

PIPELINE LAYING SYSTEM AND APPARATUS

Cross-Reference to Related Applications

This application claims the benefit of priority of Singapore Patent Application No. 10201703274P, filed 20 April 2017, the contents of which being
5 hereby incorporated by reference in its entirety for all purposes.

Field of Invention

The present invention relates to a pipeline laying system and apparatus, in particular a pipeline laying system and apparatus for use in the offshore oil and gas industry.

10 Background Art

The following discussion of the background to the invention is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was published, known or part of the common general
15 knowledge of the person skilled in the art in any jurisdiction as at the priority date of the invention.

Pipes are used to convey and transport fluids, which include but are not limited to gases and liquids. Pipes and pipe connectors may be joined together to create a pipeline. In the offshore oil and gas industry, various methods have been
20 used conventionally to lay offshore pipelines.

Known methods of assembling a large number of pipe segments on board an offshore oil and gas pipeline laying vessel require a massive and complex set-up on-board, which includes equipment such as pipe handling conveyors, welding stations, X-ray equipment and joint-coating modules. The on-site pipeline
25 assembly approach, referred to as lay-barge construction, requires relatively little external support. However, the costs associated with deploying such a vessel is huge due to the requirement of massive and complex set-up on-board the vessel. Furthermore, the existing pipeline laying facilities serve either deep water laying or shallow water laying. None of the existing facilities has the capability to serve
30 both the deep water pipeline laying and shallow water pipeline laying.

Two common pipeline laying methods are the "S-lay" and "J-lay" methods. The former typically used in shallow water pipeline laying while the latter used in deep water pipeline laying. In the S-lay method, the shape of the pipeline while being installed, has an "S" shape, where the pipes and pipeline are assembled in a horizontal orientation and a stinger is used to guide the pipeline for laying on the seabed. In the J-lay method, the pipeline is launched in a substantially vertical direction, where each succeeding pipe length must be erected into a substantially vertical position for welding to the last section. Other methods include pull/tow methods and reel pipe laying methods. Use of the various methods will depend on factors such as physical and environmental conditions, availability of equipment, costs, water depth, pipeline length and diameter, etc. However none of the method are suitable for use in both deep water pipeline laying and shallow water pipeline laying.

US 6,213,686 B1 and WO 2006/016798 A1 disclose deep water pipeline laying systems that have pipe supports that are pivotal with respect to a vessel on which they are installed. These systems however have to be actively operated to adjust the angles at which the pipeline is launched from the pipe support. An incorrect and/or inaccurate angling of the pipe support can increase the bending stresses in the pipeline. Further, the designs of these systems restrict the orientation of the pipe supports, where the pipe supports cannot be oriented horizontally. This accordingly limits the systems of US 6,213,686 B1 and WO 2006/016798 A1 to deep water pipeline laying.

US 3,581,506 discloses a deep water pipeline laying barge comprising a pipe rack support that extends through the body of the barge where the pipe rack support is free to rotate at a limited angle (conveniently about 20°) in any direction from the vertical. The location of pipe rack support at the middle of the barge however limits the movement range of said support and this accordingly restricts the application of the barge only to deep water since for shallow water operations, a pipe ramp is generally oriented horizontally and a stinger is used.

Therefore, there exists a need for a better solution to ameliorate the aforementioned problems. In particular, there exists a need for an improved pipeline laying system and apparatus for both deep and shallow waters, particularly for use in the offshore oil and gas industry.

Summary of the Invention

The present invention seeks to address and/or ameliorate the problems in the prior art by providing a pipeline laying system and apparatus particularly for the offshore oil and gas industry, where pipeline laying system and apparatus of the present invention can be used for both deep and shallow waters.

According to an aspect of the present invention, there is an offshore pipeline laying system installable on a side of a vessel, the apparatus comprising: an elongate platform for supporting an offshore pipeline, the elongate platform configured to passively pivot about at least one axis, wherein the at least one axis comprise a first axis substantially transverse to the longitudinal axis of the elongate platform; and a mount for supporting the elongate platform, the mount attachable to the side of the vessel, wherein in operation, the elongate platform passively pivots about the first axis between a first orientation and a second orientation.

According to another aspect of the present invention, there is an offshore pipeline laying vessel comprising the offshore pipeline laying system according to an aspect of the present invention, wherein the system is installed at a forward portion of the vessel.

Brief Description of the Drawings

The present invention will now be described, by way of example only, with reference to the accompanying drawings, which are for illustrative purposes only and are therefore not drawn to scale, in which:

Figure 1 provides a perspective view of a vessel having a pipeline laying system according to an embodiment of the present invention.

Figure 2 provides a side view of a vessel having a pipeline laying system according to an embodiment of the present invention.

Figure 3 provides a perspective view of a vessel having a pipeline laying system according to another embodiment of the present invention.

Figures 4 and 5 provide close-up views of a pipeline laying system according to an embodiment of the present invention.

Figure 6 illustrates an elongate platform according to an embodiment of the present invention.

Figures 7 to 9 illustrate the motion of a pipeline laying system according to an embodiment of the present invention.

Figure 10 provides a side view of a pipeline laying system according to an embodiment of the present invention.

5 Figure 11 provides a cross-sectional view of a pipeline laying system according to an embodiment of the present invention.

Figure 12 provides a perspective cross-sectional view of a pipeline laying system according to an embodiment of the present invention.

10 Figures 13 and 14 provide a perspective view of a pipeline laying system according to an embodiment of the present invention, illustrating the operation of the pipe loaders.

Figure 15 provides a side view of a pipeline laying system according to an embodiment of the present invention, illustrating the operation of the pipe loaders.

15 Figures 16 to 18 provide perspective and side views of a vessel having a pipeline laying system according to an embodiment of the present invention.

Figures 19 to 24 provide close-up perspective views of a pipeline laying system according to an embodiment of the present invention.

Figures 25 and 26 provide a side view of a pipeline laying system according to an embodiment of the present invention.

20 Figure 27 provides a perspective cross-sectional view of a pipeline laying system according to an embodiment of the present invention.

Figures 28 to 30 provide perspective and side views of a pipeline laying system according to an embodiment of the present invention, illustrating the operation of the pipe loaders.

25 **Description of Embodiments of the Invention**

Particular embodiments of the present invention will now be described with reference to the accompanying drawings. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of the present invention. Other definitions for selected terms used herein
30 may be found within the detailed description of the invention and apply throughout the description. Additionally, unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of

ordinary skill in the art to which this invention belongs. Where possible, the same reference numerals are used throughout the figures for clarity and consistency.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Furthermore, throughout the specification, unless the context requires otherwise, the word "include" or variations such as "includes" or "including" will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

The terms "passive" and "passively" used throughout the specification herein, can be used interchangeably with the term "free" and "freely", and has ordinary meaning in the art to refer to the lack or omission of an active operation of a system and/or component thereof, through the use of a power source, e.g. batteries and fuel.

The terms "pivot", "pivotal" and "pivoting" used throughout the specification includes but is not limited to "rotate", "rotation", "rotatable" and "rotating".

The present invention relates to a pipeline laying system, apparatus and mechanism that can be an alternative to conventional pipeline laying methods such as S-Lay and J-Lay methods and has several advantages over these methods. The new system/method herein is referred herein as the H-Lay or Hockey-Stick Lay system/method.

Figures 1 and 2 illustrate a pipeline laying system 110 according to an embodiment of the present invention. The pipeline laying system 110 is installable on an offshore pipeline laying vessel 100. The vessel 100 comprises a fore/forward portion 101 and an aft/rear portion 102. A bridge 104 is arranged at the aft portion 102 while the system 110 is arranged and installed at the fore portion 101 of the vessel 100. Depending on the application and requirements, the system 110 may be installed at the fore and/or aft portions the vessel 100. The vessel 100 further comprises pipes 191 stored on deck 103 and cranes 150 for transporting the pipes 191 onto the system 110. The vessel 100 may comprise more than one deck and the pipes 191 may be stored in lower decks of the vessel 100.

The pipeline laying system 110 comprises an elongate platform 111 for supporting an offshore pipeline 190 and pipes 191 that are connected to the pipeline 190 when in operation. The elongate platform 111 is hingedly connected to and pivots about the fore portion 101 of the vessel 100. The fore portion 101 comprises a cut-out portion in which the elongate platform 111 is hingedly connected. When in operation, the elongate platform 111 is capable of passively pivoting between a first orientation and a second orientation. The first orientation includes an orientation where the elongate platform 111 is substantially parallel to the deck 103 of the vessel 100, for example at a 0° angle with respect to the deck 103, and the second orientation includes an orientation where the elongate platform 111 is substantially parallel to the direction of gravity, for example at a 90° angle with respect to the deck 103, although it will be appreciated that this angle may go beyond 90° depending on the motion (e.g. pitch) of the vessel 100. Preferably, when in the first orientation, the elongate platform 111 is about 0° to about 45° with respect to the deck 103 of the vessel 100, and when in the second orientation, the elongate platform 111 is more than 45° with respect to the deck 103 of the vessel 100, preferably more than 45° to about 90° . It will be appreciated that in the first orientation, the elongate platform 111 may be considered to be in a substantially horizontal orientation, and in the second orientation, the elongate platform 111 may be considered to be in a substantially vertical orientation. In various embodiments, the elongate platform 111 is capable of passively pivoting at an angle in the range of about 0° to about 90° with respect to the deck 103 of the vessel 100 when in operation. Preferably, the elongate platform 111 passively pivots about an axis substantially transverse to the longitudinal axis of the elongate platform 111. The system 110 does not comprise actuators to actively pivot the elongate platform 111. The angle of the elongate platform 111 with respect to the deck 103 of the vessel 100 and/or the vector direction of gravity is a natural angle caused by the pipeline 190 being laid, and can be affected by several factors which include but are not limited to the length and weight of the pipeline 190, the depth of the water and tensional forces acting on the pipeline 190. It is through this passive pivoting mechanism that the pipeline 190 can be laid in both shallow water and deep water. The elongate platform 111 is used to lower the pipeline 190 onto a seabed. As the elongate platform 111 is pivotal in nature and free to take any

angle as per the direction of force acting on it, the longitudinal direction of elongate platform 111 aligns with the longitudinal direction of pipeline 190 near the forward portion 101 of the vessel 100. In other words, the elongate platform 111 aligns with the curvature of the pipeline 190 near the zone of firing/launch. As a result, there is no/minimal bending of the pipeline 190 near this zone and hence there is no or minimal stress to the pipeline 190. When the vessel 100 is in transit, the elongate platform 111 may be secured by means known in the art, which include but are not limited to locks, lashings and temporary welding.

Starting from laying the pipeline 190 in shallow water, the vessel 100 and system 110 can gradually move to deep water. Therefore when the pipeline 190 is being laid in shallow water, the elongate platform 111 may be substantially parallel to the deck 103 of the vessel 100 (although free to assume any angle depending upon the natural bending of pipeline 190 near the forward end 101). The elongate platform 111 may be in the range of about 0° to about 45° with respect to the deck 103 of the vessel 100 when the pipeline 190 is laid in shallow water. This allows for the commencement of the pipeline installation where the pipes 191 are placed on the elongate platform 111 and connected to form the pipeline 190 at an intended site. As the pipeline laying operation shifts/moves towards deep water, the inclination of the elongate platform 111 becomes more vertical and assumes the tangent angle of the pipeline 190 at the forward end of the elongate platform 111. The elongate platform 111 may be more than 45° , preferably more than 45° to about 90° , with respect to the deck 103 of the vessel 100 when the pipeline 190 is laid in deep water. As the elongate platform 111 assumes an angle tangent to the curvature of pipeline 190 at the firing end (i.e. the end of the elongate platform 111 where the pipeline 190 is launched), there is no or minimal stress in the pipeline 190 and hence there is no need for a stinger to facilitate the easy bending of the pipeline 190 and prevent damage in its structure. Therefore, the freedom of elongate platform 111 to take any angle enables it to lay the pipeline 190 in both shallow water as well as deep water.

While the J-Lay method is suitable to operate in deep water only and the S-Lay method is suitable to operate in shallow water only, the H-Lay system and method of the present invention can operate in all types of water depths ranging from shallow water to deep water since the elongate platform 111 is free to

assume any angle of convenience depending upon the angle of pipeline 190 with respect to the deck 103 of the vessel 100.

The elongate platform 111 may be substantially planar as shown in Figures 1 and 2, or may comprise a framed or enclosed portion that surrounds the pipeline 190. In various embodiments, the elongate platform 111 may be a framed (e.g. truss frame) or enclosed structure. The elongate platform 111 comprises one or more tensioners 140 for tensioning and restraining the pipeline 190 on the elongate platform 111. The tensioners 140 releasably engage with and maintain the pipeline 191 substantially stationary with respect to the elongate platform 111.

The tensioners 140 are capable of being operated by mechanisms known in the art, which include but are not limited to hydraulic systems. In various embodiments, the tensioners 140 are removable. In various embodiments, the system 110 comprises more than one tensioner 140, where one tensioner 140 is operable to restrain the pipeline 190, while the other additional tensioners offer redundancy, i.e. they may be used in the event the main tensioner fails or is undergoing maintenance. In various embodiments, the system 110 comprises one or more connecting stations (not shown) arranged on the elongate platform 111 where pipes 191 are connected to the pipeline 190 and/or to other pipes 191.

According to another embodiment of the present invention as shown in Figures 3 to 15, there is a pipeline laying system 210 installable on an offshore pipeline laying vessel 200. The vessel 200 comprises a fore/forward portion 201 and an aft/rear portion 202. A bridge 204 is arranged at the aft portion 202 while the system 210 is arranged and installed at the fore portion 201 of the vessel 200. Depending on the application and requirements, the system 210 may be installed at the fore and/or aft portions of the vessel 200. The vessel 200 further comprises pipes 291 stored on deck 203 and cranes 250 for transporting the pipes 291 onto the system 210. The vessel 200 may comprise more than one deck and the pipes 291 may be stored in lower decks of the vessel 200.

With reference to Figures 4 and 5, the pipeline laying system 210 comprises an elongate platform 211 for supporting an offshore pipeline 290 and pipes 291 that are connected to the pipeline 290 when in operation. The elongate platform 211 is hingedly connected via axle 230 to and is supported by a mount comprising a base 212 and a stand 213. The system 210 is installable on a side of the vessel

200 via the mount, where the base 212 is attachable to the deck 203 of the vessel 200. The base 212 is attached to the deck 203 by means known in the art, which include but are not limited to welding and riveting. The elongate platform 211 is connected to the stand 213 and is pivotal/rotatable about the axle 230 along an axis A (first axis) as shown in Figure 7, which is substantially transverse to the longitudinal axis of the elongate platform 211. When in operation, the elongate platform 211 is capable of passively pivoting about axis A between a first orientation and a second orientation. The first orientation includes an orientation where the elongate platform 211 is substantially parallel to the deck 203 of the vessel 200, for example at a 0° angle with respect to the deck 203 and the second orientation includes an orientation where the elongate platform 211 is substantially parallel to the direction of gravity, for example at a 90° angle with respect to the deck 203, although it will be appreciated that this angle may go beyond 90° depending on the motion (e.g. pitch) of the vessel 200. Preferably, when in the first orientation, the elongate platform 211 is about 0° to about 45° with respect to the deck 203 of the vessel 200, and when in the second orientation, the elongate platform 211 is more than 45° with respect to the deck 203 of the vessel 200, preferably more than 45° to about 90° . It will be appreciated that in the first orientation, the elongate platform 211 may be considered to be in a substantially horizontal orientation, and in the second orientation, the elongate platform 211 may be considered to be in a substantially vertical orientation. In various embodiments, the elongate platform 211 is capable of pivoting at an angle in the range of about 0° to about 90° with respect to the deck 203 of the vessel 200 when in operation.

The stand 213 is adapted to couple with the base 212 to form an axis B (second axis), as shown in Figure 7, about which the stand 213 and the elongate platform 211 are capable of pivoting/rotating. The elongate platform 211 and stand 213 passively pivot/rotate about axis B when in operation. The stand 213 is pivotal/rotatable with respect to the base 212 about axis B via means known in the art, which includes but are not limited to bearings. In various embodiments, the elongate platform 211 and stand 213 comprise a pivotal angle about the axis B in the range of -90° to 90° with respect to an axis perpendicular to axis B, for example an axis parallel to the central longitudinal axis of deck 203. The elongate

platform 211 can move freely till the edge of deck 203, which prevents further movement. It will be appreciated that the height of the stand 213 depends on application and requirements, for example the weight and size of the elongate platform 211. In various embodiments, the height of the stand 213 is sufficient to permit free movement of the elongate platform 211 to its second orientation. In a preferred embodiment with reference to Figures 10 and 11, the base 212 comprises a cavity 215 that receives the stand 213 and in which the stand 213 pivots/rotates. The cavity 215 is defined by wall 216 that substantially surrounds the stand 213. A portion 216a of the wall 216 is truncated. Preferably, this truncated portion 216a is bevelled/sloped. More preferably, the base has a substantially semi-cylindrical shape. The truncated portion 216a faces away from the side of the vessel 200 on which the base 212 is attached. This allows the elongate platform 211 to achieve an orientation substantially parallel to the direction of gravity when in operation. Without the truncated portion 216a, the wall 216 will be continuous and surround the stand 213, thereby limiting the extent at which the elongate platform 211 can pivot to the second orientation. In other words, the elongate platform 211 would not be able to achieve an orientation substantially parallel to the direction of gravity when in operation without the truncated portion 216a, since the wall 216 will act as a stop to limit the second orientation of the elongate platform 211. Further, when the pipeline laying system 210 is laying a pipeline in deep water, the elongate platform 211 becomes more vertical and if there is no truncated portion 216a, the bottom surface of the elongate platform 211 will bear against the wall 216 such that over time, the elongate platform 211 and/or the wall 216 will be worn away by one another, and will require maintenance and repair.

The system 210 does not comprise actuators to pivot the elongate platform 211. The angle of the elongate platform 211 about axes A and B with respect to the deck 203 of the vessel 200 and/or the vector direction of gravity, is a natural angle caused by the pipeline 290 being laid, and can be affected by several factors which include but are not limited to the length and weight of the pipeline 290, the depth of the water and tensional forces acting on the pipeline 290. It is through the passive pivoting mechanisms about axes A and B that the pipeline 290 can be laid in both shallow water and deep water since the combination of axes A and B

allows the elongate platform 211 to pivot in a wide range of directions and angles. It will therefore be appreciated that the combination of axes A and B allows elongate platform 211 to be considered to be capable of pivoting about more than one axis. As shown in Figure 7, axes A and B intersect one another.

5 The elongate platform 211 is used to lower the pipeline 290 onto a seabed. As the elongate platform 211 is pivotal in nature and free to take any angle as per the direction of force acting on it, the longitudinal direction of elongate platform 211 aligns with the longitudinal direction of pipeline 290 near the forward portion 201 of the vessel 200. In other words, the elongate platform 211 aligns with the
10 curvature of the pipeline 290 near the zone of firing/launch, distal from the fore portion 201. As a result, there is no/minimal bending of the pipeline 290 near this zone and hence there is no or minimal stress to the pipeline 290. When the vessel 200 is in transit, the elongate platform 211 may be secured by means known in the art, which include but are not limited to locks, lashings and temporary welding.

15 Starting from laying the pipeline 290 in shallow water, the vessel 200 and system 210 can gradually move to deep water. Therefore when the pipeline 290 is being laid in shallow water, the elongate platform 211 may be substantially parallel to the deck 203 of the vessel 200 (although free to assume any angle depending upon the natural bending of pipeline 290 near the forward end 201).
20 The elongate platform 211 may be in the range of about 0° to about 45° with respect to the deck 203 of the vessel 200 when the pipeline 290 is laid in shallow water. This allows for the commencement of the pipeline installation where the pipes 291 are placed on the elongate platform 211 and connected to form the pipeline 290 at an intended site. As the pipeline laying operation shifts/moves
25 towards deep water, the inclination of the elongate platform 211 becomes more vertical and assumes the tangent angle of the pipeline 290 at the forward end of the elongate platform 211. The elongate platform 211 may be more than 45° , preferably more than 45° to about 90° , with respect to the deck 203 of the vessel 200 when the pipeline 290 is laid in deep water. As the elongate platform 211
30 assumes an angle tangent to the curvature of pipeline 290 at the firing end (i.e. the end of the elongate platform 211 where the pipeline 290 is launched), there is no or minimal stress in the pipeline 290 and hence there is no need for a stinger to facilitate the easy bending of the pipeline 290 and prevent damage in its

structure. Therefore, the freedom of elongate platform 211 to take any angle enables it to lay the pipeline 290 in both shallow water as well as deep water.

While the J-Lay method is suitable to operate in deep water only and the S-Lay method is suitable to operate in shallow water only, the H-Lay system and
5 method of the present invention can operate in all types of water depths ranging from shallow water to deep water since the elongate platform 211 is free to assume any angle of convenience depending upon the angle of pipeline 290 with respect to the deck 203 of the vessel 200.

The elongate platform 211 may be substantially planar, or may comprise a
10 framed or enclosed portion that surrounds the pipeline 290. In various embodiments, the elongate platform 211 may be a framed (e.g. truss frame) or enclosed structure. In a preferred embodiment as shown in Figure 6, the elongate platform 211 is formed from two elongate platform halves separated along the longitudinal axis of the elongate platform 211. The elongate platform halves may
15 lie on the same plane, i.e. the elongate platform 211 is substantially planar, or they may be angled towards one another to form a groove that supports and retains the pipeline 290 and pipes 291 on the elongate platform 211. Such angling of the two elongate platform halves prevent or minimize the possibility of the pipeline 290 and/or the pipes 291 from rolling off a side of the elongate platform 211. It will be
20 appreciated that the elongate platform 211 may be formed from more than two halves and can comprise several composite parts that create a curvature/groove on the surface of the elongate platform 211 on which the pipeline 290 and pipes 291 are supported, so that the pipeline 290 and/or pipes 291 are prevented from rolling off a side of the elongate platform 211.

25 The two elongate halves as shown in Figure 3 each comprise a plurality of rollers 214 which function as guides to guide the pipeline 290 off the system 210 at the launching end distal from the fore portion 201 of the vessel 200, for laying on the seabed. The rollers 214 also function as guides to guide the connection of the pipes 291 with the pipeline 290. The rollers 214 may also serve as guides to
30 prevent the pipeline 290 and/or pipes 291 from rolling off a side of the elongate platform 211. Depending on the application, the rollers 214 may have different arrangements in each elongate platform half. It will be appreciated that other forms of guiding mechanisms in the art may be utilized in the present invention.

The elongate platform 211 comprises one or more tensioners 240 for tensioning and restraining the pipeline 290 on the elongate platform 211. The tensioners 240 releasably engage with and maintain the pipeline 291 substantially stationary with respect to the elongate platform 211. The tensioners 240 are capable of being operated by mechanisms known in the art, which include but are not limited to hydraulic systems. In various embodiments, the tensioners 240 are removable. In various embodiments, the system 210 comprises more than one tensioner 240, where one tensioner 240 is operable to restrain the pipeline 290, while the other additional tensioners offer redundancy, i.e. they may be used in the event the main tensioner fails or is undergoing maintenance. In various embodiments, the system 210 comprises one or more connecting stations (not shown) arranged on the elongate platform 211 where pipes 291 are connected to the pipeline 290 and/or to other pipes 291.

The pipeline laying system 210 comprises pipe loaders 220a, 220b for loading pipes 291 onto the elongate platform 211 for connecting to the pipeline 290. Pipe loaders 220a, 220b can be considered "revolver loaders" or "to-and-fro loader" because of their articulating action with respect to the elongate platform 211 during operation. Pipe loaders 220a, 220b are elongate structures that are capable of receiving a pipe 291, e.g. from a crane 250, and loading the pipe 291 onto the elongate platform 211. The pipe loaders 220a, 220b each comprise two elongate loader halves separated along their longitudinal axes, where these two elongate loader halves are preferably angled towards one another to form a groove that supports and retains loaded pipes 291 on the pipe loaders 220a, 220b. Such angling of the two elongate loader halves prevent or minimize the possibility of a loaded pipe 291 from rolling off a side of the pipe loader 220a, 220b. In various embodiments, each pipe loader 220a, 220b may be formed from more than two halves and can comprise several composite parts that create a curvature/groove on the surface of each pipe loader 220a, 220b on which the pipes 391 are supported, so that the pipes 291 are prevented from rolling off a side of each pipe loader 220a, 220b. The pipe loaders 220a, 220b are preferably of the same length, although it will be appreciated that pipe loader 220a can have a different length compared to pipe loader 220b to cater to different lengths of pipes 291.

Pipe loaders 220a, 220b are arranged on the sides (e.g. opposing left and right sides) of the elongate platform 211 and are connected to elongate platform 211 via one of their ends at axle 230. The pipe loaders 220a, 220b accordingly share the same axis A with the elongate platform 211. The pipe loaders 220a, 220b are also pivotal about axis A. In various embodiments, the pipe loaders 220a, 220b are connected to the elongate platform 211 at another location along its length, and do not share the same axis A as the elongate platform 211. In such embodiments, the pipe loaders 220a, 220b are pivotal about an axis parallel to axis A. The connection point of the pipe loaders 220a, 220b to the elongate platform 211 may however be closely located to the axle 230. It will be appreciated that pipe loader 220a may be connected to the elongate platform 211 at a different location compared to the location of the connection of pipe loader 220b to the elongate platform 211.

In other various embodiments, the pipe loaders 220a, 220b are pivotal about an axis substantially parallel to the direction of gravity, i.e. an axis transverse to axis A and parallel to axis B. In such embodiments, the pipe loaders 220a, 220b and the elongate platform 211 share a same plane where the pipe loaders 220a, 220b are operable to pivot away from the sides of the elongate platform 211.

With reference to Figures 6, 14 and 15, the pipe loaders 220a, 220b are operable to pivot from a loading position (away from the elongate platform 211 and towards the deck 203) to an unloading position (towards the elongate platform 211 and away from the deck 203). At the loading position, the pipe loaders 220a, 220b are not aligned with the elongate platform 211 and are capable of being loaded with pipes 291. In Figure 15, pipe loader 220b is in the loading position. At the unloading position, the pipe loaders 220a, 220b are substantially aligned with the elongate platform 211 and the pipes 291 can be loaded/shifted onto the elongate platform 211. In Figure 6, pipe loader 220a is in the unloading position. The pipe loaders 220a, 220b do not depend on the angle of the elongate platform 211 with respect to the vessel 200 at a material time, and may have varying loading and unloading positions during operation. For example, when the elongate platform 211 is substantially parallel with respect to the deck 203, the loading and unloading positions of the pipe loaders 220a, 220b may be the same, since the pipe loaders 220a, 220b cannot move below the deck 203 (i.e. below this

horizontal/parallel orientation). In such an orientation, the crane 250 may load the pipes directly on the elongate platform 211.

The pipe loaders 220a, 220b are operable to articulate with respect to the elongate platform 211, in particular, the pipe loaders 220a, 220b are operable to
5 move between the loading and unloading positions by actuating mechanisms known in the art, which includes but are not limited to hydraulic systems and gears. The pipe loaders 220a, 220b can be considered to be actively pivoting during operation. When in operation, the pipe loaders 220a, 220b are capable of alternating with respect to one another, for example at a certain point in time, pipe
10 loader 220a may be in the unloading position while pipe loader 220b may be in the loading position. This alternating, to-and-fro motion of the pipe loaders 220a, 220b is efficient and effective in providing a continual and consistent supply of pipes 291 to the elongate platform 211 for connecting with the pipeline 290.

The vessel 200 can be equipped with gantry cranes 251 that will help in
15 easy shifting of pipes 291 from the storage racks to the cranes 250 and/or pipe loaders 220a, 220b.

Once a pipe 291 is loaded onto the elongate platform 211, it is actuated towards the pipeline 290 for connection with the pipeline 290. The pipeline laying system 210 comprises a pipe connection station (not shown) along the length of
20 the elongate platform 211 for connecting the pipes 291 to the pipeline 290. The pipes 291 may be connected to the pipeline 290 by means and mechanisms known in the art, which include but are not limited to welding.

According to another embodiment of the present invention as shown in Figures 16 to 30, there is an offshore pipeline laying system 310 installable on an
25 offshore pipeline laying vessel 300. The system 310 is preferably installed at the bow of the vessel 300, on deck 303. Preferably, the system 310 is installed on an overhang of deck 303 (see for example Figure 17 and 24). Preferably, the overhang is tapered. The vessel 300 comprises a fore/forward portion 301 and an aft/rear portion 302. A bridge 304 is arranged at the aft portion 302 while the
30 system 310 is arranged and installed at the fore portion 301 of the vessel 300. Depending on the application and requirements, the system 310 may be installed at the fore and/or aft portions of the vessel 300. The vessel 300 further comprises pipes 391 stored on deck 303 and cranes 350 for transporting the pipes 391 onto

the system 310. The vessel 300 may comprise more than one deck and the pipes 391 may be stored in lower decks of the vessel 300.

The pipeline laying system 310 comprises an elongate platform 311 for supporting an offshore pipeline 390 and pipes 391 that are connected to the pipeline 390 when in operation. The elongate platform 311 is hingedly connected via axle 230 (Figure 23) to and is supported by a mount comprising a base 312 and a stand 313. The system 310 is installable on a side of the vessel 300 via the mount, where the base 312 is attachable to the deck 303 of the vessel 300. The base 312 is attached to the deck 303 by means known in the art, which include but are not limited to welding and riveting. The elongate platform 311 is connected to the stand 313 and is pivotal about the axle 330 along an axis A (first axis) as shown in Figures 23 and 24, which is substantially transverse to the longitudinal axis of the elongate platform 311. When in operation, the elongate platform 311 is capable of passively pivoting about axis A between a first orientation and a second orientation. The first orientation includes an orientation where the elongate platform 311 is substantially parallel to the deck 303 of the vessel 300, for example at a 0° angle with respect to the deck 303 and the second orientation includes an orientation where the elongate platform 311 is substantially parallel to the direction of gravity, for example at a 90° angle with respect to the deck 303, although it will be appreciated that this angle may go beyond 90° depending on the motion (e.g. pitch) of the vessel 200. Preferably, when in the first orientation, the elongate platform 311 is about 0° to about 45° with respect to the deck 303 of the vessel 300, and when in the second orientation, the elongate platform 311 is more than 45° with respect to the deck 303 of the vessel 300, preferably more than 45° to about 90° . It will be appreciated that in the first orientation, the elongate platform 311 may be considered to be in a substantially horizontal orientation, and in the second orientation, the elongate platform 311 may be considered to be in a substantially vertical orientation. In various embodiments, the elongate platform 311 is capable of pivoting at an angle in the range of about 0° to about 90° with respect to the deck 303 of the vessel 300 when in operation.

The base 312 comprises a first portion 312a and a second portion 312b. The first portion 312a is connectable to the stand 313 and the second portion 312b is attachable to the deck 303 of the vessel 300. The first portion 312a is

connectable to the stand 313 via means known in the art, which include but are not limited to rivets and welding. The first portion 312a is adapted to couple with the second portion 312b to form an axis B (second axis), as shown in Figures 25 and 26, about which the stand 313, elongate platform 311 and first portion 312a are capable of pivoting/rotating. The second portion 312b comprises a cavity in which the first portion 312a sits and pivots/rotates (Figure 27). The elongate platform 311, stand 313 and first portion 312a passively pivot/rotate about axis B when in operation. The first portion 312a is pivotal/rotatable with respect to the second portion 312a about axis B via means known in the art, which includes but are not limited to bearings. In various embodiments, the elongate platform 311, stand 313 and first portion 312a comprise a pivotal angle about the axis B in the range of -90° to 90° with respect to an axis perpendicular to axis B, for example an axis parallel to the central longitudinal axis of deck 303. The elongate platform 311 can move freely till the edge of deck 303, which prevents further movement.

The stand 313 comprises an extension 313a which connects to the elongate platform 311 via axle 330. The extension 313a distally extends the elongate platform 311 from the side of the vessel 300 on which the offshore pipeline laying system 310 is installed. This extension 313a increases the pivotal angle of the elongate platform 311 about axis B. Further, distally extending the elongate platform 311 from the side of the vessel 300 avoids limiting the angle in which the elongate platform 311 can pivot about axis A, i.e. the side of the vessel will not act as a stop to limit the second orientation of the elongate platform 311. Furthermore, when the pipeline laying system 310 is laying a pipeline in deep water, the elongate platform 311 becomes more vertical and without the extension 313a, the bottom surface of the elongate platform 311 may bear against the side of the vessel such that over time, the elongate platform 311 and/or the side of the vessel 300 will be worn away by one another, and will require maintenance and repair. It will be appreciated that the height of the stand 313 depends on application and requirements, for example the weight and size of the elongate platform 311. In various embodiments, the height of the stand 313 is sufficient to permit free movement of the elongate platform 311 to its second orientation.

The system 310 does not comprise actuators to pivot the elongate platform 311. The angle of the elongate platform 311 about axes A and B with respect to

the deck 303 of the vessel 300 and/or the vector direction of gravity, is a natural angle caused by the pipeline 390 being laid, and can be affected by several factors which include but are not limited to the length and weight of the pipeline 390, the depth of the water and tensional forces acting on the pipeline 390. It is through the passive pivoting mechanisms about axes A and B that the pipeline 390 can be laid in both shallow water and deep water since the combination of axes A and B allows the elongate platform 311 to pivot in a wide range of directions and angles. It will therefore be appreciated that the combination of axes A and B allows elongate platform 311 to be considered to be capable of pivoting about more than one axis. In the embodiment shown in Figures 16 to 30, axes A and B do not intersect with one another.

The elongate platform 311 is used to lower the pipeline 390 onto a seabed. As the elongate platform 311 is pivotal in nature and free to take any angle as per the direction of force acting on it, the longitudinal direction of elongate platform 311 aligns with the longitudinal direction of pipeline 390 near the forward portion 301 of the vessel 300. In other words, the elongate platform 311 aligns with the curvature of the pipeline 390 near the zone of firing/launch, distal from the fore portion 301. As a result, there is no/minimal bending of the pipeline 390 near this zone and hence there is no or minimal stress to the pipeline 390. When the vessel 300 is in transit, the elongate platform 311 may be secured by means known in the art, which include but are not limited to locks, lashings and temporary welding.

Starting from laying the pipeline 390 in shallow water, the vessel 300 and system 310 can gradually move to deep water. Therefore when the pipeline 390 is being laid in shallow water, the elongate platform 311 may be substantially parallel to the deck 303 of the vessel 300 (although free to assume any angle depending upon the natural bending of pipeline 390 near the forward end 301). The elongate platform 311 may be in the range of about 0° to about 45° with respect to the deck 303 of the vessel 300 when the pipeline 390 is laid in shallow water. This allows for the commencement of the pipeline installation where the pipes 391 are placed on the elongate platform 311 and connected to form the pipeline 390 at an intended site. As the pipeline laying operation shifts/moves towards deep water, the inclination of the elongate platform 311 becomes more vertical and assumes the tangent angle of the pipeline 390 at the forward end of

the elongate platform 311. The elongate platform 311 may be more than 45° , preferably more than 45° to about 90° , with respect to the deck 303 of the vessel 300 when the pipeline 390 is laid in deep water. As the elongate platform 311 assumes an angle tangent to the curvature of pipeline 390 at the firing end (i.e. the end of the elongate platform 311 where the pipeline 390 is launched), there is no or minimal stress in the pipeline 390 and hence there is no need for a stinger to facilitate the easy bending of the pipeline 390 and prevent damage in its structure. Therefore, the freedom of elongate platform 311 to take any angle enables it to lay the pipeline 390 in both shallow water as well as deep water.

While the J-Lay method is suitable to operate in deep water only and the S-Lay method is suitable to operate in shallow water only, the H-Lay system and method of the present invention can operate in all types of water depths ranging from shallow water to deep water since the elongate platform 311 is free to assume any angle of convenience depending upon the angle of pipeline 390 with respect to the deck 303 of the vessel 300.

The elongate platform 311 may be substantially planar, or may comprise a framed or enclosed portion that surrounds the pipeline 390. In various embodiments, the elongate platform 311 may be a framed (e.g. truss frame) or enclosed structure. In a preferred embodiment as shown in Figure 22, the elongate platform 311 is formed from two elongate platform halves separated along the longitudinal axis of the elongate platform 311. The elongate platform halves may lie on the same plane, i.e. the elongate platform 311 is substantially planar, or they may be angled towards one another to form a groove that supports and retains the pipeline 390 and pipes 391 on the elongate platform 311. Such angling of the two elongate platform halves prevent or minimize the possibility of the pipeline 390 and/or the pipes 391 from rolling off a side of the elongate platform 311. It will be appreciated that the elongate platform 311 may be formed from more than two halves and can comprise several composite parts that create a curvature/groove on the surface of the elongate platform 311 on which the pipeline 390 and pipes 391 are supported, so that the pipeline 390 and/or pipes 391 are prevented from rolling off a side of the elongate platform 311.

The two elongate halves as shown in Figure 22 each comprise a plurality of rollers 314 which function as guides to guide the pipeline 390 off the system

310 at the launching end distal from the fore portion 301 of the vessel 300, for laying on the seabed. The rollers 314 also function as guides to guide the connection of the pipes 391 with the pipeline 390. The rollers 314 may also serve as guides to prevent the pipeline 390 and/or pipes 391 from rolling off a side of the elongate platform 311. Depending on the application, the rollers 314 may have different arrangements in each elongate platform half. It will be appreciated that other forms of guiding mechanisms in the art may be utilized in the present invention.

The elongate platform 311 comprises one or more tensioners 340 for tensioning and restraining the pipeline 390 on the elongate platform 311. The tensioners 340 releasably engage with and maintain the pipeline 391 substantially stationary with respect to the elongate platform 311. The tensioners 340 are capable of being operated by mechanisms known in the art, which include but are not limited to hydraulic systems. In various embodiments, the tensioners 340 are removable. In various embodiments, the system 310 comprises more than one tensioner 340, where one tensioner 340 is operable to restrain the pipeline 390, while the other additional tensioners offer redundancy, i.e. they may be used in the event the main tensioner fails or is undergoing maintenance. In various embodiments, the system 310 comprises one or more connecting stations (not shown) arranged on the elongate platform 311 where pipes 391 are connected to the pipeline 390 and/or to other pipes 391.

The pipeline laying system 310 comprises pipe loaders 2320a, 320b for loading pipes 391 onto the elongate platform 311 for connecting to the pipeline 390. Pipe loaders 320a, 320b can be considered "revolver loaders" or "to-and-fro loader" because of their articulating action with respect to the elongate platform 311 during operation. Pipe loaders 320a, 320b are elongate structures that are capable of receiving a pipe 391, e.g. from a crane 350, and loading the pipe 391 onto the elongate platform 311. The pipe loaders 320a, 320b each comprise two elongate loader halves separated along their longitudinal axes, where these two elongate loader halves are preferably angled towards one another to form a groove that supports and retains loaded pipes 391 on the pipe loaders 320a, 320b. Such angling of the two elongate loader halves prevent or minimize the possibility of a loaded pipe 391 from rolling off a side of the pipe loader 320a, 320b. In various

embodiments, each pipe loader 320a, 320b may be formed from more than two halves and can comprise several composite parts that create a curvature/groove on the surface of each pipe loader 320a, 320b on which the pipes 391 are supported, so that the pipes 391 are prevented from rolling off a side of each pipe loader 320a, 320b. The pipe loaders 320a, 320b are preferably of the same length, although it will be appreciated that pipe loader 320a can have a different length compared to pipe loader 320b to cater to different lengths of pipes 391.

Pipe loaders 320a, 320b are arranged on the sides (e.g. opposing left and right sides) of the elongate platform 311 and are connected to elongate platform 311 via one of their ends at axle 330. The pipe loaders 320a, 320b accordingly share the same axis A with the elongate platform 311. The pipe loaders 320a, 320b are also pivotal about axis A. In various embodiments, the pipe loaders 320a, 320b are connected to the elongate platform 311 at another location along its length, and do not share the same axis A as the elongate platform 311. In such embodiments, the pipe loaders 320a, 320b are pivotal about an axis parallel to axis A. The connection point of the pipe loaders 320a, 320b to the elongate platform 311 may however be closely located to the axle 330. It will be appreciated that pipe loader 320a may be connected to the elongate platform 311 at a different location compared to the location of the connection of pipe loader 320b to the elongate platform 311.

In other various embodiments, the pipe loaders 320a, 320b are pivotal about an axis substantially parallel to the direction of gravity, i.e. an axis transverse to axis A and parallel to axis B. In such embodiments, the pipe loaders 320a, 320b and the elongate platform 311 share a same plane where the pipe loaders 320a, 320b are operable to pivot away from the sides of the elongate platform 311.

With reference to Figures 28 to 30, the pipe loaders 320a, 320b are operable to pivot from a loading position (away from the elongate platform 311 and towards the deck 303) to an unloading position (towards the elongate platform 311 and away from the deck 303). At the loading position, the pipe loaders 320a, 320b are not aligned with the elongate platform 311 and are capable of being loaded with pipes 391. In Figure 30, pipe loader 320b is in the loading position. At the unloading position, the pipe loaders 320a, 320b are substantially aligned with the elongate platform 311 and the pipes 391 can be loaded/shifted onto the

elongate platform 311. In Figure 30, pipe loader 320a is moving towards the unloading position. The pipe loaders 320a, 320b do not depend on the angle of the elongate platform 311 with respect to the vessel 300 at a material time, and may have varying loading and unloading positions during operation. For example, when the elongate platform 311 is substantially parallel with respect to the deck 303, the loading and unloading positions of the pipe loaders 320a, 320b may be the same, since the pipe loaders 320a, 320b cannot move below the deck 303 (i.e. below this horizontal/parallel orientation). In such an orientation, the crane 350 may load the pipes directly on the elongate platform 311.

The pipe loaders 320a, 320b are operable to articulate with respect to the elongate platform 311, in particular, the pipe loaders 320a, 320b are operable to move between the loading and unloading positions by actuating mechanisms known in the art, which includes but are not limited to hydraulic systems and gears. The pipe loaders 320a, 320b can be considered to be actively pivoting during operation. When in operation, the pipe loaders 320a, 320b are capable of alternating with respect to one another, for example at a certain point in time, pipe loader 320a may be in the unloading position while pipe loader 320b may be in the loading position. This alternating, to-and-fro motion of the pipe loaders 320a, 320b is efficient and effective in providing a continual and consistent supply of pipes 391 to the elongate platform 311 for connecting with the pipeline 390.

The vessel 300 can be equipped with gantry cranes 351 that will help in easy shifting of pipes 391 from the storage racks to the cranes 350 and/or pipe loaders 320a, 320b.

Once a pipe 391 is loaded onto the elongate platform 311, it is actuated towards the pipeline 390 for connection with the pipeline 390. The pipeline laying system 310 comprises a pipe connection station (not shown) along the length of the elongate platform 311 for connecting the pipes 391 to the pipeline 390. The pipes 391 may be connected to the pipeline 390 by means and mechanisms known in the art, which include but are not limited to welding.

The advantages of the system and method of the present invention includes but are not limited to the following:

- A stinger is not required since the pipeline does not need bigger radius to bend.

- The pipeline can be laid in both shallow and deep water and therefore the same vessel can be used to conduct the pipeline laying in both shallow and deep water.
- The elongate platform can be equipped with a single pipe connection station, where all stages of pipe connection are achieved.
- A longer length of pipes or a series of already joined pipes can be loaded onto the elongate platform for joining with the pipeline, using simple crane facilities and hence higher pipeline laying speed can be achieved
- The pipe loaders attached to the sides of the elongate platform continually supply pipes to the elongate platform.

It will be appreciated by the person skilled in the art that variations and combinations of features described above, not being alternatives or substitutes, may be combined to form yet further embodiments falling within the intended scope of the invention. In particular,

- In various embodiments, the base may be mounted to a substantially vertical surface of a hull of a vessel rather than on the deck of the vessel, such that the stand may be orientated to allow the elongate platform to passively pivot about the first axis.
- In various embodiments, the pipeline laying system does not comprise pipe loaders and other forms of loading mechanisms known in the art, e.g. cranes are used to load the pipes onto the elongate platform. In other various embodiments, only one pipe loader is utilized and may be used with other forms of loading mechanisms known in the art.

Claims

1. An offshore pipeline laying system installable on a side of a vessel, the system comprising:
 - 5 an elongate platform for supporting an offshore pipeline, the elongate platform configured to passively pivot about at least one axis, wherein the at least one axis comprise a first axis substantially transverse to the longitudinal axis of the elongate platform;
 - at least one pipe loader for receiving and loading a pipe onto the elongate platform, the pipe loader being configurable to be pivotally connected to the elongate platform at the first axis; and
 - a mount for supporting the elongate platform, the mount attachable to the side of the vessel,
 - wherein in operation, the elongate platform passively pivots about the first axis between a first orientation and a second orientation.
2. The offshore pipeline laying system according to claim 1, wherein in the first orientation, the elongate platform is about 0° to about 45° with respect to a deck of the vessel, and wherein in the second orientation, the elongate platform is more than 45° with respect to the deck of the vessel.
3. The offshore pipeline laying system according to claim 1, wherein in the first orientation, the elongate platform is substantially parallel to the deck of the vessel.
4. The offshore pipeline laying system according to claim 2, wherein in the second orientation, the elongate platform is more than 45° to about 90° with respect to the deck of the vessel.
5. The offshore pipeline laying system according to any one of the preceding claims, wherein the at least one axis comprises a second axis substantially parallel to the direction of gravity, wherein in operation, the elongate platform passively pivots about the second axis.

6. The offshore pipeline laying system according to claim 5, wherein the first and second axes do not intersect.
- 5 7. The offshore pipeline laying system according to claim 6, wherein the mount comprises a stand and a base, wherein the stand is connectable to the elongate platform to form the first axis, and the base is attachable to the side of the vessel.
- 10 8. The offshore pipeline laying system according to claim 7, wherein the stand is pivotal with respect to the base about the second axis.
9. The offshore pipeline laying system according to claim 7 or 8, wherein the base comprises a truncated portion facing away from the side of the vessel.
- 15 10. The offshore pipeline laying system according to claim 9, wherein the truncated portion is bevelled.
11. The offshore pipeline laying system according to claim 9 or 10, wherein the base has a substantially semi-cylindrical shape.
- 20 12. The offshore pipeline laying system according to claim 7, wherein the base comprises a first portion and a second portion, the first portion connectable to the stand and the second portion attachable to the side of the vessel, and wherein the first portion and the stand is pivotal with respect to the second portion about the second axis.
- 25 13. The offshore pipeline laying system according to claim 12, wherein the stand comprises an extension that is adapted to distally extend the elongate platform from the side of the vessel.
- 30 14. The offshore pipeline laying system according to claim 1, wherein the elongate platform passively pivots about the first axis at an angle in the

range of about 0° to about 90° with respect to the deck of the vessel when in operation.

- 5 15. The offshore pipeline laying system according to any one of claims 5 to 14, wherein the elongate platform comprises a pivotal angle about the second axis in the range of −90° to 90°.
- 10 16. The offshore pipeline laying system according to any one of the preceding claims, the pipe being received and loaded onto the elongate platform for connection with the pipeline.
- 15 17. The offshore pipeline laying system according to claim 16, wherein the pipe loader is operable to articulate with respect to the elongate platform.
18. 18. The offshore pipeline laying system according to claim 17 wherein the pipe loader is arranged at a side of the elongate platform.
- 20 19. The offshore pipeline laying system according to claim 18 wherein the system comprises two pipe loaders, each pipe loader arranged at opposing sides of the elongate platform.
- 25 20. The offshore pipeline laying system according to claim 19, wherein the two pipe loaders are operable to articulate in an alternating manner with respect to one another.
- 30 21. The offshore pipeline laying system according to any one of the preceding claims, the system comprising at least one tensioner configured to releasably engage with and maintain the pipeline substantially stationary with respect to the elongate platform.

- 22. The offshore pipeline laying system according to any one of the preceding claims, the system further comprising a pipe connecting station for connecting a pipe to the pipeline.
- 5 23. The offshore pipeline laying system according to any one of the preceding claims, the system further comprising at least one guide for guiding the pipeline and/or a pipe to be connected to the pipeline, along a surface of the elongate platform.
- 10 24. An offshore pipeline laying vessel comprising the offshore pipeline laying system according to any one of claims 1 to 23, wherein the system is installed at a forward portion of the vessel.