RIGID STINGER WITH ADJUSTABLE PIPELINE CURVATURE MEANS

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ABSTRACT

A nonarticulated stinger is provided which is towed through a body of water at a predetermined depth. Vertical and lateral position control means maintain the trailing end of a pivotally mounted rigid stinger at predetermined depths below the surface of a body of water. The pipeline guided by the stinger can be made to assume various radii of curvature by adjusting the elevation of pipeline support rollers and/or by adjusting the elevation of the trailing end of the pivotable stinger.
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RGID STINGER WITH ADJUSTABLE PIPELINE CURVATURE MEANS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to rigid pipeline stingers with means for controllably maintaining the pipeline's radius of curvature during underwater pipelaying operations.

2. Description of the Prior Art

Stingers used in marine pipelaying operations are normally pivoted or connected for towing through the water by the pipelaying barge or vessel. One such stinger is described in U.S. Pat. No. 3,438,213 issued Apr. 15, 1969.

One of the problems associated with known stingers is the difficulty of maintaining the trailing end of the stinger at a selected, predetermined depth in the water while the stinger is being towed by the pipelaying barge. It is not unusual for a pipelaying stinger to be several hundred feet long, and the efficiency of the pipelaying operation is to a large extent affected by the ability to maintain the trailing end of the stinger within a predetermined narrow depth range below the water surface.

One technique heretofore suggested for maintaining the stinger to a predetermined depth is by selectively controlling the buoyancy of the individual stinger sections. These sections are constructed of tubular members which are fitted with one or more bulkheads to form buoyancy chambers within the members. Suitable pumping means on the barge supply air to the individual chambers through a plurality of flexible hoses to obtain positive buoyancy. Alternatively, valves operated from the deck of the barge are used to selectively flood the individual chambers with sea water to obtain negative buoyancy. Sensing and measuring means associated with each stinger section provide an indication on board the barge of the hydrostatic forces acting on the section to thereby allow the programmed regulation of the buoyancy in the various sections and to achieve the desired stinger configuration for any particular pipelaying operation.

It has also been suggested to support the trailing or free end of the stinger with a guide line secured to an auxiliary vessel, buoy or float.

Such known means for controlling the bending moments exerted on the stinger sections about pivot axes transverse to the stern of the vessel are relatively complex and unreliable in operation. They are subject moreover to frequent malfunction, especially under adverse operating conditions.

The members having buoyant chambers therein have relatively large cross-sectional areas, thereby exposing the entire stinger to the adverse effects produced by cross currents, winds and wave action.

The flexible lines used to interconnect the individual stinger sections with the air compressors and/or water pumps on the deck of the barge are subject to frequent damage, entanglement, and even collapse from hydrostatic pressure in deep waters.

SUMMARY OF THE INVENTION

In its broader aspects, the present invention contemplates the provision of controlled pipeline stingers adapted to be towed through the water which include depth control means which may comprise a housing secured to one or more stinger sections but preferably to the trailing end of the stinger such that the stinger may twist without turning or spinning the control means, and yet vertical forces reacting on the control means will be transmitted to the stinger, and vice versa. Means associated with the control means maintain the stinger at the desired depth in the water as the stinger and control means move through the water.

In one specific embodiment, one or more spuds are lowered into the water from the pipelaying barge to control the depth of a buoyant housing and hence to hole the trailing end of the stinger at the desired depth with a wire line threaded from the end of the stinger over a fairlead on the end of the spud up to a winch on the deck of the barge. When two spuds are used, the spuds will be positioned so that the bottom fairleads on the spuds are separated in a horizontal plane from the centerline of the stinger. Thus, the wire lines can be used to exert forces perpendicular to the stinger centerline which counteract the lateral current drag forces on the stinger.

In another embodiment the depth controller includes depth sensing means to operate a pair of laterally extending, rotatably mounted wings and to thereby automatically control the depth of the controller and the adjacent portion of the stinger.

This invention also contemplates the combination of a pipeline stinger to be towed through the water and a plurality of controllers coupled to spaced longitudinal sections of the stinger for maintaining the entire length of the stinger at the desired orientation in the water.

Accordingly, it is a main object of this invention to provide depth controlled pipeline stingers intended to obviate the above-described, and other problems associated with known stingers. With the depth control attained, the preselected pipeline radius of curvature can easily be attained by adjusting the vertical position of horizontal rollers.

It is yet another object of this invention to provide an improved stinger assembly wherein sections of the stinger are constructed of structural members of reduced cross-sectional areas thereby minimizing the effects of destructive forces which can be produced by cross currents on the longitudinally extending truss members of the stinger. Reduced cross-sectional area members can be used because their principal purpose is to carry loads in the stinger and not to provide buoyancy. BRIEF DESCRIPTION OF THE DRAWINGS

Certain preferred embodiments of the invention are illustrated in the accompanying drawings in which the same reference characters are used to designate similar parts.

FIG. 1 is a view in elevation of a vertically controlled stinger assembly including a stinger coupling.

FIG. 2 is an enlarged view in elevation of a portion of the stinger assembly shown in FIG. 1.

FIGS. 3–7 are sectional views on lines 3–3 through lines 7–7, respectively, in FIG. 2.

FIG. 8 is a view in elevation of a vertically controlled stinger assembly without a stinger coupling.

FIG. 9 is a view in elevation of a vertically and laterally controlled stinger assembly; and

FIG. 10 is a view on line 10–10 in FIG. 9.

Referring now to the drawings, there is shown a pipeline stinger system, generally designated 10, for guiding a long pipeline 12 from or on a pipelaying barge or vessel 14 movable forwardly in a longitudinal direction in a body of water 15.

Pipe 12 is typically made of steel material of a suitable pipe grade. Its outer diameter varies between, say 4 inches to 12 inches, and even higher. For example, a standard X-grade, 12 inch line pipe, Schedule 60 to 120, API SL, Grade B, seamless can be layed with the depth-controlled stinger system 10 of the present invention.

Pipe 12 is typically covered with a protective outer coating. A reel 18 which may be mounted for rotation about a vertical axis and carrying a spool of the pipe 12, unwinds a span 16 of the pipeline 12. The emerging pipe span 16 from reel 18 is curvilinear. It is subsequently straightened by a straightener-and-tensioner system 20, mounted on a platform 22 for vertical reciprocation on a plurality of vertically extending posts 24. The reciprocation is synchronized with the rate of unwinding of the pipe span 16. Span 16 is advantageously vertically supported for movement along a desired trajectory in a vertical plane. Such a support is provided by stanchions 26, five of which are shown.

The manner of dispensing pipe span 16 from the stern of vessel 14 forms no part of this invention, and accordingly, no further description is believed necessary.
It is the general object of the stinger system 10 to controlably guide the pipe span 16 from the stern of vessel 14 into the body of water 15. After pipe span 16 leaves the stinger system 10, it becomes suspended in the body of water 15. The accurate trajectory 32 of the pipe span 12 as it moves through the stinger 10 may have one or more radii of curvature. The minimum radius of curvature is selected to prevent bucking of the pipe, that is ovalling of the pipe’s cross section or to minimize permanent deformation of the pipe.

The stinger system 10 includes a stinger coupling 38 and a stinger section 40 having a trailing end 41 and a leading end 28.

Section 40 is a truss-like, U-shaped structure including two laterally spaced, longitudinally extending bottom chords 50 and two laterally spaced, longitudinally extending top chords 52 positioned above chords 50. Chords 50 and 52 are interconnected by intermediate, cross bracings aligned transversely to chords 50.

The top end of each chord 52 is provided with a pivot ear 54. To each rear side bracing 56 of coupling 38 is releasably secured, as by bolts 58 extending transversely through holes 60, a pivot means 62 which pivotally accepts the ear 54 of each top chord 52 to allow stinger section 40 to pivot about a transverse, horizontal axis extending through the two laterally displaced, horizontal pivots 64 in pivot means 62. Pivot means 62 can be releasably vertically adjusted from a lowermost position to an uppermost position, as shown by the dotted lines in FIG. 1.

The stinger coupling 38 is also a truss-like, U-shaped structure including two laterally spaced, longitudinally extending bottom chords 66 and two laterally spaced, longitudinally extending top chords 68 above chords 66. Chords 66 and 68 are interconnected by intermediate, cross bracings aligned transversely to chords 66.

In order to provide horizontal support on stinger coupling 38 for the pipe span 16 along the gently curved descent trajectory 32, at least two longitudinally displaced, pipe-supporting roller frames 70 are provided for rotatably supporting horizontal rollers 72 which can be selectively and vertically adjusted and laterally spaced, vertical support guides 74 having holes 76 therein for releasably securing, as by bolts 78, a locking mechanism 80.

The two front side bracings 82 of coupling 38 form with the rear end of the pipe-laying vessel 14 a compression joint, generally designated 84, to provide an abutting engagement between the lower end of side bracings 82 and a transverse plate 86 in compression joint 84. If desired, the compression joint 84 can be releasably secured by bolts 88.

The upper end of each side bracing 82 is pivotally mounted on a pivot shaft 90 in a pivot means, generally designated 92, of conventional design. Accordingly, stinger coupling 38, when bolts 88 are removed, can be made to rotate about a horizontal axis extending through the pivot shafts 90.

In order to provide horizontal support for the pipe span 16 along the curved descent trajectory 32, a plurality of longitudinally displaced supporting roller frames 94 are provided in the stinger section 40. Each frame 94 rotatably supports horizontal rollers 96 which can be selectively and vertically adjusted along laterally spaced vertical support guides 98 having holes 100 therein for releasably securing, as by bolts 102, a locking mechanism 104.

To protect the outer jacket of pipe 12 as well as the side chords from becoming damaged, and to limit the lateral displacement of the pipe, a plurality of longitudinally displaced roller frames 106 are provided. Each frame 106 supports a pair of laterally displaced, vertical rollers 108.

At least one depth controller or paravane, generally designated 110, is preferably attached to the trailing end 41 of the stinger section 40. The attachment means 112 should preferably be fully rotatable, such as is obtained from a universal joint 114 to allow the depth controller 110 to freely rotate relative to the stinger section 40. Yet, vertical forces reacting on controller 110 will be transmitted to the adjacent trailing end 41, and vice versa.

The controller 110 can be of a known type such as described in U.S. Pat. No. 3,531,762 and typically comprises a housing 116 in which is contained a pressure-responsive assembly (not shown) of known design such as an inflatable air tank having a valve with which is in response to ambient water pressure variations. A shaft 118, laterally and transversely extending through the housing 116 supports on each side of the housing a wing 120. The shaft 118 is journaled in suitable bearings and its rotation is controlled by the displacement of said movable wall.

A suitable floatation material preferably fills the housing 116. This material may be of any desired light-weight type, such as syntactic foam, which will prevent the housing from filling with water.

Before the depth controller 110 is placed in the body of water 15, the air pressure in said air tank is adjusted for the desired stringer operating depth. As the controller 110 is dropped into the water, its wings 120 will assume their diving attitude so that the paravane will start diving to its predetermined depth. Upon reaching that depth, the diving wings 120 will extend horizontally.

When the trailing end 41 of the stinger section 40 moves below its predetermined depth, as by action of water currents, the hydrostatic water pressure will become greater than the pressure in said tank. Said movable wall will then cause the wings 120 to rotate appropriately thereby lifting the paravane 110 to its predetermined depth at which time the wings 120 will again assume their neutral or horizontal positions.

Conversely, in the event the trailing end 41 moves upwardly above its predetermined operating depth, the wings 120 will resume their diving attitude to restore the paravane 110 to its predetermined depth as shown by the dotted lines in FIG. 1. The paravane 110 may be adjusted to control the depth of the stinger section 40 to a plus or minus depth variation which will not affect the efficiency of the pipelaying operation.

Since the paravane 110 operates at water depths at which the surface wave actions are not appreciably noticeable, the paravane will be virtually unaffected by cross currents and will remain oriented with the wings extending horizontally.

While the invention has been described in connection with the use of a single paravane for controlling the trailing end 41 of a pipeline stinger system 10, it will be appreciated that two or more vertically displaced paravanes can be employed if desired. Also, the depth controller 110 may be provided with means which are responsive to a remote control transmission from the deck of said vessel 14. For example, a remotely generated electric signal may be detected by a detector in the paravane housing and the detected signal then used to rotate shaft 118 by an amount and in a direction corresponding to a parameter of the generated electric signal.

With the stinger system 10 thus far described, the curvature of the descending pipe span 16 can be controlled by adjusting the elevations of the horizontal pipe-supporting rollers 96, and by pivoting the stinger section 40 about a horizontal pivot axis at the leading end 28 thereof by the depth control device 110 attached to its trailing end 41. The depth of the leading end 28 of the stinger section 40 can also be controlled by manually moving up or down the hinge means 62 along the side bracings 66.

In FIGS. 9 and 10 is shown another embodiment which allows both the vertical and lateral control of the trailing end 41 of the stinger section 40.

Two spuds 122 and 124 extend downwardly from the bottom surface of vessel 14. Spud 122 extends substantially perpendicularly to the surface of the water 15 in a spud well 123 and diagonal spud 124 extends at an angle to the vertical in a spud well 125. Two elongated flexible cables 132, each having one end wrapped around a drum of a winch 134 on the deck of vessel 14, and each having its other end connected to a suitable buoyant structure or member, generally designated 136. Since one of the cables 132 is on one side of a vertical plane extending downwardly from the pivot means 62 and the other cable 132 is on the other side of said vertical plane, it will be appreciated that both vertical and lateral control of the
buoyant member 136 can be readily achieved by controlling the depths of spuds 122 and 124 as well as the tension in the wire lines 132. The tension in the cables 132 will be held constant by the drum of winch 134.

The depth of member 136 can be determined by measuring, for example, the number of turns of each of cables 132 on the drum of the winch. The buoyant structure 136 may be of conventional design and shape to achieve proper vertical and lateral stability.

Each of spuds 122 and 124 terminates in a sheave 140 mounted for rotation on a fairlead 142 which turns around the longitudinal axis of each spud.

Although in FIG. 9 two spuds are shown, it will be appreciated that, if desired, one such spud could be used with means to guide the spud both vertically and laterally below the bottom surface of vessel 14. Also spud 124 need not be at an angle relative to the center longitudinal plane of symmetry of the deck of vessel 14. In FIG. 9, spud 124 is shown as being diagonal because the vessel's discharge ramp 144 is near the edge of the vessel.

In FIG. 1 the rigid stinger section 40 is shown as being pivotally connected by pivot means 62 to the rear end of stinger coupling 38. Also stinger section 40 is shown as preferably having a curvature depending on the range of radii of curvature required for the guided pipeline through the stinger system 10.

In FIG. 8 the rigid stinger section 40 is shown as being directly coupled by hinge means 62 to the rear end of vessel 14. Also stinger section 40 is shown as being substantially rectilinear to indicate that the required radii of curvature can be achieved by adjusting the vertical positions of horizontal rollers 96. The positions assumed by pipeline 12, as it is being guided downwardly on rollers 96 along stinger section 40, are shown by the dotted lines.

The apparatus of the present invention provides considerable advantages in carrying out underwater pipelaying operations. The chief advantage lies in the provision of positive control means for controlling the depth of the trailing end of a rigid stinger by means which are less complex than known means for achieving similar purposes. Another advantage is the provision of simple means for manually adjusting the vertical position of horizontal pipe supporting rollers to vary the radius of curvature of the guided pipeline through the stinger system 10. Yet another advantage is obtained from the elimination from known stingers of the means for controlling the buoyancy of individual stinger sections which are articulately interconnected.

Although the invention has been described with reference to certain preferred embodiments, it will be apparent to those skilled in the art that additions, modifications, substitutions, and deletions not specifically described herein may be made which will fall within the scope of the appended claims.

What is claimed is:
1. A stinger system for guiding a pipeline into a body of water, said system comprising:
   a. a pipe-laying vessel;
   b. a pipeline extending from said vessel to said body of water;
   c. a pipe-laying section;
   d. said pipeline being adapted to bend said pipeline to a desired curvilinear configuration as said pipeline descends from the deck of said vessel into said body of water;
   e. first coupling means including pivot means on the rear end of said vessel and on the leading end of said stinger;
   f. second coupling means being adapted to mount said stinger for rotation about a generally horizontal pivot axis,

2. The stinger system of claim 1 wherein, said depth-control means includes:
   a. a depth-controlled paravane.

3. The stinger system of claim 2 wherein, said paravane includes at least one rotatably mounted wing for controlling the diving attitude of said paravane.

4. A stinger system for guiding a pipeline between a floating platform and a body of water, said system including:
   a. a stinger coupling adapted to bend said pipeline to a generally constant desired curvilinear configuration as said pipeline moves between said platform and said body of water;
   b. first coupling means on the rear end of said platform and on the front end of said stinger coupling adapted to rotatably mount said stinger coupling to said rear end of said platform;
   c. at least one pipeline support means mounted on said stinger coupling, said pipeline support means being selectively, vertically adjustable to controllably vary the desired radius of curvature of the guided pipeline configuration;
   d. an unarticulated stinger section adapted to bend said pipeline to a desired curvilinear configuration as said pipeline descends into said body of water;
   e. second coupling means including pivot means on the rear end of said stinger coupling and on the leading end of said stinger section;

5. The stinger system of claim 4 wherein, said second coupling means being adapted to mount said stinger section for rotation about a generally horizontal pivot axis,

   depth-control means below the surface of said body of water, said depth-control means adapted to automatically rotate said stinger about said pivot axis when the depth of the trailing end of said stinger varies from a predetermined depth range thereby controlling the radius of curvature of the portion of the pipeline guided by said stinger,

6. The stinger system of claim 5 wherein, said paravane includes at least one rotatably mounted wing for controlling the diving attitude of said paravane.

7. The stinger system of claim 12 wherein, said second coupling means is selectively vertically positionable to controllably vary said desired radius of curvature.