) extends at an angle (α), a support surface (25, 42) being situated along at least a part of the length of the support member, the connecting duct section (8) being placable on the support surface (25,42) to extend along the support member.

4. Hydrocarbon transfer system according to claim 3, wherein the displacement device (10) is in the connect position when the connecting duct section (8) is situated on the support surface (25,42).

5. Hydrocarbon transfer system according to any of claims 1-4, the connecting duct section (8) comprising a flexible hose.

6. Hydrocarbon transfer system according to any of the preceding claims, wherein the transfer duct section (27) comprises a rigid duct which is attached at the free end (29) of the support member to a displacement duct (30) via a fluid swivel (38) rotatable around a horizontal axis, a second end of the displacement duct being connected to the connecting duct section (8) via a second swivel (39) rotatable around a horizontal axis.

7. Hydrocarbon transfer system according to claim 6, wherein the displacement duct (30) is a rigid duct.

8. Hydrocarbon transfer system according to any of the preceding claims, the transfer structure comprising a floating hydrocarbon vessel, the support member (3) being situated at a stern (2) of the vessel, a second hydrocarbon vessel (4) being connected with its bow (5) to the stern (2) of the hydrocarbon vessel via at least one mooring line.

9. Method of transferring hydrocarbons from a hydrocarbon structure to a hydrocarbon vessel, comprising the steps of:

- mooring the hydrocarbon vessel in the vicinity of the hydrocarbon structure,
- supporting a connecting duct section in a generally vertical orientation from a displacement device at the free end of a support member on the first hydrocarbon structure, the which free end is located outboard of the hydrocarbon structure at a distance from deck level,
- connecting a connector end of the connecting duct section to the hydrocarbon vessel via a line,

- pulling the connector end of the duct section towards the hydrocarbon vessel via the line, and
- moving the displacement device downward towards deck level of the hydrocarbon structure and in a generally horizontal direction towards the hydrocarbon vessel.

10. Method according to claim 9, wherein the connecting duct section (8) is situated along the support member (3), the displacement device (10) being situated near the free end of the support member, at a forward, lowered position whereafter the displacement device (10) is raised vertically upward towards a rearward position while of after which the connecting duct section (8) is moved from its inclined position to be oriented vertically depending from the displacement device (10).

Fig 1

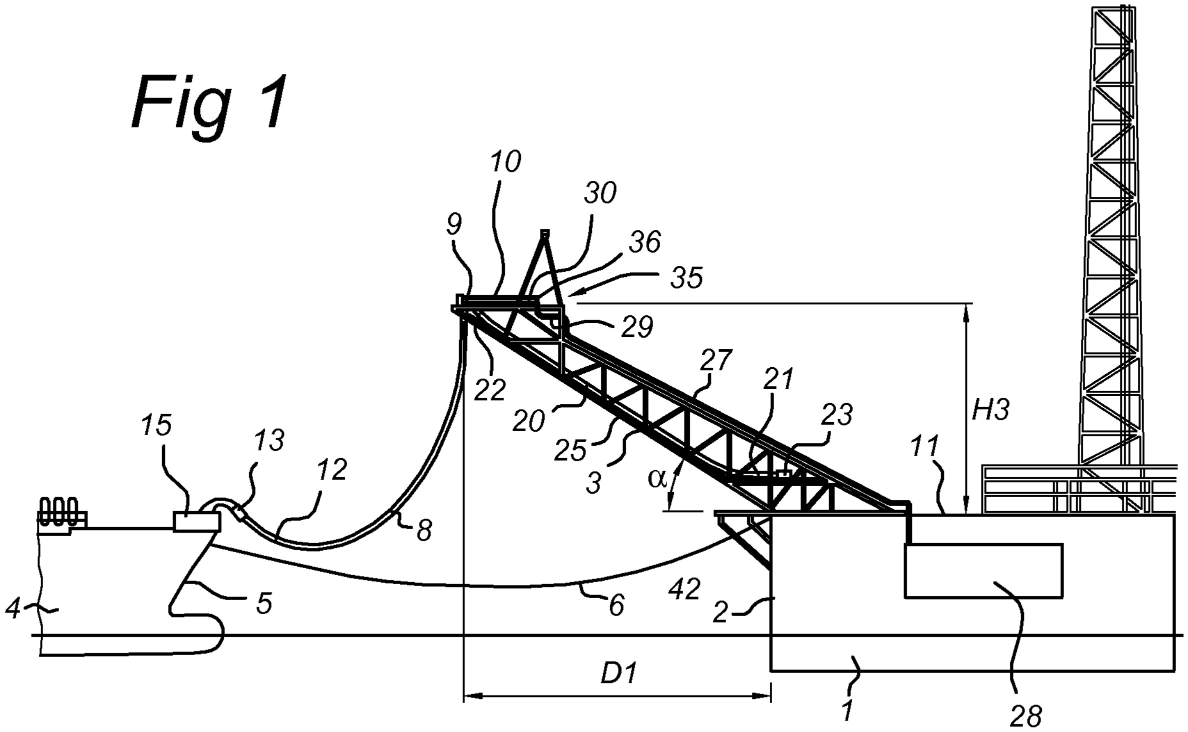

Fig 2a

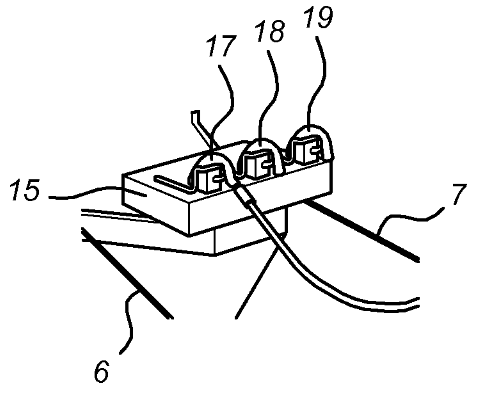

Fig 2b

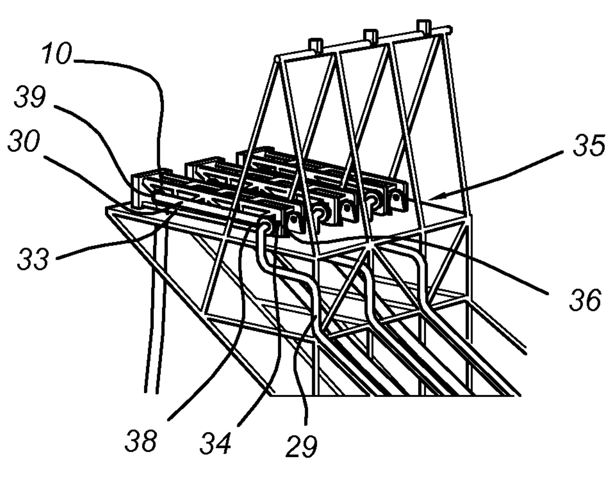

Fig 3

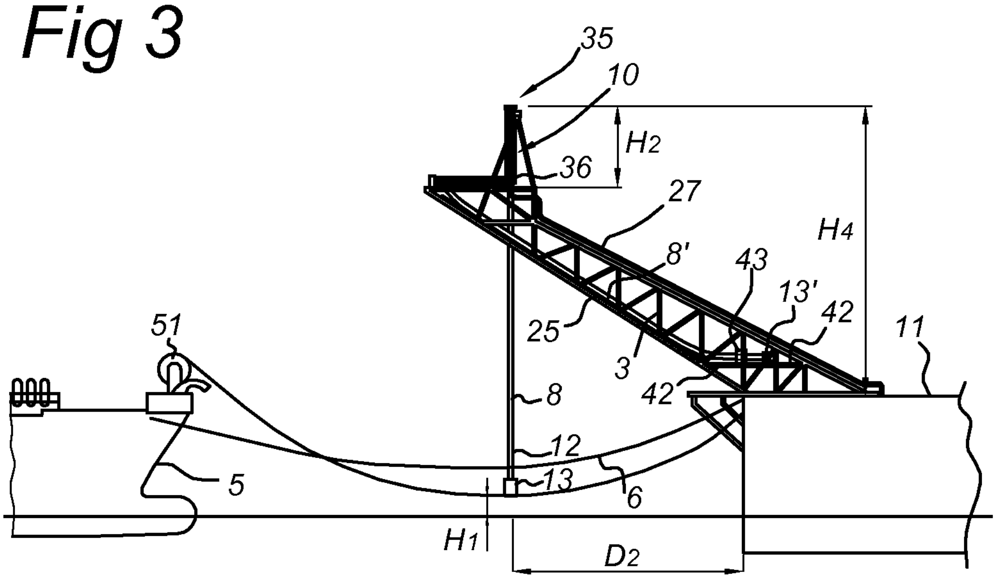

Fig 4

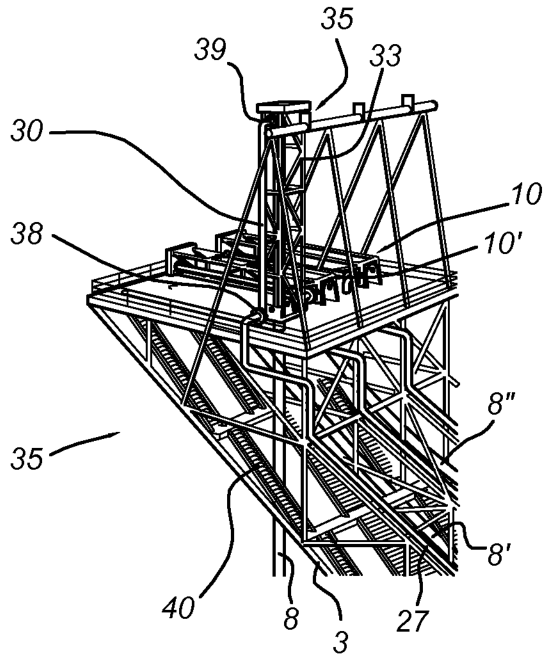

Fig 5a

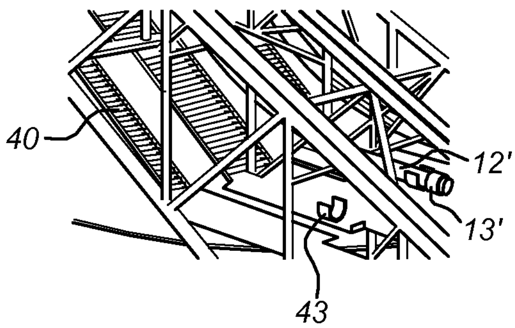

Fig 5b

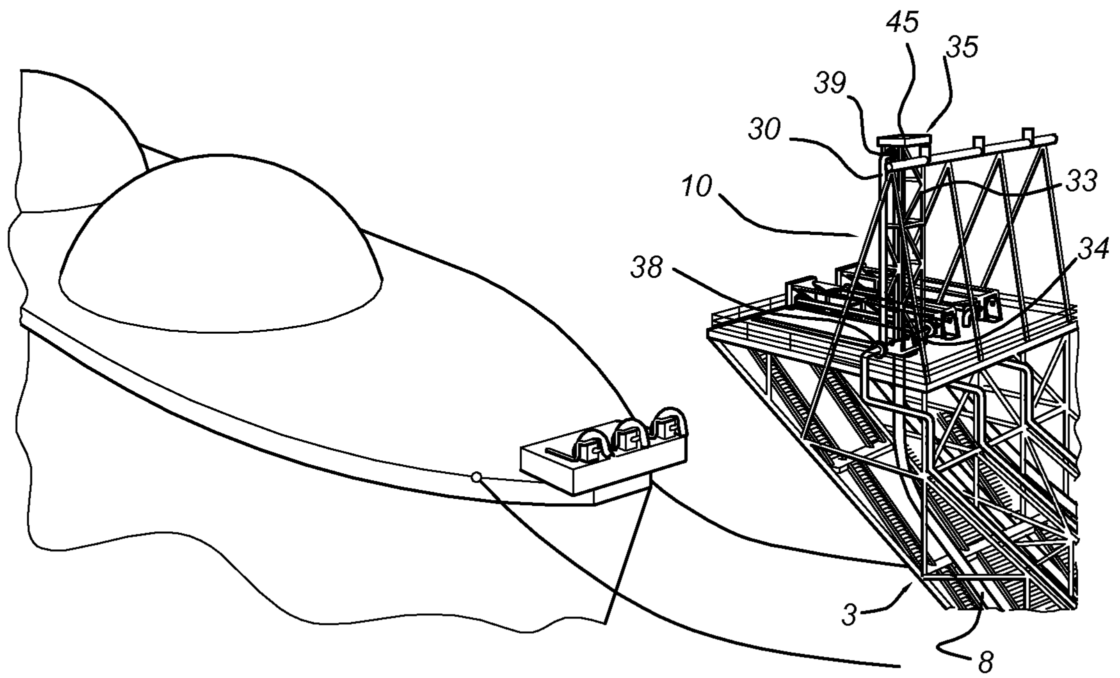

Fig 6

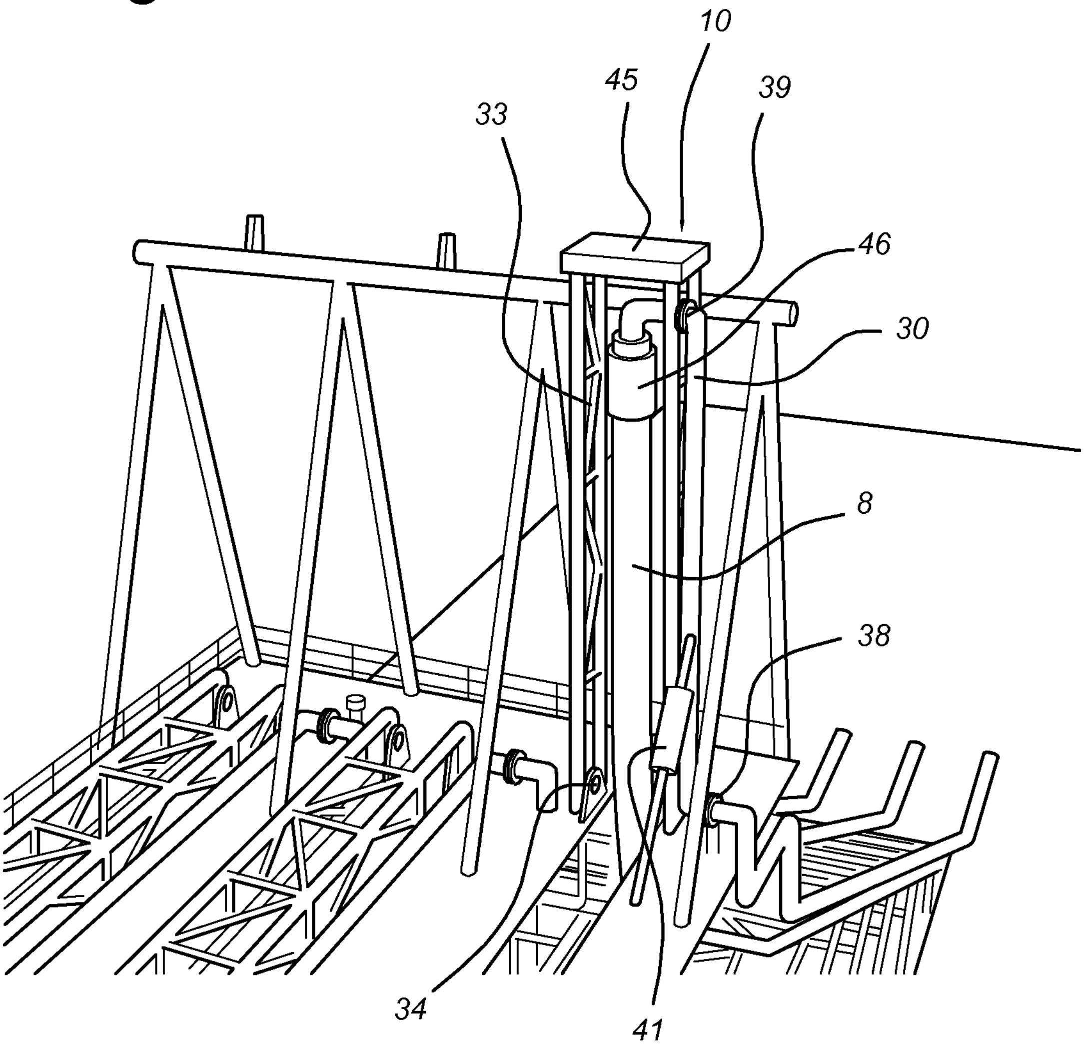

Fig 7

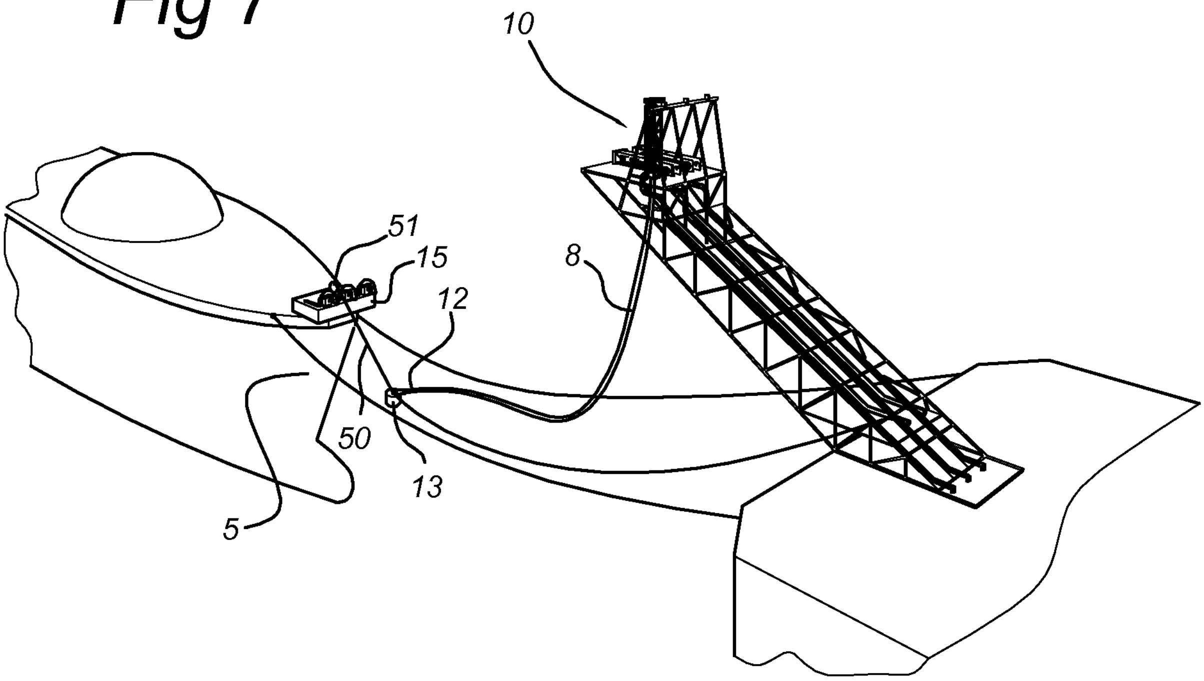

Fig 8