

United States Patent

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[54] METHOD AND APPARATUS FOR
SUBSURFACE TOWING OF
FLOWLINES

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[52] U.S. Cl. 114/235 B

[51] Int. Cl. B63b 21/00

[58] Field of Search 114/235 R, 235 B, 0.5 R;
61/72.1, 72.3

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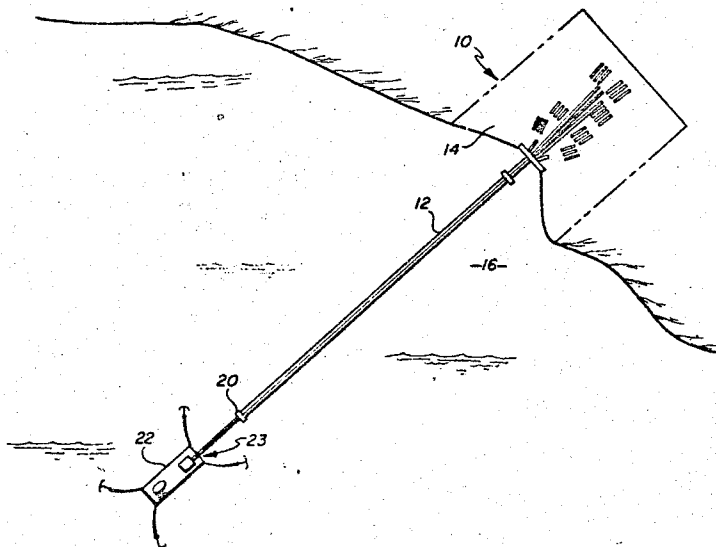
Primary Examiner—Trygve M. Blix

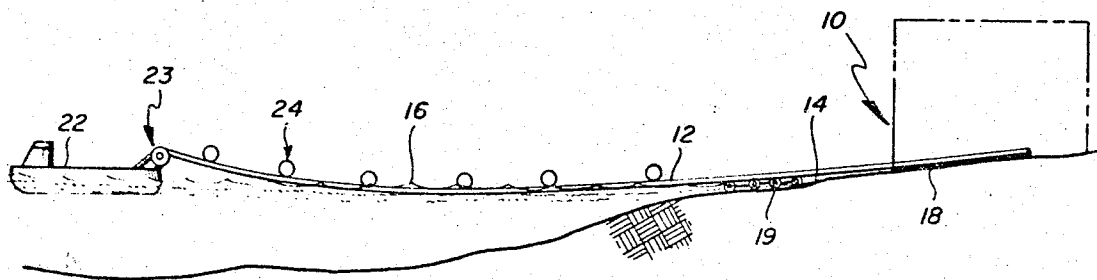
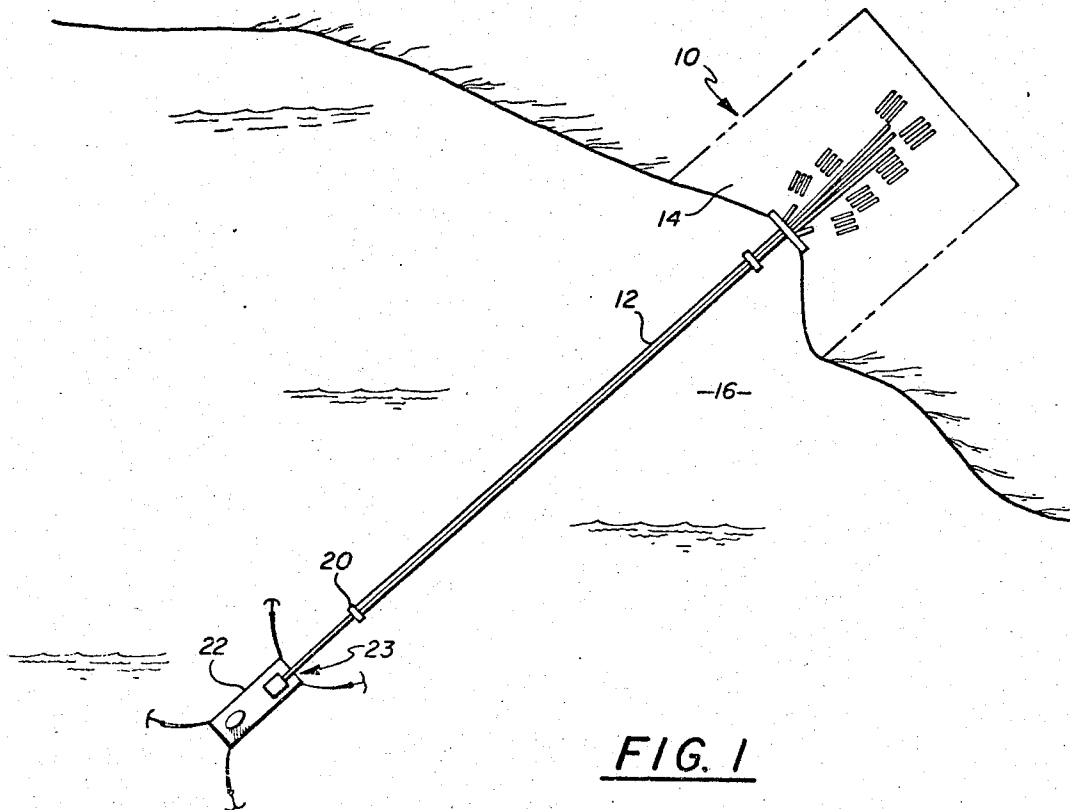
Attorney—Allan Rothenberg, Richard F. Carr and
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[57] ABSTRACT

This disclosure is directed to a method of transporting a flowline or flowline bundle for installation in an offshore petroleum field wherein the fabrication of the flowline is land based; after which the full-length flowline is towed (at a sufficient depth below the surface of the water) to the installation site, so as not to be affected by adverse sea conditions while in tow. Each free end of the line is adapted with a connecting apparatus for connecting to submerged connecting assemblies or structures. When the flowline is drawn down to the connecting assemblies, connection is made thereto just prior to the final settlement of the flowline to the ocean floor.

14 Claims, 11 Drawing Figures





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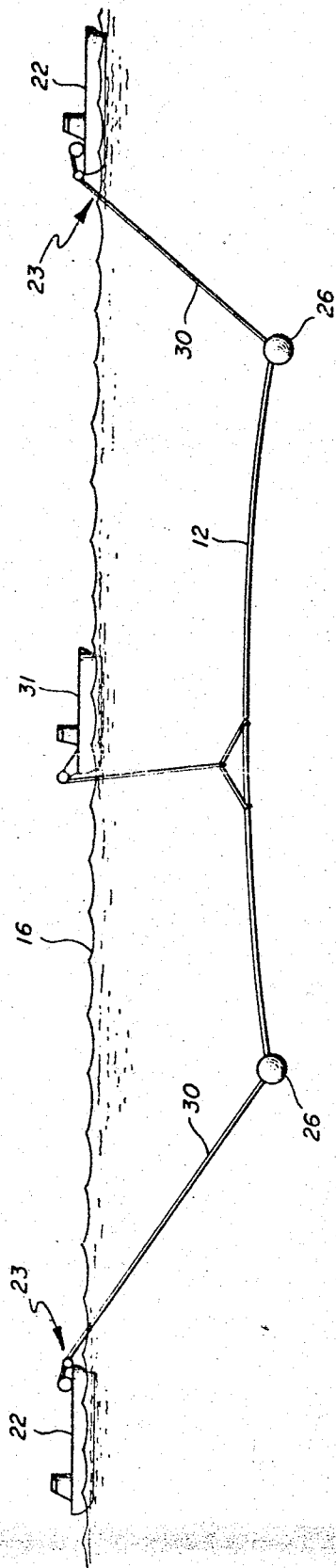


FIG. 3

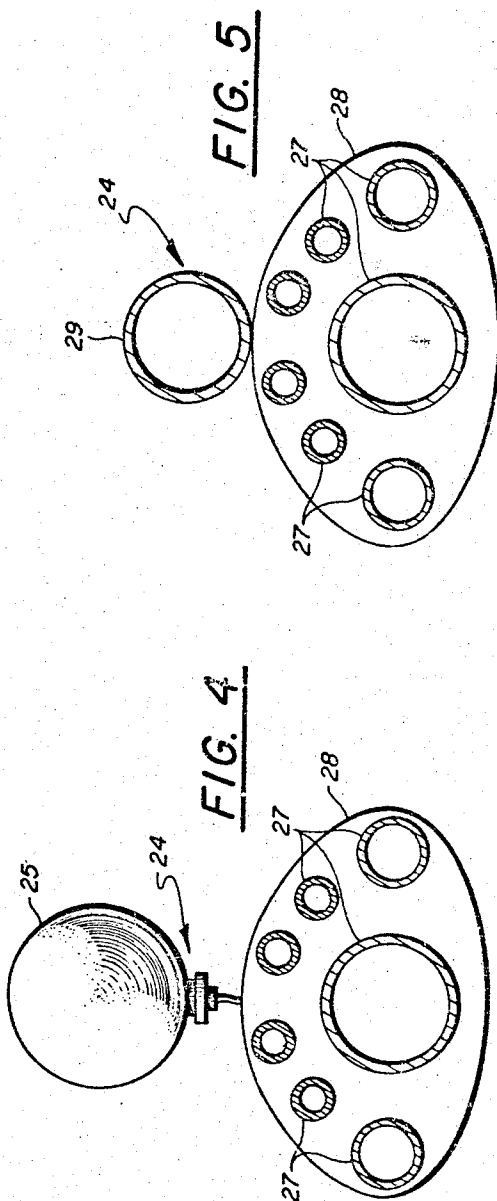


FIG. 4

FIG. 5

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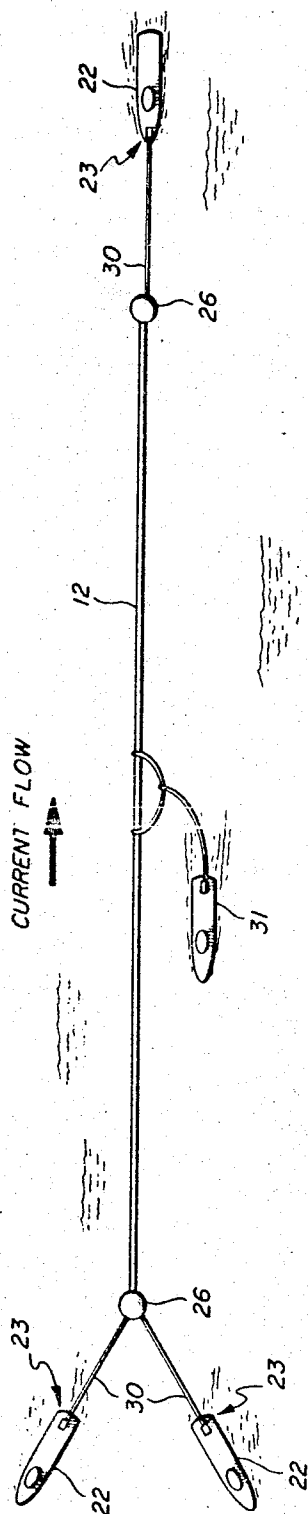


FIG. 6

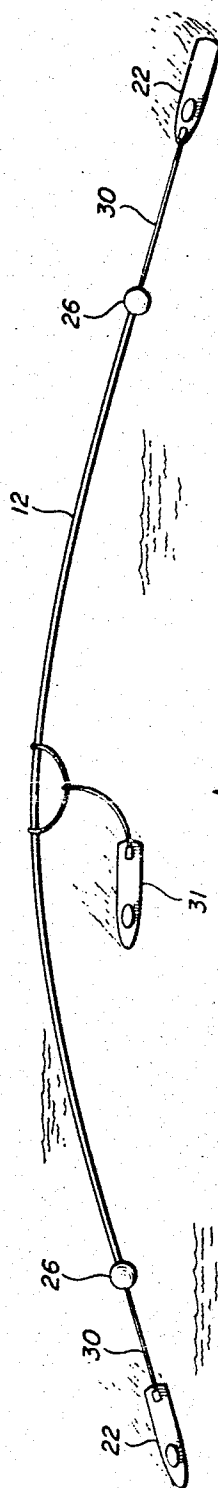
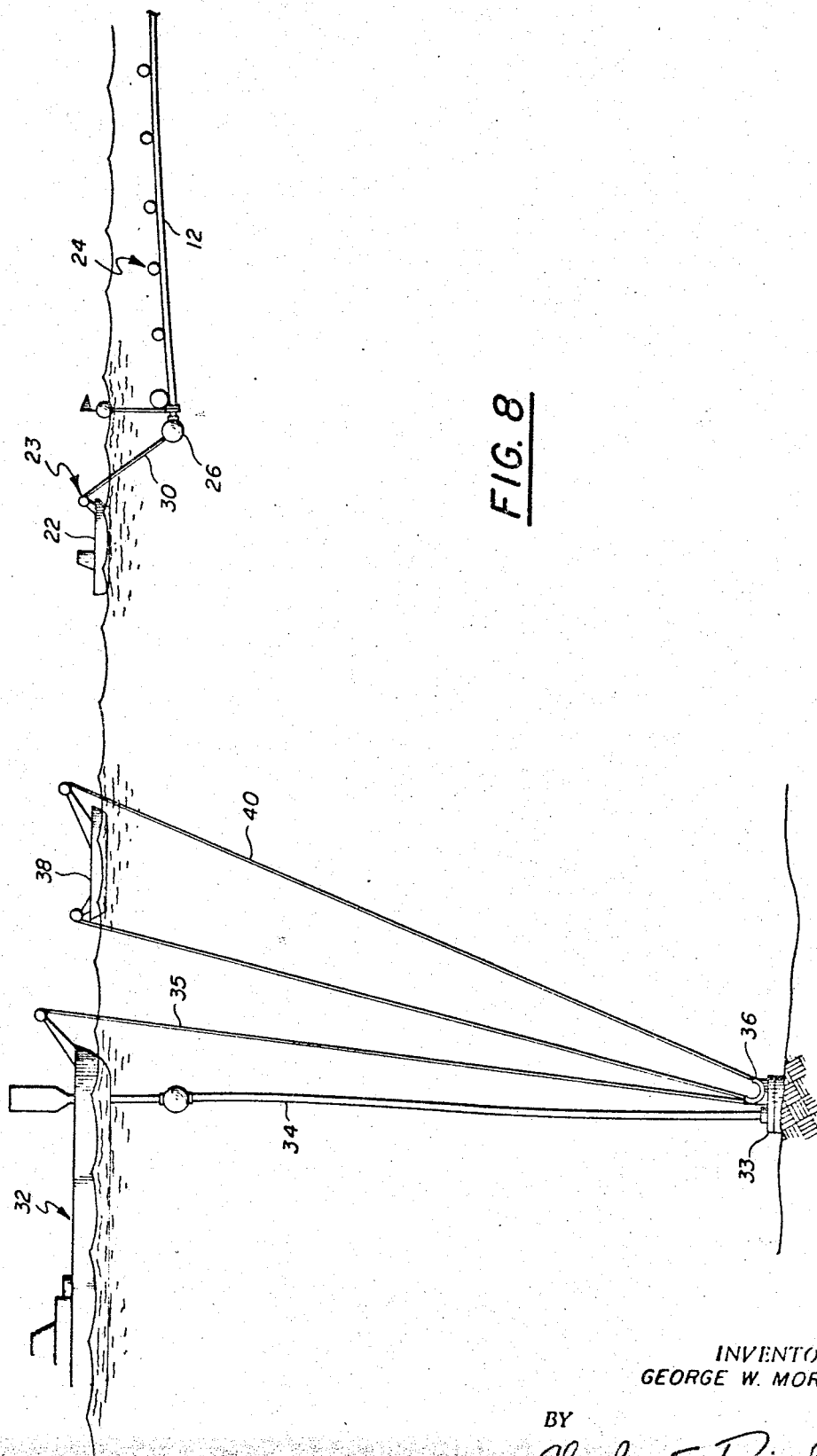


FIG. 7

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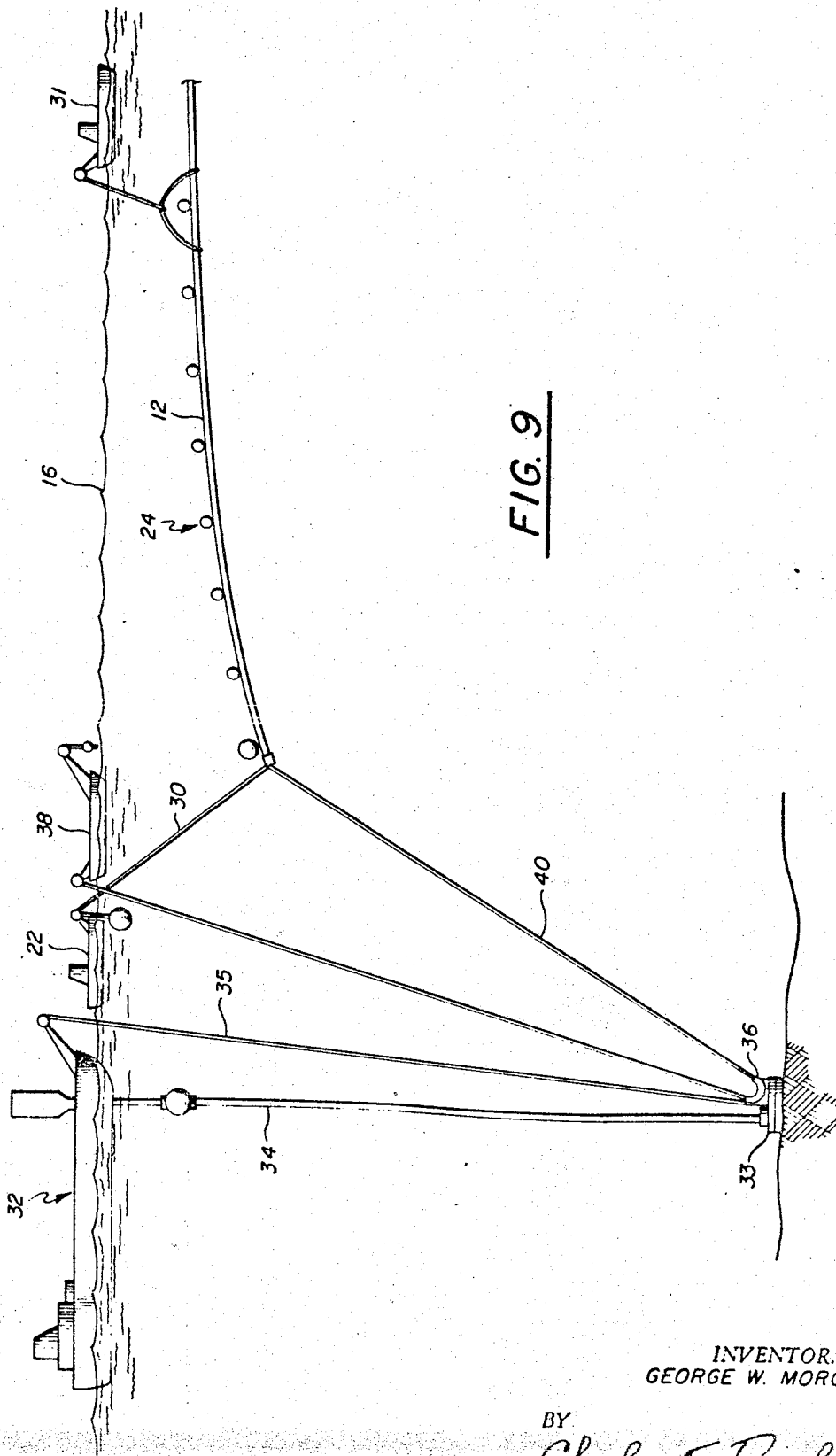


FIG. 9

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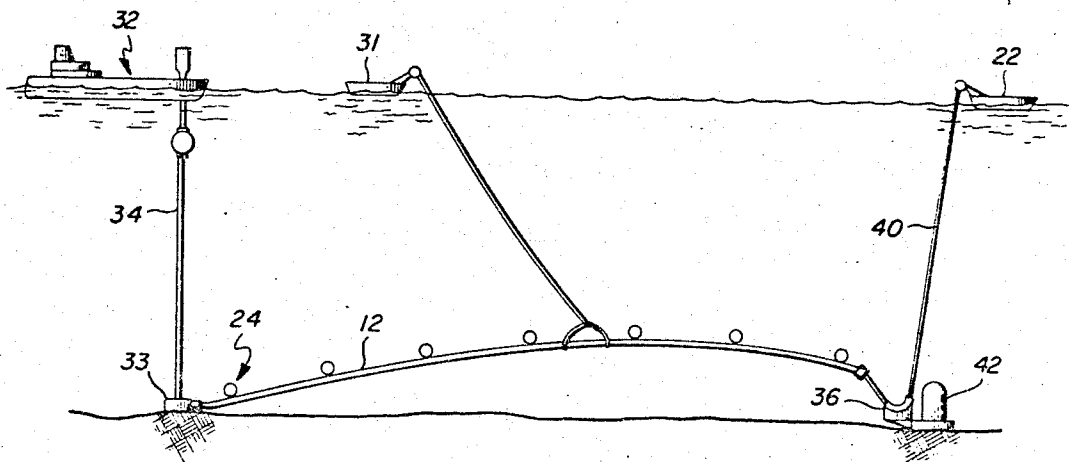


FIG. 10

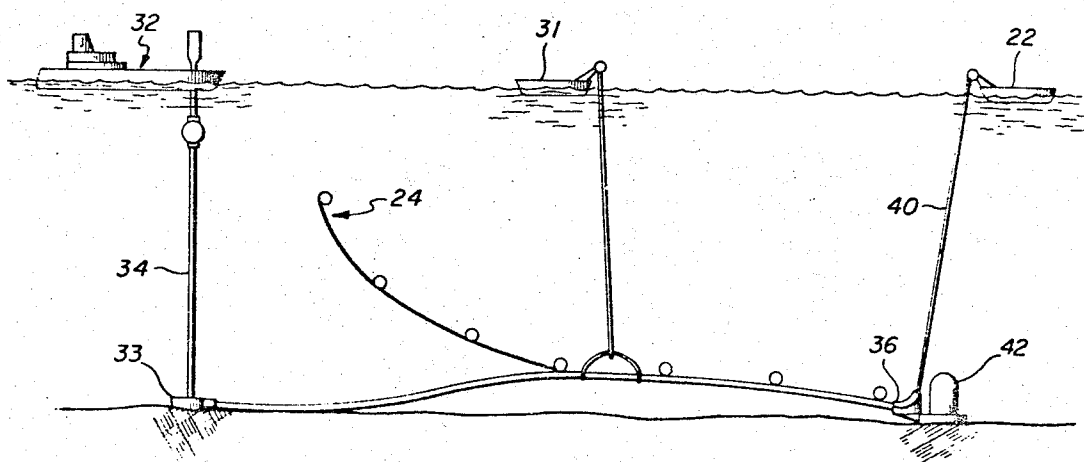


FIG. 11

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METHOD AND APPARATUS FOR SUBSURFACE TOWING OF FLOWLINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a method of transporting flowline bundles of pipe to an offshore installation and, more particularly, to transporting flowlines while submerged below the surface of the water.

2. Description of the Prior Art

At the present time, there are being conducted many varying offshore operations for the production of hydrocarbons, such as oil and/or gas at depths of 100 feet or more. There have been several methods used for the production of wells in offshore oil fields at depths of 100 feet or less and these depths are compatible with the use of divers. However, where there is production in waters of greater depths than 100 feet, the use of divers becomes dangerous and quite often impractical. Therefore, problems still continue to arise in the area of oil well productions where the depth is over 100 feet and the distance to the producing field from land is such that operations become economically unfeasible. More feasible means for installing flowlines are required so that these wells may be economically produced for future requirements. Due to the ever increasing demand for hydrocarbons such as oil and gas, potential areas of production have been and will continue to be located, but, as each zone is located, additional problems of distance from the shore also increase along with the problem relating to depth of the ocean floor.

Under some existing conditions flowlines which are to be connected from offshore structures to onshore facilities, the pipe and/or flowlines are assembled onshore and literally dragged along the ocean floor to the production stations and there connected. Others have been assembled at sea and laid into position by what is known as a lay barge. And still other flowlines have been floated on the surface of the water where the distance of the producing well from the shore line is not too great a distance. A major problem to a flowline is protecting the line from damage, particularly kinking of the pipe.

There are three particular methods in use for moving pipe and connecting the pipe or flowline to submerged structures. One method is to drag the assembled pipe along the floor of the ocean to its connecting point as it is assembled on shore. However, this becomes impractical where there is considerable distance involved due to adverse conditions of the terrain of the ocean floor which will cause serious damage to the pipe or pipe bundles. A second method of floating a flowline bundle has been used in various operations. However, the flowlines are restricted in length and to the number of pipes that may be used in a bundle system. The floating of the flowlines exposes the complete assembly to various unstable sea conditions and especially to bad weather which causes the surface of the ocean to become unduly rough. To be economically useful, flowlines in the future will have to be assembled at greater lengths than they are now presently being assembled and the bundles will require a larger number of lines per bundle. Substantial lengths of flowlines of two miles or more and bundles ranging from four or more pipelines are not capable under the present con-

ditions to withstand a rough surface of the ocean, whether it be by bad weather or just adverse conditions such as current flow. Third, there is the method of using a barge to transport and lay pipe at an installation site. It has been found by experience that laying pipe from a lay barge is not only costly but cannot be done where the bottom of the ocean is at such a depth that the flowline cannot physically maintain its proper bending configuration.

All offshore petroleum fields require flowlines and risers to transport the production products to the surface or shore installations. However, the installation techniques currently used by industry are very expensive and their principal usage appears to be limited to conditions in which the length of the pipe run is only three to four times the depth of the water, and the installation of flowline bundles are limited to not more than three to four lines.

SUMMARY OF THE INVENTION

The present invention may be briefly described as a method of transporting an assembled flowline or flowline bundle to an offshore installation and submerging said flowline for connection with submerged petroleum producing structures for the purpose of oil production.

In this method the flowline or flowline bundle is fabricated on shore and is progressively launched into the water under conditions of controlled tension and floatation. The flowline bundles are assembled on tracked dollies, using guide rollers at the shore line to guide the bundles into the sea. Since steel flowline bundles have a negative buoyancy (as is generally the case), a series of releasable buoys may be intermittently attached along the length of the bundle so as to provide a slight amount of uniformly distributed positive buoyancy. During transportation, the ends of the line bundles are attached to the terminal ballasts which are sufficiently heavy to submerge the total assembly. The amount of submergence of the total assembly is controlled by the length and angle of the tow cables which are attached to the forward and aft terminal ballast. When the flowline assembly reaches the installation area, it is connected to barges known as a drawer-down barge. The flowline bundle is lowered by means of a drawer-down cable which passes through previously lowered J-tube fixtures.

Each free end of the line is adapted with a connecting means for mating with a complementary connecting fixture. As an example, one fixture is an integral part of a submerged structure and another connecting fixture is an integral part of a second structure, which are to be interconnected by said flowline bundle. At the time of connecting the bundle, a critical damage potential exists. To reduce damage potential, the flowline is connected at both ends before the mid-portion of the line is allowed to settle on the ocean floor. This is accomplished by the use of a mid-line barge controlling the rate of descent of the mid-portion of the flowline. Generally, the line has a length longer than the distance between each underwater structure to which it is to be connected. This, thereby, allows the flowline to be lowered to the ocean floor in a gentle, arcuate curve.

OBJECTS OF THE INVENTION

A general object of this invention is to provide a method of transporting a flowline or a flowline bundle without damage to an offshore petroleum installation.

Another object of the invention is to provide an economic advantage resulting from use of a land-based assembly and minimum usage of floating stock.

A further object of the invention is to provide flowline bundles which are subjected to control tension loads as required to maintain bundle control during the fabrication, transportation, and placement phases thereof.

Another object of the invention is to provide a flowline bundle to be transported by towing said bundle below the surface of the sea but above the bottom thereof by control means.

A still further object of the invention is to provide a flowline that is not restricted to its overall length or to the number of the pipelines making up a bundle.

The characteristics and advantages of the invention are further sufficiently referred to in connection with the following detailed description of the accompanying drawings which illustrate one embodiment. After considering this example, skilled persons will understand that many variations may be made without departing from the principles disclosed and it is contemplated that the employment of any structures, arrangements or modes of operation are properly within the scope of the appended claim.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the drawings which are for illustrative purposes only:

FIG. 1 is a diagrammatic plan view showing a land-based assembly of a flowline bundle;

FIG. 2 is a diagrammatic side view of that shown in FIG. 1;

FIG. 3 is a diagrammatic view illustrating the flowline being towed under the surface of the water;

FIG. 4 is a sectional view of a typical flowline bundle having a releasable buoy attached thereto;

FIG. 5 is also a sectional view similar to FIG. 4 using a continuous tube-type of buoy arrangement;

FIG. 6 is a top plan view showing the flowline being towed under ideal conditions;

FIG. 7 is a view similar to FIG. 6 but showing the flowline subjected to a transverse current flow;

FIG. 8 is a diagrammatic view illustrating the general relationship of all major items previous to connecting and drawing down of the flowlines;

FIG. 9 illustrates the flowline attached to draw-down cables;

FIG. 10 shows the flowline connected at an end thereof to an underwater facility; and

FIG. 11 shows the completion of the underwater connections and the release of the buoy system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring more particularly to the drawings, there is shown in FIG. 1 and FIG. 2 a land-based installation site indicated generally at 10. The purpose of the land-based site is to fabricate flowlines or flowline bundles 12 on shore which is generally indicated at 14. Then

the bundle is simultaneously and progressively launched into the water 16 under conditions of controlled tension and floatation. Each flowline bundle 12 is assembled on tracked dollies 18, using guide rollers 19 at the shore line 14 to guide the bundle into the sea. From this point, the free end 20 of the line 12 is attached to a floating facility or barge 22 by controlled tensioning means such as a cable and winch generally indicated at 23.

Where steel flowline bundles are used (as is generally the case), there is created a negative buoyancy which causes the line to sink to the ocean floor. As the flowline assembly is extended out from the land base, a buoyancy means 24, shown as a series of releasable buoys, is intermittently attached to the bundle so as to provide a slight amount of uniformly distributed positive buoyancy. This can readily be seen in the diagrammatic view of FIG. 2. Therefore, during the assembly phase of the line bundle wherein the line is extended into the ocean, it is necessary for the line to have a positive buoyancy. This is accomplished, as mentioned above, by a buoyancy means 24. However, when a completed unit is assembled for towing to the production site, that is during transportation thereof, each respective free end of the line bundle is attached to a terminal ballast 26 which is sufficiently heavy to submerge the total assembly, as shown in FIG. 3. Therefore, it can be seen that controlling the means for floating the line in conjunction with the means for submerging the line, the floating facilities or tugs 22 can transport the lines submerged at any predetermined depth below the surface of the ocean 16.

In FIGS. 4 and 5 there is shown two different means for creating a buoyancy condition of the flowline bundle. Referring now particularly to FIG. 4, there is illustrated a buoyancy means comprising a ball-like buoy 25 which is releasably attached to the line bundle 12. A plurality of the ball-like buoys will be placed longitudinally along the bundle and sufficiently spaced apart whereby the entire line may be supported. Also indicated in FIG. 4 is the configuration of the pipeline assembly which comprises a plurality of various size pipes as indicated by reference numeral 27. These pipes are fixed in a spaced relationship to each other by a support wall 28.

Referring now to FIG. 5, there is illustrated an enlarged tube or pipe 29 made of lightweight material, such as aluminum, which is used as a means for positive buoyancy along the length of the flowline. This pipe is adapted to be attached along the full length of the flowline bundle and pressurized for a positive buoyancy condition. However, this pressurization is not critical and can range from 0 to 5 pounds per foot. This then will develop a residual upward tendency in floatation and provide an inverted "catenary" bridge. Therefore, the combination of pressurizing and flooding of this particular type of buoyancy means becomes an effective way to control the depth at which the flowline may be submerged during towing operations.

In addition, however, the amount of submergency for the total assembly can be controlled by the length and the angle of the tow cables 30 which are attached to the forward and aft terminal ballast 26. For example, if the tugs pay out cables and separate themselves so as to maintain some similar angle (say 45°) for the fore and

aft towlines, the flowline assembly will lower by some corresponding amount. If the tugs reel in the cables and decrease their distance of separation (holding approximately similar angles of towline inclination), the overall flowline assembly will rise. The amount of tug separation, of course, will vary with the tug surging. The distance between tugs can be continuously monitored by radar and the average separating distance is then used to evaluate the general position of the flowline bundle. Constant tension winches on the tow cables can be used to minimize the effects of tug heave and surge upon the flowline bundle. In addition, pressure transducers on the terminal ballast could be used to monitor the actual depth of the terminal ballast.

Referring now to FIGS. 3, 6 and 7, there is shown an auxiliary barge or tug 31 positioned intermediate to the ends of the bundle 12 for control of undue bending under adverse conditions such as shown in FIGS. 6 and 7. FIG. 6 illustrates a possible use of two forward tugs along with an optional intermediate tug when current results in a lateral oscillation.

FIG. 7 illustrates a possible configuration of an overall system when subjected to transverse current and an auxiliary tug is needed as mentioned above.

As one example of an area of subsea production of gas and oil, I now refer to FIG. 8 in which there is illustrated a surface facility 32 connected to a subsea manifold 33 by means of a riser 34.

There is means for submerging the flowline 12 to the ocean floor which comprises a guideline 35 for placement of a J-tube fixture 36. The guideline 35 is suspended from the surface facility 32 enabling a draw-down barge 38 to string a draw-down cable 40 therethrough. As the subsurface flowline assembly is towed into the area, the draw-down cable is then attached to the end of the flowline bundle 12 as shown in FIG. 9. A similar activity will be occurring at the aft end of the flowline bundle, as shown in FIGS. 10 and 11, in which the aft end is being connected to a satellite producing unit 42.

After connection is made at both ends of the bundle to each of the subsea units, the flowline is then permitted to settle completely on the ocean floor. That is, the flowline 12 is suspended above the bottom of the ocean while the connections between each subsea satellite in it is made. The tug 31, as shown in FIGS. 10 and 11, then allows the flowline to be lowered gently into place.

When relatively smooth and compatible bottom conditions are encountered, the buoyancy means 24 may be remotely released, coming to the surface in a connected configuration for future use. If the intermittent buoying system is replaced by the continuous line system, as shown in FIG. 5, it too may be releasably secured. However, it is contemplated that this type of buoy means will generally be used as an aid to submerging the flowline by controlled flooding of the system with sea water.

Although the present invention has been described with respect to a preferred form of the present invention with a certain degree of particularity, it is to be understood that the scope of the invention should not be limited thereto, but should be afforded the full scope of the following claims.

I claim:

1. A method of transporting an underwater flowline from an onshore assembly site to an offshore installation site having subsea units comprising the steps of:
fabricating said flowline,

launching said flowline into a body of water,
floating said flowline with a buoyant means attached thereto,

submerging said flowline at a predetermined depth under the surface of said body of water by means of weights sufficient to provide a net negative buoyancy, and

towing said submerged negatively buoyant flowline to said offshore installation.

2. A method of transporting an underwater flowline as recited in claim 1 wherein said flowline is fabricated on said onshore assembly site, and said flowline is progressively launched from said onshore assembly site into a body of water; and including attaching positive buoyant means for floating said flowline.

3. A method as recited in claim 2 wherein said step of submerging includes the steps of:

securing negative buoyant means for submerging said assembly to a predetermined depth between the surface of the water and the ocean floor; and
towing said assembly flowline below the surface of the water to said offshore installation site by means of cables exerting upwardly directed tensile forces at opposite ends of said negatively buoyant assembly.

4. A method as recited in claim 3 including the steps of:

submerging said flowline to a depth adjacent said subsea units; and
connecting each end of said flowline to said subsea units.

5. A method as recited in claim 4 including the step of:

lowering the flowline to the ocean floor after each end of said flowline is connected to each of said subsea units.

6. An apparatus for underwater towing in combination comprising:

a flowline bundle;
a positive buoyant means attached to said flowline along the length thereof;

a negative buoyant means attached to said flowline whereby said flowline may be positioned at a predetermined depth for towing below the surface of the water, and tow cables connected to forward and rearward ends of said bundle for exerting forces thereon to counter the negative buoyancy of said bundle.

7. An apparatus as recited in claim 6 wherein said positive buoyant means comprises a plurality of releasable buoys.

8. An apparatus as recited in claim 7 wherein said negative buoyant means comprises a plurality of terminal ballasts attached to each end of said flowline.

9. An apparatus as recited in claim 8 wherein said flowline bundle comprises a plurality of different diameter pipes, said pipes being arranged in a horizontal spaced relationship with each other and a plurality of support walls longitudinally spaced along said pipes.

10. A method of transporting an underwater flowline comprising the steps of

floating said flowline with a buoyant means attached thereto,

weighting both of the ends of said flowline with a negative buoyancy sufficient to provide the assembly of flowline, buoyant means and weights with a negative buoyancy, and

towing said assembly beneath the surface of the water, said last-mentioned step comprising the steps of

connecting the forward end of said flowline to a forward towing surface vessel by means of a forward tow cable,

connecting the rear end of said flowline to a rearward towing surface vessel by means of a rear tow cable, said forward surface vessel being positioned forwardly of said forward end and said rear vessel being positioned to the rear of said rearward end, whereby said forward and rear tow cables will counter the negative buoyancy of said assembly.

11. The method of claim 10 including the step of controlling depth of submergence of said assembly, said last mentioned step comprising adjusting depth of submergence of said flowline by changing the effective length of both of said forward and rearward tow cables and simultaneously changing the distance between said forward and rearward vessels.

12. The method of claim 11 including the steps of fabricating said flowline on land and simultaneously launching fabricated portions thereof as such portions

are completed and other portions are being fabricated, said steps of towing and adjusting depth of submergence of said flowline assembly being performed after completion of the full length of said flowline.

13. The method of towing a positive buoyancy flowline beneath the surface of the water comprising the steps of

weighting forward and rearward ends of said flowline in an amount to provide the weighted flowline with a net negative buoyancy,

countering negative buoyancy at the forward end of the flowline by an upwardly and forwardly directed tensile force exerted on the flowline at such forward end, and

countering negative buoyancy at the rearward end of the flowline by exerting a rearwardly and upwardly directed tensile force at the rearward end of the flowline.

14. The method of claim 13 wherein said steps of countering negative buoyancy are achieved by means of a forward cable connected between the forward end of the flowline and a forward surface vessel and a rearward cable connected between the rearward end of the flowline and a rearward surface vessel, and further including the step of controlling the depth of submergence of the flowline as it is towed by varying the effective length of said forward and rearward cables and the distance between said surface vessels.

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