Oct. 25, 1966 F. R. HAUBER ETAL 3,280,571

METHODS AND APPARATUS FOR LAYING ELONGATE FLEXIBLE MEANS ON A SUBMERGED SURFACE

Original Filed July 14, 1958 3 Sheets-Sheet 1

Fig. 1

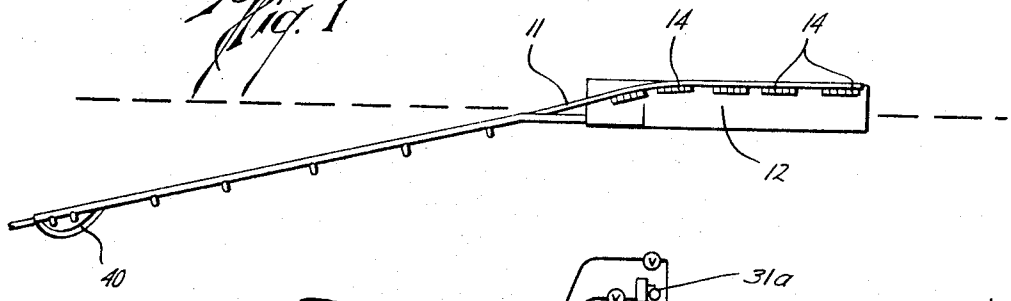
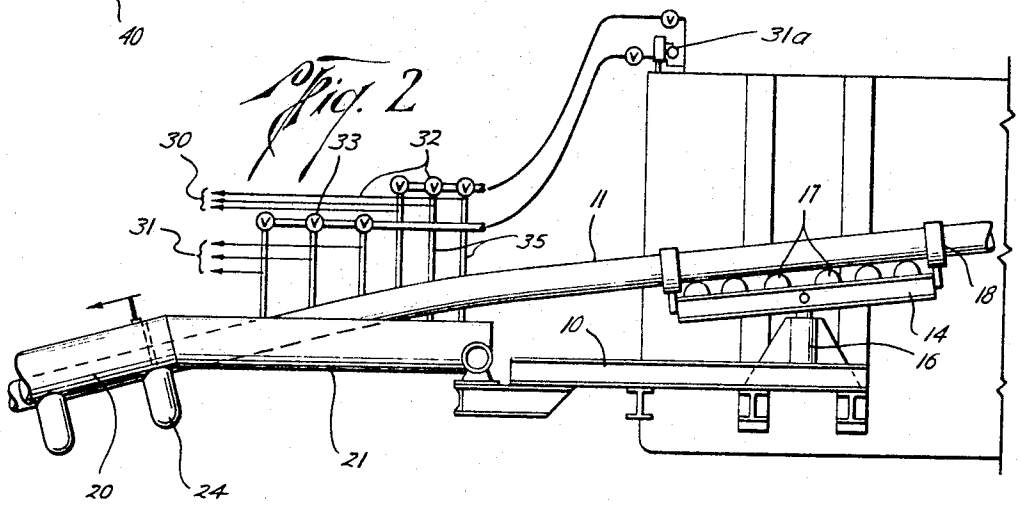


Fig. 2



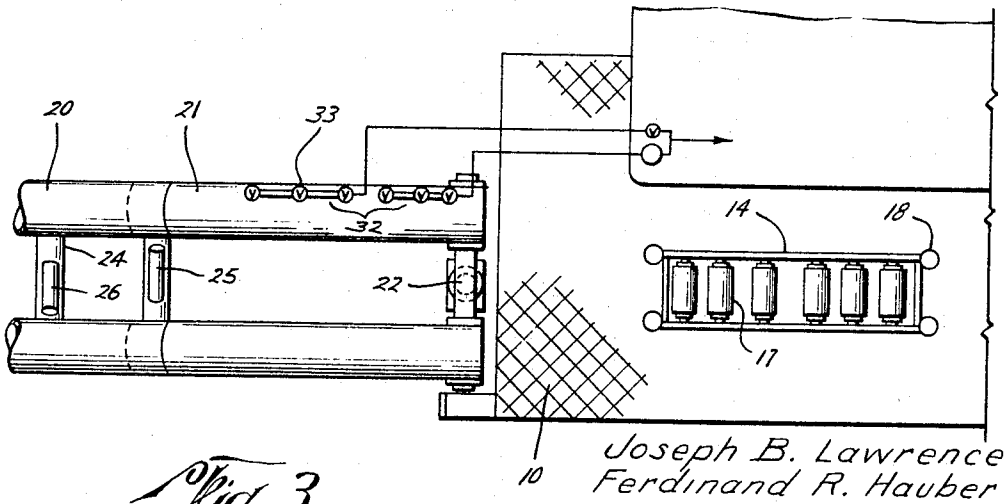


Fig. 3

Joseph B. Lawrence
Ferdinand R. Hauber
INVENTORS

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Original Filed July 14, 1958 3 Sheets-Sheet 2

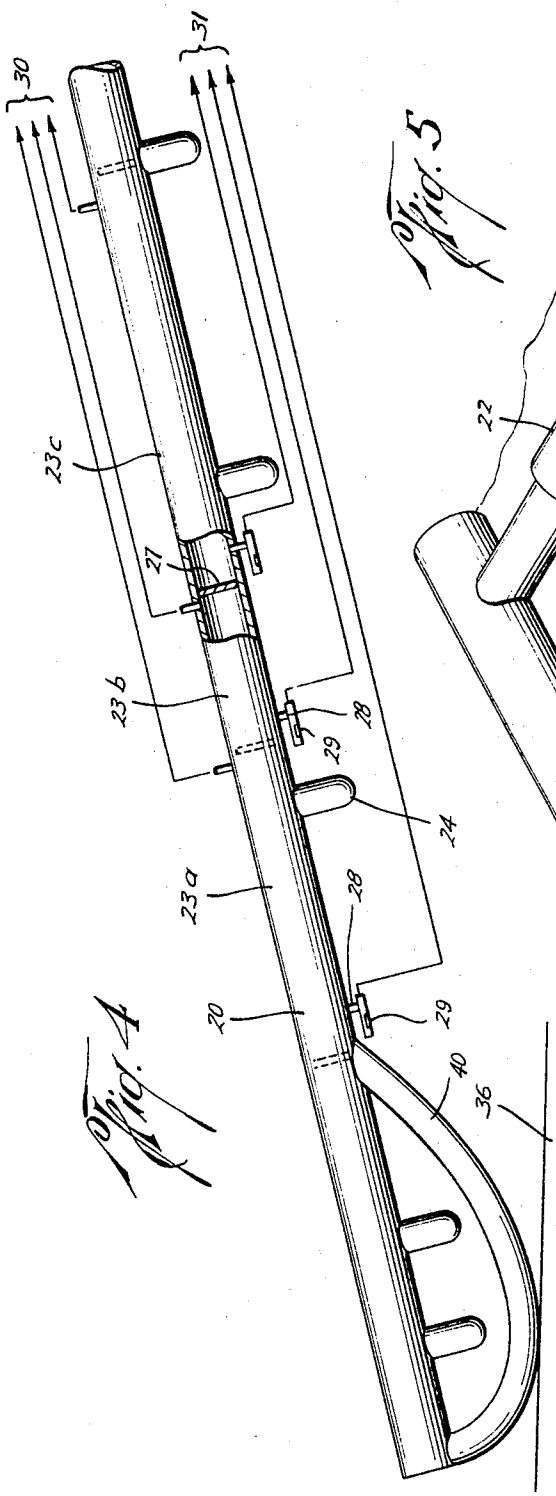

Fig. 4

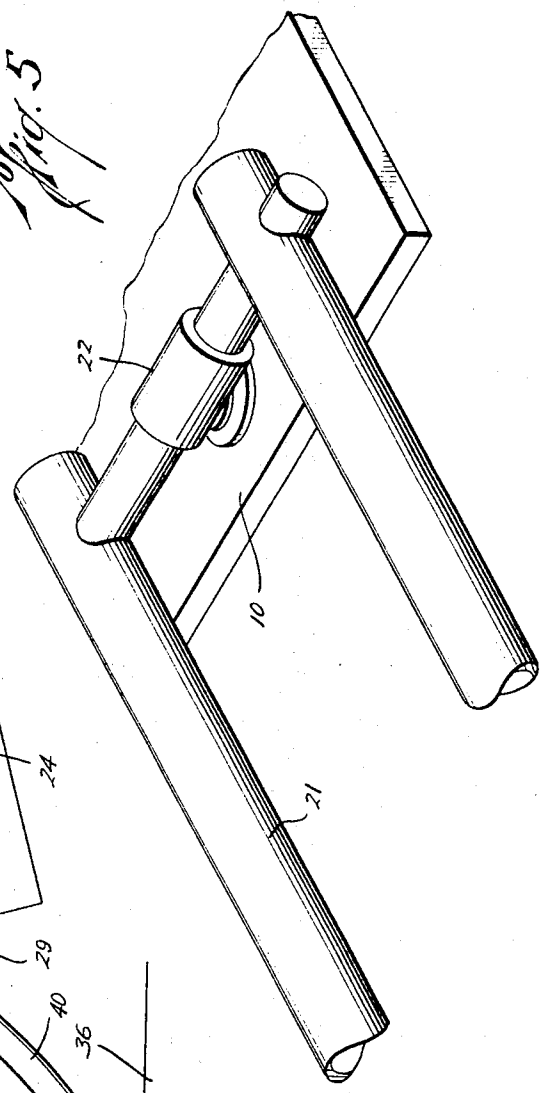

Fig. 5

Joseph B. Lawrence
Ferdinand R. Hauber
INVENTORS

BY

ATTORNEY

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Original Filed July 14, 1958

3 Sheets-Sheet 3

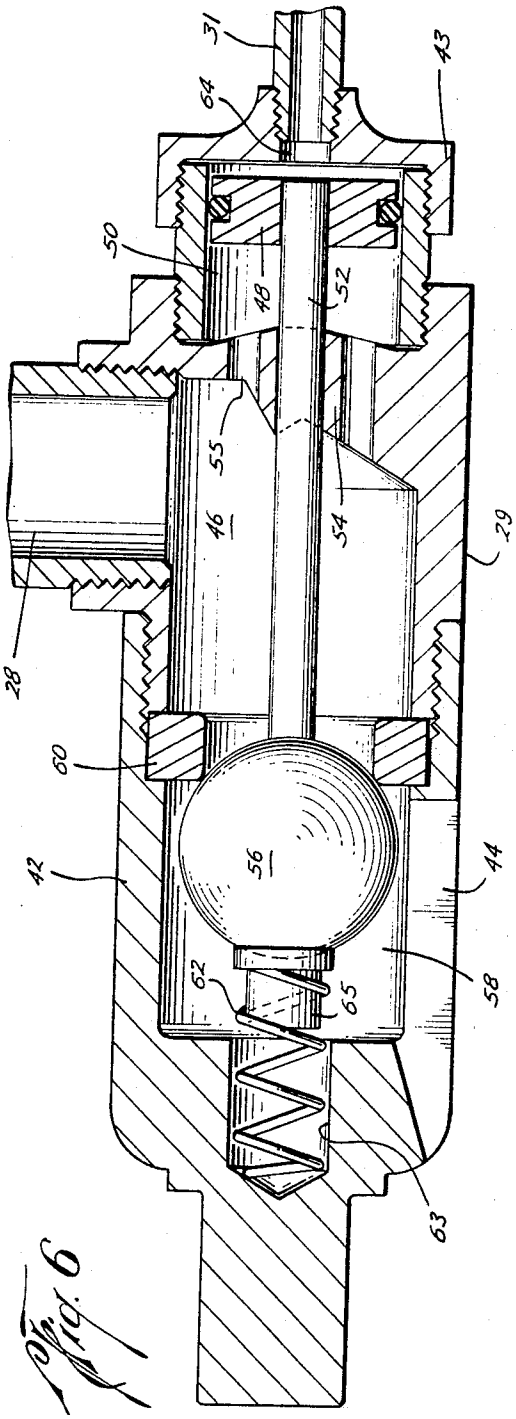

Fig. 6

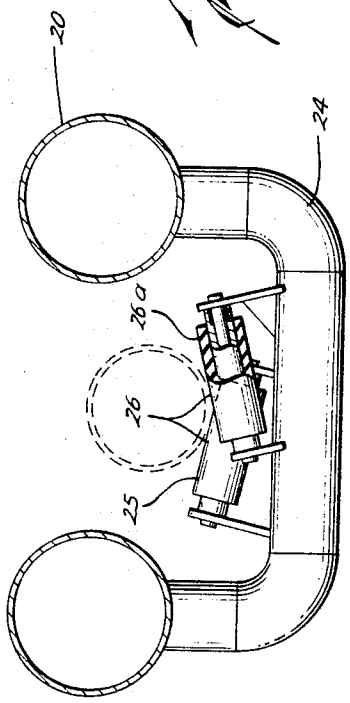

Fig. 7

Joseph B. Lawrence
Ferdinand R. Hauber
INVENTORS

BY

ATTORNEY

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METHODS AND APPARATUS FOR LAYING ELONGATE FLEXIBLE MEANS ON A SUBMERGED SURFACE

Ferdinand R. Hauber and Joseph Benton Lawrence, Houston, Tex., assignors to Brown & Root, Inc., Houston, Tex., a corporation of Texas

Continuation of application Ser. No. 157,531, Dec. 6, 1961, which is a continuation of application Ser. No. 748,373, July 14, 1958. This application Apr. 30, 1965, Ser. No. 457,239

11 Claims. (Cl. 61—72.1)

This is a continuation of application Serial No. 157,531, filed December 6, 1961, now abandoned, which in turn was a continuation of application Serial No. 748,373, filed July 14, 1958 and now abandoned.

The invention pertains to the laying of pipelines in underwater ditches or on the bottom of water covered terrain. More particularly, the invention pertains to the laying of pipelines in water up to 100 feet in depth. This type of operation requires that the pipe being laid be supported through the major portion of its trip from assembly and treating to final position on the bottom.

There are a few laborious methods, employing relatively crude devices, now in use for the above purposes. However, the ability of the known devices to lay pipe underwater is severely limited to depths greater than 25 feet.

The greatest limitation of the known devices is their inability to properly support the pipeline between the time it leaves the water craft (usually a barge) on which it is assembled and treated, until it comes to rest on the bottom. Furthermore, such support as is given by known devices is erratic and uneconomic of effort and expense.

The laying of pipelines in water up to 100 feet in depth is not economically feasible with known devices.

In convention practice, the assembled pipe slides off the rear of the barge into the water as the barge moves forward. A roller or skid member is located on the rear of the barge for the operation. Some of these barges have a hinged floating ramp attached to the rear which is equipped with the rollers or skids. The floating end of such hinged ramps is depressed by the weight to the pipe sliding thereover. Of course, such a ramp can give only a nominal amount of support to the pipe in the water at or near the surface thereof, which is limited to the unvariable buoyancy of the ramp. The portion of the pipe suspended in the water between barge ramp and the bottom is unsupported and the length of the bending radius of such portion of the pipe cannot be effectively controlled.

If the water is of more than nominal depth, the unsupported weight of the pipe in the water will often reduce the bending radius thereof to the point that great stresses are set up in the pipe and its covering, causing rupture of one or both. In the deeper water, conventional practice is to support the portions of the pipe suspended underwater by attaching pontoons with floating release lines, to the pipe at spaced intervals. However, the expense, effort, and time required, together with the generally inaccurate and unsatisfactory results obtained, make such operations not feasible in depths exceeding 50 feet.

The principal object of the invention is to provide a means for laying pipe in water more efficiently and in greater depths than heretofore possible.

One of the principal objects of the invention is to properly support pipelines suspended underwater during laying operations.

Another object of the invention is to control the bending radius of the pipe as it is laid from a water craft in order to alleviate stresses and to prevent collapse, rupture or fatigue of pipe and cover.

Another object of the invention is to provide buoyant supporting means for the pipe suspended underwater which are not attached thereto.

Another object of the invention is to provide means for continuous and interacting support of the pipe both above and below the surface of the water.

Another object of the invention is to provide means for remotely controlling the location and amount of buoyant support given portions of the pipeline suspended underwater during laying operations.

Another object of the invention is to provide a means for facilitating the handling of pipelines on barges whereby the assembled pipeline is protected from damage by excessive bending or twisting and the stresses imposed thereby, in the process of assembling and treating the pipe on the barge.

Briefly, the invention comprises an elongated, buoyant pipe cradle device, which is flexibly attached to the rear of a pipe laying barge, and pipe supporting and guiding elements on the barge itself. The buoyant pipe cradle comprises two elongated cylindrical pontoons assembled in a parallel position and joined by downwardly disposed U shaped tubular cross members. A comparatively short portion of the cradle nearest the barge is downwardly angularly displaced at approximately 30 degrees from the rest of the cradle. This portion of the cradle is not joined by crossmembers. This upper portion serves to horizontally space the angled cradling portions of the cradle from the barge in order to allow a longer pipe bending radius while passing over the barge into the cradle portion.

The pontoons are longitudinally compartmented by transverse bulkheads. Each of the compartments are equipped to be flooded or to be blown out by compressed air. Each compartment is equipped with a novel gas operated and remotely controlled sea cock or valve.

The middle portions of the transverse crossmembers are lower than the pontoons and have angularly mounted transverse rollers thereon. The transverse members are hollow and serve as "balance pipes" between compartments of the opposite pontoons to obtain lateral floatational stability of the pipe cradle. The uppermost surfaces of the rollers mounted on alternate crossmembers are oppositely inclined, which tends to "center" as well as support the pipe passing thereover.

The supporting and guiding elements mounted on the barge comprise, raised, rockably mounted, roller equipped horizontal shoes with vertical rollers on their lateral extremities. The shoes are adjustably elevated above the barge as another means of lengthening the bending radius of the pipe passing over the barge and into the water. The shoes are usually located in tandem and spaced apart about 40 feet.

As the assembled pipe moves over the barge, it is supported and guided by the shoes. The pipe is guided and supported by the buoyant cradle at the surface and under the water. Selected parallel compartments of the cradle are equipped with an air intake line and a blow-off pipe containing remotely a controlled gas operated sea cock or valve which has a fail-safe device incorporated therein.

The amount of buoyancy and the location of the center of buoyancy of the cradle is remotely controlled at a control panel where valves in the operating or pressure lines for the sea cocks are located. These allow the remote control of the "blowing out" or venting and flooding of selected compartments. This is accomplished by controlling operating gas pressure transmitted to the bore of the novel operating remote control sea cocks which allows the operation of the ball check compartment of the sea cocks. A remotely controlled sea cock is located in each blow-off pipe in each compartment.

The pontoons have semi-elliptical skids on their lower ends so that the cradle can be slidably moved along the bottom if such procedure is desirable. The flexible

mounting of the cradle also allows lateral angular displacement from the barge so that temporary directional instability of the barge itself need not drag portions of the pipe, already laid, out of position.

By means of the controllably variable amount of buoyancy and the controllably variable location of the center of buoyancy of the cradle, the vertical angular displacement between the sections of the pipeline on the barge, cradle, and in the water may be easily kept within desirable limits.

The most important advantage of the invention is that the assembled pipe is almost continuously supported from the point of assembly to its permanent underwater position, thereby allowing operation in water of greater depths than heretofore possible.

Another advantage is that the lateral angular distortion of the pipe, and the stresses caused thereby, are easily controllable.

The versatility of the device, in its ability to obtain the above advantages under widely varying conditions and depths of water, is another advantage.

Another advantage is the great saving time, effort, and expense in laying pipe in shallow water.

Another advantage of the device is its unique ability to lay pipe in depths of water up to 100 feet.

Other objects and advantages of the invention will appear from the following description of a preferred embodiment of the invention wherein:

FIGURE 1 is a schematic side view of the invention showing the invention mounted on a pipe laying barge.

FIGURE 2 is a partly elevational, partly schematic side view of a portion of the invention showing the relative positions of the upper end of the pontoon cradle, the rear of the barge and the schematic of the control headers for the gas pressure lines.

FIGURE 3 is a top view of the portions of the invention shown in FIGURE 2.

FIGURE 4 is a partly side elevational, partly schematic view of a portion of a pontoon showing the compartmentation and the schematic location of the gas pressure line and remotely controlled sea cocks.

FIGURE 5 is a perspective view of the flexible joint between the pipe pontoons and the barge.

FIGURE 6 is a vertical sectional view of the novel, remote control sea cock used in each compartment.

FIGURE 7 is a partly cross sectional, partly elevational view of the buoyant pipe cradle taken at line 7—7 of FIGURE 3 showing the crossmember and pipe supporting and guiding rollers.

Referring now to FIGURES 1, 2 and 3, ramp **10** is mounted on a barge, float or ship **12** which is processing and laying pipe **11**. Rockable shoes **14** in any number necessary are mounted in tandem on vertical adjustable swivel pedestals **16** on ramp **10**. Horizontal rollers **17** and vertical guide rollers **18** comprise the upper elements of shoe **14**. Pontoons **20** are pivotally and rotatably connected to ramp **10** by universal joint **22** (see FIGURE 5). Pontoons **20** are parallel to each other and joined together by hollow U shaped tubular crossmembers **24** welded therebetween so as to define buoyant ramp means (see FIGURE 7 also). The portions **21** of pontoons **20**, nearest the barge are disposed at an obtuse vertical angle to the rest of the pontoons and such portions are not joined by crossmembers other than at universal joint **22**. Crossmembers **24** have transverse inclined rollers **25**, having rubber surfaces **26***a* mounted thereon (see FIGURE 7 also). The uppermost surfaces **26** of such rollers on alternate crossmembers are oppositely axially inclined (see also FIGURE 7).

The pontoons have hermetically sealed compartments **23** formed by water tight bulkheads of which at least three, **23***a*, *b* and *c* are equipped with generally downwardly disposed blow-off pipes **28** which have remotely operated sea cocks **29** on the outer end thereof (see also FIGURE 6). The compartments **23***a*, *b* and *c* are connected to a source of compressed air by lines **30**. Sea cocks **29** are connected to a source of valve operating gas pressure by line **31** which is connected to an external source of fluid pressure through pressure regulator **31***a*. All gas pressure lines are connected through central control panel **32**. Remote control pressure line valves **33** for sea cocks **29** and three way valves **34** for operating gas pressure lines **30** are located in panel **32**. Gas lines **30** and **31** are contained and protected by headers **35** which together with valves **33** and **34** form control panel **32** which is mounted on a normally horizontal section **21** of pontoons **20**. Semi-elliptical tubular skid members **40** are welded to the lower ends of pontoons **20** (see FIGURE 4.)

Referring to FIGURE 4, pontoon **20** is shown cutaway revealing transverse air tight bulkheads **27** forming the compartments. Air lines **30** from control panel **32** are connected to compartments **23***a*, *b* and *c* and instrument air lines **31** are connected to sea cocks **29** controlling the flow through blow-off pipes **28**, respectively.

Referring now to FIGURE 6, the sea cock **29** comprises a substantially cylindrical housing **42** having an outside port **44** and compartment port **46** connected to blow-off pipe **28**, in the wall thereof. Operating piston **48** is slidably disposed in cylinder bore **50** and attached thereto is rod **52** slidably disposed in guide **54** which has passages **55** therethrough. Ball check member **56** is disposed in chamber **58**, seats on annular ring **60** and is biased to close by spring **62** which is seated in well **63** and which spring surrounds guide plug **65** which also seats in well **63**. Instrument gas pressure is received through instrument fluid pressure port **64** in cylinder head **43**.

In operating, the pipe **11** is assembled on barge **12**. As the barge moves forward, the pipe slides rearwardly and downwardly over the rollers of rockable shoes **14** which support and assume positions roughly parallel to the pipe passing thereover. As the pipe passes to the rear over the shoes, it passes headers **35**, over the end of ramp **16** and universal joint **22**, over normally horizontal sections **21** and between pontoons **20**. After it leaves the barge, the pipe is next supported by rollers **25** mounted on crossmembers **24** which center and support the pipe below and between the pontoons **20**.

The pipe continues downwardly between the pontoons and is laid in permanent position on the bottom **36**. The vertical angular displacement between the buoyant cradle and barge is determined by the weight of the pipe, the total buoyancy of the cradle, and the location of the center of buoyancy of the pontoons. The buoyant factors of the pontoons are remotely controlled by flooding or evacuating selected compartments **23***a*, *b* and *c*. The other compartments are sealed voids which are sufficient in number and buoyancy to give the shoe cradle a zero weight under water when all active compartments are flooded. Buoyancy in a given active compartment is maintained by gas pressure introduced into the pontoons by the air lines **30** and the operation sea cocks **29** which controls the inlet or exhaust of water in the compartment. Each of these operations are remotely controlled. Active compartments can be emptied by the use of instrument gas pressure to the sea cocks and the introducing of sufficient operation gas pressure through lines **30** to blow out the water through blow-off pipes **28** and sea cocks **29**. In deeper water, where greater cradle angularity is desired, selected active compartments may be flooded to lessen total buoyancy and move the center of buoyancy towards the barge. In accomplishing this, air pressure in line **30** is shut off by means of three way valves **34** at the panel **32** and at the same time air pressure lines **30** are used to exhaust air from the compartments while the sea cocks **29** are opened by instrument gas pressure in lines **31** controlled by valves **33** in panel **32** to allow water to enter the compartments through the blow-off pipes **28**. Variations of such procedures may be followed to obtain any cradle buoyancy, and inclination, desired.

Specifically, sea cocks **29** are opened by introducing fluid pressure into cylinder bore **50** through port **64**, which drives piston **48** and rod **52** toward ball member **56**. Rod **52** contacts ball **56**, pushing it off its seat **60** against bias spring **62** which is guided by plug **65** sliding into well **63** and which operation allows water to enter through outside port **44**, pass through annular seat **60** and into the compartment port **46** when the compartments are being flooded. When such operation is accomplished, operating pressure is relieved in bore **50**, bias spring **60** pushes ball **56** back on seat **60** which in turn urges rod **52** and piston **48** toward rest position. The fluid pressure in the compartment also acts on the reverse face of piston **48** through passages **55**. The same operation, in conjunction with the use of operating fluid pressure, "blowsout" or empties the compartments.

It is possible, if desired and where water depth permits, to allow semi-elliptical skids **40** to drag the bottom whereby the pipe is continuously supported from point of assembly to permit disposition on the bottom.

While a preferred embodiment of the invention has been shown and described, many modifications thereof may be made by a person skilled in the art without department from the spirit of the invention and it is desired to protect by Letters Patent all of the inventions falling with the scope of the following claims:

We claim:

1. An apparatus for laying elongate, flexible means on a submerged surface, said apparatus comprising:

floating vessel means;

elongate, unitary ramp means;

connecting means pivotably attaching said elongate ramp means to said floating vessel means such that said ramp means extends longitudinally away from said floating vessel means and is pivotable about a generally horizontal axis;

said ramp means having at least a portion submerged and inclined relative to a horizontal plane, and a lower end terminating above said submerged surface;

first support means on said floating vessel means for supporting a portion of elongate, flexible means for axial, slidable movement therealong with the axis of said portion extending in a generally straight line;

second support means on said floating vessel means for supporting a portion of elongate, flexible means for axial, slidable movement therealong with the axis of said portion being curved;

third support means carried by said ramp means for supporting a portion of elongate, flexible means for axial, slidable movement therealong with the axis of said portion extending in a generally straight line;

said ramp means including a plurality of mutually independent compartment means displaced longitudinally therealong;

first buoyancy adjusting means for selectively and independently supplying ballast to each of a plurality of said compartment means;

second buoyancy adjusting means for selectively and independently removing ballast from each of a plurality of said compartment means;

control means for operating said first and second buoyancy adjusting means so as to adjust the inclination of at least a submerged and inclined portion of said ramp means to a predetermined position, to maintain said position, and to maintain the lower end of said ramp means at a predetermined elevation above said submerged surface; and

said control means including separate controls for first and second buoyancy adjusting means for each of a plurality of longitudinally displaced compartment means whereby an upwardly directed buoyant force exerted by each of said plurality of compartment means may be selectively and independently varied.

2. In combination:

elongate, flexible conduit means;

floating vessel means;

elongate, unitary ramp means;

connecting means pivotably attaching said elongate ramp means to said floating vessel means such that said ramp means extends longitudinally away from said floating vessel means and is pivotable about a generally horizontal axis;

said ramp means having at least a portion submerged and inclined relative to a horizontal plane, and a lower end terminating above said submerged surface;

first support means on said floating vessel for supporting a portion of said elongate, flexible means for axial slidable movement therealong with the axis of said portion extending in a generally straight line;

second, vertically adjustable, suppport means on said floating vessel means for supporting a portion of said elongate, flexible means for axial, slidable movement therealong with the axis of said portion being curved;

third support means carried by said ramp means for supporting a portion of said elongate, flexible means for axial, slidable movement therealong with the axis of said portion extending in a generally straight line;

said elongate flexible conduit means being disposed such that a portion is supported for axial, slidable movement on said first supporting means, a portion is supported on said second supporting means for axial slidable movement, a portion is supported on said third support means for axial slidable movement, a portion thereof is unsupported between the lower end of said ramp means and said submerged surface, and a portion lies on said submerged surface;

said ramp means including a plurality of mutually independent compartment means displaced longitudinally therealong;

first buoyancy adjusting means for selectively and independently supplying ballast to each of a plurality of said compartment means;

second buoyancy adjusting means for selectively and independently removing ballast from each of a plurality of said compartment means;

control means operable from said floating vessel means for operating said first and second buoyancy adjusting means so as to remotely adjust the inclination of at least said submerged and inclined portion of said ramp means to a predetermined position, maintain said position, and maintain the lower end of said ramp means at a predetermined elevation above said submerged surface; and

said control means including separate controls for first and second longitudinally displaced buoyancy adjusting means for each of a plurality of compartment means whereby an upwardly directed buoyant force exerted by each of said plurality of compartment means may be selectively and independently varied.

3. A combination as described in claim **2**:

wherein an unsupported portion of said flexible conduit means extends between said second support means and said third support means;

wherein said connecting means is disposed at an elevation beneath said second support means;

wherein said ramp means terminates substantially at said connecting means;

wherein said ramp means comprises a pair of generally parallel and tubular pontoons;

wherein each compartment means comprises,

laterally adjacent and generally tubular wall portions of said pair of pontoons,

longitudinally spaced wall means within each of said pontoons which cooperate with said pontoon wall portions to define closed chambers, and

chamber connecting conduit means extending transversely between said pontoon wall portions and

connecting the closed chambers of each of said pontoon portions in fluid communicating relationship,

said connecting conduit means extending beneath said third support means;

said third support means being supported by said connecting conduit means of said ramp means and disposed at an elevation lower than the longitudinal axes of said pontoons;

wherein said third support means slidably supports a portion of said elongate, flexible conduit means with the axis thereof disposed beneath and between the axes of laterally adjacent portions of said pair of pontoons;

wherein said first and second support means each comprise

a plurality of roller means; and

wherein said second support means includes

adjustable mounting means for at least some of the roller means thereof adapted to secure said roller means in selectively adjustable positions of elevation, and

pivot means supporting at least some of said roller means for pivotable movement about a generally horizontal axis extending generally transversely of a median plane extending longitudinally of said flexible conduit means.

4. A combination as described in claim **3**:

wherein said third support means comprises an individual roller mounted on each connecting conduit means of said float means and having an axis of rotation inclined relative to a horizontal plane;

wherein said rollers, in a direction extending longitudinally of said ramp means, are alternately inclined in generally opposite directions; and

wherein said rollers are disposed on said connecting conduit means such that mid-portions of said rollers engage lower portions of said flexible conduit means.

5. A combination as described in claim **3**:

wherein each of said pontoons of said ramp means has a substantially straight portion adjacent said connecting means which is inclined relative to another, substantially straight, and submerged portion of said pontoon.

6. A combination as described in claim **3**:

wherein said first buoyancy adjusting means comprises in association with each of said compartment means,

a first fluid line and

means for supplying and withdrawing air from said compartment means through said first fluid line; and

wherein said second buoyancy adjusting means comprises, in association with each of said compartment means,

a second fluid line, and

a valve in said second fluid line, said valve comprising a water inlet, a resiliently biased check valve closing said water inlet, and fluid pressure operated means for opening said check valve, and

means for supplying fluid pressure to said pressure operated means to cause said pressure operated means to open said check valve whereby said compartment means may be flooded with water.

7. A combination as described in claim **3**:

wherein each of said pontoons of said ramp means has a substantially straight portion adjacent said connecting means which is inclined relative to another, substantially straight, and submerged portion of said pontoon;

wherein said first buoyancy adjusting means comprises, in association with each of said compartment means,

a first fluid line and

means for supplying and withdrawing air from said compartment means through said first fluid line;

wherein said second buoyancy adjusting means comprises, in association with each of said compartment means,

a second fluid line, and

a valve in said second fluid line, said valve comprising a water inlet, a resiliently biased check valve closing said water inlet, and fluid pressure operated means for opening said check valve, and

means for supplying fluid pressure to said pressure operated means to cause said pressure operated means to open said check valve whereby said compartment means may be flooded with water;

wherein said third support means comprises an individual roller mounted on each connecting conduit means of said float means and having an axis of rotation inclined relative to a horizontal plane;

wherein said rollers, in a direction extending longitudinally of said ramp means, are alternately inclined in generally opposite directions; and

wherein said rollers are disposed on said connecting conduit means such that mid-portions of said rollers engage lower portions of said flexible conduit means.

8. A method of laying elongate, flexible means on a submerged surface, said method comprising:

buoyantly supporting a portion of elongate, flexible means on a vessel floating on a fluid body such that said portion is axially slidable;

buoyantly supporting another portion of said elongate, flexible means with the axis thereof extending generally downwardly and outwardly from said vessel, with said other portion being at least in part submerged beneath said fluid body and axially slidable;

exerting longitudinally spaced, and selectively and independently variable buoyant lifting forces on said other portion of said elongate, flexible means, with said buoyant forces being generated within said fluid body and generally adjacent said other portion of said elongate flexible means; and

selectively and independently adjusting said buoyant lifting forces from said vessel so as to obtain and maintain a predetermined positioning of said other portion of said elongate, flexible means with the axis thereof extending generally downwardly and outwardly from said vessel.

9. A method as described in claim **8**:

wherein said buoyant lifting forces are generated generally laterally of and on each side of said other portion of said elongate, flexible means and transmitted to the underside of said other portion; and

wherein said buoyant forces generated on laterally adjacent, opposite sides of said other portion are balanced.

10. A device for laying underwater pipelines comprising:

means for slidingly engaging, supporting, and guiding a pipeline above the surface of the water, and

a cradle, vertically pivotally attached to said means, extending first substantially horizontally outwardly and thence outwardly and downwardly from said means to a point below the surface of the water, said cradle comprising

a pair of transversely connected fluid-tight tubular members, and

means transversely dividing said tubular members into a plurality of fluid-tight compartments extending throughout substantially the full length of the cradle,

means for controlling the vertical angular position of said cradle with respect to the first named means, comprising means for selectively flooding and remov-

ing water from at least some of said compartments, and

means on said cradle for supporting a pipeline.

11. An apparatus for laying elongate, flexible means on a submerged surface, said apparatus comprising:

elongate, flexible means;

floating vessel means;

elongate, unitary ramp means;

connecting means pivotably attaching said elongate ramp means to said floating vessel means;

said ramp means having at least a portion submerged, and extending generally downwardly and away from said floating vessel means;

support means on said pivotably connected floating vessel means and ramp means supporting said elongate flexible means for generally axial, slidable movement;

said ramp means including a plurality of mutually independent compartment means displaced longitudinally therealong;

buoyancy adjusting means for selectively and independently supplying ballast to each of a plurality of said longitudinally displaced compartment means and removing ballast from each of said plurality of said compartment means; and

control means on said floating vessel means for operating said buoyancy adjusting means so as to adjust the orientation of at least a submerged portion of said ramp means to a predetermined position and to maintain said position;

said control means including separate controls for each of said plurality of longitudinally displaced compartment means whereby an upwardly directed buoyant force exerted by each of said plurality of compartment means may be selectively and independently varied.

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JACOB L. NACKENOFF, *Primary Examiner.*

CHARLES E. O'CONNELL, *Examiner.*

J. SHAPIRO, *Assistant Examiner.*