United States Patent

Mott

[15] **3,685,306**

[45] **Aug. 22, 1972**

[54] **SUBSEA PIPE LAYING APPARATUS AND METHOD**

[72] Inventor: **George E. Mott,** Metairie, La.

[73] Assignee: **Texaco Inc.,** New York, N.Y.

[22] Filed: **Oct. 29, 1970**

[21] Appl. No.: **85,017**

[52] **U.S. Cl.** **61/72.3,** 226/24

[51] **Int. Cl.** **F16l 1/00,** B63b 35/04, B65h 25/24

[58] **Field of Search** 61/72.3, 72.1, 72.4; 226/24, 226/25, 172

[56] **References Cited**

UNITED STATES PATENTS

3,372,461	3/1968	Tesson	61/72.3
3,313,346	4/1967	Cross	226/172 X
3,390,532	7/1968	Lawrence	61/72.3
3,331,212	7/1967	Cox et al.	61/72.3
2,931,185	4/1960	Ashby	61/72.3 X
3,353,762	11/1967	Baselice	226/25 X
3,447,213	6/1969	Dost et al	226/24 X

FOREIGN PATENTS OR APPLICATIONS

601,103	1948	Great Britain	61/72.3

Primary Examiner—Jacob Shapiro
Attorney—Thomas H. Whaley and Carl G. Reis

[57] **ABSTRACT**

The invention relates to a method and apparatus for laying a continuous pipeline or conduit from a floating barge, onto the floor of a body of water. The apparatus includes a floatable barge which supports an upstanding spool of continuously wound rigid, though resilient walled pipe. The spool is operably carried in an upright position on a reel stand whereby the conduit can be controllably unwound and the reel promptly replaced. Immediately after leaving the reel and prior to entering the water, the conduit is passed progressively through a pipe tensioner, a straightener, and a strain sensor. By coordinating the tension in the pipe with the forward movement of the barge, the configuration of the pipe between the barge and the ocean floor, can be regulated to minimize tensional and bending strain induced into the pipe by reason of its extending to the ocean floor.

8 Claims, 5 Drawing Figures

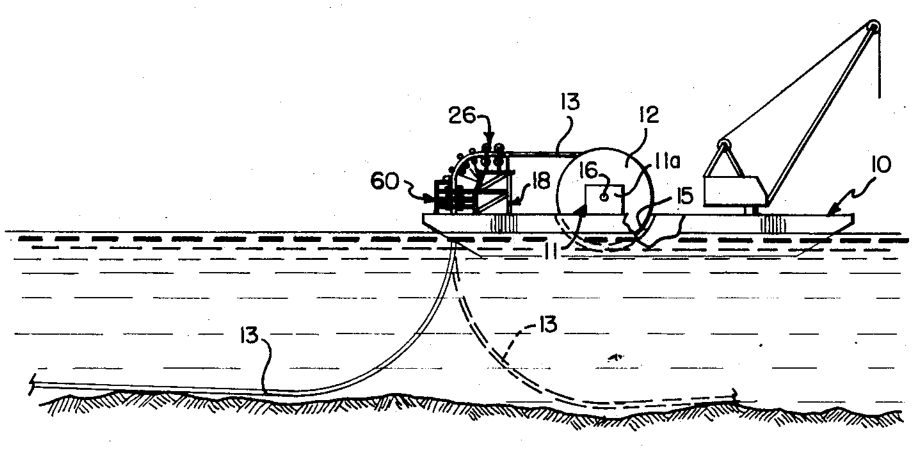


FIG. 1

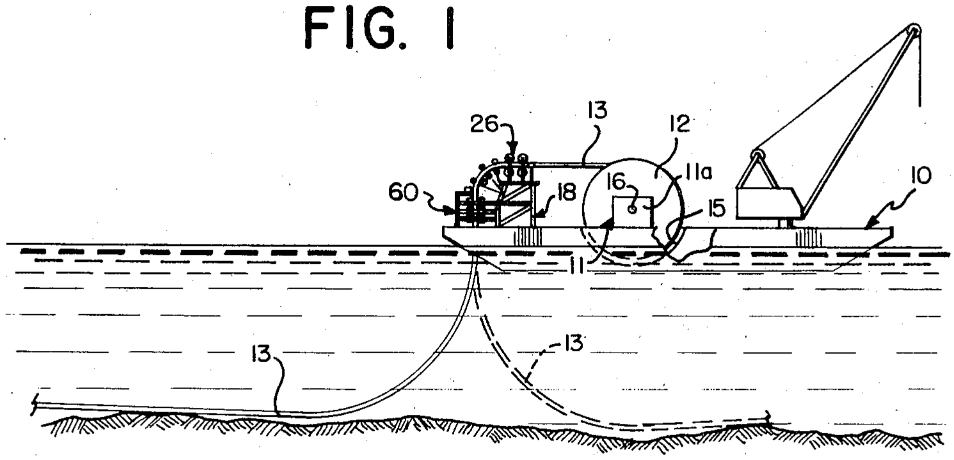

26
13
12
60
16
11a
18
10
15
11
13
13

FIG. 2

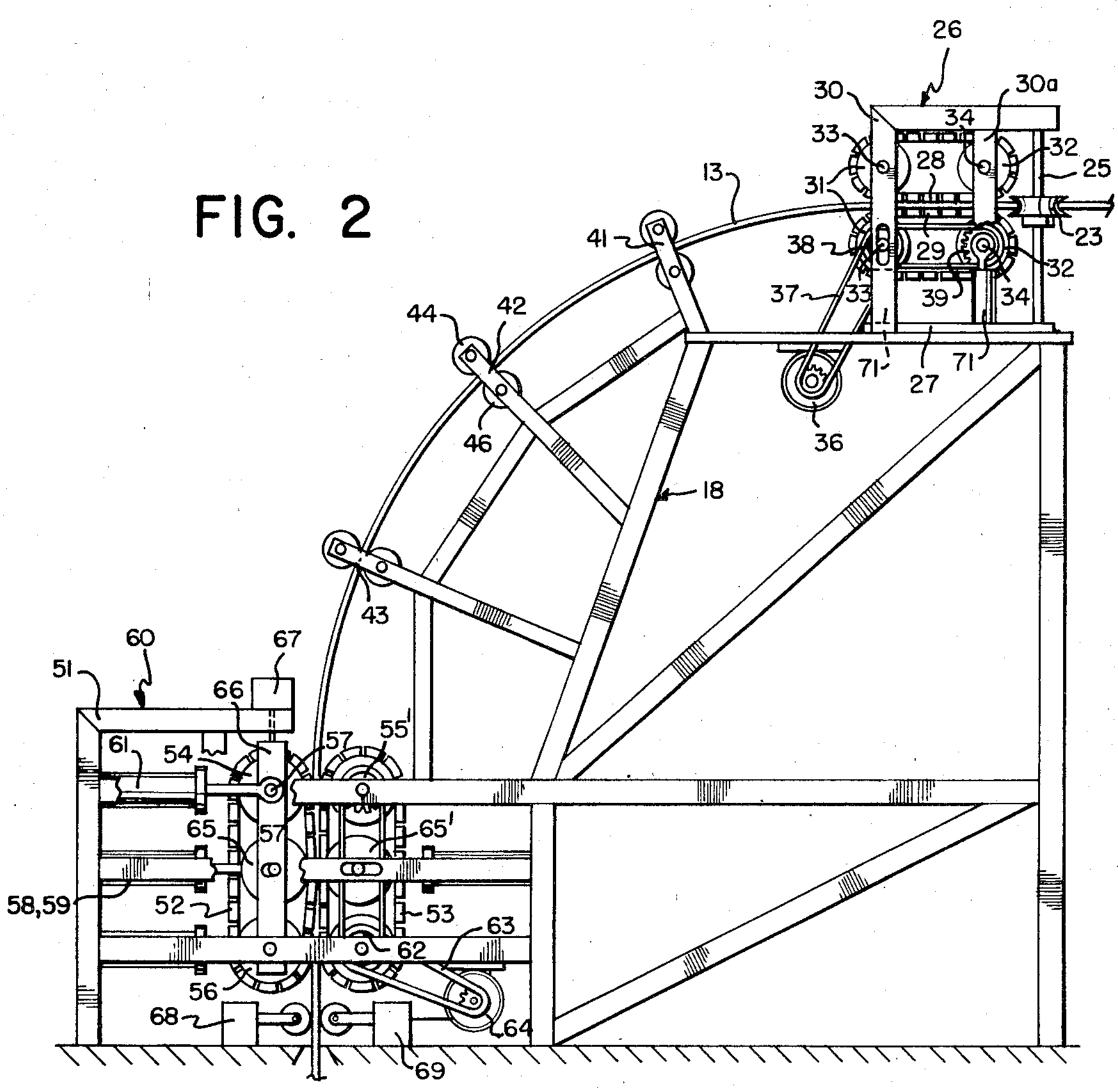

26
30
30a
34
33
32
28
25
13
31
41
23
29
38
32
37
33
39
34
44
42
71
71
27
36
46
18
43
60
67
51
66
57
55'
54
61
65
57
65'
58,59
52
53
63
62
56
68
64
69

FIG. 3

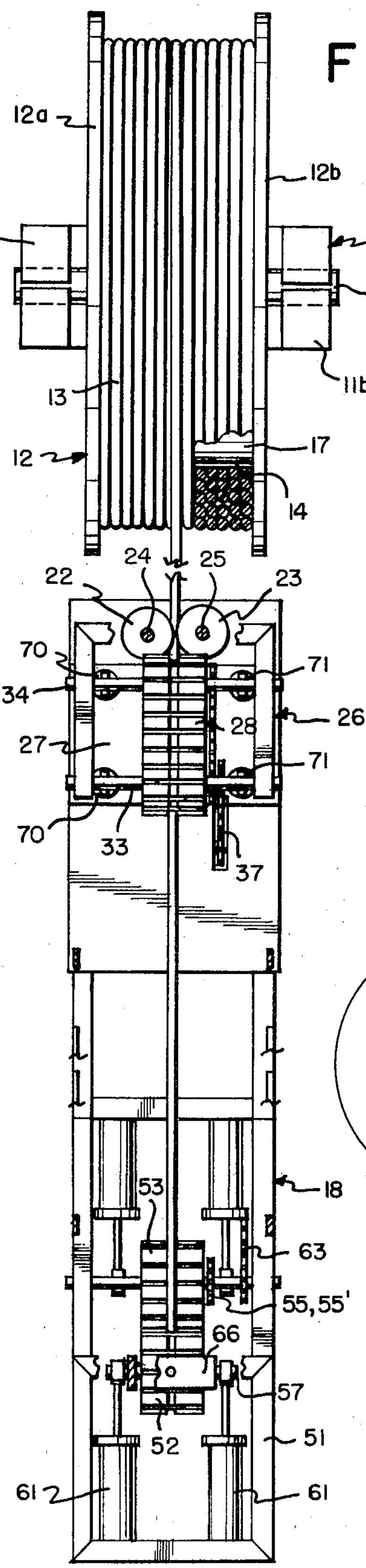


FIG. 5

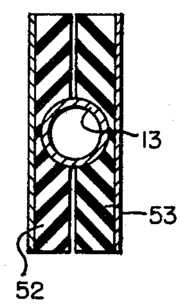
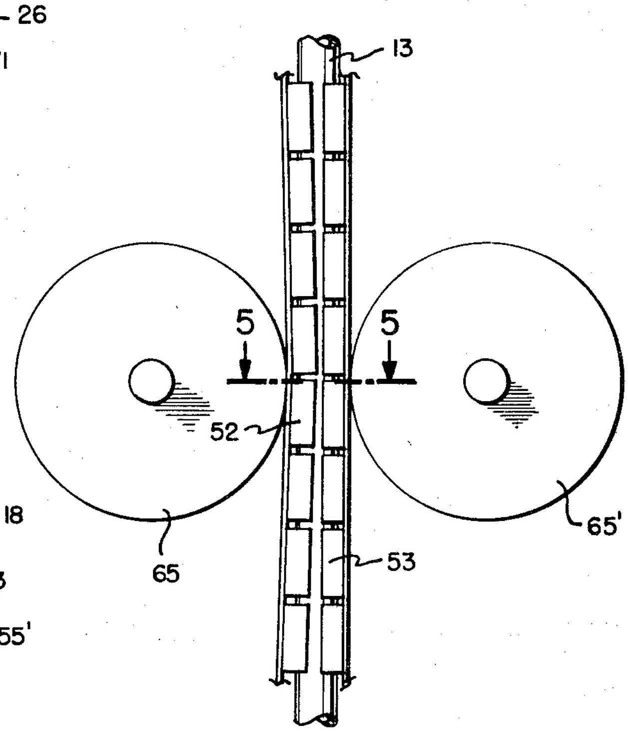


FIG. 4



SUBSEA PIPE LAYING APPARATUS AND METHOD

BACKGROUND OF THE INVENTION

In the laying of pipelines beneath the surface of a body of water, there are essentially two advanced methods in general practice. One method consists of laying relatively short, straight sections of the rigid pipe, which sections are sequentially welded one to the other and passed from a floating barge to the ocean floor. In most instances the pipe must be supported as it leaves the barge so as not to exceed an acceptable stress level in the pipe walls. In the alternative, it has been found feasible to lay the pipe from a floating barge which supports a reel spool upon which a relatively elongated, continuous section of the pipe has been precoiled. However, support means extending from the barge to the ocean floor is also required when using this method.

In the latter method, the continuous pipe is unwound from the spool in such manner as to apply a relatively constant restraining pull on the pipe, as well as applying a forward tension. The combination of the two opposing forces permits the pipe to be unwound in an orderly manner and yet be simultaneously straightened to remove the strained condition resulting from the initial pipe winding operation.

It has been found that a practical method for supporting wound pipe while lowering it to the ocean floor is to cause the pipe to assume a generally double reverse, parabolic configuration whereby the stress in all parts of the pipe wall is minimized. This can be achieved in a number of ways. In any event, one point at which excessive stress is normally induced, is at the upper end of the pipe as the latter leaves the barge and enters the water. In such instance, to alleviate pipe wall stress and to minimize the chances of damage, the barge is provided with a stinger along which the pipe may slide whereby to enter the water at a desired angle.

Structurally, the stinger can be relatively straight and depend downwardly from the barge at a predetermined angle or curvature. Alternatively, it can consist of an elongated member having a desired curvature whereby the pipe, as it leaves the barge, will rest on the stinger and assume the curvature of the latter thereby minimizing bending stress induced into the pipe. Since the permissible angle which the stinger can make with the barge is relatively small, stingers tend to become quite long and cumbersome when utilized in deep water.

It is therefore one of the objects of the invention herein described, to provide a method and apparatus for passing a continuous length of pipe or conduit from a pipe reel on a floating barge, to the ocean floor. Further, this is achieved without the use of a guiding stinger or other similar support means. A further object is to provide an apparatus which facilitates the laying of a continuous pipeline particularly in deep water, by expediting the replacement of empty pipe reels on the barge.

In overcoming the above noted problems, and toward achieving the objectives of the invention, the disclosed apparatus includes a reel-carrying vessel commonly referred to as a lay-barge, which is normally powered by a supplementary source such as tug boats or the like. The vessel or barge operably supports one or more reeled spools of continuous pipe which is con-

nected to form a conduit. At least one pipe reel is operably supported on a stand provided with rotating and braking means whereby to control the speed with which the pipe is carried to or from the reel. Curved pipe leaving the rotating reel is thereafter introduced to a pipe tensioner which applies the necessary pull for the orderly removal of the pipe from the reel.

The curved pipe is then carried along a guide frame for passage through a straightener member in which the pipe's preinduced wall stress is removed by applying lateral pressure to the pipe in such manner to affect a straightening of the same. The straightened pipe is thus in a generally vertical disposition, and is passed through a tension sensor which operably engages the pipe outer wall in such manner to permit the determination of, and control of the pipe's arcuate configuration. The forward movement of the lay-barge is regulated in accordance with the passage of the pipe downwardly into the water whereby the stresses induced into the pipe are maintained uniform and to a minimum level.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a vertical elevation showing a barge of the type illustrated laying a continuous pipe or conduit onto the floor of a body of water.

FIG. **2** is an enlarged segmentary view of the lay-barge illustrating the pipe handling section including the disclosed apparatus.

FIG. **3** is an enlarged segmentary view in partial cross-section, taken along line **3—3** in FIG. **1**.

FIG. **4** is a side view of the pipe bending device.

FIG. **5** is a section taken along line **5—5** in FIG. **4**.

Referring to FIG. **1**, the novel apparatus herein disclosed comprises a floatable barge **10** which is normally floated at the surface of a body of water. While not presently shown in detail, the barge would normally be propelled by its own power source. In the alternative however, it can be propelled and properly positioned by supplementary craft.

In the normal process of depositing such a continuous conduit or pipeline at the floor of a body of water, barge **10** is properly aligned, and its forward speed regulated in accordance with a predetermined course or plan. Barge **10** includes a stand **11** which is so mounted to rotatably and removably support a pipe spool **12**. The spool support member consists of a reel stand having a bearing arrangement together with a rotating and braking mechanism whereby reeling or unreeling of pipe from the spool can be controlled.

Spool **12** is provided with a predetermined length of continuously wound pipe **13** of the size to be laid at the ocean floor. The size can of course vary, and will determine the length thereof that can be properly carried on a particular reel size. Normally, the preliminary reeling is done at a shore based installation having the proper facilities for prewinding the pipe directly onto the spool, thereby inducing an initial curvature into the pipe wall.

Barge **10** further includes a well or depression **15** formed into the barge deck, of sufficient width to receive one or more of the spools **12**. Barge **10** further includes stand **11** which as mentioned, is so positioned with respect to well **15** that the one or more pipe spools **12** can be operably supported for removing reeled pipe therefrom. Said stand **11** comprises a plurality of upstanding, spaced apart stanchions **11***a* and **11***b* incorporating split bearing means at the upper end to rotatably mount a reel shaft **16**. Reel **12** is thus operably journalled in the respective split bearings to be freely rotatable therein. However, such rotation is of necessity restrained and controlled by braking means carried in the respective stanchions which is adjustable to regulate the rotational speed of the reel and consequently the rate at which pipe may be reeled or unreeled therefrom.

As seen in FIG. **3**, spool **12** is provided with a central drum **17** which defines a peripheral pipe receiving surface **14**. Pipe **13** is continuously wound onto said surface during the winding operation of the spool **12** in such manner that the walls of the pipe are strained into an arcuate configuration. A pair of end flanges **12***a* and **12***b* extend radially from opposed edges of drum **17** to define a channel-like pipe accommodating space therebetween.

The pipe removing and straightening mechanism is normally mounted at one extremity of barge **10** in such manner that pipe **13** can be fed vertically into the water from the barge edge after being straightened. Thus, the straightening mechanism is mounted in its entirety upon an enlarged frame **18**.

Frame **18** supports a pipe lead-in mechanism comprising a pair of rollers **22** and **23** rotatably mounted in a horizontal position on upstanding shafts **24** and **25**. Rollers **22** and **23** are provided with compatible peripheral grooves of sufficient width to cooperatively receive and urge the pipe **13** toward pipe tensioner **26**. Rollers **22** and **23** together define a large enough groove to accommodate all of the pipe sizes intended to be laid whereby to direct the pipe into the pipe tensioner at the desired angle and attitude.

Pipe tensioner **26** functions to apply a controllable horizontal pull or tension to the pipe, against the reel braking force, while the pipe is strained into a curved shape and as the latter leaves reel **12**. Said tensioner includes a carriage **27** depending from the upper side of frame **18**, and having upright braces **30** and **30***a* positioned to support oppositely positioned tensioning treads **28** and **29**.

Treads **28** and **29** are mounted face to face on adjacently positioned pulleys **31** and **32**, each of which is supported on a shaft **33** and **34**. The latter are in turn journalled to the upright members **30** and **30***a* respectively. A drive mechanism transmits rotational movement to treads **28** and **29** through a controllably regulated drive motor **36**. The latter is speed controlled either electrically or through a suitable gear reducing transmission, represented in FIG. **2** by a drive chain **37** connected respectively to drive sprockets **38** and **39** hinged to shafts **33** and **34**.

The corresponding faces of the respective treads **28** and **29** are characterized by a surface adapted to forcibly bear against opposite walls of pipe **13** when the latter is between the treads, whereby to apply a sufficient frictional force thereagainst as to exert tension on pipe **13**. The continuous tread surface can therefore be provided with a series of pads formed of a resilient material such as hard rubber or the like, which is bonded or otherwise connected to a steel tread unit. The surface of the rubber pad can be flat but is preferably formed as shown in FIG. **5** with a suitable contour such as an arcuate or similar indentation, as required to best bear against the surface of the pipe and exert the desired frictional hold.

To assume a controlled operation, lower track is vertically adjustable whereby to permit alteration of the engaging pressure with pipe **13**. As shown in FIG. **3** such adjustment means includes hydraulic cylinders **70** and **71** which are actuatable to provide the desired degree of shaft spacing which determines said pressure. Thus, the spacing of the intermediate tracks **28** and **29** can be regulated in response to the coaction of the tracks with the pipe.

As pipe **13** is drawn through pipe tensioner **26**, a restraining force is simultaneously applied to the pipe by actuation of the reel brake mechanism at stand **11**. Thus, through the controlled manipulation of the opposed drawing forces on the pipe, the latter can be unreeled at a desired rate of speed as will be hereinafter noted.

Pipe **13**, while off the reel and still in a condition of being temporarily strained into an arcuate configuration, is directed downwardly toward the deck of barge **10**. Thus, a pipe guide unit comprising guide roller pairs such as **41**, **42** and **43** depend from frame **18**. In the instance of member **42**, the latter includes a plurality of arcuately spaced elements comprising spaced apart, though cooperating rollers **44** and **46** having adjacently disposed peripheral surfaces. The latter are adapted to register between them the advancing pipe **13**, and to guide the latter toward the next succeeding pipe guide element **43**. Said guide elements, rather than being rollers, may similarly comprise a collar or other ring-like member having a sufficiently wide opening to slidably register the pipe as it progresses from the tensioner to pipe straightener.

The curved pipe **13** is directed from the lower guide unit **43**, into the pipe straightening section **60** to substantially remove any curvature, and to leave the pipe in a relatively straight condition. This operation is achieved in pipe straightener **60** which depends from frame **18** and is aligned in a generally vertical disposition.

Said pipe straightener **60** includes in brief, a supporting frame **51** having a pair of adjacently disposed flexible endless belts. The latter are rigidly supported along their respective common faces, and are provided with means to apply a horizontally oriented straightening force against the pipe being carried intermediate said belt faces.

As shown, adjacently positioned straightening belts **52** and **53** are formed as a continuous track about horizontally opposed drums **54** and **56** respectively. The latter are carried on a shaft such as **57** which is in turn journalled to positioning frame **51**. The overall straightening section comprises three vertically aligned and horizontally adjustable stations, each being individually horizontally actuatable from opposite directions to apply a desired lateral force against the intermediate pipe **13**.

Belt **52** is therefore provided with one or more intermediate rollers such as **65**, which is similarly journalled to a support shaft, and which is horizontally movable. Since the respective vertically aligned force-applying stations are similar in structure, the following remarks are directed toward the uppermost unit as representative of the structural configuration of each.

Referring to FIGS. **2** and **3**, each side of the upstanding straightening section embodies three sets of independently hydraulically actuated cylinders. The latter are supported on frame **51** and include a horizontally movable piston **61** which engages transverse shaft such as **57**. Shaft **57** is journalled to beam **66** which is in turn supported by a load cell **67**. The latter is firmly supported on frame **51** to register a vertical force applied to the pipe straightener as the result of the latter's engagement with pipe **13**.

The center pair of hydraulic cylinders **58** and **59** are connected to intermediate roller **65** which, although supported by beam **66**, is free to adjust horizontally independently of said beam **66**. On the opposing side of the pipe straightener section a similar roller **65'** corresponds with roller **65**, and is connected to horizontal adjusting means such as the abovementioned hydraulic cylinders whereby to be controllably set to adjust the lateral force engaging pipe **13**. Also in the opposing side of the pipe straightener, sprockets **55** and **55'** engage belt **53**. Sprocket **55** further carries a sprocket **62** or similar transmission member which is connected to a drive system comprising electric motor **64** together with chain **53**. The shafts for sprockets **55** and **55'** are journalled to support frame **51** and are therefore not only limitedly movable either horizontally or vertically. Straightening tread or belt **53** is connected to be driven and regulate the downward progress of pipe **13** simultaneous with the straightening operation performed by the central rollers.

At the lower station in the pipe straightener **60**, the pipe **13** will pass, substantially free of curvature, and in condition to be lowered from the water's surface to the floor of the ocean.

The disposition of pipe **13** as it extends from the surface to the ocean floor is controlled whereby to maintain the pipe as near as possible to a catenary configuration. By so doing, tensile rather than bending stresses are induced into the pipe thereby minimizing the chance for inadvertent wall damage. A sensor member is positioned adjacent to the lower end of the pipe straightener. Said sensor unit comprises a pair of inoppositely positioned load cells **68** and **69**, spaced horizontally apart on opposite sides of the pipe **13**. Horizontal forces exerted on pipe **13** as a result of movement of barge **10** are monitored by the load cells and recorded. Similarly, vertical force exerted by pipe **13** is monitored by load cell **67**. Each of said load cell functions in the normal manner to generate an electrical signal in accordance with the load imposed on the cell. The respective signals are thereafter analyzed and assimilated. The resultant of said signals is utilized to regulate the unreeling speed of pipe **13** whereby the ideal rate of unwinding can be maintained.

In the method of laying a continuous pipe at the floor of the ocean or a similar body of water, the pipe is initially applied at a land base as a continuous length onto a spool or reel **12**. At least one, and preferably a plurality of said reels are positioned on lay barge **10** and journalled within the respective reel stands **11**. As each successful reel becomes unwound and the pipe is led at the floor of the ocean, the process is continued by welding the end of the unwound section of pipe to the beginning of the adjacent reel. Thereafter, the empty reel **12** can be removed from reel stand **11** and replaced by a full reel.

One method to facilitate this step of the operation is to pivotally mount frame **18** to the barge deck and thus be actuatable in a horizontal direction by a mover such as a hydraulic cylinder connected to one or both sides of the frame. Thus, the latter is horizontally adjustable to be brought into alignment with the pipe reel **12'** to permit welding of the two pipe ends in anticipation of continuing the operation. Normally however, if the respective pipe reels are located a sufficient distance from the pipe tensioning device, the pipe will deflect sufficiently as it leaves the reel to make the welded connection.

As the welded and straightened pipe passes through sensor unit **68**, the latter, together with data from load cell **67**, will as noted above provide the data necessary to calculate the location or the disposition of the pipe as it extends to the ocean floor.

Obviously many modifications and variations of the invention, as hereinafter set forth, may be made without departing from the spirit and scope thereof, and therefore, only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. Marine apparatus for laying a continuous pipeline onto the floor of a body of water from the surface thereof, which comprises;

a floatable vessel, and means for propelling said vessel along the water's surface,

at least one upstandingly positioned pipe reel, including a drum having a center axis, and means for maintaining a continuous length of prewound pipe onto said drum,

a pipe reel stand carried on said vessel, and being operable to removably engage said pipe reel whereby to align said drum center axis in a substantially horizontal disposition and to permit rotation of the reel thereabout,

pipe handling means including;

an upright frame having upper and lower segments,

tension means carried on the upper of said segments including; means to operably engage said pipe when the latter is in a curved condition, and to apply a longitudinal force thereto whereby to unwind said pipe from said drum, and

pipe straightening means carried at the lower segment of said frame, being operable to receive curved pipe from said tension means and to apply a lateral force thereto whereby to straighten the pipe into a substantially noncurved configuration.

2. In an apparatus as defined in claim **1**, including; sensor means carried on said vessel, and when urged into contact with a straightened portion of said pipe, said sensor means being adapted to register the disposition of said pipe between said floor and the surface of said water.

3. In an apparatus as defined in claim **1**, including; a curved pipe guide means disposed intermediate said pipe tensioning and straightening means respectively, whereby to guide said curved portion of pipe into the latter.

4. In an apparatus as defined in claim **3**, wherein said pipe guide means includes; a plurality of guide units spaced apart along a curved path, and adapted to slidably receive and guide said curved pipe.

5. In an apparatus as defined in claim 3, wherein said pipe guide means includes; a plurality of discrete roller guides spaced apart along a curved path, and adapted to receive and rollably guide said curved pipe toward said pipe straightening means.

6. In an apparatus as defined in claim 1, wherein said tension means is horizontally adjustable to be arranged in alignment with curved pipe leaving said upstandingly positioned pipe reel.

7. In an apparatus as defined in claim 1, wherein said pipe handling means upright frame is pivotally operable in a horizontal plane whereby to align said tension means carried at the upper of said segments into alignment with the said at least one pipe reel.

8. Marine apparatus for laying a continuous pipeline onto the floor of a body of water, which comprises;

a vessel floatable at the surface of said body of water, and including means for propelling said vessel along said water's surface,

reel stand means including a plurality of adjacently disposed reel supports adapted to removably receive a plurality of pipe holding reels in a generally upright disposition, said reels support stands being operable to support a pipe reel and to permit controlled rotation of the latter for reeling pipe therefrom,

pipe tensioning means disposed adjacent to said plurality of pipe reels to receive curved pipe therefrom,

pipe straightening means carried on said vessel and positioned cooperatively with said pipe tensioning means to receive a curved pipe from the latter,

whereby to straighten said pipe and direct the same toward the floor of said body of water.

* * * * *