United States Patent [19]

Lloyd, III

[11] E **Re. 28,922**

[45] **Reissued Aug. 3, 1976**

[54] **COLUMN STABILIZED STINGER**

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[73] Assignee: **Santa Fe International Corporation,** Los Angeles, Calif.

[22] Filed: **Aug. 21, 1974**

(Under Rule 47)

[21] Appl. No.: **499,431**

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: **3,685,305**
Issued: **Aug. 22, 1972**
Appl. No.: **64,267**
Filed: **Aug. 17, 1970**

U.S. Applications:

[63] Continuation-in-part of Ser. No. 22,634, March 25, 1970.

[52] **U.S. Cl.** ..... **61/108;** 114/61; 114/.5 R; 114/.5 T

[51] **Int. Cl.²** **B63B 35/04; F16L 1/00**

[58] **Field of Search** ..... 61/72.3, 72.1, 46.5; 114/61, .5 F

[56] **References Cited**

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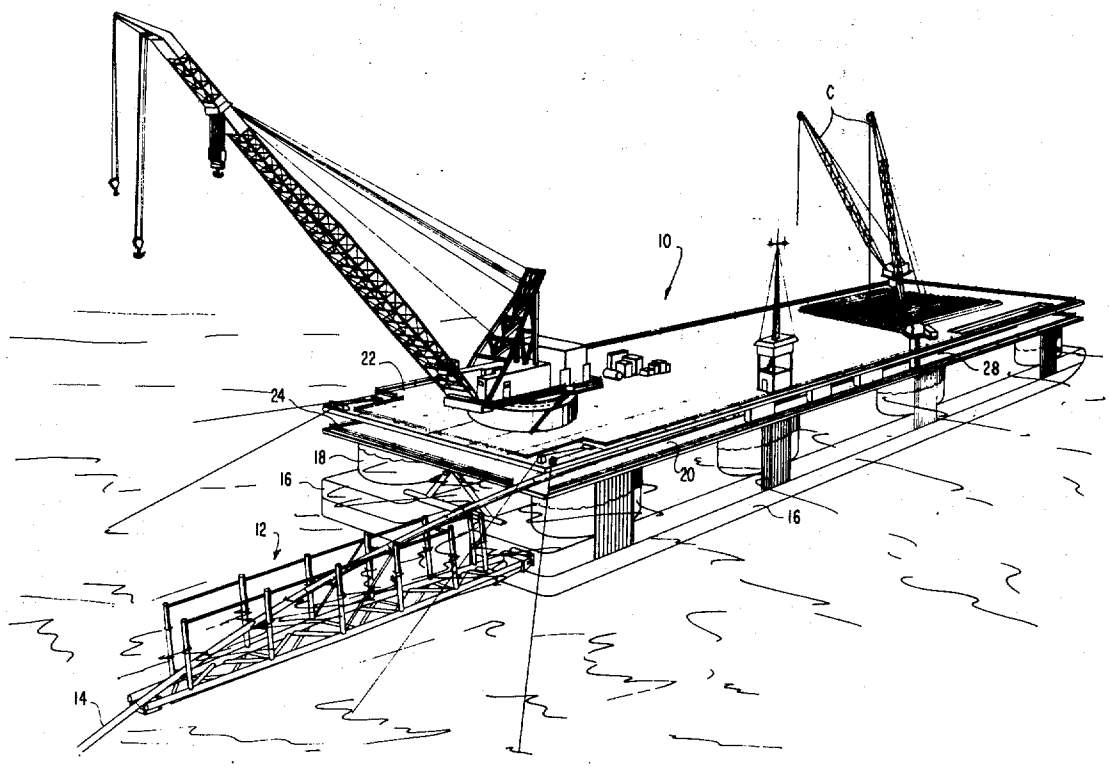
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Primary Examiner—Jacob Shapiro
Attorney, Agent, or Firm—LeBlanc & Shur

[57] **ABSTRACT**

The stinger includes a base structure having a plurality of upstanding stabilizing columns on opposite sides of its pitch and roll axes and carrying pipeline supports which permit translational movement of the pipeline relative to the stinger. The stinger is pivotably secured behind the pipelaying barge and is ballasted from a low draft condition with the base structure having freeboard to a high draft condition. The pipeline supports progressively decrease in height above the base structure from the end of the segment nearest the barge whereat the pipeline is supported in the air toward the opposite end whereat the aft pipeline support disposes the pipeline below the mean waterline. The pipeline centerline extending along the supports defines a radius of curvature at least equal to and preferably much greater than the minimum allowable radius of curvature for the pipeline. The stinger is preferably configured such that the combined natural frequency of the stinger and pipeline match as nearly as possible the natural frequency of the pipelaying barge.

57 Claims, 13 Drawing Figures



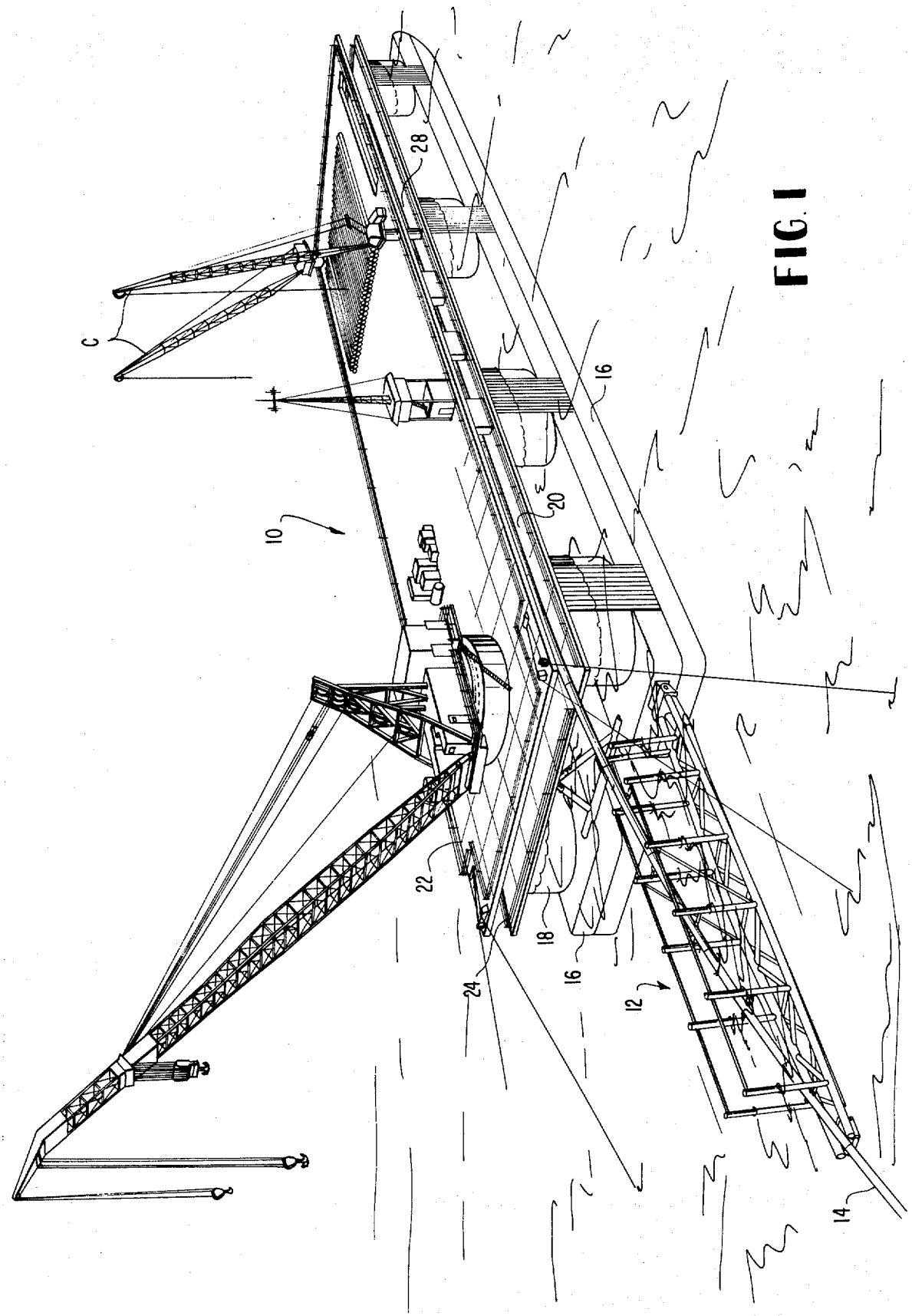


FIG. 1

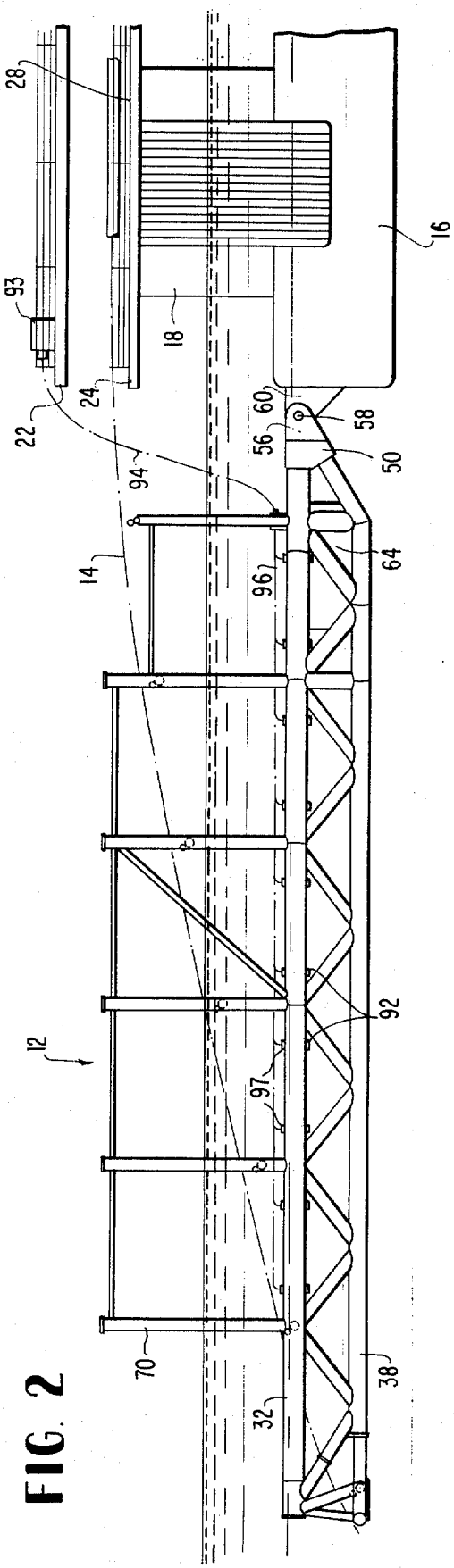

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FIG. 2

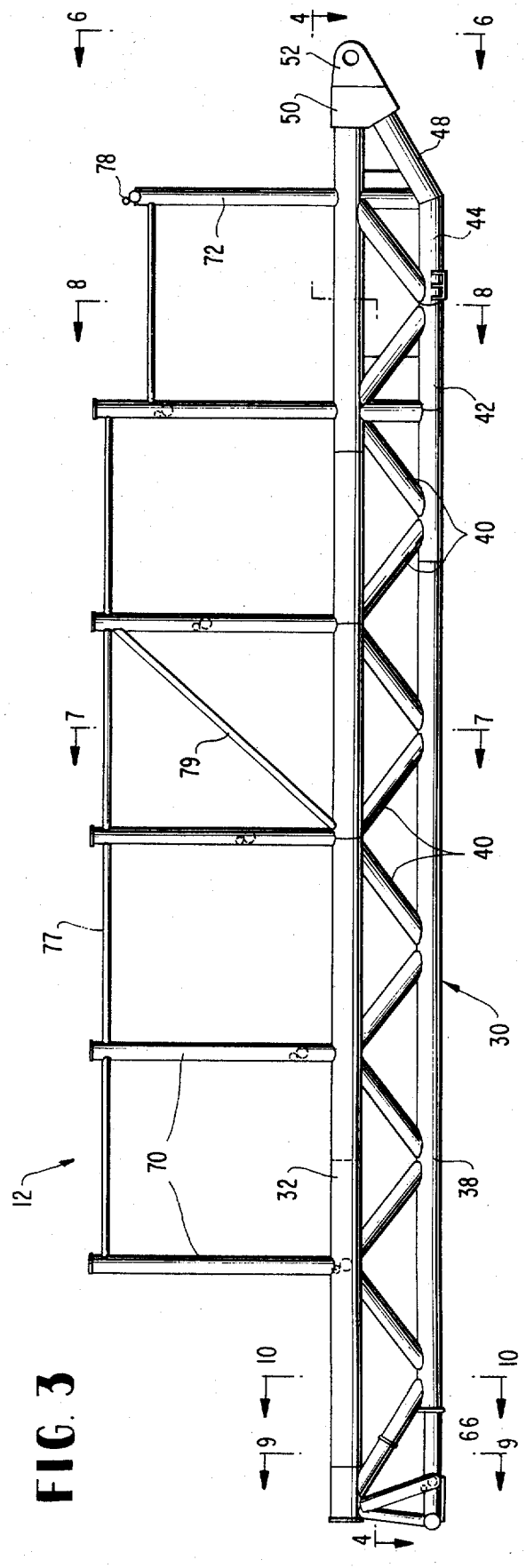

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52
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48
78
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79
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FIG. 3

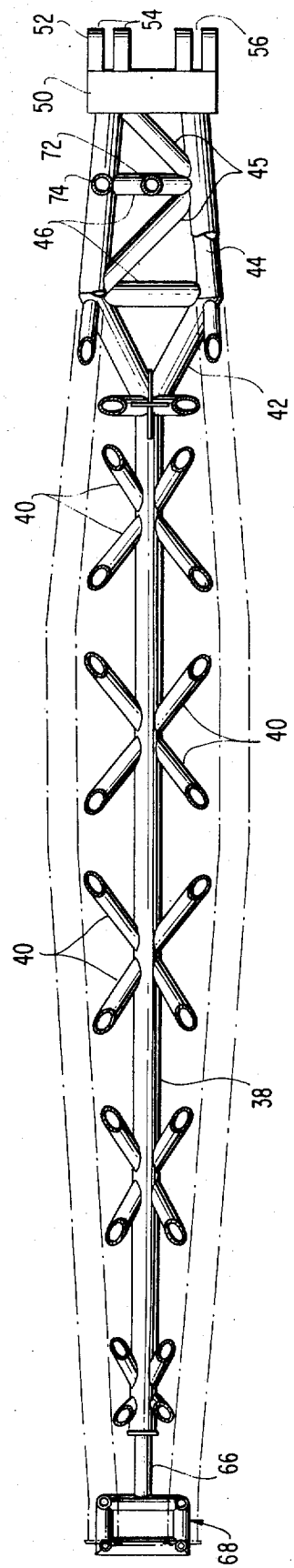

52
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FIG. 4

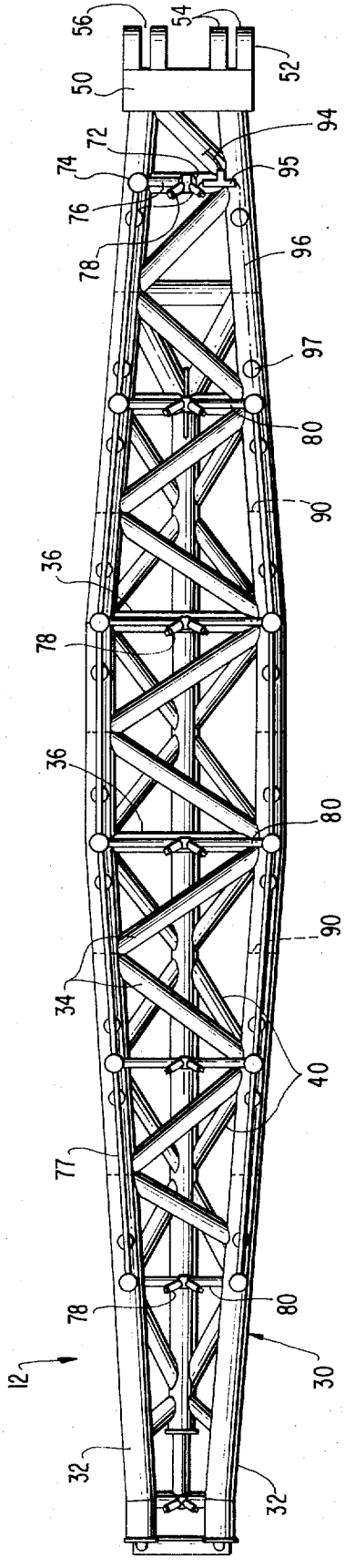

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FIG. 5

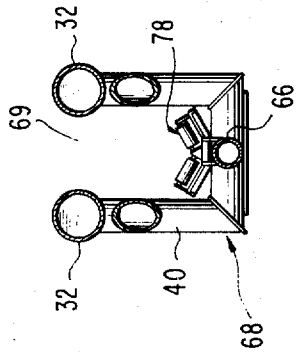


FIG. 9

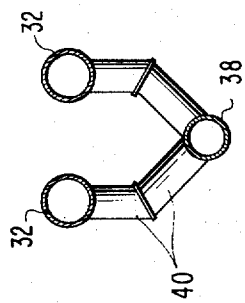


FIG. 10

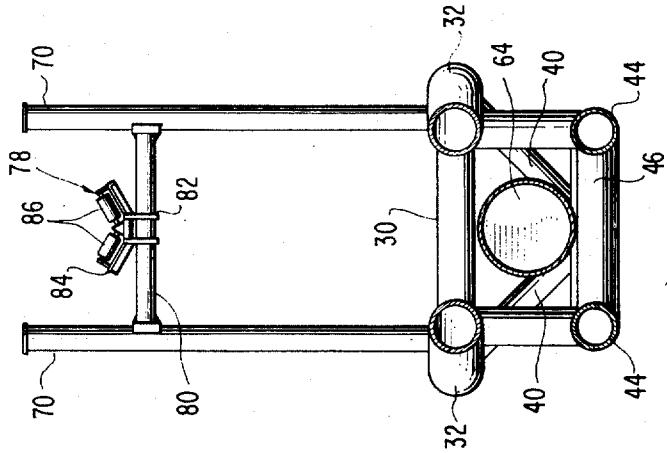


FIG. 8

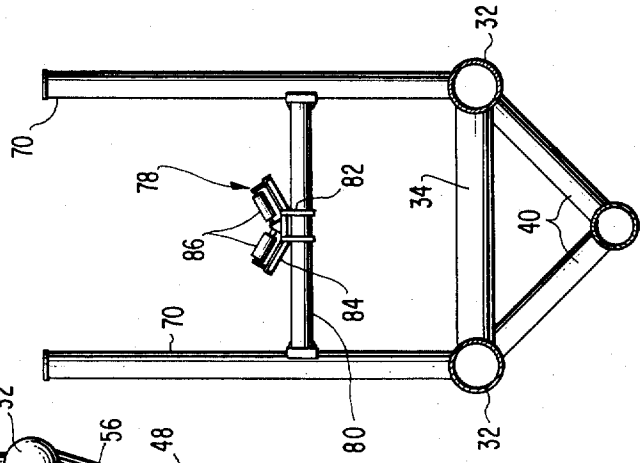


FIG. 7

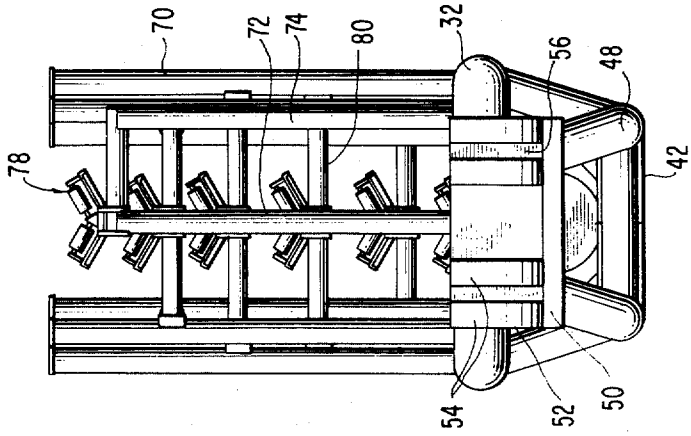


FIG. 6

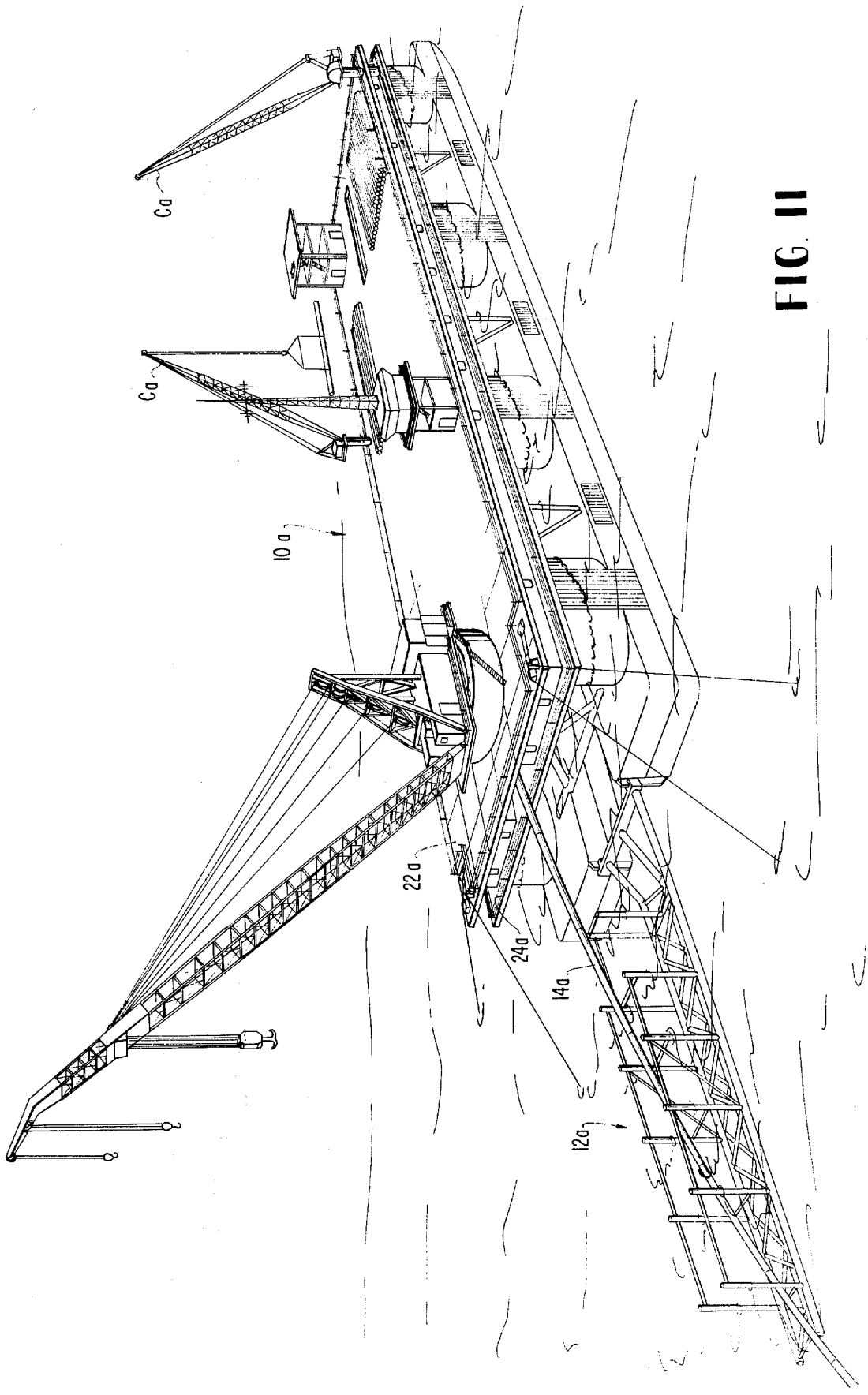


FIG. 11

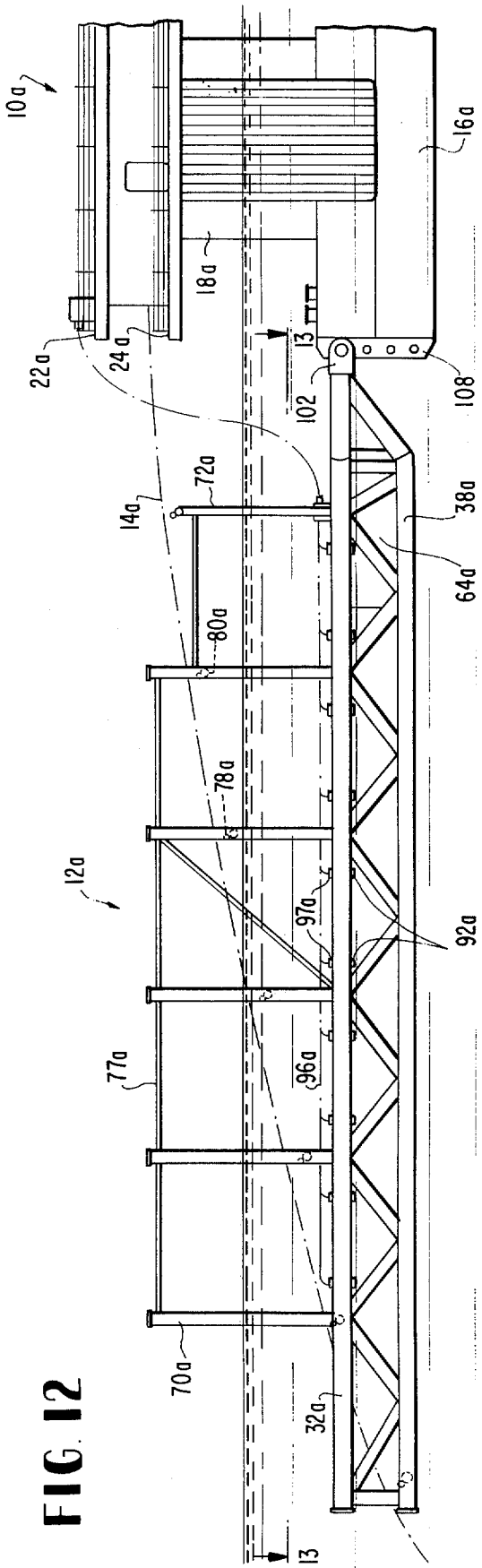

10a
16a
18a
22a
24a
13
102
108
72a
14a
38a
64a
80a
78a
12a
97a
92a
77a
96a
70a
32a
13

FIG. 12

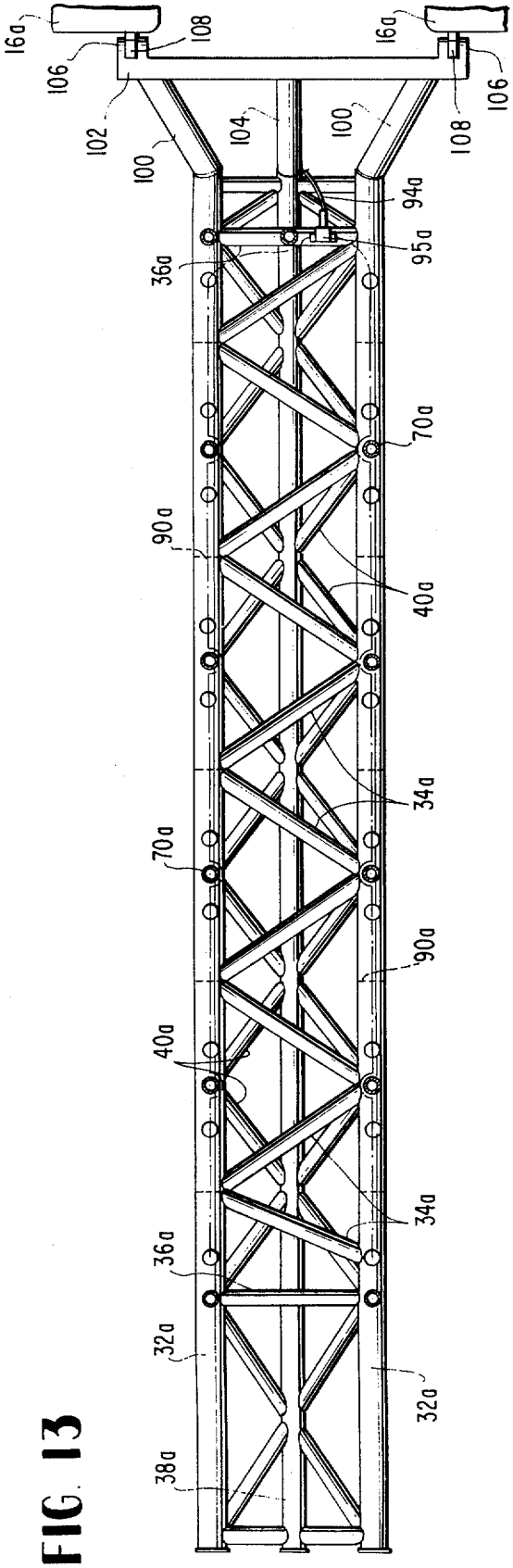

16a
108
106
102
104
100
94a
95a
36a
70a
90a
40a
34a
32a
38a

FIG. 13

COLUMN STABILIZED STINGER

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This application is a continuation-in-part of my copending application Ser. No. 22,634 filed Mar. 25, 1970.

The present invention relates to a subaqueous pipe and cable laying apparatus and particularly relates to a column stabilized stinger for pipe or cable laying barges having elevated working platforms.

Increased activity in offshore gas and oil exploration and development has created an insistent demand for cables and pipelines connecting the offshore sites with onshore terminals. For example, it is often desirable to directly connect an offshore oil producing well with an onshore terminal by means of a pipeline laid along the sea floor whereby oil issuing from the well may be directly communicated to the onshore terminal. Apparatus for laying pipelines along the sea floor has been provided in the past and oftentimes includes pipelaying barges whereon the pipes are connected one to the other and then payed out from the barge for disposition on the seabottom as the barge advances. Pipelines, of the type commonly employed for this purpose, are capable of resisting bending stresses within predetermined limits. Such stresses would not normally be exceeded in shallow water pipelaying operations. However, as the water depth increases, the length and hence weight of pipe which must be supported from the pipelaying barge increases with the pipeline obtaining a generally S-shaped configuration between the barge and the seabottom, the radiuses of curvature of the pipe tending to decrease as the distance between the barge and seabottom or water depth increases. Hence, there is a limit to the radius of curvature which a specified pipeline can obtain without incurring bending stresses exceeding the maximum allowable bending stresses for that particular pipeline and which stresses would result in rupture of the pipeline.

Stingers have been employed in the past in efforts to overcome the foregoing and other problems associated with laying subaqueous pipelines, particularly in deep water. Stingers, either fixed or articulated, comprise devices used to support the pipeline after it has been payed out from the barge and prior to its disposition on the seabottom. Conventionally, the stinger connection to the pipelaying apparatus, which is normally a surface floating barge, is located at or near the operating waterline of the lay barge. An inclined ramp is conventionally constructed on the lay barge to assist in obtaining the proper curvature of the pipeline as it enters the stinger, the ramp usually terminating at the operating waterline. The inclined ramp, however, reduces the available work space on the lay barge due to its disposition near the waterline. More importantly, the surface floating pipelaying barge is subject to wind and wave action which causes excessive barge and stinger motion. As is usually the case, pipelaying operations must be terminated in medium to high seas (waves in excess of 4 or 5 feet) due to large heave motions of the stinger and pipelaying vessel and mismatched vertical motion between the pipelaying barge and the stinger due to wave action. When large heave motions are obtained, there is increased likelihood that the pipeline will exceed its allowable bending stress and rupture.

Accordingly, it is desirable to employ a pipelaying vessel which has minimum motion response to wave excitation forces whereby the vessel can be substantially motionless even in high seas. Such a vessel having a minimum motion characteristic is disclosed in my U.S. Pat. application Ser. No. 705,175, filed Feb. 13, 1968 and is characterized by the provision of a plurality of stabilizing columns having a base flotation stucture at their lower ends and a work platform adjacent their upper ends. This vessel is supported in a low draft condition by the base flotation structure and in a high draft condition, by preferably ballasting the base structure, by the residual displacement of the base structure and the submerged portion of the columns. In the high draft condition with the mean waterline located intermediate the height of the columns and with the base structure fully submerged, the vessel obtains minimum motion response to wave action. As a necessary condition to its effective employment, the work deck of this vessel must be elevated a considerable distance above the mean waterline (even in the high draft condition the work deck is about 15 to 20 feet above the mean waterline). Apart from the foregoing, it has also been found desirable to maintain the work area or platform on which the pipeline sections are connected one to the other and from which the sections are paved out onto the stinger well above the mean waterline such that work can be efficiently conducted and continued even during heavy seas. Thus, when employing a column stabilized vessel for pipelaying operations on which the work platform is both necessarily and desirably elevated above the mean waterline in the high draft column stabilized condition of the vessel or when a conventional ramp-less barge is employed wherein the work area for connecting and paying out the pipe sections is elevated a significant distance above the mean waterline, there is a large length of pipeline which must be supported in the air from the elevated after deck portion of the column stabilized or ramp-less pipelaying barge to the point at which the pipeline enters the water (in addition to the portion of the pipeline extending from the surface of the water to the seabottom). A conventionally constructed stinger cannot be employed by itself for this purpose as it is simply not designed to provide support for and transition of the pipeline from an elevated work deck through the air to its point of entry into the water. Also, the frequency response of the conventional stinger (having a relatively large water-plane area) to wave action would not normally be the same as or bear any relation to the frequency response of the pipelaying barge to wave action and this would result in mismatched heave motions deleterious to effective pipelaying operations particularly in heavy seas.

Accordingly, it is a primary object of the present invention to provide a novel stinger for subaqueous pipeline laying operations from a lay vessel having an elevated work deck.

It is another object of the present invention to provide a column stabilized stinger for supporting a pipeline as it is payed out from a pipelaying vessel in a manner to minimize and substantially eliminate heave motions of the pipeline due to excitation forces caused by wave action on the pipelaying barge and stinger.

It is still another object of the present invention to provide a column stabilized stinger for supporting the

air length of a pipeline between the elevated work area of a pipelaying barge and the point of entry of the pipeline transition into the water as well as for supporting an immersed portion of the pipeline in a manner to substantially preclude rupture of the pipeline due to relative motion of the pipelaying barge and the ground supported pipeline.

It is a further object of the present invention to provide a column stabilized stinger having a natural frequency matched as nearly as possible to the natural frequency of the accompanying pipelaying barge when in a pipeline supporting condition to preclude relative motion between the pipelaying barge and the stinger due to wave action on both the barge and stinger.

It is a still further object of the present invention to provide a column stabilized pipelaying barge and a column stabilized stinger configured to minimize barge and stinger motion due to excitation forces thereon caused by wave action (hereinafter called "motion minimizing characteristics").

These and further objects and advantages of the present invention will become more apparent upon reference to the following specification, claims and appended drawings, wherein:

FIG. 1 is a perspective view illustrating one form of a pipelaying apparatus constructed in accordance with the present invention;

FIG. 2 is a fragmentary side elevational view thereof;

FIG. 3 is a side elevational view of one form of a column stabilized stinger constructed in accordance with the present invention;

FIG. 4 is a cross-sectional view thereof taken generally about on line 4—4 of FIG. 3;

FIG. 5 is a top plan view of the stinger hereof;

FIG. 6 is an end elevational view of the stinger hereof;

FIGS. 7, 8, 9 and 10 are cross-sectional views thereof taken generally about on lines 7—7, 8—8, 9—9, and 10—10 respectively in FIG. 3;

FIG. 11 is a perspective view of another form of pipelaying apparatus hereof;

FIG. 12 is a fragmentary side elevational view thereof; and

FIG. 13 is a fragmentary cross-sectional view thereof taken about on line 13—13 in FIG. 12.

Referring now to FIG. 1, there is illustrated a form of the present invention in which a pipelaying barge, generally indicated 10, is illustrated towing a column stabilized stinger, generally indicated 12 for laying pipeline indicated 14. In the form of the invention illustrated in FIG. 1, the pipelaying barge is, per se, a column stabilized barge and may be of the type disclosed in copending application Ser. No. 705,175 filed Feb. 13, 1968 of common assignee herewith, the disclosure of which application is incorporated herein by reference as though herein fully set forth, *said application Ser. No. 705,175 being parent application to application Ser. No. 161,865 filed July 9, 1971 as a continuation of application Ser. No. 705,175 incorporated herein by reference and which application Ser. No. 161,865 issues as U.S. Pat. No. 3,835,800 dated Sept. 17, 1974.* Briefly, pipelaying barge 10 comprises a pair of transversely spaced elongated hulls 16 each carrying a plurality of upstanding stabilizing columns 18. Columns 18 support a work platform 20 adjacent their upper ends, platform 20 lying in spaced relation above hulls 16 a predetermined height at least equal to the maximum anticipated wave height and preferably comprising upper and lower

decks 22 and 24 respectively. The hulls 16 include ballast compartments, not shown, and barge 10 is configured such that it floats in an unballasted low draft condition with the hulls having freeboard when in transit between work sites, with the mean waterline M.W.L. lying below the top side of the hulls 16. At a work site, for example, astride a track along the seabottom on which pipeline is to be laid, the hull compartments are ballasted to submerge the hulls and portions of columns 18 such that the mean waterline is located at approximately one-half the effective height of columns 18 as illustrated whereby a high draft condition and substantial transparency to wave action is obtained. Furthermore, the cross-sectional area and configuration of columns 18, the weight distribution of barge 10 and the geometry of submerged hulls 16 are such as provide vessel motion minimizing characteristics in roll, pitch, and heave in the high draft condition illustrated in FIG. 1. That is to say, barge 10 is configured to provide minimum motion response to wave excitation forces in the high draft condition. Additionally, the vessel is configured to have long natural periods in heave, pitch and roll in the high draft condition and which periods are beyond the range of anticipated wave periods as to avoid motion amplification due to interaction of vessel and wave motion. It will be appreciated that auxiliary equipment including cranes C for storing, manipulating, racking, connecting, etc. the various pipe sections to be laid are carried by pipelaying barge 10 on work platform 20 and that in the ballasted high draft pipelaying condition the work platform 20 remains elevated a substantial distance above the mean waterline, for example, on the order of 15 to 20 feet. Particularly, the pipe sections P.S. stored on upper deck 22 are lowered by cranes C through an opening 26 in upper deck 22 for disposition in a work area generally indicated 28 along one side of the vessel on lower deck 24, the assembled pipeline being payed out from the between deck work area aft onto the stinger 12 for disposition on the seabottom. Thus, by locating the assembly area for the pipe sections between decks 22 and 24, the workmen can work in an enclosed protected area. Further, by such disposition, the height of the pipe above the mean waterline is reduced as compared with dispensing the work area in the open on deck 22 and this reduces the design requirements for the stinger as discussed hereinafter. Also, it is desirable in pipelaying operations conducted in deep water to apply a predetermined axial tension to the pipeline in order to reduce the curvature of the generally S-shaped pipeline portion which extends between the pipelaying apparatus and the seabottom. To this end, a plurality of rollers, not shown, can be disposed in the work area 28 on lower deck 24 in a position engaging about the pipe. The rollers can be controlled by a suitable drive mechanism, not shown, to provide a constant tension on the pipe thereby to increase the radius of curvature of the depending pipeline in comparison with the radius of curvature of an un-tensioned pipeline. As will be appreciated, the pipeline is thus laid in tension with the barge being periodically stopped such that additional pipe sections can be added and secured to the pipeline and advanced such that the additional sections can be payed out from the barge. For purposes of this application, the term pipeline as employed herein is intended also to include one or more cables within its scope.

Referring now to FIGS. 2, 3 and 4, stinger 12 is preferably an all steel tubular welded construction includ-

ing a generally triangularly shaped base or hull structure 30 having a pair of transversely spaced elongated tubular or pontoon-like members 32 connected one to the other by a plurality of diagonally disposed cross tubular members 34 and a pair of transversely extending tubular members 36 located centrally of stinger 12. The elongated members 32 converge inwardly toward one another at opposite ends of stinger 12 with a central portion of members 32 between cross members 36 lying generally parallel one with the other. Tubular members 32 are generally symmetrical with respect to one another about a longitudinal axis. A lower centrally disposed tubular keel 38 depends from tubes 32 by a framework including a plurality of diagonally extending inwardly inclined tubular braces 40 connecting between central tube 38 and respective tubular members 32. Keel 38 extend short of the opposite ends of stinger 12 and its forward end is connected to a pair of outwardly diverging tubular members 42. The forward ends of members 42 are, in turn, connected with a pair of transversely spaced forwardly and inwardly converging tubular members 44, members 42 and 44 lying in a common substantially horizontal plane. Suitable diagonally and transversely extending cross braces 45 and 46 respectively are provided between members 44 and their forward ends are connected with upwardly inclined tubular members 48 (FIG. 3). The forward ends of tubular members 32 and members 48 are connected to a transversely extending cross member 50 carrying a pair of laterally spaced hinge mountings 52. Specifically, each hinge mounting 52 includes a pair of vertically extending spaced plates 54 having registering openings 56 for receiving hinge pins 58 for connecting the stinger to the barge 10. Particularly, as seen in FIGS. 1 and 2, the barge 10 includes a pair of transversely spaced, vertically extending plates 60 carried on the hull 16 below work area 28, the plates 60 having openings and being receivable between the plates 54 of hinge mountings 52 with hinge pins 58 providing the stinger to barge coupling. A cylindrical flotation tank 64 is disposed between and below members 32 above members 44 to provide additional buoyancy to stinger 12.

Turning now to the aft end of stingers 12, keel 38 has a reduced diameter extension 66 connected to a tubular subassembly 68 having a rectangular plan form as seen in FIG. 4. A plurality of upwardly and inwardly inclined tubular members 67 are connected at their lower ends to the corners of rectangular subassembly 68 and are connected at their upper ends to the aft end portions of tubular members 32. As seen particularly in FIG. 9, this arrangement provides an upwardly opening channel shaped slot 69 at the aft end of stinger 12 whereby pipeline can issue from stinger 12 from a point directly above the lowermost portion of stinger 12.

As specifically illustrated in FIGS. 3, 7 and 8, there is provided a pipeline supporting and stinger stabilizing structure upstanding from the base or hull structure 30. This upstanding structure includes a plurality of stabilizing columns 70 suitably secured at their lower ends to the tubes or pontoon-like members 32. Columns 70 extend upwardly from the upper surface of base structure 30 an effective height which may be equal to and is preferably greater than the maximum anticipated wave height, i.e., the vertical distance between wave crest and trough. In the preferred embodiment, five pairs of columns 70 are equally longitudinally spaced one from the other along base structure 30 with the column arrangement on each tube or pontoon-like member 32 being symmetrical with respect to the column arrangement on the other tubular or pontoon-like member 32. As illustrated in FIGS. 3 and 5, columns 70 are preferably circular in cross section and constant in cross-sectional area throughout their effective height. Columns 70 provide for motion minimizing characteristics when the stinger segment lies in a semisubmerged high draft operating condition as described hereinafter and provides stability to the stinger when disconnected from the barge. The upstanding structure also includes a forward pair of columns 72 and 74 having like characteristics as columns 70. Column 72 is however disposed on the centerline of stinger 12 on a cross tubular member 76 connecting between members 32 whereas column 74 upstands from one of the longitudinal members 32. Longitudinally extending support struts 77 extend between the upper ends of columns 70 on opposite sides of stinger 12. Also, a pair of diagonal tubular supports 79 connect between members 32 and the central longitudinal support member 77 to reinforce the pipeline support structure.

A plurality of pipeline supporting carriages, generally indicated at 78 are preferably mounted along the longitudinal centerline of stinger 12 on support members 80 which preferably extend transversely between corresponding stabilizing columns 70 upstanding from the tube-like members 32. A similar carriage is carried by columns 72 and 74 at the forward end of stinger 12 and on the rectangular subassembly 68 at the aft end of stinger 12. At best illustrated in FIGS. 7–8, each pipeline support carriage 78 includes a base 82 secured to its associated support member 80. Base 82 mounts a pair of laterally upwardly inclined supports 84, which, in turn, mount laterally inclined rollers 86. By inclining rollers 86 as illustrated, there is formed a trough for receiving the pipeline whereby the latter is maintained against lateral movement relative to stinger 12 on pipeline support carriages 78. Pipeline support rollers 86, of course, permit translational movement of the pipeline relative to stinger 12 for disposition on the seabottom.

As illustrated in FIG. 3, the pipeline support carriages 78 are carried by the stabilizing columns 70 in a progressively decreasing height above the base structure 30 from the end of the stinger nearest the pipelaying vessel toward the opposite end of the stinger whereat the aft pipeline support carriage is disposed below members 32 such that a curved line extending along carriages 78 has a radius of curvature at least equal to and preferably greater than the minimum allowable radius of curvature for the particular pipeline portion carried by the stinger. That is to say, the pipeline supporting carriages 78 support the pipeline in a manner such that the radius of curvature of the pipeline portion is always greater than that radius of curvature which would permit bending stresses on the pipeline in excess of the maximum allowable bending stress. The carriage support member 80 are preferably adjustable in height along the columns relative to base structure 30, by means not shown, whereby the radius of curvature of the portion of the pipeline extending over the carriages 78 can be preselected, if desired, in accordance with the characteristics of the pipeline being laid to avoid pipeline rupture.

Referring now to FIG. 5, it will be seen that each of the pontoon-like members 32 is compartmented to form a plurality of ballast chambers 90 for varying the draft of stinger 12. Any number of chambers 90 can be

provided as desired to perform the intended ballasting and deballasting function and each chamber is provided with a remotely controlled valve **92** for selectively opening and closing the associated chamber to the surrounding sea. The ballasting and deballasting of the stinger is preferably controlled from the pipelaying barge. To this end, and in addition to suitable conventional controls, not shown, for operating valves **90** remotely, there is provided a suitable air pump, schematically illustrated at **93** in FIG. **2** in communication with each chamber **90** by a conduit **94** which, through a tee connection **95,** lies in communication with a pair of conduits **96,** each serving the compartments **90** in the respective tubular members **32.** Conduits **95** and **96** serve as both exhaust lines for permitting air to vent from compartments **90** when ballasting stinger **12** and supply lines for introducing air into compartments **90** when deballasting stinger **12** in a manner and for reasons to be described. Suitable remotely controlled valves **97** are provided in air lines **95** to selectively vent compartments **90** and to provide communication between pump **93** and compartments **90.**

In use, stinger **12** is coupled to the pipelaying barge **10** by hinge connections **54, 56** and **60.** In the normal transit condition to a work site, for example, in transit to an area where pipeline is to be laid, the barge **10** is maintained in an unballasted low draft condition whereby the hulls **16** support the barge in the water and float with freeboard. Similarly, the stinger **12** is also maintained in an unballasted condition whereby the base or hull structure **30** supports stinger **12** in the water in a low draft condition with the tubular hull members **32** floating with freeboard. At the work site, both the ballast compartments in the barge **10** and in the stinger **12** are ballasted to submerge the respective hulls **16** and base structure **30** such that the columns **18** on barge **10** and columns **70** and **72** on stinger **12** are submerged for approximately one-half their effective height, thereby locating the mean waterline above the upper surface of the hulls **16** and base structure **30.** The ballasting of stinger **12** is accomplished by remote actuation of valves **92** to permit ingress of sea water into compartments **90** while the air valves **97** are also remotely actuated to vent air from ballast compartments **90** through lines **94** and **96** to atmosphere at pump **93** (a suitable valve, not shown, being provided at pump **93**) and thereby permit the ingress of ballast water.

When the barge and stinger are ballasted to their working draft conditions, the pipeline carried by the barge can then be assembled on the work area **28** and payed out onto the carriage supports **78** and through the slot **72** at the aft end of stinger **12** for disposition on the seabottom. As the pipeline is initially payed out from barge **10** onto carriage supports **78,** the remotely actuated valves **92** are opened to provide free communication between the surrounding seawater and compartments **90** and valves **97** are actuated to connect the air pump to air lines **94** and **96.** The compartments **90** are progressively deballasted as additional pipeline is payed out from the barge onto stinger **12.** By progressively deballasting compartments **90** as additional pipeline is disposed onto stinger **12,** the latter is maintained in a predetermined column stabilized high draft position relative to the pipelaying barge **10** and the draft of stinger **12** is not substantially altered as the weight of the additional pipeline is added thereto.

It will be appreciated that the displacement of the submerged portions of columns **70, 72** and **74** and the residual displacement of the base structure **30** are adequate to maintain stinger **12** in a floating semisubmerged or high draft condition supporting the pipeline on carriages **78.** In this manner, wave action is prevented from acting against base structure **30** and acts only on columns **70, 72** and **74** and the pipeline support structure in the open frame area between columns **70, 72** and **74** and above base structure **30.** This reduces the adverse effect of wave action on the stinger **12** which, by proper configuration of the columns and the weight and displacement of stinger **12,** has excellent motion minimizing characteristics in the floating high draft condition.

It will be appreciated that a primary purpose of utilizing both a column stabilized stinger and a column stabilized pipelaying barge is to minimize the vertical heave motions of these floating structures due to wave action. Ideally, this is accomplished by submerging stinger **12** and barge **10** to approximately one-half the effective height of the respective columns to preclude wave action against their respective base structures. The present pipelaying apparatus can accordingly operate efficiently in high sea conditions, for example, sea conditions having waves 11 to 12 feet in height or higher with minimum motion response to wave action. However, even when operating in the high draft condition with the motion minimizing characteristics afforded by the particular configuration of the pipelaying barge and column stabilized stinger, there is some response to wave action, i.e., the wave action against columns **18** and **70, 72** and **74.** Because of this, when the natural period of the combined pipelaying barge and stinger is the same as or close to the period of the waves according to existent sea conditions, there is amplification of the motion of the entire pipelaying apparatus which may become so excessive as to interfere with pipelaying operations even though both the barge and stinger are semisubmerged to the usual operating condition with the mean waterline located at approximately one-half the effective height h of stabilizing columns **18** and **70, 72** and **74.** It is therefore desirous to alter the motion of the apparatus when such motion amplification occurs and this can be accomplished by either ballasting or deballasting concurrently both the barge and stinger within certain predetermined limits to submerge or emerge the barge and stinger to a greater or lesser extent from the ideal submergence which locates the mean water surface at one-half the effective height h. The maximum variation of submergence of the stinger from the ideal submergence by ballasting or deballasting the stinger is, however, limited to distances within a range which do not reorient the barge and stinger to positions wherein wave action there against causes excessive impact. Thus, to preclude excessive barge and stinger heave motion and impact caused by interaction of the barge and stinger with wave motion, a maximum variation, i.e., submergence or emergence of barge **10** and stinger **12** as by ballasting or deballasting, respectively from the ideal submergence of one-half h, is such that the distance between the mean water surface and either the upper end of the columns **18** and **70, 72** and **74** or the topside of the hulls **16** and base structure **30** is not less than 0.75 of the mean wave height. It is thus significant that the foregoing barge and stinger have optimum stability characteristics in the floating semisubmerged or high draft condition.

It will thus be appreciatd that stinger **12** provides adequate support for the pipeline as the latter is payed

out from the pipelaying barge **10.** Particularly, stinger **12** supports that length of pipeline which extends through the air from the elevated work area **28** on deck **24** adjacent the aft end of the pipelaying barge to the point of entry of the pipeline into the water in a manner which substantially precludes relative heave motion of stinger **12** and pipelaying barge **10.** These features permit the work area **28** on which the pipe sections are connected one to the other and payed out from the barge to lie at an elevated position above the mean waterline for example, on the order of about 15 feet. Note that the air length of the pipeline between the work deck and its point of entry into the water is fully supported and that the pipeline obtains a radius of curvature in its transition from the work deck to the water well within the allowable radius of curvature whereby rupture of the pipeline is avoided.

It will be appreciated that stinger **12** also provides support for an immersed portion of the pipeline from its point of entry into the water at the mean waterline (about medially of the length of stinger **12**) to the aft end of the stinger whereby the use of articulated linkages, etc. employed in conventional stingers is entirely eliminated. Thus, stinger **12** serves to fully support the pipeline as it transitions through the air from an elevated position well above the mean waterline on the barge to a submerged position well below the mean waterline at the aft end of the stinger without the requirement of any additional supporting structure. Moreover, this is provided in a manner such that the pipeline, when supported by the stinger, obtains a radius of curvature well within the allowable radius of curvature whereby rupture of the pipeline is avoided.

It is a further particular feature hereof that the column stabilized stinger can be employed with barges of conventional construction and having elevated work areas or column stabilized barges of the type herein illustrated, that is, a column stabilized type barge as disclosed in application Ser. No. 705,175 of common assignee herewith. To this end, stinger **12** is constructed to obtain a specified natural period. When the pipeline portion is laid over the stinger and the stinger attached, this combination provides a known predetermined natural period. Note that this natural period can be altered by changing the submergence level to vary the draft and displacement of the stinger thereby obtaining a natural period of the stinger and pipeline combination which is adjustable to a limited extent within a predetermined range. The natural period of a pipelaying barge is known from its physical characteristics. By matching the natural period of the stinger including the pipeline carried thereby, with the pipelaying barge, that is, by particularly configuring the stinger and considering the weight of the pipeline to provide a natural period approximating the natural period of the barge with which the stinger will be utilized, it is possible to match their natural periods whereby substantially identical stinger and pipelaying barge response to wave action can be achieved. Where the combination of stinger and pipeline has a natural period which cannot be altered by variation in the submergence level by ballasting or deballasting to approximate the natural period of the pipelaying barge with which the vessel will be utilized, the stinger **12** can be constructed to obtain a natural period more nearly approximate to the natural period of the pipelaying barge by proper design of the cross section area of the columns, by altering its weight and displacement, its length and width configuration and other factors.

In the preferred embodiment hereof illustrated in FIGS. **1–10,** particularly configured for employment with the column stabilized barge described and illustrated in my copending application Ser. No. 705,175 filed Feb. 13, 1968, stinger **12** has an overall length of about 178 feet and a beam from centerline to centerline of members **32** of about 20 feet. The centerlines of the members **32** at the aft end of a stinger **12** are about 9 feet apart whereas the corresponding portions at the forward end of stinger **12** are about 10 feet apart. The centerline of keel **38** depends a vertical distance of about 10 feet from a horizontal plane containing the centerlines of members **32.** Members **32** preferably have outside diameters of 42 inches and stabilizing columns **70, 72** and **74** preferably have an outside diameter of about 20 inches. Columns **70** upstand from the centerlines of members **32** a distance of about 31 feet. Diagonal bracing **40** preferably has outside diameters of 2 feet while transversely extending members **36** have outside diameters of 30 inches. The centerlines of columns **70** are longitudinally spaced about 26 feet one from the other and are disposed symmetrically about the pitch axis. Anodes, not shown, are preferably disposed on the stinger to preclude corrosion.

Referring now to the embodiment hereof illustrated in FIGS. **11–13,** there is disclosed a stinger **12a** for use with a pipelaying barge **10a** of a type similar to that disclosed in my copending application Ser. No. 705,175 filed Feb. 13, 1968, wherein the work area for assembling and paying out pipe sections from the barge is disposed along the longitudinal centerline of the pipelaying barge rather than along one side thereof as disclosed in the embodiment hereof illustrated in FIGS. **1–10** hereof. The stinger in this form is similar to the stinger described and illustrated with respect to FIGS. **1–10** hereof and like reference numerals are applied with the parts in this form being designated by a letter a following the reference numeral.

The base structure **30a** of stinger **12a** is substantially identical with the base structure **30** previously described except that the members **32a** constituting the forward portion of stinger **12a** lie in spaced parallel relation one to the other rather than converged inwardly toward one another as in the previous embodiment. The keel **38a** extends forwardly to the forwardmost portion of stinger **12a** and suitable diagonal bracing **40a** and vertically extending bracing interconnect keel **38a** with the longitudinal members **32a.**

At the forward end of stinger **12a** there is provided a pair of members **100** connected to the forward ends of members **32a,** members **100** lying in a common plane with members **32a** and diverging outwardly in a forward direction for connection with a transverse member **102.** Also, a member **104** connects with the forward end of keel **38a** and extends upwardly for connection with member **102.** Hinge mounts **106** are provided on the opposite ends of member **102** for hingedly connecting stinger **12a** to the hulls **16a** barge **10a.** Specifically, barge **10a** includes a pair of vertically extending plates **108** disposed on the inboard sides at the aft ends of each of hulls **16a.** Plates **108** have a series of vertically spaced openings and hinge pins couple hinge mountings **106** to plates **108** at selected elevations therealong whereby stinger **12a** is pivotally connected to barge **10a.**

In this form, there is provided a central tunnel between decks **22a** and **24a** for assembling and paying out pipeline onto the centrally disposed stinger **12a.** An opening is provided through the upper deck **22a** adjacent the forward end of barge **10a** whereby pipe sections carried on deck **22a** can be lowered into the pipe assembly area on lower deck **24a** by the cranes. By disposing stinger **12a** along the extended centerline of barge **10a,** the stinger and hence the pipeline carried thereby is less susceptible to roll motions than in the form previously described. Balanced forces also act on the stinger in this stinger-barge configuration. As in the previous form, stinger **12a** supports the pipeline issuing from barge **10a** as the pipeline makes the transition through the air from the aft end of barge **10a** to its point of entry into the water and also supports an immersed portion of the pipeline from the point of entry in the water to the aft end of stinger **12a.** Thus, additional stinger segments or articulated linkages as are commonly employed in the prior art are eliminated.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. A flotation member for laying pipeline on an underwater surface from a floating vessel having a pipeline work deck elevated above the mean waterline comprising:

an elongated base structure comprised of a pair of transversely spaced hulls, at least a portion of said hulls converging toward one another in one of the fore and aft directions;

a plurality of elements upstanding from said hulls with at least a portion of said elements comprised of a plurality of stabilizing columns located on opposite sides of the pitch and roll axes of the member;

means for submerging said base structure and portions of said upstanding elements below the waterline to obtain a high draft floating condition, the displacement of the submerged base structure and portions of said upstanding elements being sufficient to maintain the member buoyant in a pipeline portion supporting condition with the mean waterline located intermediate the height of said columns;

coupling means carried by said base structure adjacent its forward end for pivotally coupling the flotation member to the pipelaying vessel;

and means carried by said flotation member for supporting a portion of a pipeline for translational movement therealong, said pipeline support means being located above said base structure at elevations of decreasing height relative to said base structure in a forward to aft direction along said flotation member, the pipeline support means being adapted to receive pipeline payed out from the elevated work deck of the pipelaying vessel.

2. Apparatus according to claim **1** including means for varying the submergence of the flotation member in the high draft condition to alter the natural period of the flotation member to preclude amplification of flotation member motion due to interaction of wave and flotation member motion.

3. Apparatus according to claim **1** wherein said stabilizing columns have a substantially uniform cross-sectional area throughout their height.

4. Apparatus according to claim **1** wherein said submerging means includes means for ballasting and deballasting said base structure.

5. Apparatus according to claim **4** wherein each of said hulls include a plurality of compartments, valve means associated with said compartments for introducing water ballast into and expelling water ballast from said compartments.

6. Apparatus according to claim **1** wherein said support means comprises a plurality of rollers disposed at longitudinally spaced positions along said stinger and lying substantially coincident with the longitudinal centerline of the stinger.

7. Apparatus according to claim **6** wherein at least a pair of said columns are carried by each of said hulls, a plurality of support struts extending between laterally adjacent columns, said rollers being disposed on said support struts.

8. Apparatus according to claim **1** including said vessel, said coupling means coupling said flotation member to the aft end of said vessel to position the flotation member for receiving pipeline payed out from said vessel.

9. Apparatus according to claim **8** wherein said vessel has a work area adjacent one side of the vessel for assembling pipe sections, said member being coupled to said vessel to lie in substantial longitudinal alignment with said one vessel side.

10. Apparatus according to claim **8** wherein said vessel has a work area substantially along the centerline of said vessel, said member being coupled to said vessel such that the centerlines of said vessel and said member lie in substantial longitudinal alignment one with the other.

11. Apparatus according to claim **8** wherein said vessel includes a base structure and a plurality of columns upstanding from said base structure, and means for ballasting and deballasting said vessel between high and low draft conditions, said vessel being column stabilized in the high draft condition.

12. Apparatus according to claim **11** wherein said vessel has a work area adjacent one side thereof for assembling pipe sections, said vessel hull structure including a pair of elongated hulls spaced one from the other on opposite sides of said vessel, and means carried by the aft portion of the one hull on the said side of said vessel as said work area and cooperable with said coupling means on said stinger for releasably connecting said flotation member to said vessel.

13. Apparatus according to claim **11** wherein said vessel has a work area substantially along the centerline of said vessel for assemblying pipe sections, said vessel hull structure including a pair of elongated hulls spaced one from the other on opposite sides of said vessel, and means carried by the aft portions of said hulls and cooperable with said coupling means on said flotation member for releasably connecting said flotation member to said vessel.

14. Apparatus according to claim **8** wherein the natural period of said flotation member and the pipeline portion carried thereby substantially match the natural frequency of said vessel.

15. Apparatus according to claim 8 wherein said vessel and said flotation member and pipeline portion carried thereby have predetermined natural periods, and means for selectively ballasting and deballasting the flotation member to substantially match the natural period of the flotation member and pipeline portion carried thereby with the natural period of the vessel.

16. Apparatus according to claim 1 wherein at least a pair of said columns are carried by each of said hulls, said base structure being configured to float the member in a low draft condition with the base structure having freeboard, said submerging means including means for ballasting said hull to change the draft of the member from said low draft condition to said high draft condition.

17. Apparatus according to claim 1 wherein said base structure includes a keel spaced below said hulls, and means connecting said hulls and said keel one to the other.

18. Apparatus for laying pipeline on an underwater surface comprising:

a floating vessel having a pipeline work deck elevated above the mean waterline;

a flotation member having an elongated base structure;

a plurality of elements upstanding from said base structure with at least a portion of said elements comprised of a plurality of stabilizing columns located on opposite sides of the pitch and roll axes of said flotation member;

means for submerging said base structure and portions of said upstanding elements below the waterline to obtain a high draft floating condition, the displacement of the submerged base structure and portions of said upstanding elements being sufficient to maintain the flotation member buoyant in a pipeline portion supporting condition with the mean waterline located intermediate the height of said columns;

means carried by said base structure adjacent its forward end pivotally coupling said pipelaying vessel and said flotation member one to the other;

and means carried by said flotation member for supporting a portion of a pipeline for translational movement therealong, said pipeline support means being located above said base structure at elevations of decreasing height relative to said base structure in a forward to aft direction along said flotation member, the pipeline support means being adapted to receive pipeline payed out from the elevated work deck of said vessel;

said flotation member comprising the sole means for supporting the pipeline as it is payed out from said vessel.

19. Apparatus for laying pipe on an underwater surface comprising:

a floating vessel including a pair of elongated hulls disposed in spaced side-by-side relation;

a working platform including a generally horizontally disposed pipeline work deck on which pipe sections are joined end to end one with the other and from which work deck the pipeline is payed out from the aft end of said vessel;

means for supporting said platform in fixed spaced relation a predetermined height above said hulls including columns connected to said hulls and said platform, at least three of such columns being connected with each of the hulls on opposite sides of the roll axis of the vessel, at least one column on each hull being disposed adjacent the aft end of said hull;

said elevated pipeline work deck on said platform and said columns being relatively disposed such that pipeline is payed out from said pipeline work deck and from the aft end of said vessel at an elevation no lower than the juncture of the upper ends of the aftmost columns on said hulls and the underside of said platform;

the distance between the extremities of said vessel along its longitudinal centerline being substantially greater than the distance between the extremities of said vessel along its transverse centerline;

said hulls having ballast compartments for ballasting said vessel to alter its draft between a low draft hull supported floating condition with the hulls having freeboard and a high draft semisubmerged column stabilized floating and pipelaying condition with said pipeline work deck elevated above the mean waterline whereby pipeline payed out from said elevated pipeline work deck and from the aft end of said vessel, when the vessel lies in said high draft pipelaying condition, curves downwardly toward the water as it extends through the air between the aft end of the vessel and a location spaced from said vessel at which the pipeline enters the water;

said columns having predetermined cross-sectional areas and being located on the hulls to provide righting moments about the pitch and roll axes of said vessel when in high draft condition; and

means connected to the aft end of said vessel and extending generally longitudinally therefrom for supporting at least the downwardly curved portion of the pipeline payed out from said elevated pipeline work deck and the aft end of said vessel which extends through the air between the aft end of the vessel and the location spaced from said vessel at which the pipeline enters the water, said support means including means for maintaining the radius of curvature of the downwardly curved pipeline portion greater than the radius of curvature which would permit bending stresses on the pipeline in excess of its allowable bending stress, said maintaining means including a plurality of discrete supports longitudinally spaced one from the other along said support means and arranged such that a curved line through successive ones of said supports has a radius of curvature greater than the radius of curvature which would permit bending stresses on the pipeline in excess of its allowable bending stress.

20. Apparatus according to claim 19 including means for adjusting the elevation of said supports relative to said work deck.

21. Apparatus according to claim 19 including means for adjusting the elevation of said supports relative to the mean waterline, and means carried by said vessel and coupled to said adjusting means for controlling the elevation of said supports relative to the mean waterline from said vessel.

22. Apparatus according to claim 19 including means for pivotally connecting said support means and said vessel adjacent the aft end of said vessel.

23. Apparatus according to claim 19 wherein said work deck is located at an elevation at least 15 feet above the mean waterline when said vessel lies in said high draft condition.

24. Apparatus according to claim 19 including means for pivotally connecting said support means and said

vessel adjacent the aft end of said vessel, said work deck being located at an elevation at least 15 feet above the mean waterline when said vessel lies in said high draft condition.

25. Apparatus according to claim 19 wherein said supports include at least a forwardmost pair of longitudinally spaced supports for supporting the pipeline portion which extends through the air and which pair of supports lie at an elevation above the mean waterline, at least one additional support located aft of the forwardmost pair of supports on said support means for supporting a portion of the pipeline below the mean waterline and which latter support lies at an elevation below the waterline.

26. Apparatus according to claim 19 wherein said elevated pipeline work deck extends substantially along the centerline of said vessel and said pipeline support means extends substantially longitudinally along the centerline of the vessel extended from the aft end of the vessel.

27. Apparatus according to claim 19 wherein said elevated pipeline work deck extends longitudinally substantially along one side of the centerline of said vessel, said pipeline support means extending longitudinally from the aft end of the vessel and from said one side of the vessel.

28. Apparatus according to claim 19 including a crane located adjacent said one end of the vessel, said vessel including structure below said crane defining an opening through which the pipeline passes as the pipeline is transferred from the vessel to the support means.

29. Apparatus according to claim 24 wherein each of said hulls has top and bottom substantially planar horizontally disposed surfaces extending substantially perpendicular to a vertical plane through the longitudinal centerline of said vessel with the transverse horizontal dimension of each hull being greater than its vertical dimension for a major portion of the length of said hulls so as to provide increased mass resistance to movement of said hulls through water in a vertical direction when said vessel lies in said high draft column stabilized semisubmerged pipelaying condition, said columns being substantially constant in cross section for substantially their entire height between said platform and said hulls, at least one of said columns on each said hull having a dimension in the longitudinal direction greater than its dimension in the transverse direction, said maintaining means including a plurality of discrete supports longitudinally spaced one from the other along said pipeline support and arranged such that a curved line through successive ones of said supports has a radius of curvature which would permit bending stresses on the pipeline in excess of its allowable bending stress.

30. Apparatus for laying pipe on an underwater surface comprising:

a floating vessel including a pair of elongated hulls disposed in spaced side-by-side relation;

a working platform including a generally horizontally disposed pipeline work deck on which pipe sections are joined end to end one with the other and from which work deck the pipeline is payed out from the aft end of said vessel;

means for supporting said platform in fixed spaced relation a predetermined height above said hulls including columns connected to said hulls and said platform, at least three of such columns being connected with each of the hulls on opposite sides of the roll axis of the vessel, at least one column on each hull being disposed adjacent the aft end of said hull;

said elevated pipeline work deck on said platform and said columns being relatively disposed such that pipeline is payed out from said pipeline work deck and from the aft end of said vessel at an elevation no lower than the juncture of the upper ends of the aftmost columns on said hulls and the underside of said platform;

the distance between the extremities of said vessel along its longitudinal centerline being substantially greater than the distance between the extremities of said vessel along its transverse centerline;

said hulls having ballast compartments for ballasting said vessel to alter its draft between a low draft hull supported floating condition with the hulls having freeboard and a high draft semisubmerged column stabilized floating and pipelaying condition with said pipeline work deck elevated above the mean waterline whereby pipeline payed out from said elevated pipeline work deck at the aft end of said vessel, when the vessel lies in said high draft condition, curves downwardly toward the water as it extends through the air between the aft end of the vessel and a location spaced from said vessel at which the pipeline enters the water;

said columns having predetermined cross-sectional areas and being located on the hulls to provide righting moments about the pitch and roll axes of said vessel when in high draft condition;

means connected adjacent the aft end of said vessel and extending generally longitudinally therefrom for supporting at least the downwardly curved portion of the pipeline payed out from said elevated pipeline work deck which extends through the air between the aft end of the vessel and a location spaced from said vessel at which the pipeline enters the water, said support means including a flotation member having an elongated base structure, a plurality of elements upstanding from said base structure comprised of a plurality of stabilizing columns located on opposite sides of the pitch and roll axes of the member;

means for submerging said base structure and portions of said upstanding elements below the waterline to a high draft floating condition, the displacement of the submerged base structure and portions of said upstanding elements being sufficient to maintain the member buoyant in a pipeline portion supporting condition with the mean waterline located intermediate the height of at least a plurality of said columns;

coupling means carried by said base structure adjacent its forward end for pivotally coupling the flotation member to said vessel; and

means carried by said flotation member for supporting the pipeline for translational movement therealong and at elevations of decreasing height relative to said base structure in a fore to aft direction along said flotation member.

31. Apparatus according to claim 30 wherein said elevated pipeline work deck extends substantially along the centerline of said vessel and said flotation member extends substantially longitudinally along the centerline of the vessel extended from the aft end of the vessel.

32. Apparatus according to claim 30 wherein said elevated pipeline work deck extends longitudinally substantially along one side of the centerline of said vessel, said flotation member extending longitudinally from the aft end of the vessel and from said one side of the vessel.

33. Apparatus according to claim 30 including a crane located adjacent said one end of the vessel, said vessel

including structure below said crane defining an opening through which the pipeline passes as the pipeline is transferred from the vessel to said flotation member.

34. Apparatus for laying pipe on an underwater surface comprising:

a floating vessel including a pair of elongated hulls disposed in spaced side-by-side relation;

a working platform including a generally horizontally disposed pipeline work deck on which pipe sections are joined end to end one with the other and from which work deck the pipeline is payed out from one end of said vessel;

means for supporting said platform in fixed spaced relation a predetermined height above said hulls including columns connected to said hulls and said platform with at least one column on each hull disposed adjacent the aft end of said hull;

said elevated pipeline work deck on said platform and said columns being relatively disposed such that pipeline is payed out from said pipeline work deck and from the aft end of said vessel at an elevation no lower than the juncture of the upper ends of the aftmost columns on said hulls and the underside of said platform;

the distance between the extremities of said vessel along its longitudinal centerline being greater than the distance between the extremities of said vessel along its transverse centerline;

said hulls having ballast compartments for ballasting said vessel to alter its draft between a low draft hull supported floating condition with the hulls having freeboard and a high draft semisubmerged column stabilized floating and pipelaying condition with said pipeline work deck elevated, above the mean waterline whereby pipeline payed out from said elevated pipeline work deck at the aft end of said vessel, when said vessel lies in said high draft pipelaying condition, curves downwardly toward the water as it extends through the air between the aft end of the vessel and a location spaced from said vessel at which the pipeline enters the water;

said columns having predetermined cross-sectional areas and being located on the hulls to provide righting moments about the pitch and roll axes of said vessel when in high draft condition;

means connected to the aft end of said vessel and extending generally longitudinally therefrom for supporting at least the downwardly curved portion of the pipeline payed out from said elevated pipeline work deck which extends through the air between the aft end of the vessel and a location spaced from said vessel at which the pipeline enters the water, said support means including means for maintaining the radius of curvature of the downwardly curved pipeline portion greater than the radius of curvature which would permit bending stresses on the pipeline in excess of its allowable bending stress, said maintaining means including a plurality of discrete supports longitudinally spaced one from the other along said support means and arranged such that a curved line through successive ones of said supports has a radius of curvature greater than the radius of curvature which permit bending stresses on the pipeline in excess of its allowable bending stress; and

means for pivotally connecting said support means and said vessel adjacent the aft end of said vessel, said work deck being located at an elevation at least 15 feet above the mean waterline when said vessel lies in said high draft condition.

35. Apparatus according to claim 34 including means for adjusting the elevation of said supports relative to said support deck.

36. Apparatus according to claim 34 including means for adjusting the elevation of said supports relative to the mean waterline, and means carried by said vessel and coupled to said adjusting means for controlling the elevation of said supports relative to the mean waterline of said vessel.

37. Apparatus according to claim 34 wherein each of said hulls has top and bottom substantially planar horizontally disposed surfaces extending substantially perpendicular to a vertical plane through the longitudinal centerline of said vessel with the transverse horizontal dimension of each hull being greater than its vertical dimension for a major portion of the length of said hulls so as to provide increased mass resistance to movement of said hulls through water in a vertical direction when said vessel lies in said high draft column stabilized semisubmerged pipelaying condition, said columns being substantially constant in cross section for substantially their entire height between said platform and said hulls, at least one of said columns on each said hull having a dimension in the longitudinal direction greater than its dimension in the transverse direction, said maintaining means including a plurality of discrete supports longitudinally spaced one from the other along said pipeline support and arranged such that a curved line through successive ones of said supports has a radius of curvature greater than the radius of curvature which would permit bending stresses on the pipeline in excess of its allowable bending stress.

38. Apparatus according to claim 34 wherein said elevated pipeline work deck extends substantially along the centerline of said vessel and said pipeline support means extends substantially longitudinally along the centerline of the vessel extended from the aft end of the vessel.

39. Apparatus according to claim 34 wherein said elevated pipeline work deck extends longitudinally substantially along one side of the centerline of said vessel, said pipeline support means extending longitudinally from said one end of the vessel and from the aft side of the vessel.

40. Apparatus according to claim 34 including a crane located adjacent the aft end of the vessel, said vessel including structure below said crane defining an opening through which the pipeline passes as the pipeline is transferred from the vessel to the support means.

41. Apparatus for laying pipe on an underwater surface comprising:

a floating vessel including a pair of elongated hulls disposed in spaced side-by-side relation;

a floating vessel including a pair of elongated hulls disposed in spaced side-by-side relation;

a working platform including a pipeline work deck on which pipe sections are joined end to end one with the other and from which work deck the pipeline is payed out from one end of said vessel;

means for supporting said platform in fixed spaced relation a predetermined height above said hulls including columns connected to said hulls and said platform, at least three of such columns being connected with each of the hulls on opposite sides of the roll axis of the vessel with a pair of such columns being located near respective opposite ends of each of

said hulls on opposite sides of the pitch axis of the vessel and another of said columns being located at an intermediate position on each hull;

the distance between the extremities of said vessel along its longitudinal centerline being substantially greater than the distance between the extremities of said vessel along its transverse centerline;

said hulls having ballast compartments for ballasting said vessel to alter its draft between a low draft hull supported floating condition and a high draft semi-submerged column stabilized floating and pipelaying condition with said pipeline work deck elevated above the mean waterline whereby pipeline payed out from said elevated work deck at one end of said vessel when said vessel lies in said high draft condition curves downwardly toward the water as it extends through the air between said one vessel end and a location spaced from said vessel at which the pipeline enters the water;

said columns having predetermined cross-sectional areas and being located on the hulls to provide righting moments about the pitch and roll axes of said vessel when in high draft condition;

means for providing a significantly greater righting moment about the transverse pitch axis of the vessel than the righting moment about the longitudinal roll axis of the vessel when said vessel is in high draft semisubmerged operating condition, the latter means including at least three of the aforementioned columns connected with each of the hulls on opposite sides of the roll axis of the vessel with pairs of such columns being located near opposite ends of each of said hulls on opposite sides of the pitch axis of the vessel and another of said columns being located at an intermediate portion on each hull and with the configurations and areas of said columns and the distances of said columns from the longitudinal roll axis and transverse pitch axis of said vessel being such that in the vessel's semisubmerged operating condition the latter means provides a significantly greater righting moment about said transverse pitch axis than about said longitudinal roll axis; and

means connected to one end of said vessel and extending generally longitudinally therefrom for supporting at least the portion of the pipeline payed out from said elevated pipeline work deck which extends through the air between said one vessel end and a location spaced from said vessel at which the pipeline enters the water, said support means including a flotation member having an elongated base structure, a plurality of elements upstanding from said base structure comprised of a plurality of stabilizing columns located on opposite sides of the pitch and roll axes of the member;

means for submerging said base structure and portions of said upstanding elements below the waterline to a high draft floating condition, the displacement of the submerged base structure and portions of said upstanding elements being sufficient to maintain the member buoyant in a pipeline portion supporting condition with the mean waterline located intermediate the height of at least a plurality of said columns;

coupling means carried by said base structure adjacent its forward end for pivotally coupling the flotation member to said vessel; and

means carried by said flotation member for supporting the pipeline for translational movement therealong and at elevations of decreasing height relative to said base structure in a fore to aft direction along said flotation member.

42. Apparatus according to claim 41 wherein said elevated pipeline work deck extends substantially along the centerline of said vessel and said flotation member extends substantially longitudinally along the centerline of the vessel extended from said one end of the vessel.

43. Apparatus according to claim 41 wherein said elevated pipeline work deck extends longitudinally substantially along one side of the centerline of said vessel, said flotation member extending longitudinally from said one end of the vessel and from said one side of the vessel.

44. Apparatus according to claim 41 including a crane located adjacent said one end of the vessel, said vessel including structure below said crane defining an opening through which the pipeline passes as the pipeline is transferred from the vessel to said flotation member.

45. Apparatus according to claim 18 wherein said vessel comprises

a pair of elongated hulls disposed in spaced side-by-side relation;

a working platform spaced above said hulls a predetermined height and carrying said work deck;

means for supporting said platform in fixed spaced relation above said hulls including columns connected to said hulls and said platform;

the distance between the extremities of said vessel along the longitudinal centerline of said vessel being substantially greater than the distance between the extremities of said vessel along the transverse centerline of said barge;

said hulls having ballast compartments for ballasting said vessel to alter its draft between a low draft hull supported floating condition and a high draft semi-submerged column stabilized floating condition;

said columns having predetermined cross-sectional areas and being located on the hulls to provide righting moments about the pitch and roll axes of said vessel when in high draft condition;

the area of said columns, the number thereof and the distance of said columns from the longitudinal and transverse centerlines of said vessel being such as to provide a greater righting moment about the transverse pitch axis than the righting moment about the longitudinal roll axis when said vessel is in high draft semisubmerged condition.

46. Apparatus according to claim 18 wherein said pipeline support means are located to support the pipeline such that the radius of curvature of the pipeline lies within its allowable radius of curvature whereby rupture of the pipeline is avoided.

47. Apparatus according to claim 18 wherein said pipeline work deck supports the pipeline at an elevation on the order of about 15 feet above the mean waterline at the location where the pipeline is transferred between said vessel and said flotation member.

48. A column stabilized semisubmersible pipelaying barge and pipeline support apparatus comprising:

a pair of elongated hulls disposed in spaced side-by-side relation;

a working platform spaced above said hulls a predetermined height including a pipeline work deck, and means on said work deck for securing pipe sections in end-to-end relation one to the other to form a pipeline extending generally parallel to the longitudinal centerline of said barge;

means for supporting said platform in spaced relation above said hulls including columns connected to said

hulls and said platform on opposite sides of the pitch and roll axes of said barge;

the distance between the extremities of said barge along the longitudinal centerline thereof being substantially greater than the distance between the extremities of said barge along its transverse centerline;

said hulls having ballast compartments for ballasting said barge to alter its draft between a low draft hull supported floating condition with the hulls having freeboard and a high draft semisubmerged column stabilized floating and pipelaying condition with the pipeline work deck elevated above the mean waterline whereby pipeline payed out from said elevated pipeline work deck, when said barge lies in said high draft condition, curves downwardly toward the water as it extends through the air between said elevated pipeline work deck and a location at which the pipeline enters the water,

said columns having predetermined cross-sectional areas and being located on the hulls to provide righting moments about the pitch and roll axes of said barge when in said high draft condition;

an elongated pipeline support pivotally connected to said barge and extending generally longitudinally in a predetermined attitude relative to said barge for supporting at least the downwardly curved portion of the pipeline payed out from said elevated pipeline work deck which extends through the air between said barge and the location at which the pipeline enters the water, and

means for maintaining said elongated pipeline support in said predetermined attitude relative to said barge thereby to maintain the radius of curvature of the downwardly curved pipeline portion greater than the radius of curvature which would permit bending stresses on the pipeline in excess of its allowable bending stress.

49. Apparatus according to claim 48 wherein the pivotal connection between said pipeline support and said barge lies at an elevation below said work deck and below the pipeline at like longitudinal location along said barge as the longitudinal location of said pivotal connection along said barge.

50. Apparatus according to claim 49 wherein each of said hulls has top and bottom substantially planar horizontally disposed surfaces extending substantially perpendicular to a vertical plane through the longitudinal centerline of said vessel with the transverse horizontal dimension of each hull being greater than its vertical dimension for a major portion of the length of said hulls so as to provide increased mass resistance to movement of said hulls through water in a vertical direction when said vessel lies in said high draft column stabilized semisubmerged pipelaying condition.

51. Apparatus according to claim 50 wherein said columns are substantially constant in cross section for substantially their entire height between said platform and said hulls.

52. Apparatus according to claim 51 wherein said pivotal connection lies at an elevation below the elevation of said top hull surfaces.

53. Apparatus according to claim 48 wherein said pipeline work deck is generally horizontally disposed, at least three columns disposed on each said hull, said work deck and said columns being relatively disposed such that pipeline is payed out from said pipeline work deck at an elevation no lower than the juncture of the upper ends of the columns and the underside of said platform.

54. Apparatus according to claim 48 wherein one of said three columns is disposed adjacent the aft end of said vessel, said work deck and said columns being relatively disposed such that pipeline is payed out from said pipeline work deck and from the aft end of said vessel at an elevation no lower than the juncture of the upper ends of the aftmost columns on said hulls and the underside of said platform, said pipeline support being pivotally connected to said barge adjacent its aft end and extending generally longitudinally therefrom for supporting at least the downwardly curved portion of the pipeline payed out from said elevated pipeline work deck and the aft end of said vessel which extends through the air between said barge and the location at which the pipeline enters the water.

55. Apparatus according to claim 54 wherein each of said hulls has top and bottom substantially planar horizontally disposed surfaces extending substantially perpendicular to a vertical plane through the longitudinal centerline of said vessel with the transverse horizontal dimension of each hull being greater than its vertical dimension for a major portion of the length of said hulls so as to provide increased mass resistance to movement of said hulls through water in a vertical direction when said vessel lies in said high draft column stabilized semisubmerged pipelaying condition, said columns being substantially constant in cross section for substantially their entire height between said platform and said hulls, at least one of said columns on each said hull having a dimension in the longitudinal direction greater than its dimension in the transverse direction, said maintaining means including a plurality of discrete supports longitudinally spaced one from the other along said pipeline support and arranged such that a curved line through successive ones of said supports has a radius of curvature greater than the radius of curvature which would permit bending stresses on the pipeline in excess of its allowable bending stress, said work deck being located at an elevation at least 15 feet above the mean waterline when said barge lies in said high draft column stabilized pipelaying condition.

56. Apparatus according to claim 55 including means for adjusting the elevation of said supports relative to said work deck.

57. Apparatus according to claim 55 including means for adjusting the elevation of said supports relative to the mean waterline, and means carried by said vessel and coupled to said adjusting means for controlling the elevation of said supports relative to the mean waterline from said vessel.

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