



(51) International Patent Classification:
B63B 21/50 (2006.01)

(21) International Application Number:
PCT/NL2010/050280

(22) International Filing Date:
12 May 2010 (12.05.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09006397.5 12 May 2009 (12.05.2009) EP

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

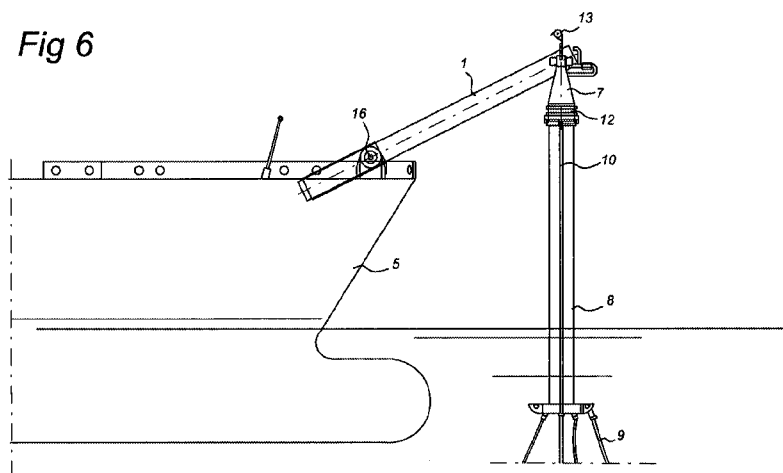
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished upon receipt of that report (Rule 48.2(g))

(54) Title: 2 STEP CAM SYSTEM

Fig 6



(57) Abstract: This invention relates to a mooring system comprising a vessel and a elongate mooring column having an upper end connected to an arm on the vessel projecting from the vessel bow and a lower end connected to the sea bed via anchor lines, characterised in that the arm is pivotable around a transverse axis.

2 STEP CAM SYSTEM

The present invention relates to an offshore system for mooring a vessel in a sea comprising: a vessel; a mooring column having a height and having an upper end and a lower end; a pivoting mooring arm coupling the upper end of said mooring column to
5 said vessel for permitting the mooring column to rotate about a pair of horizontal axes relative to the vessel; a plurality of heavy chains having upper ends coupled to the lower end of said mooring column, said heavy chains extending in loose catenary curves to the sea floor and giving the restoring force required to keep the vessel moored once
10 connected; the mooring column being free of attachment to any buoyant body, the system is self buoyant holds up the chains weight at the bottom and restrains the chains from drifting.

15 BACKGROUND OF THE INVENTION

Hydrocarbons can be transferred from an undersea pipeline, such as one which leads to undersea wells, to tankers at the sea surface, by a variety of types of offshore terminals. Under severe environmental conditions, such as where there are intrusions of ice packs as well as severe storms, it is desirable to enable a tanker to disconnect from the
20 terminal to sail away, while much of the terminal sinks a considerable depth below the sea surface to lie free of much of the severe environmental conditions. One type of offshore terminal which can be used under these conditions includes a riser having a lower end that is loosely anchored to the sea floor, as through a group of catenary chains. The chains hold the riser deep under water but above the sea floor, while enabling the
25 riser to be easily lifted up to the vessel. Improvements in such a system which facilitate connection of the top of the riser to the vessel and which provide improved mooring at minimal cost, one of considerable value.

A known system from The US Patent No.4,645,467 describes an offshore
30 structure of a type which includes a riser that is loosely anchored as by chains, which can facilitate the dynamics of anchoring. In a detachable riser, the riser can be lifted until

most of its height extends out of the sea and have a lower end that is weighted, to provide better mooring dynamics. The weight can include a clump weight hanging from the lower end of the riser.

5 Another patent Re32,578 describes a mooring system comprising a floating device, chains for anchoring the floating device, said chains being connected to a body which is rotatable about a vertical axis on an arm attached to the floating device. Conduits extend through the body, from the sea bottom towards the floating device. The patent focuses more particularly on the improvement in which the arm is rigidly attached
10 to the floating device and the body comprises a buoy having its own buoyancy, which buoy can be connected to or disconnected from the arm via a quick connecting coupling comprising releasable locking means.

 The present invention describes a two-step lifting of a mooring column during
15 connection of the vessel via its mooring arm to the mooring column. This 2 stage lifting during connection has the advantage of minimizing both the size and stiffness of the winching equipment. Should this lift be made entirely by the winching equipment (winch, line, sheaves, etc), this equipment would be large and negatively impact the geometry, physics and cost of the connection equipment. Making the initial lift short with low
20 tension winching equipment, keeps the components small and results in a lower tension and stiffness for the lifting line which eases the initial connection. The structural connection according to the present invention can handle large loads and thus the hydraulic lift system on the mooring arm is designed to lift the CAM to its highly tensioned moored operating position.

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SUMMARY OF THE INVENTION

 It is an object of the present invention to provide an offshore system for mooring a vessel wherein after the connection of the vessel with the mooring column is done, the
30 upward lifting of the heavy chains with the mooring column is realized by the use of the pivoting arm only.

It is therefore an further object of the present invention to provide a system of the above-mentioned type which is cost-efficient and which is also suitable for use at smaller water depths than corresponding systems according to the prior art.

According to the present invention, the offshore mooring system provides a pivoting arm
5 and mooring arrangement where the arm reaching down and lifting up the mooring column is eased and does not require the use of an expensive and large-size winch.

Further, in the configuration according to the present invention, the arm is mounted to allow it to be moved from an inboard position to its operating position projecting beyond
10 the vessel's bow and hence prevents components from hanging over the bow and from potentially being damaged, partly by green water impact, while in transit.

The novel features of the invention are set forth with particularity in the appended claims. The invention will be best understood from the following description when read
15 in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1a and 1b shows a detailed view of the mooring arm retractor mechanism.

20 Fig. 2 shows a three dimensional view of one possible embodiment the mooring arm retractor mechanism according to the present invention.

Fig. 3 to 6 show the system according to the invention in different step of the connecting procedure

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1a and 1b show top views of the system according to the present invention. According to the present invention, the mooring arm 1 is mounted horizontally on a vessel 5 on bogie wheels/rails that allow it to be moved forward to its operating position
30 projecting beyond the vessel's bow as shown in figure 1b. In Figure 1a, the arm 1 is stowed and does not project beyond the vessel's bow 15 which prevents components

from hanging over the bow and from potentially being damaged, partly by green water impact, while in transit.

Figure 2 shows a three-dimensional view of one possible embodiment of a mooring arm retractor mechanism according to the present invention. In the embodiment shown, a rack and pinion driving system 17,18 for the retraction and extension of the arm 1 is used. Teeth 17 of a rack of the pinion system are provided along the length of the arm 1, whereas a toothed sprocket wheel 18 is provided on the box 3. The pinion is driven by a hydraulic or electrical motor. The rack and pinion restrict the arm 1 from accelerating due to dynamic motions of the vessel. The sliding of the arm is done via friction pads 2 that are positioned inside a box type structure 3. The box 3 will also function as a pivoting system to pivot the arm 1 down- and upwards, around axis 16. The box 3 is hinged onto two supports 19 with shafts (not shown).

The arm 1 pivots around the axis 16 under the action of heavy duty hydraulic cylinders 4. When the upper position of the arm has been reached a mechanical locking system is activated in order to release the hydraulic pressure in the cylinders 4. The cylinders 4 are provided with a mechanical failsafe system when failure occurs during operation. The connection of the piping of the retractable arm 1 will be done with a spool piece that can retract and extend side ways. When the arm is extended the spool piece will extend and connected with a graylock to the export line on the arm.

To operate the system, the vessel 5 sails close to a mooring column 8 that projects above water level and the vessel stops and maintains station. Figure 3 shows the vessel 5 when the mooring arm 1 is moved forward along the rails 6 on deck and through a gate in the vessel's bow until the arm 1 projects to a pre-determined distance beyond the bow 15. The export line on the arm is located inside the arm to avoid problems with the sliding box system.

Figure 4 shows the first connecting step, when the vessel 5 is in contact with the mooring column 8. The mooring column 8 is a Counterweight Articulated Mooring

(CAM) that comprises a slim structural riser column, floating vertically in the water with its upper end projecting above water and its lower end secured to the sea bed by mooring chains 9 in a catenary configuration. In operation, the first part of the system is connected to the mooring column 8 by means of a mechanical connector 7 with articulated joints to permit free weathervaning of the moored vessel as well as heave, pitch, surge, sway and roll motions of the vessel 5.

A piping system 10 is provided on both the arm 1 and the mooring column 8 to allow the transfer of natural gas (or other product) from the vessel's storage tanks to a seabed pipeline to shore, or, from a seabed pipeline into the vessel.

A pick-up line is lowered from the outward end of the mooring arm 1 for connection (by work boat) to a line 11 that is pre-attached to the top of the CAM column. The mooring arm 1 is then articulated downwards using hydraulic rams at the vessel's deck such that the outward end of the arm 1 is close to the top of the mooring column.

Figure 5 shows the step further when the pick-up line has been pulled in to lift the mooring column top 12 into contact with the mechanical connector 7 and mooring arm 1 and mooring column 8 are connected together. By making the initial lift short with a low tension winching equipment 13 keeps the components small and results in a low tension requirement for the lifting line.

This low tension requirement results in a much softer line that will stretch more easily and better avoid line snatch loads that result from the physics of the initial lift of the mooring column 8 where the relative motions between the column 8 and vessel 5 are brought into unison. As the column 8 is lifted by the line toward the connector 7 the now in phase motions allow for a low impact structural connection.

Figure 6 shows the ultimate step of the connection between the vessel and the mooring column. In this embodiment it is clearly shown that the mooring arm 1 is articulated back up to a higher position (and not only back to horizontal) and the vessel is now safely

moored to the mooring column 8. The structural connection can handle large loads and thus the hydraulic lift system on the mooring arm 1 is designed to lift the column to its highly tensioned moored operating position.

5 This is the ultimate step when mooring chains are lifted from the sea floor increasing the tension in the lifting line. Hence the heavy chains are giving the restoring force required for the mooring column function.

The piping systems 10 of the mooring arm 1 and the mooring column 8 are connected and product may then be transferred from (or to) the vessel 5.

10 To disconnect the two parts of the mooring system after cargo transfer, the piping systems are first flushed clean and disconnected. The mooring arm is then pivoted back to its lower level and the mechanical connector is then released. The vessel moves away from the mooring point.

15 In the event of an emergency the mooring column 8 and piping 10 can be rapidly disconnected and released from the operational mooring position.

Further, in order to cope with a collision the column 8 needs to have watertight compartments all along its length. Watertight compartments are accessible via a bolted flange access with a gasket in between the flanges.

20 A fender system may be installed around the top of the column 8 to allow a support vessel to moor onto the column and facilitating personnel intervention and maintenance.

As will be apparent to those skilled in the art in the light of the foregoing disclosure, many alterations and modifications are possible in the practice of this invention without departing from the spirit or scope thereof. Accordingly, the scope of the invention is to be construed in accordance with the substance defined by the following claims.

CLAIMS

1. Mooring system comprising a vessel (5) and a elongate mooring column (10) having an upper end (12) connected to an arm (1) on the vessel (5) projecting from the vessel bow (15) and a lower end connected to the sea bed via anchor lines (9), characterised in that the arm (1) is pivotable around a transverse axis (16).
5
2. Mooring system according to claim 1, wherein the arm (1) comprises a displacement member(2,3) for moving the arm in a length direction of the vessel (5) between a retracted position in which the arm (1) for at least a larger part extends inboard of the vessel and a mooring position in which the arm (1) projects outboard from the bow (15).
10
3. Mooring system according to claims 1 or 2, wherein the arm (1) can pivot along axis (16) in an upward direction relative to the horizontal.
15
4. Mooring system according to any of the preceding claims, wherein the arm (1) is displaceable in the length direction via a pinion system (17,18).
20
5. Mooring system for mooring a vessel (5) according to claim 4 the mooring column being pivotable about a pair of horizontal axes relative to the vessel; a plurality of chains having upper ends coupled to the lower end of said mooring column, said chains extending in catenary curves to the sea floor and giving the restoring force required to keep the vessel moored once connected; the mooring column being free of attachment to any buoyant body, the column is being self-buoyant and holding up the chains weight at the bottom and restraining the chains from drifting, characterized in that after the connection of the vessel with the mooring column lifting up of the chains and the mooring column is realized
25
30 by the use of the pivoting arm only, the pivoting of the arm being able to apply the required tension.

6. Mooring system for mooring a vessel as claimed in claim 2 wherein the pivoting arm is also retractable so that it can be move forward to its operating position projecting beyond the vessel's bow and backwards so that it does not project beyond the vessel's bow during transit.

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7. Method for mooring a vessel in a sea comprising: a vessel (5); a mooring column (10) having a height and having an upper end (12) and a lower end; a pivoting arm (1) coupling the upper end of said mooring column to said vessel for permitting the mooring column to pivot about a pair of horizontal axes relative to the vessel; a plurality of chains (9) having upper ends coupled to the lower end of said mooring column, said heavy extending in catenary curves to the sea floor and giving the restoring force required to keep the vessel moored once connected; the lower half of said mooring column being free of attachment to any buoyant body having a greater positive buoyancy than the negative buoyancy of said heavy chains, the method comprising the steps of:
- sailing the vessel to the point where the upper end of the mooring column projects above water
 - stoping the vessel and maintaining station
 - moving the pivoting arm along the length direction until the arm projects to a pre-determined distance beyond the bow
 - lowering a pick-up line from the outward end of the mooring arm for connection to a messenger line that is pre-attached to the top of the elongated mooring column by means of a pull in line
 - articulating the pivoting arm downwards about axis (16) using hydraulic rams at the vessel's deck such that the outward end of the arm is close to the top of the upper part of the elongated mooring column
 - Pulling in the pick-up line to bring the top of mooring column up into contact with a mechanical connector until the pivoting arm and the mooring column are connected together, wherein
 - after the connection, the pivoting arm is articulated back up to a level applying tension in the mooring column and chains to moor the vessel to the mooring column, and wherein

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- Piping systems of the arm and the buoy element are connected and product is transferred from /or to the vessel via the piping systems.

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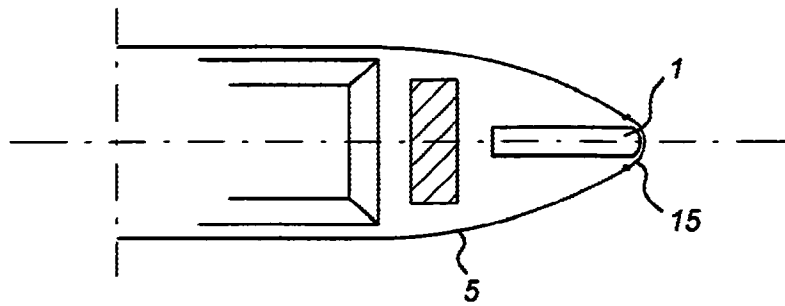
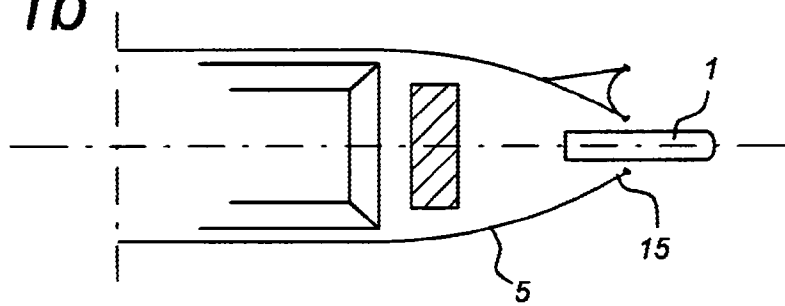
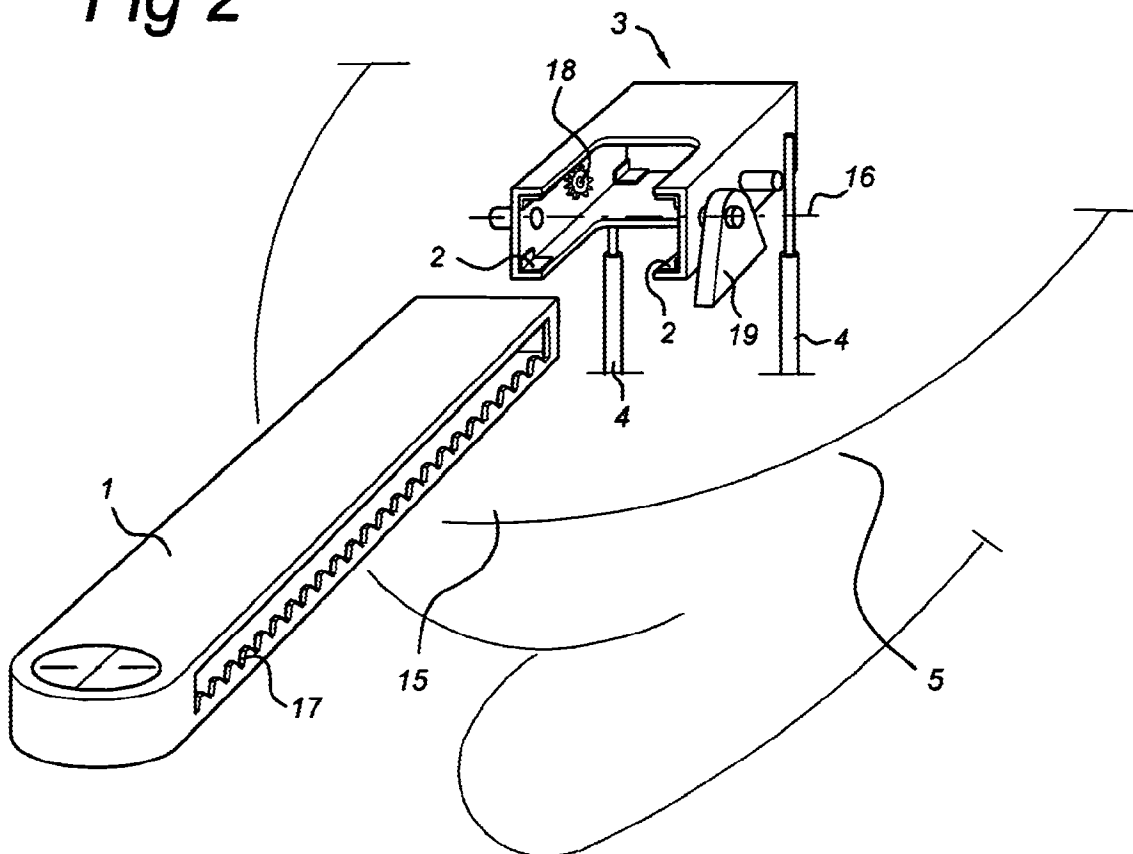
Fig 1a*Fig 1b**Fig 2*

Fig 3

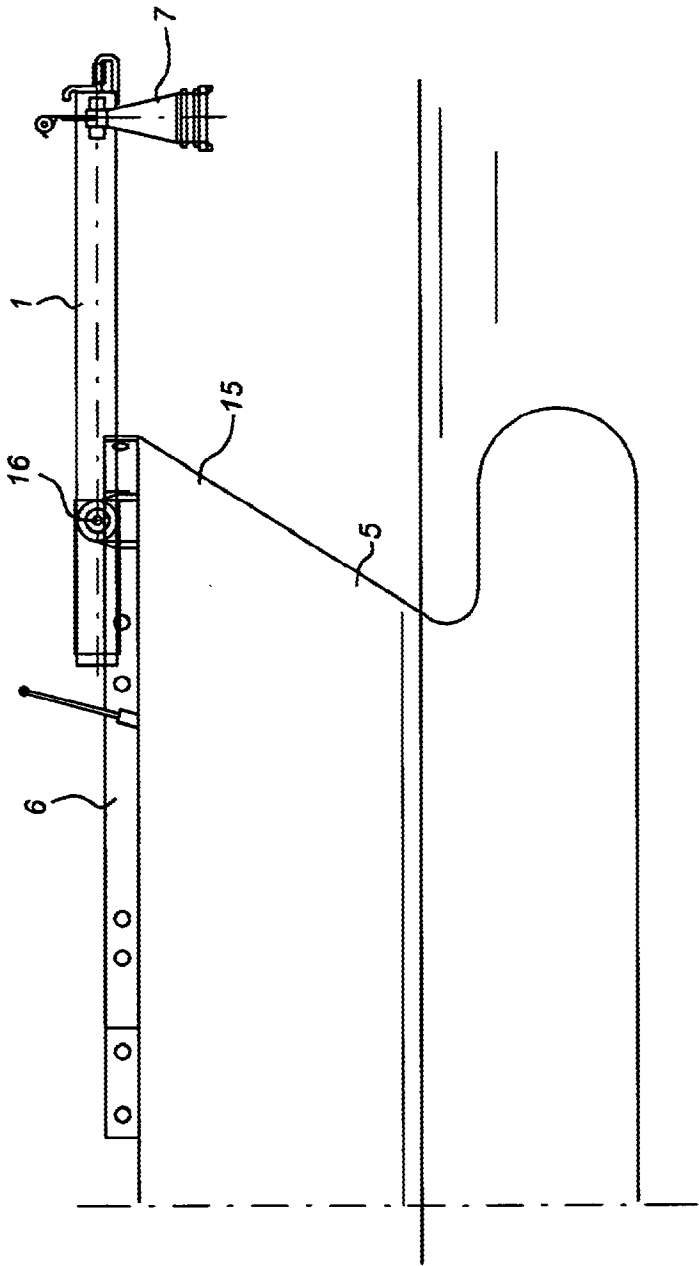


Fig 4

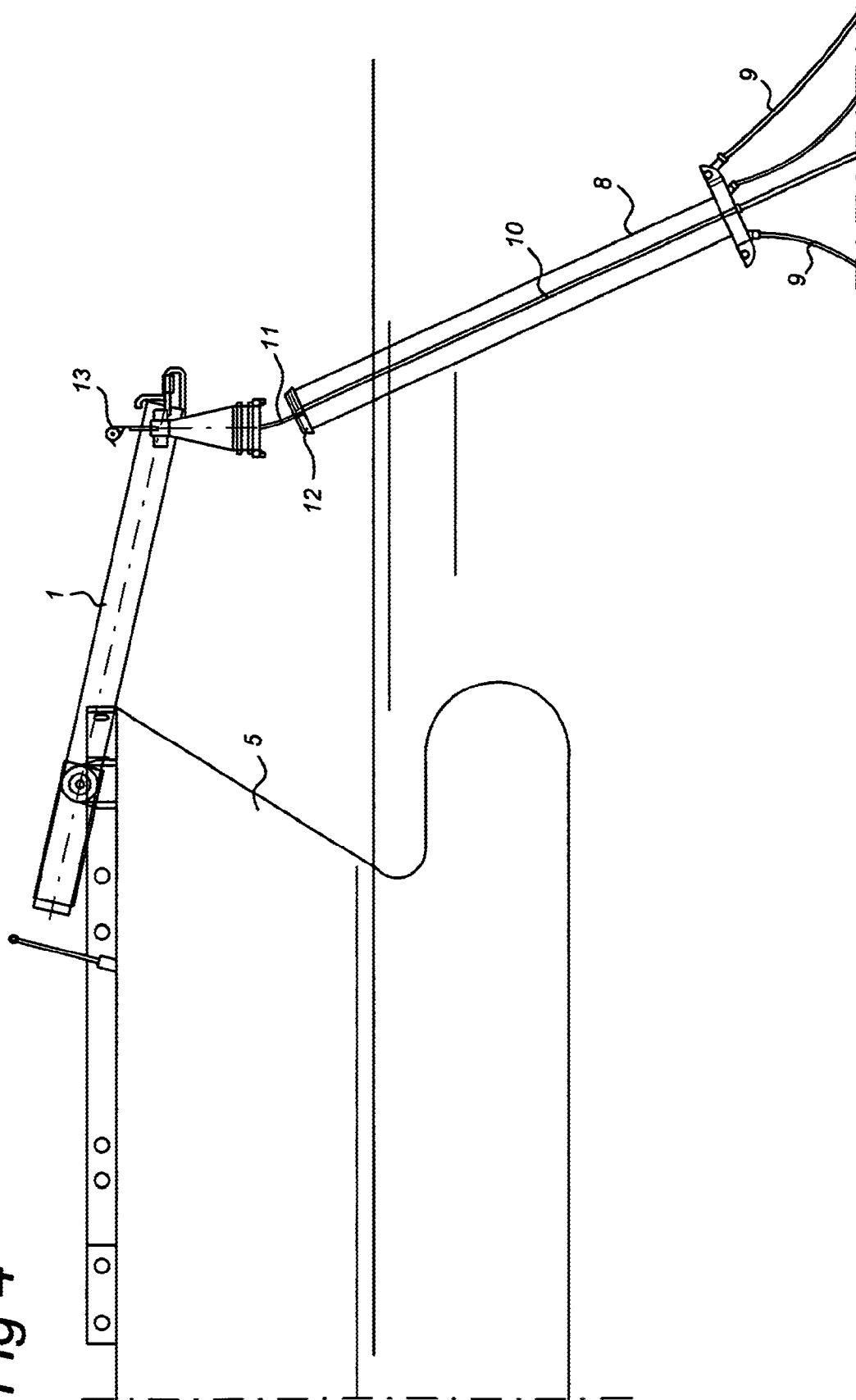


Fig 5

