Abstract: A fluid transfer hose manipulator (1) is presented having an articulated arm (100) having a plurality of arm sections (110). A first arm section (110a) of the plurality of arm sections (110) and a second arm section (110b) of the plurality of arm sections are connected to each other by a first pivot joint (130a). A base (220) supports the first arm section (110a). At least one flexible hose (150) for fluid transfer extends movably along at least the first and second arm sections, and is directed and supported by at least two hose guides (140). At least one hose tensioner (160) is in contact with the flexible hose to adjust the tension on the at least one flexible hose (150).
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FLUID TRANSFER HOSE MANIPULATOR AND METHOD OF TRANSFERRING A FLUID

The present invention relates to a fluid transfer hose manipulator. In another aspect, the present invention relates to a method of transferring a fluid between first and second structures.

The transfer of fluids, such as processed or unprocessed hydrocarbons or their derivatives, between structures, when at least one of the structures is moveable and may therefore not be stationary, poses a number of technical problems. This is particularly the case when at least one or both of the structures is a floating structure. For instance, such a fluid transfer system should be capable of mitigating against a relative motion between the structures, particularly in terms of one or more of the heave, yaw, sway, pitch, surge and roll experienced by a floating structure.

In particular, a system for fluid transfer from or to a floating structure should compensate for heave produced by wave motion or tidal motion, as well as for height differences between the source and destination. Such height differences may arise, for instance, due to the differences in the vertical position of the fluid transfer system on one structure relative to the fluid manifold on another structure to which the transfer system is to be connected. One example of where such a fluid transfer system would be required is in a floating production, storage and offloading (FPSO) facility. A FPSO is a floating structure which receives hydrocarbon from nearby platforms or directly from a subsea hydrocarbon reservoir, processes the hydrocarbon and
stores the processed hydrocarbon until it can be offloaded onto a carrier vessel.

Similarly, a Floating Liquefaction Storage Off-shore (FLSO) facility combines the natural gas liquefaction process, storage tanks, loading systems and other infrastructure into a single floating structure. Such a structure is advantageous because it provides an off-shore alternative to on-shore liquefaction plants. An FLSO structure can be moored off the coast, or close to or at a gas field, in waters deep enough to allow off-loading of the LNG product onto a carrier vessel. It also represents a movable asset, which can be relocated to a new site when the gas field is nearing the end of its productive life, or when required by economic, environmental or political conditions.

Such floating structures require the transfer of fluids, typically processed hydrocarbons such as LNG, between the floating structure on which the hydrocarbon is processed e.g. where natural gas is optionally purified, then liquefied and temporarily stored, to the processed hydrocarbon carrier vessel e.g. an LNG carrier vessel. Similarly, the processed hydrocarbon cargo, such as LNG, must then be transferred from the carrier vessel to an on-shore import or processing facility.

US Patent Publication No. US 2010/0263389 discloses methods for the dockside regasification of LNG. In one embodiment disclosed in Figure 2, a high pressure arm to transfer high pressure gas is mounted on a dock or regasification vessel. An LNG hard arm similar to the high pressure arm to transfer LNG from a ship-to-dock or a dock-to-ship is also disclosed. The arm comprises transfer piping and may contain multiple joints, a dampener and counterweights to allow movement or
articulation of arm sections. One problem associated with the hard arm of US 2010/0263389 is that it has a limited vertical range i.e. the range of height which the end of the hard arm can reach, when connecting to a fluid manifold. In addition, the hard arm and the base, such as a deck, to which it is connected must be designed to bear the weight of the hard arm, including the counterweights and damper. Furthermore, the large mass of the upper arm section also increases the inertia of the arm movement, making it more difficult to control the arm movement in response to wind and wave motion.

In a separate embodiment, US 2010/0263389 discloses in Figure 8 the transfer of LNG from a storage tank on an LNG carrier through a manifold system having liquid conduits coupled to liquid hoses. Although the deck can support a portion of the liquid hoses, it is apparent from the Figure that these hang in a U-shape over the water separating the two fluid manifolds. One problem associated with the manifold and hose system of US 2010/0263389 is that liquid may accumulate in the lowest section of the U-shape hose and it is difficult to drain such liquid after fluid transfer. In addition, the free-hanging liquid hoses are uncontrolled, which can lead to impact between adjacent hoses or between a hose and the side of the vessel as a result of relative movement between the manifolds.

In a first aspect, the present invention provides a fluid transfer hose manipulator, said hose manipulator comprising at least:

- an articulated arm comprising a plurality of arm sections, each arm section having a longitudinal axis, said plurality of arm sections comprising at least a first arm section and a second arm section, said first
arm section connected to said second arm section by a first pivot joint;
- a base supporting said first arm section;
- at least two hose guides;
- at least one flexible hose for fluid transfer, said flexible hose extending movably along at least said first and second arm sections and directed and supported by said at least two hose guides;
- at least one hose tensioner in contact with the flexible hose to adjust the tension on the at least one flexible hose.

In a second aspect, a method of transferring a fluid between first and second structures, wherein at least one of the first and second structures is a moveable structure, preferably a floating structure, is provided, said method comprising at least the steps of:
- providing a first structure comprising a fluid transfer hose manipulator as described herein, the at least one flexible hose of the fluid transfer hose manipulator having a proximal end connected to a fluid first manifold and having a distal end;
- providing a second structure comprising a fluid second manifold;
- aligning the fluid second manifold of the second structure with the fluid transfer hose manipulator of the first structure;
- adjusting the configuration of the fluid transfer hose manipulator so that the distal end of the at least one flexible hose can be connected to the fluid second manifold;
- connecting the distal end of the at least one flexible hose to the fluid second manifold;
- purging the at least one flexible hose;
- passing a fluid through the at least one flexible hose;
- purging the at least one flexible hose;
- disconnecting the distal end of the at least one flexible hose from the fluid second manifold;
- adjusting the configuration of the fluid transfer hose manipulator to withdraw the distal end of the at least one flexible hose from the fluid second manifold and second structure.

In one embodiment of the second aspect, the fluid first manifold can be in fluid connection with at least one fluid first storage tank and the fluid second manifold can be in fluid connection with at least one fluid second storage tank.

Embodiments of the present invention will now be described by way of example only and with reference to the accompanying non-limited drawings in which:

Figure 1 is a diagrammatic scheme of one embodiment of a fluid transfer hose manipulator described herein;

Figure 2 is a diagrammatic scheme of another embodiment of a fluid transfer hose manipulator described herein;

Figure 3 is a diagrammatic scheme of a further embodiment of a fluid transfer hose manipulator described herein; and

Figure 4 (parts A to C) diagrammatically shows various storage and fluid transfer configurations of a fluid transfer hose manipulator described herein.

For the purpose of this description, a single reference number will be assigned to a line as well as a stream carried in that line. Same reference numbers refer to similar components. The person skilled in the art will readily understand that, while the invention is illustrated making reference to one or more a specific
combinations of features and measures, many of those features and measures are functionally independent from other features and measures such that they can be equally or similarly applied independently in other embodiments or combinations.

The fluid transfer hose manipulator described below is suitably employably particularly for the transfer of fluids to or from a floating structure, especially in the marine environment. The fluid transfer hose manipulator is particularly suitable for the transfer of cryogenic fluids, especially liquefied natural gas (LNG). A method of fluid transfer using such a hose manipulator is also disclosed.

The presently proposed fluid transfer hose manipulator has an articulated arm comprising a plurality of arm sections interconnected by pivod joints and at least one flexible hose for fluid transfer. The flexible hose extends movably along arm sections and is directed and supported by at least two hose guides. At least one hose tensioner is provided in contact with the flexible hose to adjust the tension on the at least one flexible hose.

The hose tensioner may operate to maintain a constant tension on the flexible hose. Maintaining constant tension can prevent the flexible hose from sagging or breaking (or at least prevent the flexible hose from becoming over tensed) during transferring of a fluid through the flexible hose.

With the presently disclosed fluid transfer hose manipulator it is possible to replace the hard arm or manifold system of the prior art and therewith to address various problems associated with the hard arm or manifold system of the prior art.
A first of said arm sections may be supported on a base. The tensioner may be supported by one of said arm sections or directly by said base.

As examples, the fluid transfer hose manipulator may be located on a floating structure, such as a carrier vessel, a floating production platform or a floating processing platform and operate to transfer fluid to another floating structure or a non-floating structure. Alternatively, the fluid transfer system may be located on a non-floating structure, such as a fixed production or processing platform or on-shore, such as on a jetty of an import or export terminal or of a processing facility, and operate to transfer fluid to or from a floating structure, such as a carrier vessel.

The fluid to be transferred by the hose manipulator may be an unprocessed hydrocarbon e.g. one extracted from an undersea reservoir, or a processed hydrocarbon, such as LNG or a hydrocarbon derivative.

The hose manipulator described herein has a number of advantages. It can transfer fluid from or to a fluid manifold for supplying or receiving a fluid located at a wide range of heights relative to the base to which the hose manipulator is attached. In particular, the hose manipulator described herein has a much wider vertical range of operation compared to the hard arm of US 2010/0263389. In addition, it does not require the presence of a counterweight such that the articulated arm and the base to which it is attached need only support the load of the arm sections and flexible hose.

Furthermore, the hose manipulator may be located on a manifold platform, which due to the reduced mass of the hose manipulator compared to a counterweighted hard arm, does not need to be reinforced to bear the weight.
In addition, in contrast to the dampener of US 2010/0263389, which is attached to and operates on the entire upper articulated section of the hard arm, the tensioner of the hose manipulator disclosed herein operates directly on the flexible hose, and not on an arm section.

Also, by utilising flexible hose rather than rigid piping, there is no need to provide swivel joints connecting the pipes in different sections of the articulated arm.

The hose manipulator is also advantageous because it maintains the flexible hose in a substantially vertical or a "n-shaped" configuration, eliminating fluid retention. In contrast, flexible hoses which are not supported in this way, such as in the manifold and hose system of US 2010/0263389, can adopt a "u-shaped" configuration in which fluid can accumulate at the base of the "u".

In one embodiment, one of said at least two hose guides may be located at or near an end of the longitudinal axis of each arm section. As used herein, the longitudinal axis is the longest dimension of the arm section.

In another embodiment, the at least one flexible hose may further comprise a proximal end and a distal end. The proximal end may be connected to the base. The proximal end may be configured in fluid communication with a fluid first storage tank. Said distal end may suitably comprise a restriction cone and a fluid connector. For instance, the proximal end may be connected to a fluid first manifold which is in fluid communication with a fluid first storage tank, typically a plurality of fluid first storage tanks. The fluid
first storage tank preferably has a fixed position relative to the base.

In another embodiment, the hose tensioner maintains the at least one flexible hose under constant tension. The tension under which the at least one flexible hose is maintained may change and can be selected depending upon one or more of the following criteria: whether the distal end of the flexible hose is attached to a fluid manifold, the relative distance between the hose manipulator and a fluid manifold to which it is attached, particularly the vertical distance between the base of the hose manipulator and the fluid manifold to which it is attached, whether fluid is being transferred through the at least one flexible hose and/or the characteristics of any fluid being transferred, such as the fluid temperature or density.

In one embodiment, the at least one hose tensioner may be connected to the base of the hose manipulator. The base may be, for instance, a deck of a carrier vessel or PFSP, particularly the manifold deck, or the surface of a jetty. This is advantageous because it provides a stable arrangement of the hose connector, in which the hose tensioner is attached to the base rather than one of the arm sections.

In alternative embodiments, the at least one hose tensioner may be connected to an arm section of the hose manipulator, particularly an arm section other than the first arm section, preferably the second or any third arm section. Supporting the at least one hose tensioner off of one or the arm segments, preferably the second or any third arm segment, is advantageous because it can provide a greater deflection of the flexible hose from the longitudinal axis of the arm section to which the hose
tensioner is connected, thereby facilitating a larger operating envelope, in terms of the relative positions of the hose manipulator and the manifold to which the flexible hose can be attached.

In a further embodiment, the hose tensioner may comprise a tensioner hose guide to direct and optionally support the at least one flexible hose. Such tensioner hose guide may direct the at least one flexible hose along a path that is deflected from a nominal path. The nominal path may be any suitable reference path depending on the circumstances of the specific embodiment. For instance, if the tensioner hose guide interacts with the flexible hose in a section of the flexible hose that extends between two adjacent hose guides, the nominal path may be defined by the line that tangentially connects the two adjacent hose guides. Alternatively, if for instance the tensioner hose guide interacts with the flexible hose in a section of the flexible hose that extends between the proximal end and the first hose guide of the hose guides, the nominal path may be defined by or by the line that tangentially connects the first hose guide with the proximal end of the flexible hose. The proximal end may be connected in a fixed point relative to the base.

The tensioner hose guide may be movable in a direction having a transverse directional component relative to the nominal path. Herewith the amount of deflection of the hose from the nominal path can be variably changed.

The hose tensioner may suitably be connected to one of said arm sections, wherein the tensioner hose guide can move along a path at a non-zero path angle at to the longitudinal axis of the arm section to which it is
connected, thereby changing the amount of deflection of the hose from its nominal path.

In a yet another embodiment, when the hose tensioner is connected to one of the arm sections, the deflection of the path of the hose by the movement of the tensioner hose guide may occur on either side of the longitudinal axis of the arm section to which the tensioner is connected. The longitudinal axes of two connected arm sections can define an arm section angle $\beta$ at the pivot joint connecting them. When the arm section angle $\beta$ is other than $180^\circ$, the longitudinal axes of the two connected arm sections can define an arm pivoting plane which passes through both longitudinal axes. The non-zero path angle $a$ may be a positive or a negative angle measured with respect to the longitudinal axis of the arm section to which the hose tensioner is connected in the arm pivoting plane or a plane parallel thereto.

The hose guides for a particular flexible hose may be positioned parallel to the arm pivoting plane. For instance, when a plurality of flexible hoses are present on a hose manipulator, equivalent hose guides for different flexible hoses may be arranged symmetrically about to the arm pivoting plane.

In a further embodiment, the hose tensioner may be connected at or near the centre of the longitudinal axis of said arm section and the path which the tensioner hose guide can move along is at an angle $a$ of approximately $90^\circ$ to the longitudinal axis of the arm section to which it is connected.

In a still further embodiment, the tensioner hose guide can be moved by one or more of the group comprising a tensioner cylinder, electric motor and wire sheave.
In a further embodiment, one or more, preferably all, of the hose guides may be sheaves. This embodiment may include the tensioner hose guide, as well as the hose guides connected to the arm sections which do not form part of the hose tensioner.

The first arm section is suitably connected to a second arm section by a first pivot joint. In another embodiment, the hose manipulator may further comprise a third arm section and a further hose guide, wherein the third arm section is connected to said second arm section by a second pivot joint and the third arm section has the further hose guide positioned thereon. The flexible hose can extend movably along the longitudinal axis of the third arm section. The second pivot joint may be connected to the second arm at the opposite end of the longitudinal axis to the end which is connected to the first pivot joint.

In another embodiment, the distal end of the at least one flexible hose may comprise an emergency release coupling, optionally in addition to the restriction cone and fluid connector. The emergency release coupling is configured to quickly separate the at least one flexible hose, and particularly the distal end, from a fluid manifold to which it is connected, for instance if conditions arose in which the hose manipulator extended beyond its safe operating envelope while connected to a fluid manifold during fluid transfer.

In a further embodiment, the hose manipulator may further comprise a position monitoring system to monitor the position of the distal end of the flexible hose. The position of the distal end may be monitored as an absolute position, i.e. with regard to the location of the distal end on the earth, or in relative terms, for
instance the position of the distal end may be monitored with respect to a relative position on the hose manipulator, such as a relative position on an arm section or the base.

In a yet further embodiment, the position monitoring system may comprise a positioning sensor to measure the position of the distal end of the flexible hose. For instance, the positioning sensor may be connected to the end of an arm section, preferably a second or third arm section. The positioning sensor may operate by laser, radar, lidar, echolocation or taught wire etc. For example, a taught wire sensing system may comprise a wire connected between the distal end of the flexible hose, such as a restriction cone located on the distal end, or a tie bar on the distal end, and a gimbal head affixed to the second or any third arm section. A gimbal head sensor, such as a laser, can measure the angle of the gimbal head to calculate the position of the distal end from the angle and the length of the taught wire.

In an alternative embodiment, the distal end of the at least one flexible hose may further comprise a position referencing sensor, particularly a vertical position referencing sensor such as GPS or the like. In this case, it is not necessary to determine the position of the distal end of the flexible hose with respect to a position on the hose manipulator. Instead, the absolute position of the distal end of the at least one flexible hose may be determined.

In a further embodiment, the hose manipulator may comprise at least two flexible hoses for fluid transfer, typically two flexible hoses, with each of the flexible hoses having hose guides and a hose tensioner. Preferably, the flexible hoses are arranged in planes
located symmetrically on either side of the arm pivoting plane. Providing hose guides, and more significantly a hose tensioner, dedicated to a specific flexible hose, allows each flexible hose to be manipulated independently, particularly with regard to the tension of each flexible hose controlled by each hose tensioner. Thus the magnitude of the path deflection of a specific flexible hose produced by the hose tensioner can be controlled independently of any other hoses on the hose manipulator. It will be apparent that different flexible hoses may carry different fluids, which may have different characteristics, such as densities and/or temperatures, for instance when one flexible hose is carrying LNG and another flexible hose is carrying boil off gas, such that the deflection of the paths of two flexible hoses, even on the same hose manipulator, may be required to be different e.g. in order to provide a given tension.

In another embodiment, the fluid to be transferred in the hose manipulator may be a cryogenic fluid, such as LNG.

In a further embodiment, the hose manipulator may further comprise a storage spool for the flexible hose. The storage spool allows the length of the flexible hose connecting to a manifold for fluid to be adjusted. However, this embodiment is not preferred. Instead, the hose manipulator would not typically comprise a storage spool for the flexible hose, such that the extent to which a flexible hose of fixed length extends beyond an end of the final arm section, e.g. a second or third arm section, is determined only by the magnitude of the deflection of the path of the flexible hose by the hose tensioner.
In a still further embodiment, the arm sections of the hose manipulator may be articulated at a pivot joint by one or more hydraulic cylinders, electric motors or wire sheaves.

The following discussion relates to the operation of a fluid transfer hose manipulator in the context of the transfer of LNG from an FLSO unit to an LNG carrier vessel. However, it should be understood that the hose manipulator is not limited to the transfer of LNG, but is suitable for the transfer of any fluid or fluids, such as other hydrocarbon liquids or hydrocarbon gases, over a wide range of temperatures and pressures, typically temperatures in the range of -200 to 200 °C and/or pressures up to 10.5 bar.

Similarly, although the hose manipulator is located on a FPSO unit in the following embodiments, it can operate on any floating structure, such as an LNG carrier vessel or on any non-floating structure, such as an off-shore fixed platform or an on-shore jetty. Although many of the advantages of the hose manipulator arise when it is used to transfer fluid when at least one, typically both, of the fluid source and fluid destination are moveable structures, particularly floating structures, it can also be used for fluid transfer between two non-floating structures.

Figure 1 shows a first embodiment of the fluid transfer hose manipulator described herein. The hose manipulator comprises an articulated arm 100 fixed to a base 220. The articulated arm 100 comprises a plurality of arm sections 110. The base 220 may be, for instance, the manifold deck of an FLSO or attached to such a deck. The base 220 may function as the reference point from which the position of the arm sections 110 and at least...
one flexible hose 150, particularly a distal end 180 of a flexible hose 150, can be determined. The hose manipulator 1 may be located outboard of the fluid (e.g. LNG) manifold.

Each arm section 110 has a longitudinal axis 120, defining the longest dimension of the arm section. The embodiment of Figure 1 shows an articulated arm 100 comprising first arm section 110a and second arm section 110b. The first arm section 110a has a first section longitudinal axis 120a, and the second arm section 110b has a second section longitudinal axis 120b.

The base 220 supports the first arm section 110a. The first arm section 110a is connected to base 220 and is preferably fixed immovably to the base 220, with its longitudinal axis 120a vertical. The first arm section 110a is connected to the second arm section 110b by a first pivot joint 130a, such as a hinge or any type of joint allowing for a relative rotational movement of the first arm section relative to the second arm section.

The first pivot joint 130a allows rotation of the second arm section 110b about a first joint axis 135a. The rotation of the second arm section 110b can be in a plane (the arm pivoting plane) defined by the first and second longitudinal axes 120a, 120b.

The articulation of the second arm section 110b may be achieved by a hydraulic cylinder (not shown) or other suitable means. The hydraulic cylinder may be part of a hydraulic system and can be connected to a hydraulic power unit with associated directional valves and pumps.

This is preferably a duplex system with duplicate hydraulic pumps and associated controls. In a further preferred embodiment, the hydraulic system may be fitted with hose burst valves so that the arm sections can
remain in position it the event of a failure of the hydraulic system. The hydraulic system may comprise a low pressure circulation circuit for normal operation and a high pressure circuit for activation of the emergency release, which is discussed below.

The fluid transfer hose manipulator 1 further comprises at least one flexible hose 150. The type of flexible hose 150 will be determined by the fluid to be carried within it. The flexible hose 150 should be selected to retain its flexibility during fluid transfer i.e. the temperature and pressure and pressure of the fluid being transferred. The flexible hose 150 may comprise a thermoplastic or composite material.

For instance, when the fluid to be transferred is a cryogenic fluid such as LNG, the flexible hose 150 may be a composite flexible hose, typically comprising a polyester lining with a polyamide outer cover reinforced with stainless steel wire. Typically, the flexible hose 150 may be selected to meet the requirements of BS EN 13766:2003 for thermoplastic multi-layer (non-vulcanised) hoses and hose assemblies for the transfer of liquid petroleum gas and liquefied natural gas.

When the fluid to be transferred is a gas, such as a pressurised hydrocarbon gas, the flexible hose 150 may be a composite flexible hose. For instance, for working pressures up to 5 bar, the flexible hose may typically comprise a polypropylene and/or polytetrafluoroethylene lining with a polyester outer cover, optionally coated with polyvinyl chloride, and reinforced with stainless steel wire.

The at least one flexible hose 150 may comprise a proximal end 170 and a distal end 180. The proximal end 170 may be connected to a fluid first manifold 310, which
can be situated on the manifold deck of the FLSO. The at least one flexible hose is has a length of approximately 30 m. In a preferred embodiment the flexible hose 150 is not wound around an storage spool.

The fluid first manifold 310 may comprise a fluid manifold restriction collar 320. The fluid manifold restriction collar 320 may be configured as an open cone and operates to prevent the flexible hose 150 from adopting a configuration with a bending radius less than its minimum. The distal end 180 of the flexible hose 150 is configured to be attached to a fluid second manifold, for instance on an LNG carrier vessel to which the LNG fluid is to be transferred. The distal end 180 of the flexible hose 150 is discussed in more detail in the embodiment of Figure 3.

The at least one flexible hose 150 extends movably along first and second arm sections 110a, 110b of the articulated arm 100. In particular, when not deflected by the hose tensioner 160 that will be discussed below, the flexible hose should extend along the longitudinal axis (or an axis parallel to this) of the arm sections 110a, 110b.

The flexible hose 150 is directed and supported by at least two hose guides 140. The hose guides 140 allow free movement of the flexible hose 150 along the guides, and transfer the weight of the flexible hose 150 and any fluid therein to the hose manipulator 1, and specifically the arm sections 110 to which they can be attached. The hose guides 140 can act to change the direction of the flexible hose 150 and ensure that the any bending of the hose is greater than or equal to its minimum bending radius.
When the proximal end 170 of the flexible hose 150 is fixed to fluid first manifold 310, and the flexible hose 150 is of a fixed length, rotation of second arm section 110b about the first pivot joint 130a can control the vertical height of distal end 180 with respect to the base 220 of the hose manipulator 1.

The embodiment of Figure 1 shows arcuate hose guides 140 over which the flexible hose 150 is directed. The flexible hose 150 may run along grooves or channels on such hose guides 140. The grooves or channels on each hose guide 140 can be aligned in the same plane, such as a plane parallel to the arm pivoting plane, in order to direct a single flexible hose 150 along a route in a single plane. The hose guides 140 may be made of a polymer, metal, such as aluminium, alloy, such as steel, typically nickel steel, or composite, such as a composite comprising polymer, particularly a composite comprising polymer and metal or alloy such as those already mentioned. When the flexible hose 150 is to carry a cryogenic fluid, the hose guides 140 may comprise 9 wt% nickel steel. The hose guide 140 may comprise a material which reduces the frictional contact with the flexible hose 150, thereby allowing freedom of movement. For instance, the grooves or channels on the hose guides 140 may be lined with TEFLON™.

The at least two hose guides 140 may be fixed to the articulated arm 100. Figure 1 shows first hose guide 140a fixed to first arm section 110a, and second hose guide 140b fixed to second arm section 110b. Preferably, the hose guide 140 is attached at or near to an end of an arm section 110, the ends lying at either end of longitudinal axis 120 of an arm section 110.
The articulated arm 100 further comprises at least one hose tensioner 160. The hose tensioner 160 operates to adjust the tension on the at least one flexible hose 150 and is thus in contact with the flexible hose 150. The hose tensioner 160 is connected to one of the arm sections 110 or the base 220 of the hose manipulator 1. The hose tensioner 160 operates to maintain a constant tension on flexible hose 150, particularly when both proximal and distal ends 170, 180 are connected to fluid manifolds.

In the embodiment of Figure 1, the hose tensioner 160 comprises a tensioner hose guide 165, such as an arcuate tensioner hose guide, and a tensioner arm 175, e.g. a telescopic tensioner arm, to direct the flexible hose 150 along a path that is deflected from a nominal path 155.

In the embodiment of Figure 1, the nominal path 155 is taken to be the line that tangentially connects the first hose guide 140a with the proximal end 170 of the flexible hose 150. The tensioner hose guide 165 is movable in a direction having a transverse directional component relative to the nominal path 155. Movement in such a direction allows to variably change the degree of deflection of the hose from the nominal path 155.

The tensioner hose guide 165 can be connected to one of the arm sections 110 of the articulated arm 100, such as the first arm section 110a, via the tensioner arm 175. Although the hose tensioner 160 is shown as being attached to the first arm section 110a in Figure 1 for simplicity, it is preferred that it is attached to a second or further arm section 110b in order to provide a greater range of movement, by distancing it from base 220 and any adjacent deck.
The tensioner hose guide 165 functions to restrain and guide flexible hose 150 to ensure that the any bending of the hose is greater than or equal to its minimum bending radius, in a similar manner to the hose guides 140.

Furthermore, the tensioner hose guide 165 can move along a path at a non-zero path angle \(a\), measured from the longitudinal axis of the arm section to which it is attached. When both proximal and distal ends 170, 180 of the flexible hose 150 are connected to fluid manifolds, moving the tensioner hose guide 165 along non-zero path angle \(a\) will change the deflection of the hose, thereby changing the tension of the hose. The non-zero path angle \(a\), measured with respect to the longitudinal axis 120a of the first arm section 110a to which the hose tensioner 160 is connected, is typically approximately 90°, more typically 90°. The movement of the tensioner hose guide 165 can be achieved by increasing or decreasing the length of a telescopic tensioner arm 175.

It is apparent that by moving the tensioner hose guide 165 away from the first arm section 110a, the deflection of the path of the flexible hose 150 is increased e.g. with respect to the shortest path between proximal end 170 and first hose guide 140a. Figure 1 shows a second configuration of the hose tensioner 160' comprising tensioner hose guide 165' having an increased deflection of the path of the flexible hose 150.

For a fixed length of flexible hose 150 attached to the fluid first manifold 310, increasing the deflection of the path of the flexible hose 150, for instance by moving the tensioner hose guide 165 along a non-zero path angle \(a\) away from the first arm section 110a, would lead to distal end 180 being drawn towards the second hose.
guide 140b at the end of the second arm section 110b. If the distal end 180 were attached to a fluid second manifold, this would increase the tension of the flexible hose 150. However, if the position of the distal end 180 of the flexible hose 150 attached to a fluid second manifold were to approach that of second hose guide 140b, for instance due to the effect of upward wave heave on a floating structure to which the distal end 180 was attached, then increasing the deflection of the path of the flexible hose 150 by the hose tensioner 160 could reduce the length of flexible hose extending beyond second hose guide 140b. Thus, maintaining the flexible hose 150 under constant tension via the hose tensioner 160 can prevent the flexible hose sagging under an upwards heave motion.

Similarly, decreasing the deflection of the path of the flexible hose 150, for instance by moving the tensioner hose guide 165 along a non-zero path angle a closer to the first arm section 110a, would lead to distal end 180 being lowered away from the second hose guide 140b at the end of the second arm section 110b, for instance to compensate for a downward heave wave motion. Thus, maintaining the flexible hose 150 under constant tension via the hose tensioner 160 can prevent the flexible hose from becoming over tensed under a downwards heave motion. It will be apparent that the hose tensioner 160 may also compensate for other wave motions, such as sway and surge, which would also result in changes of the distance between the distal end 180 of the flexible hose and the second hose guide 140b.

In operation, once the configuration of the arm sections 110 of the articulated arm 100 is fixed i.e. the arm section angle at the first pivot joint is fixed, the
relative movement of the fluid second manifold can be observed with respect to the hose manipulator 1, and particularly the base 220 or the end of the last arm, e.g. in this embodiment, second arm 110b, particularly second hose guide 140b.

The tensioner hose guide 160 can be moved along non-zero path angle a by, for instance a hydraulic cylinder (not shown). The hydraulic cylinder may be connected to first arm section 110a, or base 220. The hydraulic cylinder can be part of the hydraulic system.

Figure 2 shows a second embodiment of the fluid transfer hose manipulator 1 described herein. Where identical reference numerals are used to those of figure 1, equivalent components are referred to. In this embodiment, the hose guides 140a, 140b and 165 are present as sheaves. The sheaves may be connected to the arm sections 110, for instance at the pivot joints 130, typically sharing the same axis of rotation of the pivot joint and/or at an end of the longitudinal axis 120 of an arm section 110.

In this embodiment, the hose tensioner 160 is connected to the base 220 of the hose manipulator 1. The hose tensioner 160 comprises a tensioner hose guide 165, which is a sheave, and a tensioner arm 175. In this embodiment, the tensioner arm may be of fixed length. In contrast to the embodiment of Figure 1, the path of the flexible hose 150 is deflected by an arcuate movement of the sheave tensioner hose guide 165, by tensioner arm 175 rotating about tensioner pivot joint 225 on the base 220. The deflection of the path of the hose can be described by measuring the non-zero angle β, between the base 220 and the tensioner arm 175.
Figure 2 shows a second configuration of the hose tensioner 160' comprising tensioner hose guide 165' having an decreased deflection of the path of the flexible hose 150 between the proximal end 170 and the first hose guide 140a. A decreased deflection is achieved by increasing the non-zero angle $\beta$ to $\beta'$. The hose tensioner 160 can be moved along its arcuate path by, for instance, connecting tensioner arm 175 to a hydraulic cylinder (not shown) to move the arm and thereby the hose tensioner hose guide 160. The hydraulic cylinder can also be fixed to the base 220 or first arm section 110a. The hydraulic cylinder can be connected to the hydraulic system discussed.

When the articulated arm 100 is in a fixed configuration i.e. the first pivot joint 130a is set at a fixed arm section angle between the first and second arm sections 110a, b and distal end 180 of the flexible hose 150 is unconnected to a fluid second manifold, the second configuration of hose tensioner 160' will result in a lower vertical position of the distal end 180', with respect to base 220. Thus, when the distal end 180 of the flexible hose 150 is connected to a fluid second manifold and the vertical position of the fluid second manifold, with respect to base 220, changes from position 180 to the position of the distal end 180', for instance as a result of a downward heave wave motion of the fluid second manifold (and the floating structure to which it is attached), this movement can be compensated for, and the tension on the flexible hose 150 maintained, by moving the hose tensioner to position 160'.

Figure 3 shows a preferred embodiment of the fluid transfer hose manipulator 1 as described herein. Identical reference numerals to those of Figure 1 or
Figure 2 correspond to equivalent components. In this embodiment, the hose manipulator comprises a first and a second flexible hose 150a, 150b respectively, each with independent first and second hose tensioners 160a, 160b respectively. The first and second flexible hoses 150a, 150b may be of 20.32 cm (8 inch) internal bore diameter and 30 m in length.

A manifold platform 330 may also be present where the base 220 is connected to the first arm section 110a, to facilitate inspection of the hose manipulator and particularly the connection of fluid first manifold 310 to the proximal ends of the first and second hoses 150a, 150b.

The articulated arm 100 comprises first, second and third arm sections 110a, 110b and 110c. The first arm section 110a can be secured at one longitudinal end to base 220. The first arm section 110a is connected at its other longitudinal end to the second arm section 110b by a first pivot joint (not shown). The movement of the first pivot joint can be achieved by first arm section hydraulic cylinder 230a. First hose guide 140a, which is present as a sheave, can share the same axis of rotation as the first pivot joint.

Second and third arm sections 110b, 110c are connected by a second pivot joint (not shown). The movement of the second pivot joint can be achieved by second arm section hydraulic cylinder 230b. Second hose guide 140b, which is present as a sheave, can share the same axis of rotation as the second pivot joint. A third hose guide 140c, which is present as a sheave, is positioned at the opposite end of the longitudinal axis of the third arm section 110c from the second pivot joint. The first, second and third sheave hose guides
140a, 140b, 140c may have a similar composition to those of the embodiment of Figure 2.

The third arm section 110c may comprise a guide-way to support and/or direct each flexible hose 150a, 150b between the respective second and third hose guides 140b, 140c. The guide-way may be comprised of a metal or alloy, such as aluminium or 9 wt% nickel steel and may optionally be lined with a friction reducing material such as TEFLONM.

In this embodiment, the first, second and third hose guides 140a, 140b, 140c are present in pairs, with each of the first and second flexible hoses 150a, 150b having dedicated first, second and third hose guides. First and second hose tensioners 160a, 160b are provided, one for each of the first and second flexible hoses 150a, 150b. The hose tensioners 160a, 160b are present on the second arm section 110b. Correspondingly, the nominal path 155a (for the first flexible hose 150a) is suitably taken to the defined by the line that tangentially connects the first hose guides 140a and the second hose guide 140b (which first and second hose guides are adjacent to each other). This is an advantageous configuration, because it provides a greater range of movement to each hose tensioner, allowing an increase in the maximum deflection of the flexible hoses 150a, 150b. It is preferred that the hose tensioners 160a, 160b operate independently. Consequently, the first and second flexible hoses 150a, 150b can carry fluids of different density, temperature and/or pressure etc., while still maintaining the flexible hoses under constant tension.

Each hose tensioner 160a, 160b comprises a tensioner hose guide, present as a sheave, and a tensioner hydraulic cylinder 240a, 240b. The tensioner hydraulic
cylinders 240a, 240b can each move the tensioner hose guide along a path at 90° to the longitudinal axis of the second arm section 110b, parallel to the plane defined by any two of the longitudinal axes of the three arm sections 110a, 110b, 110c. In this way, the path of each of the flexible hoses 150a, 150b can be deflected from the respective nominal paths between the first and second hose guides 140a, 140b.

Each flexible hose 150a, 150b is connected at a proximal end to fluid first manifold 310 by a connector. In the embodiment of Figure 3, both flexible hoses are connected to the same fluid manifold by a first Y-connection. The first Y-connection may have lines for the purging, draining and/or drying of the flexible hose. The first Y-connection may further comprise orifice plates to reduce the effects of a fluid surge. However, in an alternative embodiment (not shown), the first and second hoses 150a, 150b could be connected to different fluid manifolds, carrying the same or different fluids.

The distal end of each flexible hose 150a, 150b may comprise a restriction cone 190a, 190b and an optional emergency release coupling 210a, 210b. The emergency release coupling 210a, 210b of each flexible hose can be linked to a fluid connector, here provided in the form of a second Y-connector 200 so that both flexible hoses may transfer fluid to the same fluid manifold. The second Y-connector 200 may have lines for the purging, draining and/or drying of the flexible hoses 150a, 150b. The second Y-connector may further comprise orifice plates to reduce the effects of a fluid surge.

The emergency release couplings 210a, 210b operate to sever the connection between the flexible hose 150a, 150b and the second Y-connector, thereby releasing the
flexible hoses 150a, 150b from their attachment to the fluid second manifold, should there be insufficient time to achieve disconnection via the second Y-connector 200. The emergency release couplings 210a, 210b may each comprise double valves to minimise any spillage from the flexible hoses 150a, 150b and fluid second manifold upon emergency disconnection.

The first and second arm section hydraulic cylinders 230a, 230b, the tensioner hydraulic cylinders, 240b and the emergency release couplings 240a, 240b can form part of the hydraulic system. The hydraulic system may be operated by a programmable logic controller. The programmable logic controller can be provided with the positions of the hydraulic cylinders, in order to determine the arm section angles, and tension of the flexible hose.

Furthermore, the addition of an accumulator to a high pressure circuit in the hydraulic system will ensure that emergency release is possible, particularly with regard to severing the connection between the first and second flexible hoses 150a, 150b and the second Y-connector 200 and to the retraction of the articulated arm 100 and flexible hose 150a, 150b, even in the event of the loss of electrical or hydraulic power. The hydraulic lines to the emergency release coupling 210a, 210b may be provided by an umbilical line (not shown) to a distribution block on a tie bar 250. The tie bar 250 may link the first and second flexible hoses 150a, 150b, typically below restriction cones 190a, 190b (which may be provided in the form of restriction collars 190a, 190b). The umbilical line may be supported by a guide wire (not shown).
The fluid transfer hose manipulator 1 may further comprise a position monitoring system to monitor the position of the distal ends of the flexible hoses 150a, 150b. This position is preferably monitored relative to a position on the hose manipulator, such as on an arm section 110a, 110b, 110c or base 220. By monitoring the position of the distal ends of the flexible hoses 150a, 150b, it can be determined whether the hose manipulator is functioning within an acceptable operating envelope.

For instance, a narrow connection limit operating envelope may be defined, with a broader warning limit envelope and a still broader disconnect limit envelope. If the distal ends of the flexible hoses 150a, 150b exceed the disconnect limit envelope, the emergency release coupling can be activated, for instance via the hydraulic system through the umbilical line.

The position monitoring system may be connected to the programmable logic controller which can control, via the hydraulic system, one of more, preferably all of: the configuration of the arm sections 110 of the articulated arm 100, the tension of the flexible hose 150 via the hose tensioner 160 and the emergency release coupling 210.

The position monitoring system may be, for instance a guide wire and gimbal system. The guide wire may be connected between tie bar 250 on the distal ends of the flexible hoses 150a, 150b and a gimbal head located on the end of the third arm section 220c having third hose guide 140c. A sensor, such as a laser, can measure the angle of the guide wire at the gimbal head. The location of the distal end of the flexible hose 150a, 150b can therefore be determined from the gimbal head angle and
the length of the guide wire for a given hose tensioner
160a, 160b position.
For instance, the embodiment of Figure 3 having a
flexible hose length of approximately 30 m, and a minimum
mooring separation of 3.7 m between the FLSO carrying the
fluid transfer hose manipulator and the LNG carrier
vessel, the hose manipulator may operate in sea
conditions with relative dynamic motions between the
vessels of +/- 0.75 m for each of heave, surge and sway.

Multiple hose manipulators may be provided on the
FLSO, for instance, four or five hose manipulators, each
comprising two flexible hoses, may be located on the
manifold platform.

Figures 4A, 4B and 4C illustrate three configurations
1a, 1b and 1c of the fluid transfer hose manipulator 1
according to the embodiment of Figure 3 on an FLSO 300.

Figure 4A shows the hose manipulator 1 in a storage
configuration 1a, when not in use for fluid transfer.
The first arm section is fixed immovably to the base 220,
with its longitudinal axis vertical, while second and
third arm sections are in a substantially vertical
configuration along their longitudinal axes by virtue of
the first and second pivot joints and first and second
arm section hydraulic cylinders. It will be apparent
that this configuration is advantageous for storage
because it minimises the footprint of the hose
manipulator 1.

Figure 4B shows the hose manipulator 1 in an
operational configuration 1b, when transferring LNG to an
LNG carrier vessel 400. This operational configuration
can be adopted when the fluid second manifold 410 on the
carrier vessel 400 is at substantially the same height as
the base 220 of the hose manipulator 1. This may occur,
for instance, when the LNG carrier vessel 400 is a 145,000 m$^3$ carrier. The first arm section can be fixed immovably to the base 220, with its longitudinal axis vertical, the second arm section can be held with its longitudinal axis in a substantially vertical orientation by virtue of the first pivot joint and first arm section hydraulic cylinder, while the third arm section can be held, by second arm section hydraulic cylinder and the second pivot joint, at an angle of typically -20 to +20$^\circ$ from the horizontal, more typically -15 to +15$^\circ$ from the horizontal, measured from the axis of the second pivot joint. As used herein, the term "substantially vertical" is intended to mean within +/- 10$^\circ$ of vertical.

Figure 4C shows the hose manipulator 1 in an operational configuration 1c, when transferring a fluid to an LNG carrier vessel 400. This operational configuration can be adopted when the fluid second manifold 410 on the LNG carrier vessel 400 is at substantially lower height than the base 220 of the hose manipulator 1. This may occur, for instance, when the LNG carrier vessel 400 is a 10,000 m$^3$ carrier. The first arm section can be fixed immovably to the base 220, with its longitudinal axis vertical, the second arm section can be held, by the first pivot joint and first arm section hydraulic cylinder, with its longitudinal axis at an angle of from -10 to -30$^\circ$ from the horizontal measured from the first pivot joint, while the third arm section can be held substantially vertically by second arm section hydraulic cylinder and the second pivot joint.

In a further embodiment, a method of transferring a fluid, such as a cryogenic fluid, for instance LNG, between first and second structures using a hose
manipulator described herein is also disclosed. The method is particularly advantageous when at least one, typically both, of the first and second structures is a moveable structure, preferably a floating structure.

The method may comprise providing a fluid transfer hose manipulator as described herein on a first structure. The first structure may be a first non-floating structure, like an off-shore platform or a jetty or the first structure may be a first floating structure, typically a FSO, FPSO, FLSO or carrier vessel. The hose manipulator may be in a storage configuration, as described above and shown as 1a in Figure 4A. The hose manipulator can be connected to a fluid first manifold, which is in fluid communication with one or more fluid first storage tanks 340. The one or more fluid first storage tanks 340 may be one or more of insulated, cooled and pressurised first fluid storage tanks, particularly if the fluid to be transferred is a cryogenic fluid such as LNG. The one or more fluid first storage tanks may be empty or partially full, if the fluid is to be transferred to these tanks, of full or partially full, if the fluid is to be transferred from these tanks.

A second structure can be provided. The second structure may be a first non-floating structure, like an off-shore fixed platform or a jetty or the second structure may be a first floating structure, typically a FSO, FPSO, FLSO or carrier vessel. The second structure may comprise a fluid second manifold, in fluid communication with one or more fluid second storage tanks 440. These one or more fluid second storage tanks may be similar to the fluid first storage tanks already discussed.
The fluid second manifold of the second structure should be aligned with the hose manipulator, typically a flexible hose of the hose manipulator, more typically the distal end of a flexible hose, still more typically a connector of a second end, such as a Y-connection, of the first structure. This alignment may be achieved by moving one or both of the first and second structures. For instance, when one or both of the first and second structures are floating structures, they can be positioned at a minimum distance of 3.7 m. When both first and second structures are floating vessels, the alignment may be achieved by a side-by-side arrangement e.g. starboard to port or port to port or port to starboard of the two vessels.

In one embodiment, the maximum vertical distance between first and second fluid manifolds is in the range of from -19.2 m to +3.7 m. The maximum horizontal distance between first and second manifolds is in the range of from 9.6 m to 13.6 m. The maximum lateral misalignment between first and second manifolds is in the range of from -1.05 m to +1.05 m.

In one embodiment, the first and second structures are floating structures. For instance, the first structure is an FLSO 300 and the second structure is an LNG carrier vessel 400 as shown in Figures 4B and 4C. In another embodiment, one of the first and second structures is a floating structure and the other is a non-floating structure, for instance, the first structure may be a jetty, while the second structure may be an LNG carrier vessel. Typically, the first structure may be the jetty of an LNG import or export terminal and the second structural may be an LNG carrier vessel.
Once the fluid second manifold is aligned, the hose manipulator can be moved from storage position 1a into the operating position. The configuration of the operating system will depend on the height of the fluid second manifold 410 versus that of base 220. Figures 4B and 4C show two potential operational configurations 1b and 1c.

Once the correct operational position such as 1b, 1c has been adopted, a connector, such as a Y-connector, at the distal end of the flexible hose may be connected to the fluid second manifold 410 of the second floating structure, such as LNG carrier vessel 400. This can be achieved by bolting the connector to the fluid second manifold 410.

The flexible hose can then be purged. For instance, when the fluid to be transferred is LNG, the purge fluid may be nitrogen.

The fluid, such as LNG, can then be transferred between first and second structures, such as the FLSO 300 and LNG carrier vessel 400. Once the fluid transfer has been completed, the flexible hoses can then be purged with purge fluid, such as nitrogen. The connector of the distal end of the flexible hose may then be disconnected from the fluid second manifold 410. The hose manipulator may then be returned to storage configuration 1a. The first and second structures may then be moved apart.

The person skilled in the art will understand that the present invention can be carried out in many various ways without departing from the scope of the appended claims.

For instance, one or more of the arm sections, typically the section furthest along the articulated arm from the first arm section connected to the base, may be
telescopic. In particular, such a telescopic arm section could be configured to change the length of the arm section along its longitudinal axis. The length may be changed by a hydraulic cylinder, which can be connected to the hydraulic system of the articulated arm.
A fluid transfer hose manipulator, said hose manipulator comprising at least:
- an articulated arm comprising a plurality of arm sections, each arm section having a longitudinal axis, said plurality of arm sections comprising at least a first arm section and a second arm section, said first arm section connected to said second arm section by a first pivot joint;
- a base supporting said first arm section;
- at least two hose guides;
- at least one flexible hose for fluid transfer, said flexible hose extending movably along at least said first and second arm sections and directed and supported by said at least two hose guides;
- at least one hose tensioner in contact with the flexible hose to adjust the tension on the at least one flexible hose.

The hose manipulator of claim 1, wherein said hose tensioner is supported off of one of said arm sections or supported on said base.

The hose manipulator of claim 1 or claim 2, wherein the hose tensioner comprises a tensioner hose guide to direct the at least one flexible hose along a path being deflected from a nominal path by an amount, wherein said tensioner hose guide is movable in a direction having a transverse directional component relative to the nominal path, whereby the amount of deflection of the flexible hose from the nominal path is variable.
4. The hose manipulator of any of the preceding claims, wherein the at least one hose tensioner is connected to the base.

5. The hose manipulator of any of the preceding claims, wherein the at least one hose tensioner is connected to the second arm section.

6. The hose manipulator of any of the preceding claims, wherein one or more, preferably all, of the hose guides are sheaves.

7. The hose manipulator of any of the preceding claims, further comprising a third arm section and a further hose guide, said third arm section connected to said second arm section by a second pivot joint and having the further hose guide positioned thereon, said flexible hose extending movably along the longitudinal axis of the third arm section.

8. The hose manipulator of any of the preceding claims, wherein said at least one flexible hose further comprises a proximal end and a distal end, said proximal end in fluid communication with a fluid first storage tank and wherein said distal end comprises a restriction cone and a fluid connector.

9. The hose manipulator of claim 8, wherein the distal end further comprises an emergency release coupling.

10. The hose manipulator of claim 8 or claim 9, further comprising a position monitoring system to monitor a position of the distal end of the flexible hose, preferably relative to a reference position on one of the arm sections.

11. The hose manipulator of claim 10, wherein the position monitoring system comprises a positioning sensor connected to the end of one of the arm sections, preferably to the end of the third arm section, to
measure the position of the distal end of the flexible hose.

12. The hose manipulator of any of the preceding claims, comprising two flexible hoses for fluid transfer, each said flexible hose having dedicated hose guides and tensioner.

13. The hose manipulator of any of the preceding claims, wherein the fluid is a cryogenic fluid, for instance LNG.

14. A method of transferring a fluid between first and second structures, wherein at least one of the first and second structures is a moveable structure, typically a floating structure, comprising at least the steps of:
   - providing a first structure comprising a fluid transfer hose manipulator according to any of claims 1 to 13, the at least one flexible hose of the fluid transfer hose manipulator having a proximal end connected to a fluid first manifold and having a distal end;
   - providing a second structure comprising a fluid second manifold;
   - aligning the fluid second manifold of the second structure with the fluid transfer hose manipulator of the first structure;
   - adjusting the configuration of the fluid transfer hose manipulator so that the distal end of the at least one flexible hose can be connected to the fluid second manifold;
   - connecting the distal end of the at least one flexible hose to the fluid second manifold;
   - purging the at least one flexible hose;
   - passing a fluid through the at least one flexible hose;
   - purging the at least one flexible hose;
   - disconnecting the distal end of the at least one flexible hose from the fluid second manifold;
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- adjusting the configuration of the fluid transfer hose manipulator to withdraw the distal end of the at least one flexible hose from the fluid second manifold and second structure.

15. The method of claim 14, wherein the fluid first manifold is in fluid connection with at least one fluid first storage tank and the fluid second manifold is in fluid connection with at least one fluid second storage tank.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63B27/24
ADD.

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 practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C.  
[X] See patent family annex.

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Date of the actual completion of the international search: 27 November 2012

Date of mailing of the international search report: 03/12/2012

Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016

Authorized officer: Brumer, Alexandre

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