



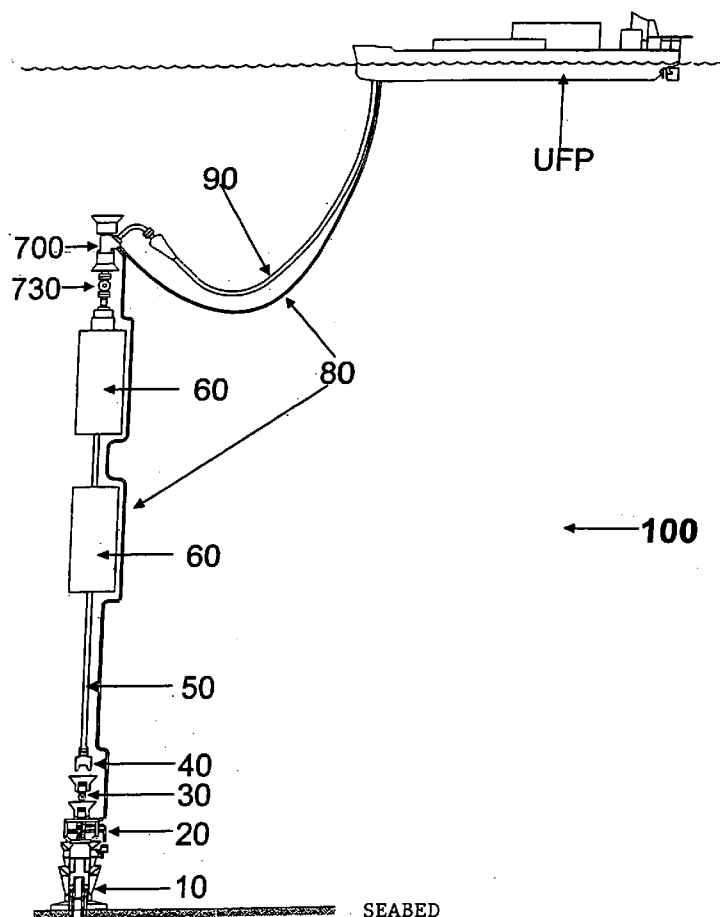
US 20070044972A1

(19) **United States**(12) **Patent Application Publication**
Roveri et al.(10) **Pub. No.: US 2007/0044972 A1**(43) **Pub. Date: Mar. 1, 2007**(54) **SELF-SUPPORTED RISER SYSTEM AND
METHOD OF INSTALLING SAME**(52) **U.S. Cl. 166/367**(76) **Inventors: Francisco Edward Roveri**, Rio de
Janeiro (BR); **Cezar Augusto Silva**
Paulo, Rio de Janeiro (BR); **Roberto**
Rodrigues, Rio de Janeiro (BR);
Renato Brandao Monsano, Vila Velha
(BR); **Carlos Alberto Giacomini**
Pereira, Vitoria (BR)(57) **ABSTRACT**

Correspondence Address:

TRASK BRITT**P.O. BOX 2550****SALT LAKE CITY, UT 84110 (US)**

A self-supported riser system (100) for an Anticipated Production System (ASP) Test or a Long Duration Production (LDP) Test in a subsea petroleum production system, utilizing an ANM coupled to a wellhead and Floating Production Unit (FPU) is disclosed. The system includes a wellhead at the seabed, connected to an ANM (20) provided with a preventor (BOP of workover) (30). The preventor (30) is connected to a production riser (50) through a connection tool (40). The riser (50), mounted internally within a buoy assembly (60), is maintained under traction with the aid of a buoy assembly. The upper end of the riser (50) is provided with a Subsea Intervention Terminal (700), the Terminal being interlinked to the FPU by a flexible jumper (90) to carry the oil produced to the FPU. Two methods for installing the self-supported riser system (100) are also disclosed.

(21) **Appl. No.: 11/218,926**(22) **Filed: Sep. 1, 2005****Publication Classification**(51) **Int. Cl.**
E21B 17/01 (2006.01)

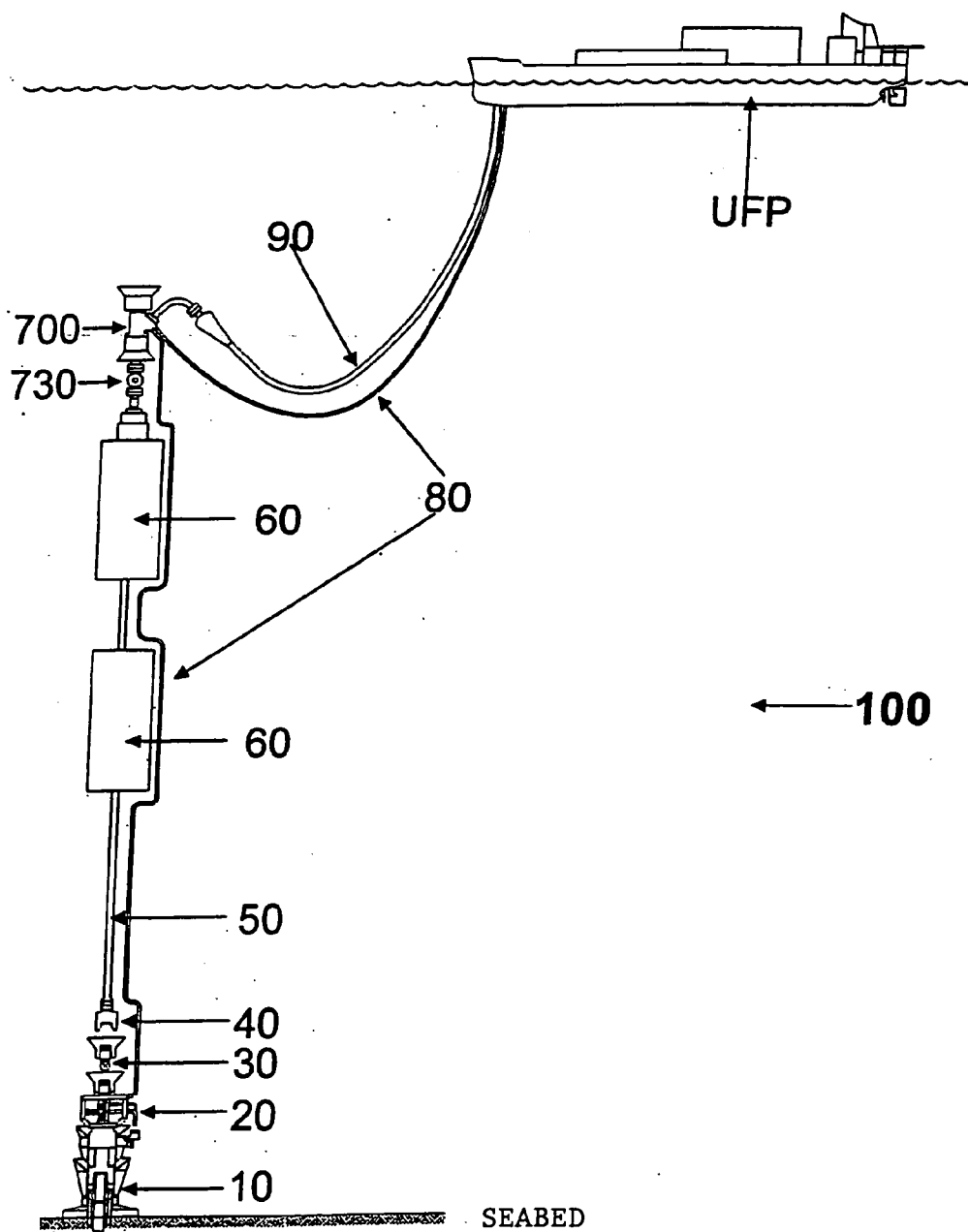


Fig. 1

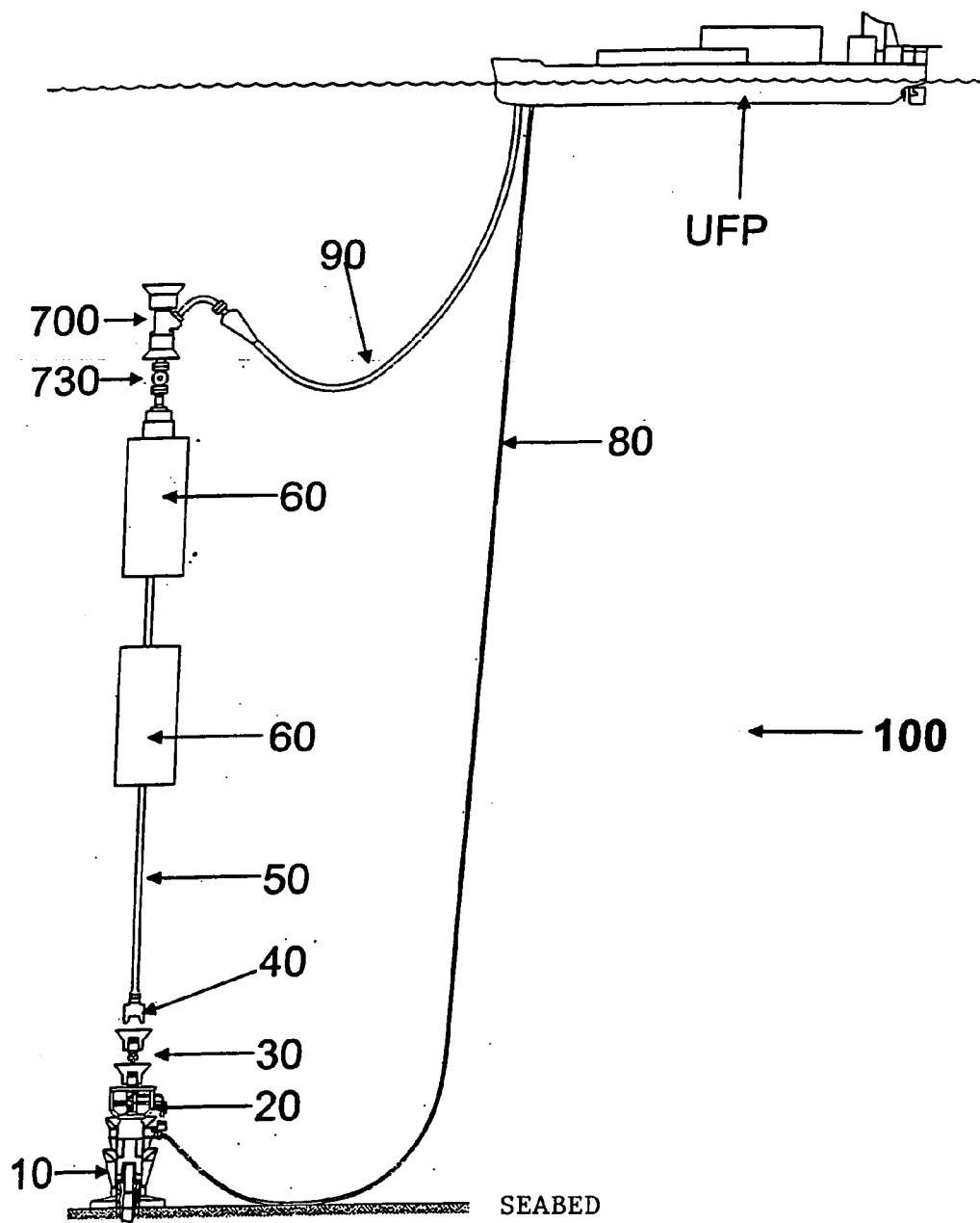


Fig. 2

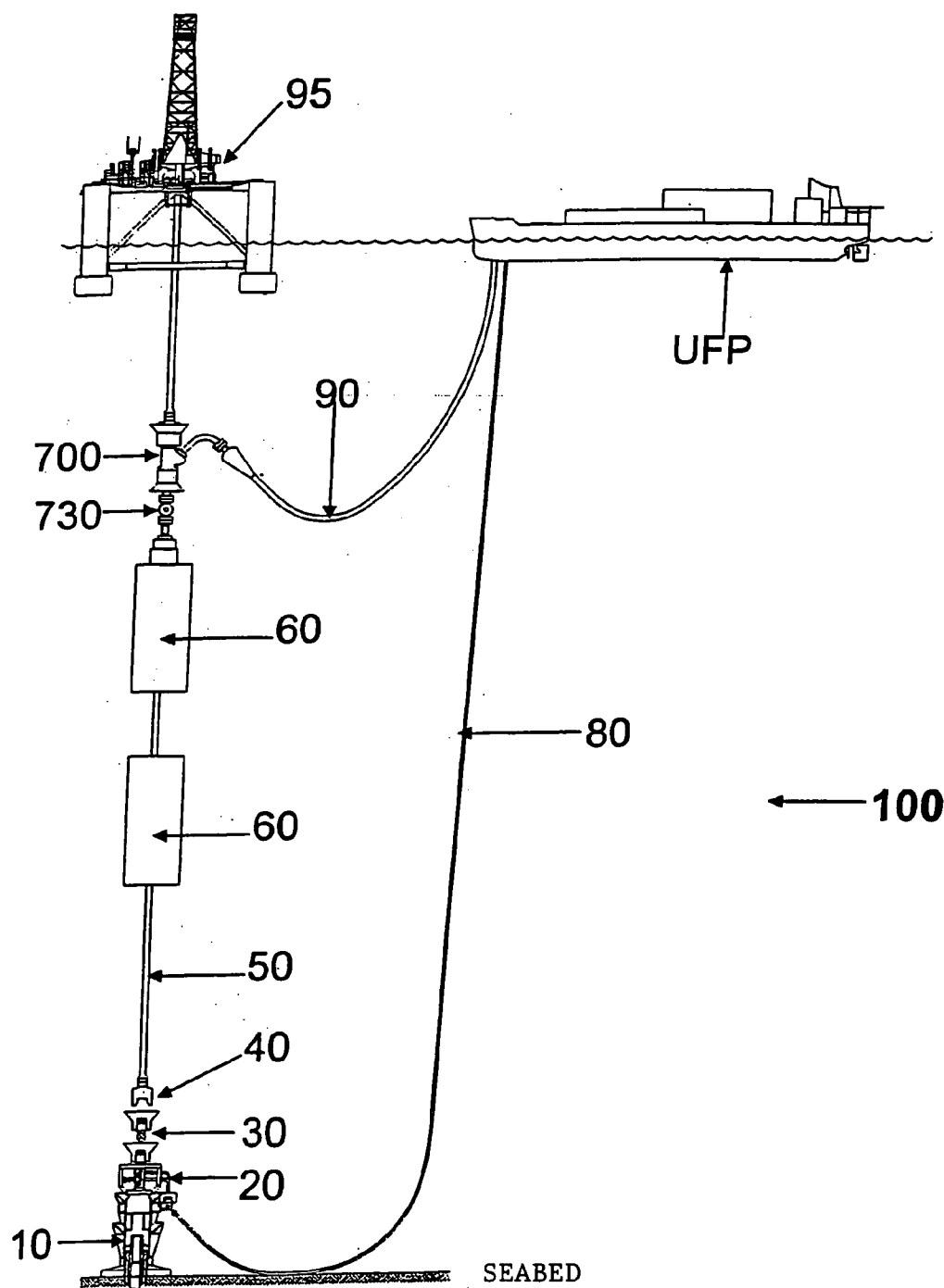
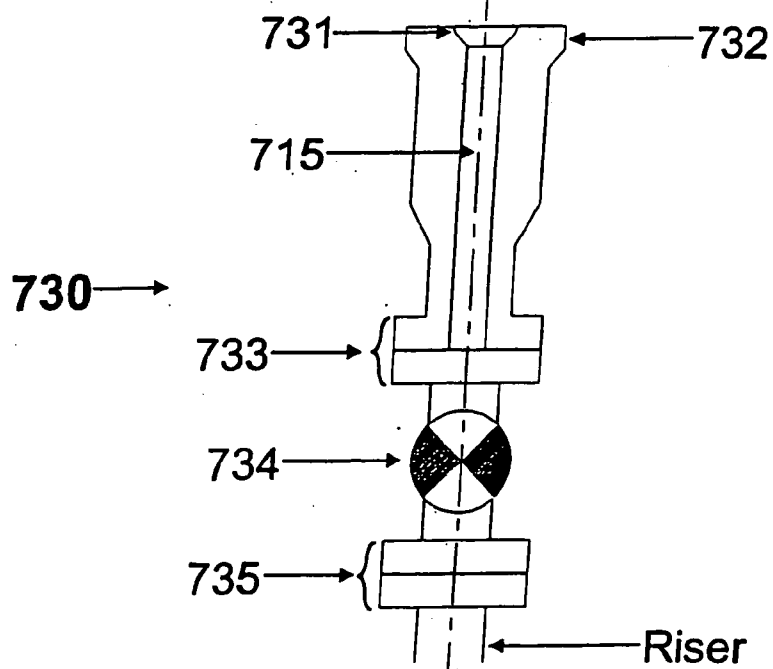
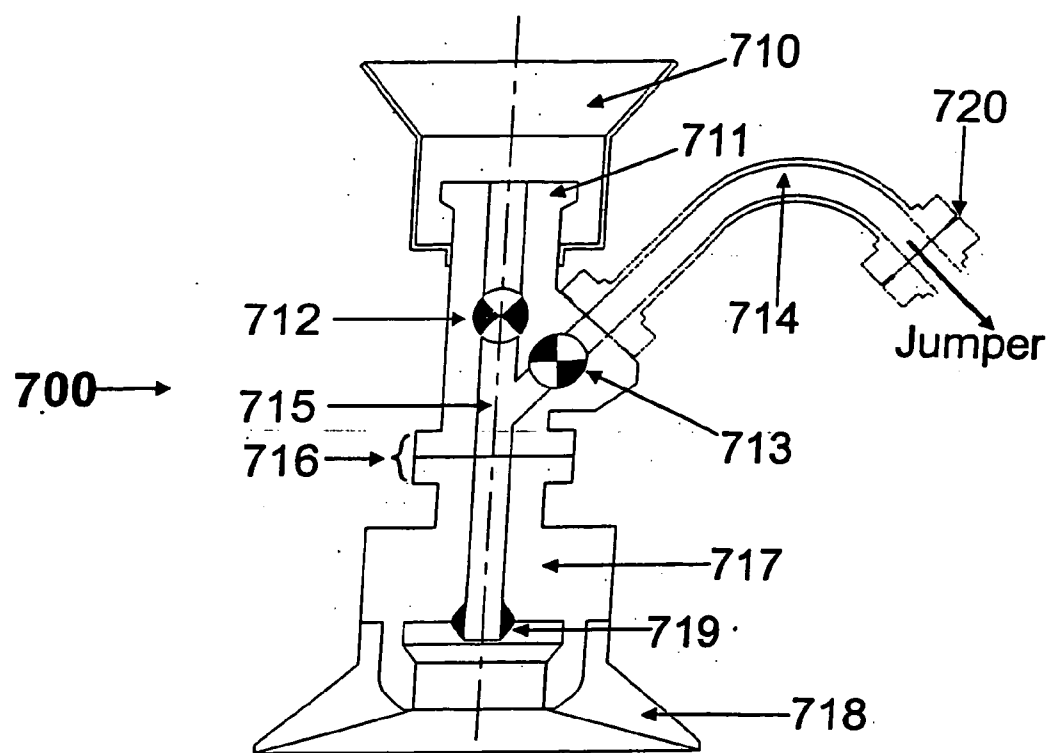


Fig. 3



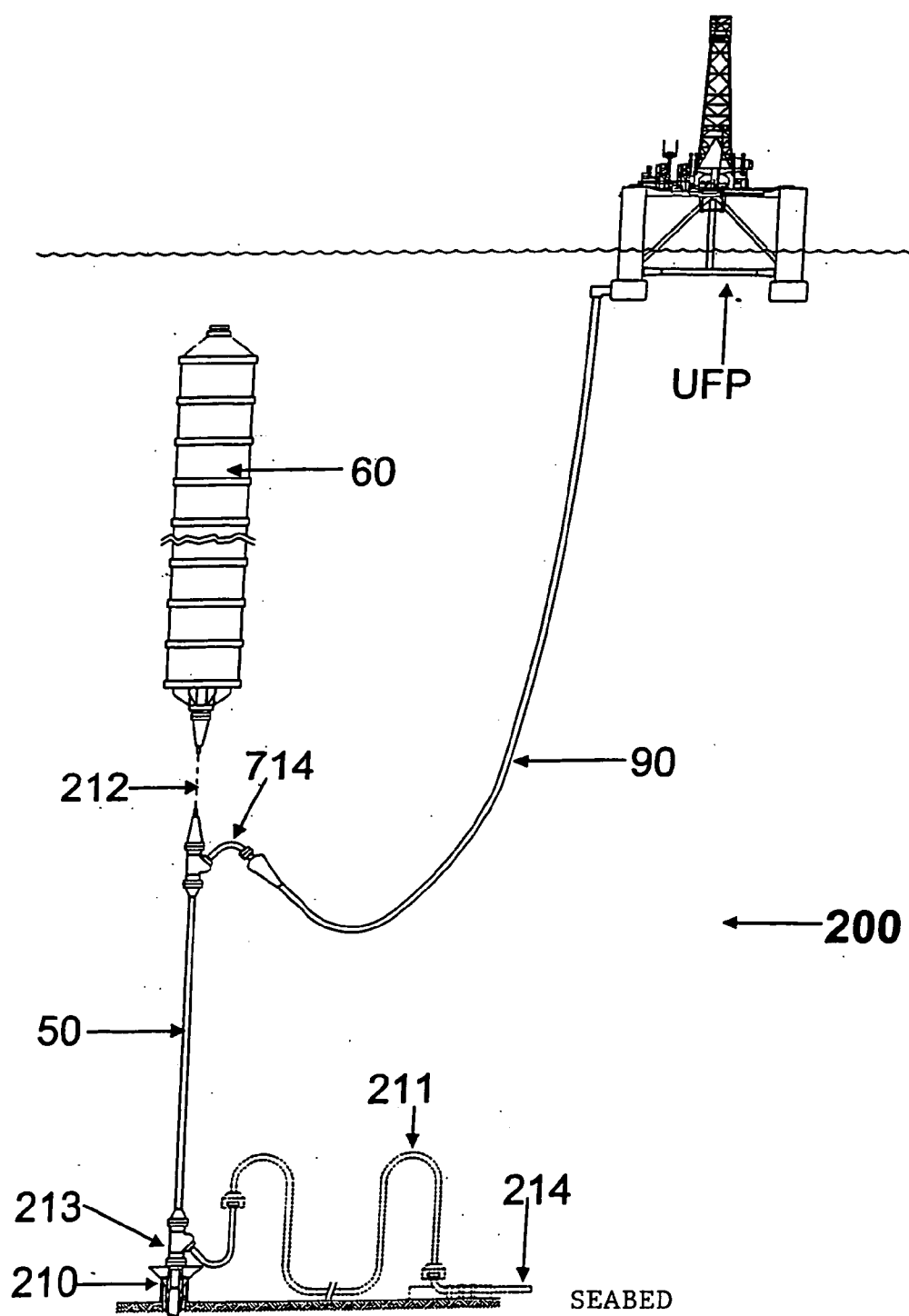


Fig. 5

PRIOR ART

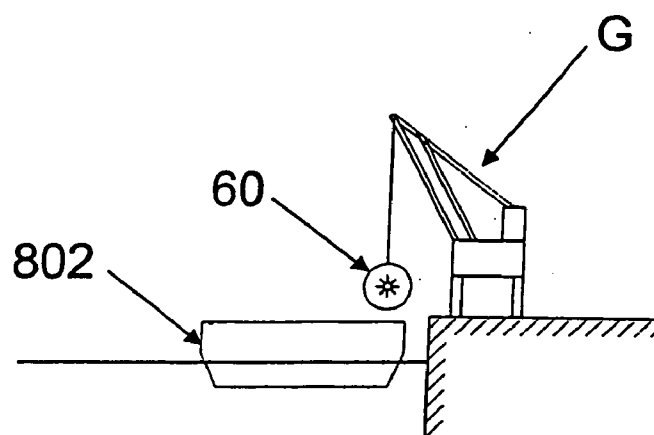


Fig. 6

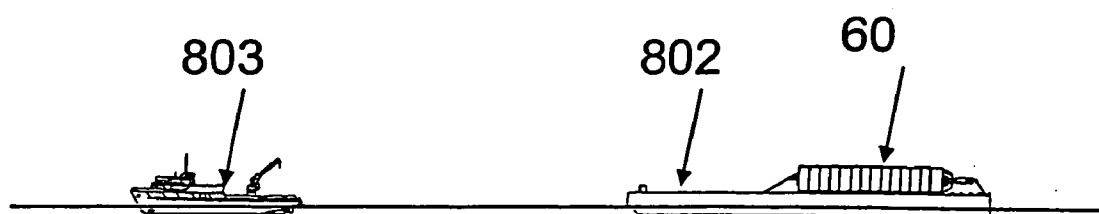


Fig. 7

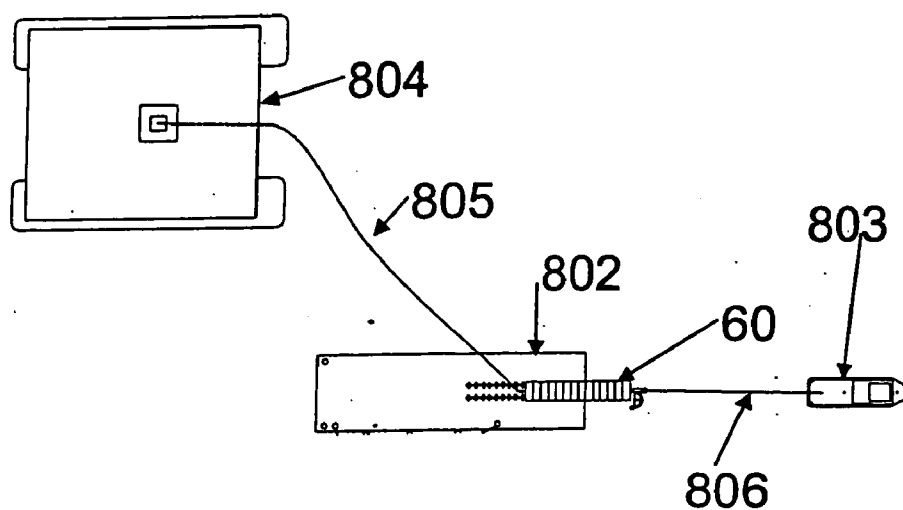


Fig. 8

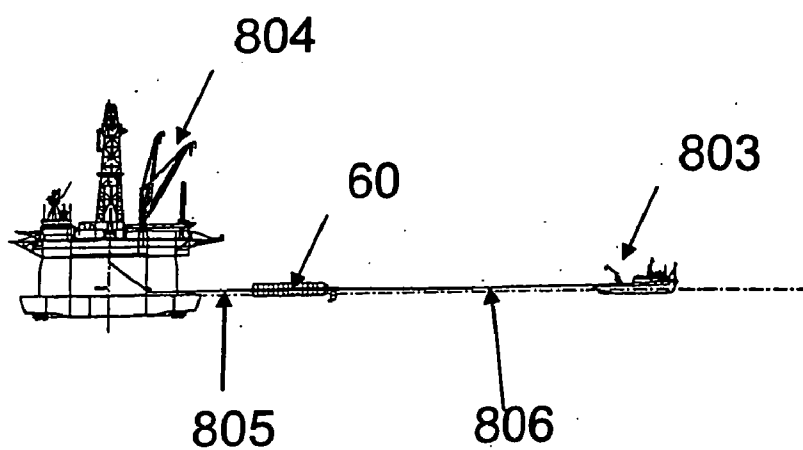


Fig. 9

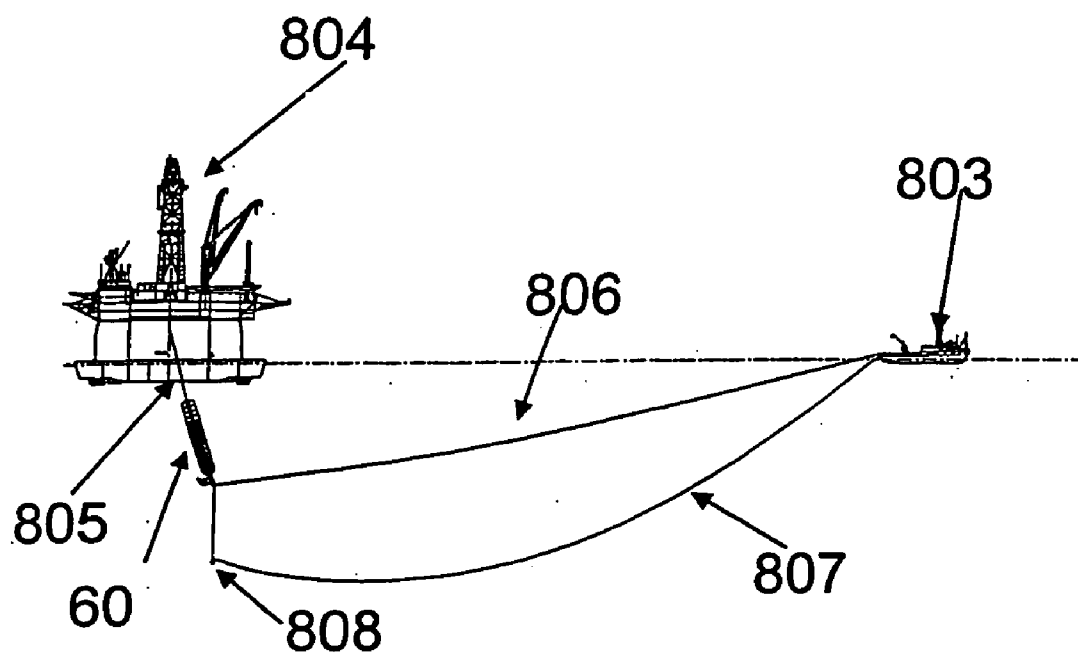


Fig. 10

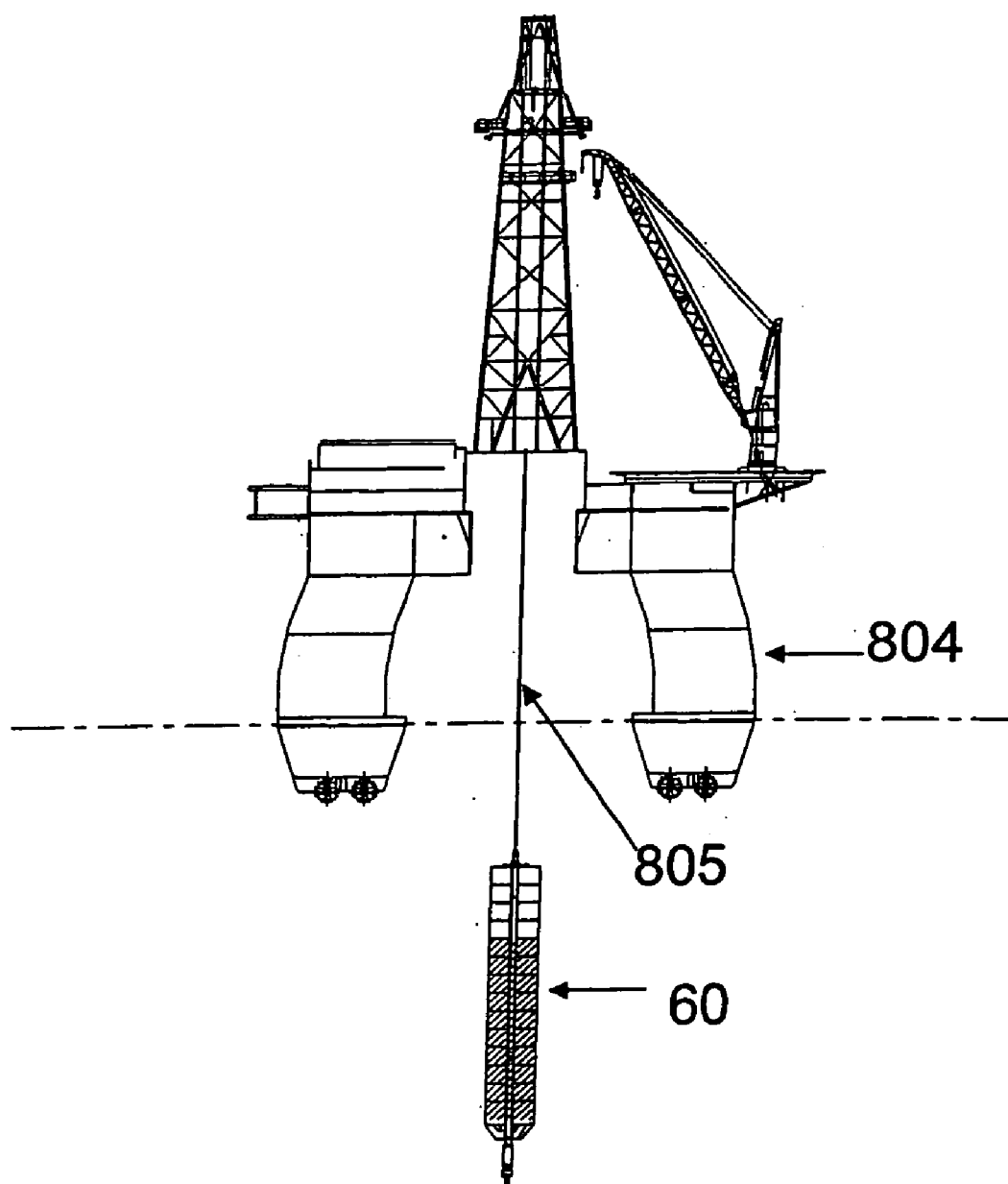


Fig. 11

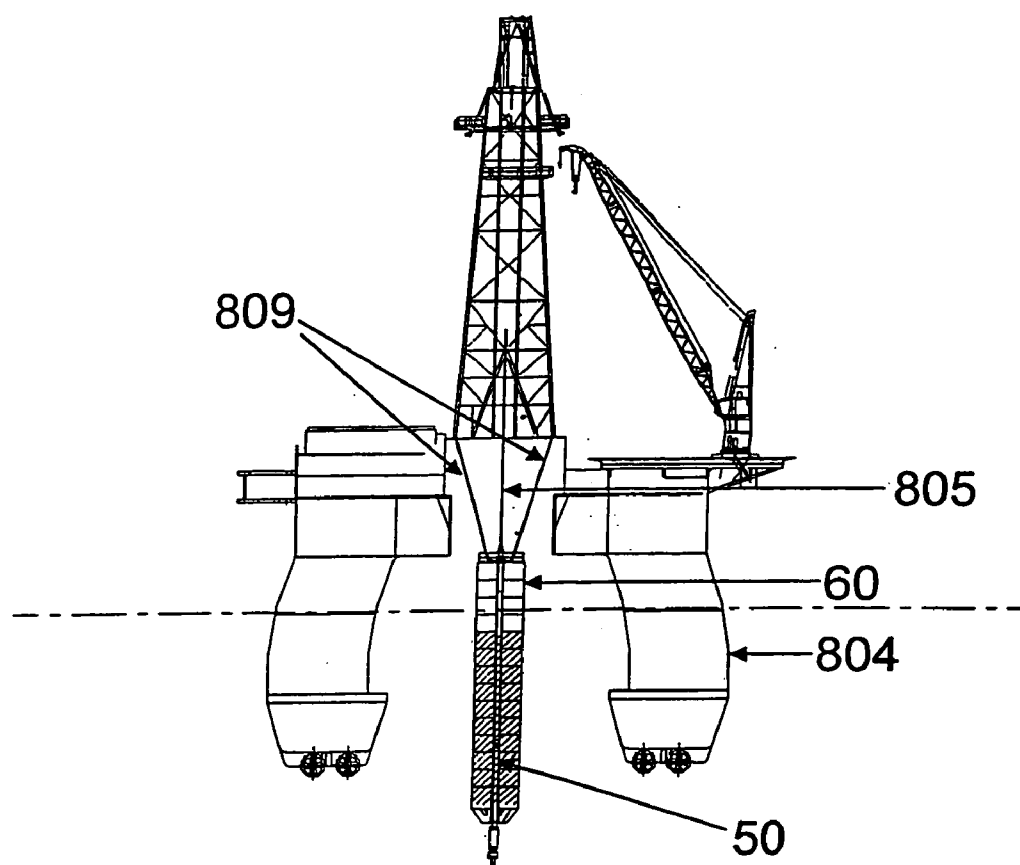


Fig. 12

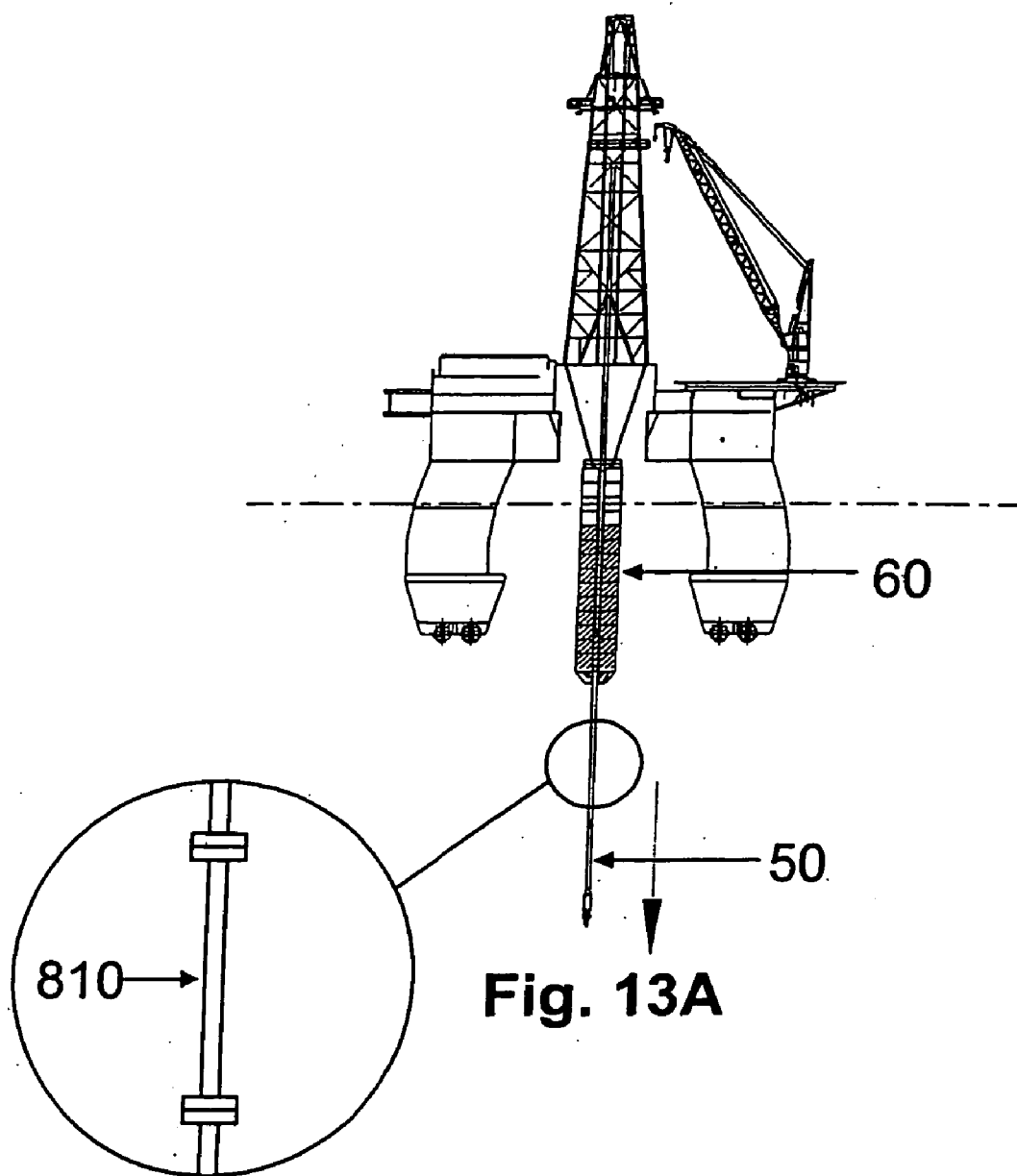


Fig. 13A

Fig. 13B

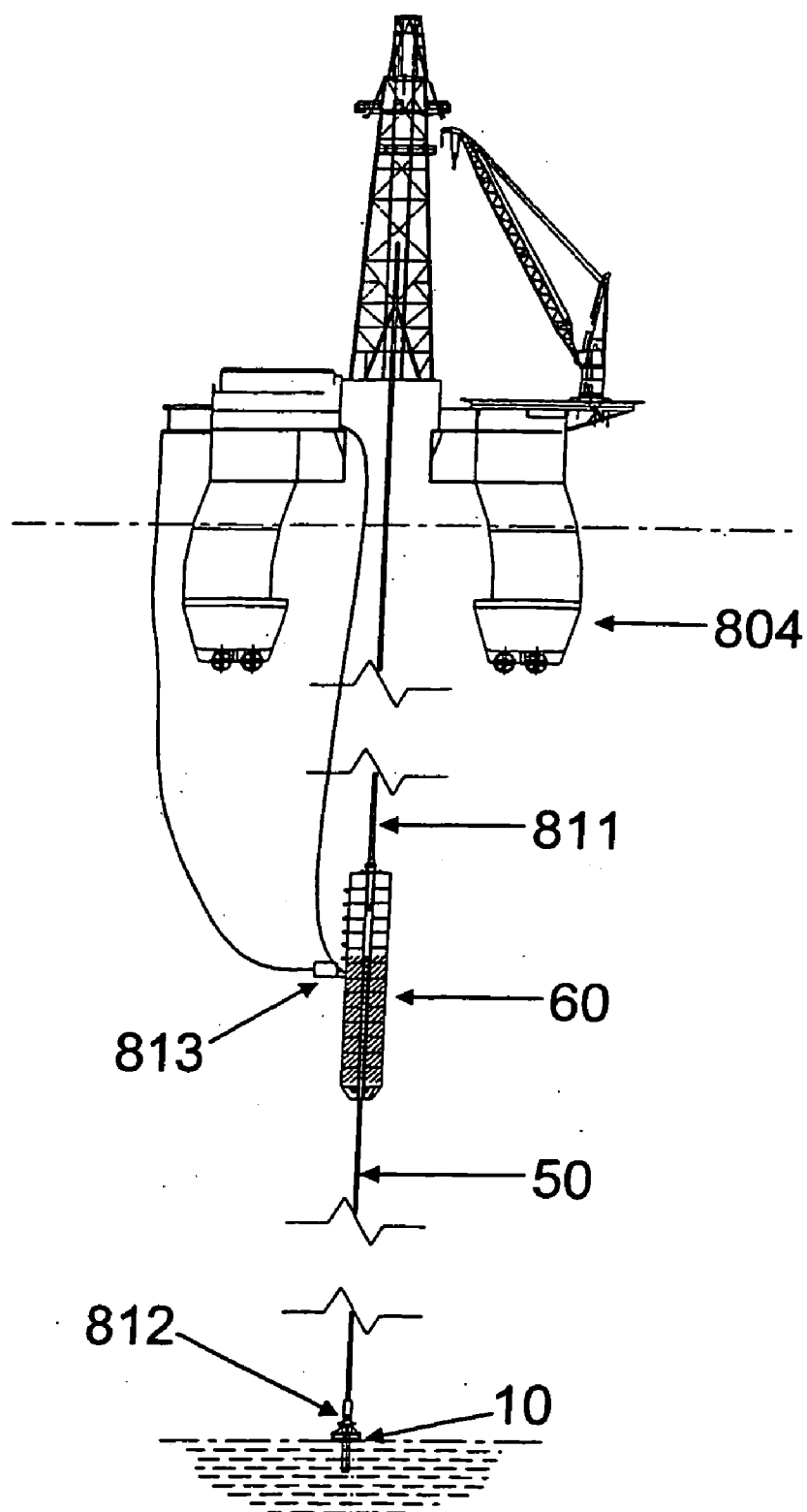


Fig. 14

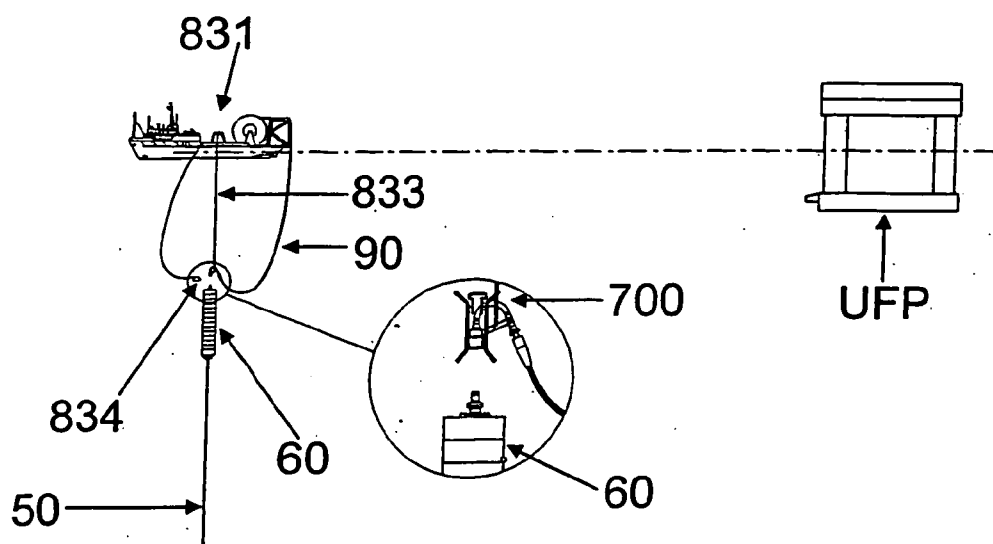


Fig. 15

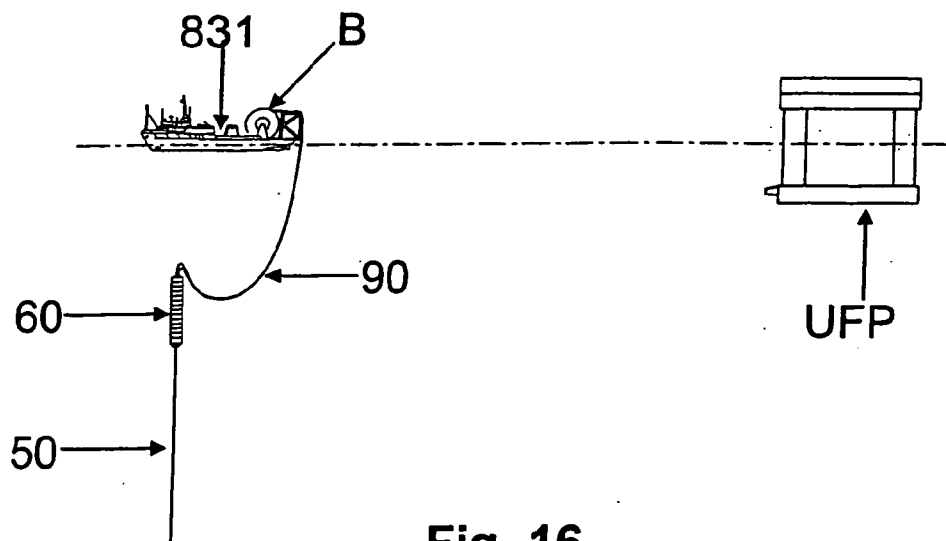


Fig. 16

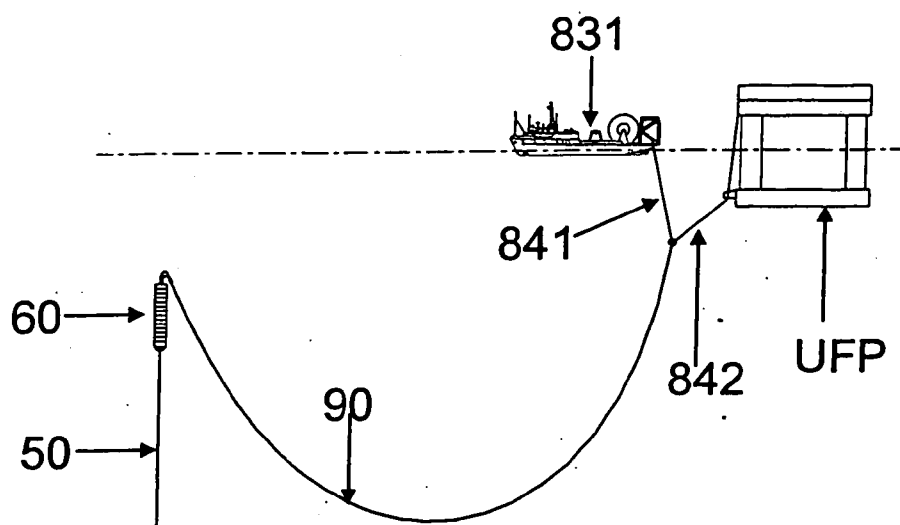


Fig. 17

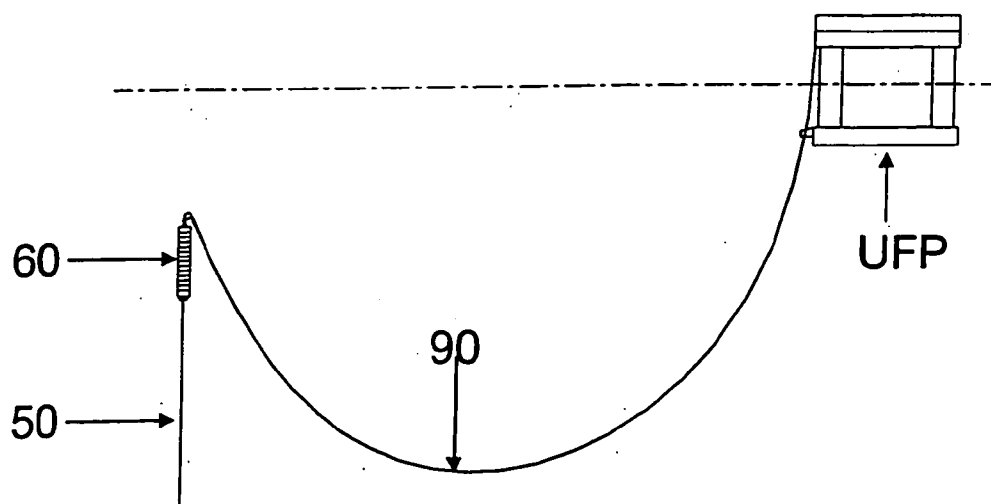
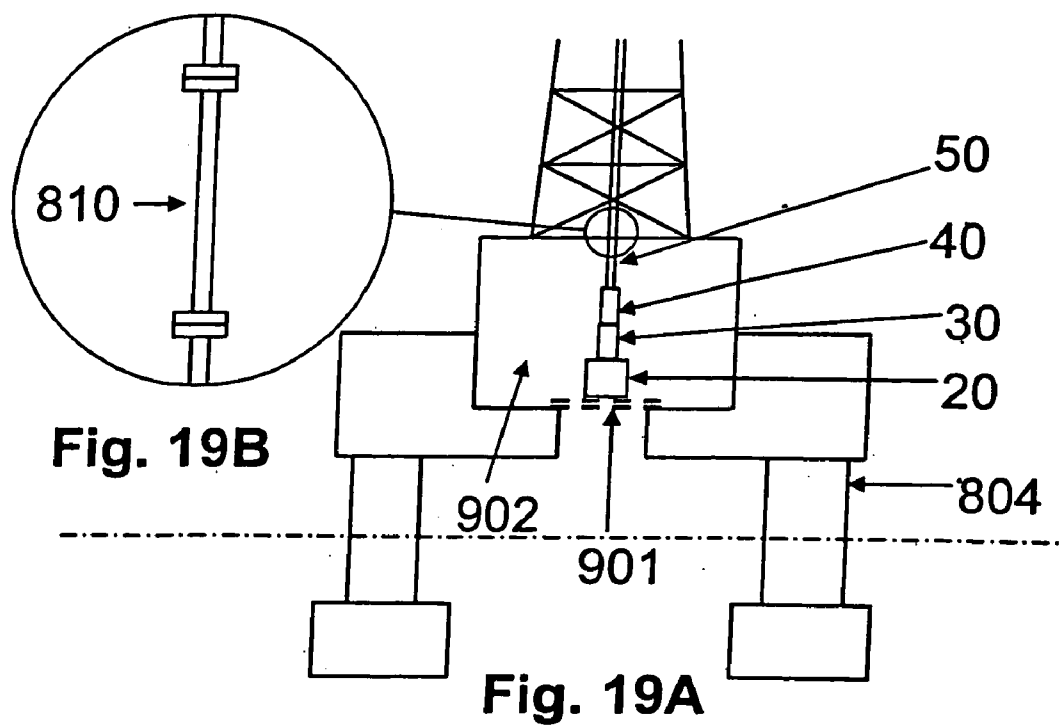
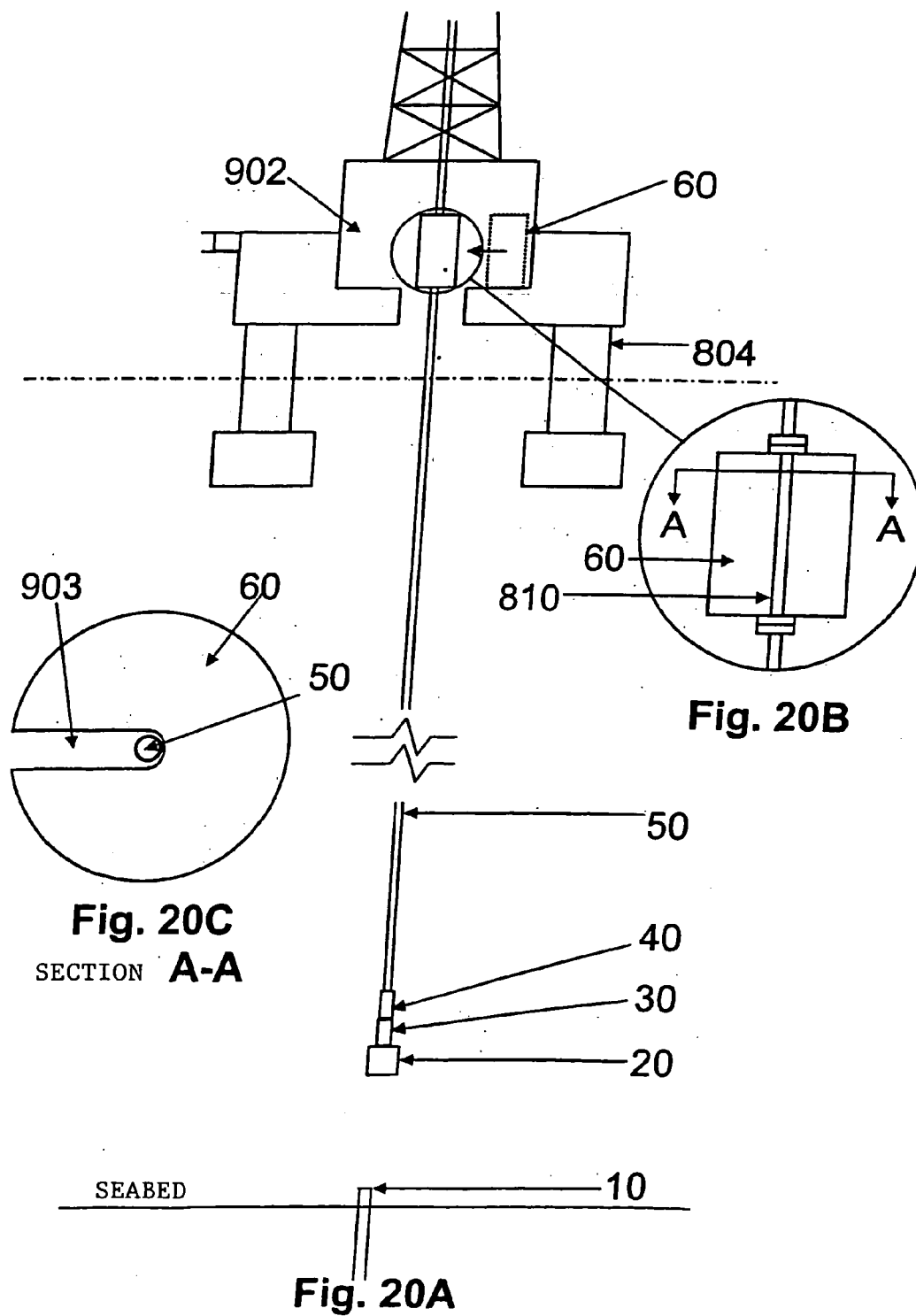


Fig. 18





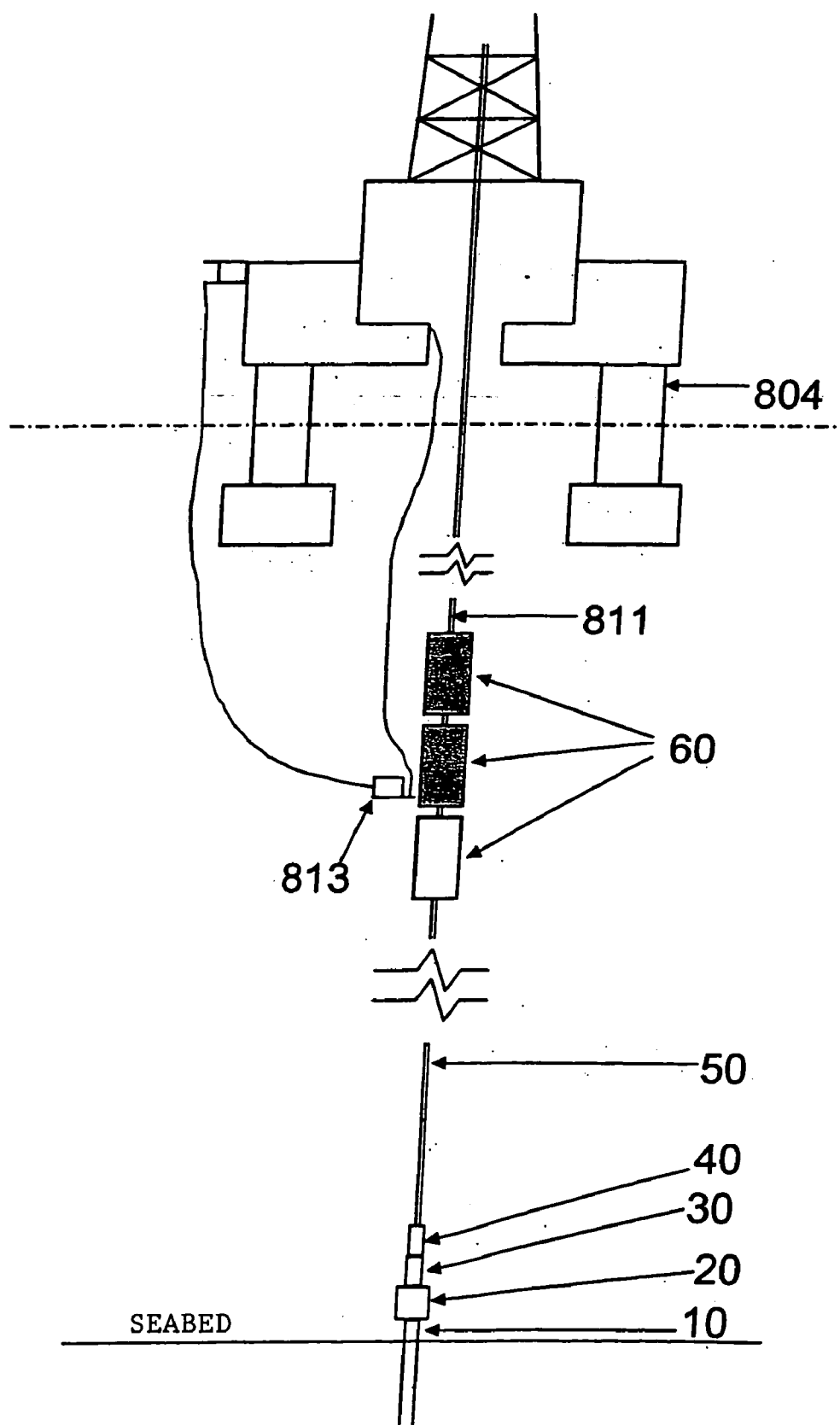


Fig. 21

SELF-SUPPORTED RISER SYSTEM AND METHOD OF INSTALLING SAME

FIELD OF THE INVENTION

[0001] The present invention relates to a system of a self-supported riser, and more specifically, to a system where a riser is coupled at its lower end to equipment of the type known as a WCT—Wet Christmas Tree or a manifold, the riser being supported in an straight position (vertically) by a group of buoys located proximate the upper end of the riser, which also comprises a Submarine Intervention Unit connected to a Floating Production Unit (FPU) through a flexible jumper. The invention is to be applied in Anticipated Production Systems (APS), in Long Duration Tests (LDT) for better evaluation of reservoirs and may also be used as a completion riser. The present invention further relates to a method for installing of said self-supported riser system.

BACKGROUND OF THE INVENTION

[0002] One of the production systems presently utilized by the Applicant employs a production system which utilizes a dynamically positionable offshore vessel fitted with a derrick, and a riser constructed of threaded sections of drill pipe. The riser stability is provided by the traction applied to the top end of the riser by a vessel tension device which is located beneath the derrick. This production system is characterized by its high operational cost, in as much as it utilizes a vessel of low availability in the world service market.

[0003] The self-supported riser system concept is known in the art and is utilized in production as well as in completion systems. For example, U.S. Pat. No. 4,234,047 (hereinafter the '047 reference) describes the use of a self-supported drilling riser utilizing inflatable buoys installed in the upper end of the riser, permitting a quick disconnection of the floating vessel with upper segment while the lower segment riser remains buoyantly in place, on the sea bed, in a vertical position. Although the specification of the '047 reference does not explicitly address this technical aspect, the use of a drilling rig and a compensator are necessary for the handling of the upper segment of the riser, as may be seen in the figures accompanying this reference.

[0004] A flotation riser free-standing, containing various annular chambers to control buoyancy is described in U.S. Pat. No. 4,646,840. Only anchored vessels may be used in this configuration since there is no unwinding system or solution which provides the function of a swivel. The arrangement described in U.S. Pat. No. 4,646,840 provides little practicability for lowering a WCT utilizing a production riser.

[0005] U.S. Pat. No. 4,762,180 describes a configuration with a wellhead, a riser, a riser tensioning buoy and a WCT on top of the buoy. This configuration is not suitable for a LDT since after the referenced test it is intended to achieve production of the well with typical equipment and configurations, namely a wellhead, a submarine WCT, a production column supported at the ocean bed and finally a riser in ascendant catenary to the FPU.

[0006] U.S. Pat. No. 5,046,896 describes a riser with air filled buoys instead of rigid buoys (rigid steel cans). This concept, although not directly addressed in the specification

of the patent, also requires a drilling rig and a compensator for handling the top section of the riser.

[0007] It is appropriate to stress that in all the references mentioned above, the technologies therein described require that the vessel be fitted with a drill and compensator for handling the upper section of the riser (i.e., the section above the point of disconnection).

[0008] U.S. Pat. No. 6,082,391 and U.S. Pat. No. 6,321,844 both describe an instrument to transport petroleum products in deep water from the ocean bed to a floating structure at the surface, where at least one rigid and straight riser is vertically extended. The hybrid riser comprises a central rigid tubular section surrounded by a cylindrical block of syntactic material which provides both buoyancy and thermal insulation to the riser. A plurality of rigid ducts is inserted in the syntactic material to surround a central structure for receiving petroleum products from the seabed. Flexible pipes connect rigid pipes in the riser to the floating structure. The prior art rigid riser does not foresee passage through the floating reservoir as in the present invention or the configuration of the inflatable buoys. In addition, a riser containing several ducts (conveyance pipes) and an insulation system, constructed and assembled at a dry enclosed location (on land) can prove troublesome and quite limited once it is relocated and installed in place, since the procedure of soldering joints cannot be adapted for variable water depths (WD), such procedure being limited to specific and fixed water depths (WD).

[0009] Applicant's Brazilian application PI 0301255-7, incorporated herein by reference, describes the installation and retrieval by cable of a subsea pumping module, coupled to a WCT, in order to recover the oil produced.

[0010] Hence, in spite of the technological advances in the area, there is a continuing need for an self-supported riser system comprised of interconnected sections forming a unit, this unit being coupled at the lower end to a subsea equipment type WCT or manifold and at the upper end to a buoy assembly, the riser being fitted with a Subsea Intervention Unit for ease of access and maintenance of the well, for easy installation and retrieval and adapted for different water depths (WD), such riser system and associated installation method being described and claimed in the instant specification.

SUMMARY OF THE INVENTION

[0011] In a broad sense, the invention is comprised of a self-supported riser system used in both an Anticipated Production System (APS) and in a Long Duration Tests (LDT) in offshore petroleum production utilizing a WCT and a Floating Production Unit (FPU), such a system including:

[0012] A riser, including sections or joints connected one to another, with the lower end of the riser being coupled to an WCT or a manifold and the upper end being coupled to tensioning buoy assembly that maintains the rise straight and in an approximately vertical position;

[0013] A rigid buoy assembly, inflatable buoys or a combination thereof, with instrumentation for controlling variable buoyancy;

[0014] A Submarine Intervention Unit suited for connecting the riser upper-end with an Intervention Unit.

[0015] A flexible jumper between the Submarine Intervention Unit and the Floating Production Unit, for production conveyance.

[0016] An umbilical for controlling, monitoring and transmitting electrical and hydraulic power; connecting the UFP to the WCT, supported by the riser or alternately, by means of a free catenary, wherein;

[0017] i) the riser is installed internally within the buoy assembly;

[0018] ii) the riser coupling to the Submarine Intervention Unit, with the assistance of this Unit, permits vertical access to the well in order to perform well maintenance; and

[0019] iii) The riser is used to lower and install the WCT, a procedure which saves rig time and reduces maneuvering steps.

[0020] The installation method of the self-supported riser system will be described in detail below. Furthermore, the specification will outline the characteristics of ease of retrieval, transport and installation of the invention in a new location.

[0021] The present invention provides a self-supported riser system to be utilized in an Anticipated Production System or Long Duration Test, utilizing a riser which comprises interconnected joints or sections, with the lower-end being connected to a WCT or a manifold and the upper-end being connected to a buoy assembly which maintains the riser straight and in an approximately vertical position.

[0022] The present invention also provides a self-supported riser system to be utilized in an Anticipated Production System or in a Long Duration Test wherein the upper end of the riser is connected to a Submarine Intervention Unit, which permits well maintenance, while providing vertical access to the well.

[0023] The present invention also provides a self-supported riser system for use in an Anticipated Production System or in a Long Duration Test in which the riser is used to lower and install the WCT, thereby saving rig time and reducing the maneuvering steps.

[0024] Additionally, the present invention provides a self-supported riser system for use in an Anticipated System Production or in Long Duration Test wherein the system is positioned internally within the buoy assembly.

[0025] The present invention also provides a self-supported riser system for use in an Anticipated Production System or in a Long Duration Test having a double function: a production riser supported by a buoy assembly and alternately a completion riser, without the use of the buoy assembly.

[0026] In addition the instant invention provides a self-supported riser system for use in an Anticipated Production System or in a Long Duration Test with a Subsea Intervention Unit thereby permitting a disconnection of the jumper for maintenance purposes.

[0027] The present invention also provides a self-supported riser system to be utilized in an Anticipated Produc-

tion System or in a Long Duration Test which permits surge production, as well as production utilizing a pumping module connected to the WCT.

[0028] The present invention also provides an installation procedure for the self-supported riser system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] FIG. 1 is schematic view of an embodiment of the invention with an umbilical in a free catenary supported by the riser.

[0030] FIG. 2 is a schematic view of another embodiment of the invention, with the umbilical in free catenary.

[0031] FIG. 3 is a schematic view of the invention shown in a condition of intervention, i.e., with an intervention rig connected to the Submarine Intervention Unit.

[0032] FIG. 4 is a schematic view of the Submarine Intervention Unit, or a workover operation.

[0033] FIG. 5 is a schematic view of a prior art self-supported riser system.

[0034] FIGS. 6-18 illustrate a method of installing the self-supported riser system of the instant invention.

[0035] FIG. 6 illustrates the hoisting of the buoy assembly to be transported by a raft.

[0036] FIG. 7 illustrates a tug transporting the raft and the assembly of buoys to the installation location of the riser system.

[0037] FIG. 8 illustrates the connection of the buoy assembly to a semi-submersible platform, followed by the process of sliding the assembly of buoys over the raft deck with the assistance of a tug.

[0038] FIG. 9 illustrates the separation of the raft from the buoy assembly, the latter being connected, in a free floating mode, to the semi-submersible platform and the tug.

[0039] FIG. 10 illustrates the process of keel hauling (cargo transfer operation) from the buoy assembly under the semi-submersible platform.

[0040] FIG. 11 illustrates how, at the end of the keel hauling process, the buoy assembly is supported by the derrick of the semi-submersible platform through the means of a cable.

[0041] FIG. 12 illustrates how the upper end of the buoy assembly is brought to the moon pool area of the semi-submersible platform and the weight of the buoy assembly is transferred to the steel tensioning cables of the drilling system of the semi-submersible platform.

[0042] FIG. 13 illustrates how, after the cable which supports the buoy assembly is disconnected, the riser joints, which form the riser system, are connected and lowered through the inside of the buoy assembly until the required riser length is obtained.

[0043] FIG. 14 illustrates the lowering of the buoy assembly to the operational depth and the connection of the riser to the wellhead at the seabed, while air is injected into the buoy assembly.

[0044] FIG. 15 illustrates the installation process of the production flexible jumper and the connection of the Subsea Intervention Unit to the buoy assembly with the aid of a flexible pipe launch vessel.

[0045] FIG. 16 illustrates how, after the connection of the jumper, the flexible pipe launch vessel navigates towards the (FPU) while unwinding the reel of stowed jumper.

[0046] FIG. 17 illustrates the transfer of the end of the jumper to the FPU with the aid of auxiliary cables.

[0047] FIG. 18 illustrates the self-supported hybrid riser system installed and ready for operation.

[0048] FIGS. 19 to 21 illustrate another embodiment of the method of installation of the riser system of the present invention.

[0049] FIG. 19A illustrates the connection of the production riser to a connection tool. FIG. 19B is a detail illustrating a riser joint.

[0050] FIG. 20A illustrates the connection and lowering of the riser joints and the buoy assembly. FIG. 20B is a detail of the riser joint connected to a buoy of the assembly of buoys and FIG. 20C shows a transversal section of the encasement of the coupling of the riser joint with the buoy assembly.

[0051] FIG. 21 shows the lowering of the assembly of buoys and the connection of the lower end of the riser to the wellhead at the seabed.

DETAILED DESCRIPTION OF THE INVENTION

[0052] In accordance with the invention, as set forth in the specification and claims of the instant application the following terms are defined as follows:

[0053] Long Duration Test (LDT): is a test of a well wherein the production is collected at the FPU during a period of 2 to 6 months and periodically transported to a storage terminal located on land.

[0054] Anticipated Production System (APS): a provisional system intended to operate a few producing wells until the main production system is operational.

[0055] As is described in the instant specification, the instant invention refers to a self-supported riser system.

[0056] A first depiction of the invention is the self-supported riser itself.

[0057] The invention will be described with reference to the attached drawing figures.

[0058] FIG. 1 shows a general configuration of an embodiment of the invention depicted with an umbilical supported by the riser.

[0059] In accordance with FIG. 1, the self-supported riser system, generally designated by the number (100), comprises a wellhead (10) at the seabed, connected to an WCT(20) provided with a blow-out preventor, (hereinafter, the workover BOP)(30), the workover BOP(30) being connected to a production riser (50) by a connection device (40). The riser (50) is maintained under tension with the aid of an assembly of buoy assembly (60).

[0060] The riser system (100) eliminates the need for a physical link to any vessel in order to provide structural stability of the system, or to assure its coupling to the subsea equipment.

[0061] The system assembling is performed in such a way such that the riser (50) is internal to the buoy assembly (60).

[0062] The upper end of the riser (50) is linked to a FPU by a flexible jumper (90) for conveying the produced oil to this FPU.

[0063] The riser (50) is formed of joints or sections joined by threads or a mechanical connector. The riser is connected at its lower end to a WCT (20) and at its upper end to a buoy assembly (60) that apply a buoyant force which tractions the column of the riser (50).

[0064] The buoy assembly (60) may include buoys of various types, such as inflatable buoys, rigid solid buoys, rigid air filled buoys, or other types of buoys. The buoy assembly (60) may comprises similar buoys or of any other types of buoys.

[0065] The buoy assembly (60) should permit variation in the total buoyancy force applied to the riser (50) since the buoy assembly should be preferably installed and retrieved without a buoyancy load acting on the buoys (waterlogged or uninflated condition). Only after assembling and subsea coupling, are the buoys inflated to create the necessary buoyancy. In addition, the number of buoys used is variable, according to the water depth (WD) at which the riser (50) is to be installed.

[0066] In the present invention, the use of inflatable buoys is preferred inasmuch as an inflatable buoy is easily manipulated, due to its low weight and dimensions, when uninflated, and furthermore, because it may be inflated below the moon pool of the rig, where limited space is available.

[0067] The functions of controlling, monitoring and transmission of electrical and hydraulic energy are accomplished with the aid of an umbilical (80). The umbilical (80) may be supported by the riser (50) as shown in FIG. 1 or, alternately it may be installed in the free catenary mode as shown in FIG. 2. The umbilical (80) should comprise sections, to permit varied lengths in accordance to the WD where the system will be installed. For example, sections of 1,300 meters, 1,000 meters, 600 meters, 300 meters, and 100 meters may ease the construction of an umbilical assembly of a required length.

[0068] FIG. 3 shows an embodiment with the intervention rig (95) coupled to a Subsea Intervention Unit (700), wherein the system is positioned over a buoy assembly (60).

[0069] The Subsea Intervention Unit (700) connects the upper-end (730) of the riser (50) to the intervention rig (95).

[0070] As illustrated in FIG. 4A, the Subsea Intervention Unit (700) includes a superior guide funnel (710) and is fitted with an internal mandrel (711) for coupling to the intervention tool. An intervention valve (712) is positioned in the Unit (700), over the "Y" joint for conveyance of the production fluid. A production valve (713) is located at the production pipe. Secured thereto is a curved section (714), shaped as a gooseneck, within which the production fluid flows. The section (714) is connected to a flexible jumper (90) through a connection structure such as a flange (720).

The Subsea Intervention Unit (700) is fitted with a passage (715) for the production fluid and any intervention device.

[0071] The mandrel (711) is linked to a connector (717) by means of a device (716) such as a flange.

[0072] The connector (717) links the unit (700) to terminal (730) at the upper-end of the riser of FIG. 4B. The connector (717) is provided with a funnel guide to facilitate coupling to the terminal (730).

[0073] The central part of the connector (717) is fitted with a metallic sealing ring (719), adapted with a recess (731) shaped for coupling to the mandrel at the terminal (730). As is depicted in FIG. 4B the mandrel (732) is linked to the connector (717). The mandrel (732) connects to an isolation valve (734) off of the riser (50) through a connection device (733), such as a flange. A connection device (735) links the valve (734) to the riser (50) upper-end. The isolation valve (734) of the riser (50) upper end is utilized to isolate the content of the riser (50), thereby permitting the retrieval of unit (700) for maintenance.

[0074] When a need for workover procedures occurs at the wellhead (10), the valve (713) is closed and any equipment is lowered or retrieved through the riser (50), with valve (712) open.

[0075] Furthermore, the unit (700) permits the retrieval and maintenance of the jumper (90) inasmuch as the jumper is connected to the buoy assembly (60). The closure of the valve (734) permits an uncoupling of the unit (700) from terminal (730) for maintenance of any type.

[0076] In a manner distinct from the state of the art, the instant self-supported riser system (100) incorporates the use of a threaded riser in a self-supported configuration, directly coupled to the subsea equipment, dispensing with the need for a towered vessel.

[0077] Furthermore, distinct from the state of art, the Subsea Intervention Unit (700), coupled to the top of the self-supported riser system (100), permits a workover in the well through the interior of the riser (50), avoiding the need of retrieving the riser system (100) and the flexible jumper (90).

[0078] The FPU may be of the FPSO (Floating Production Storage and Offloading) type. This vessel, which may be anchored or may be of the DP (Dynamic Positioning) type, does not necessarily require a tower. In case of the DP type vessel, it will be necessary to install an extra component, e.g., a swivel, which will be required to avoid the rotation of the conjoint flexible jumper (90)/riser (50). It follows that during continuous operation the vessel may rotate along its own vertical axis. The swivel may be installed on the upper end of the riser (50) or at the entrance of the FPU (the preferred position for the construction of the invention), since the maintenance and inspection of the swivel are facilitated, and the swivel operates under lower external pressure.

[0079] The preferred use of the self-supported riser system of the invention is as a production riser.

[0080] Alternatively, this system also may be used as a completion riser, without the accompanying buoy assembly (60).

[0081] The invention may also be used for surge production.

[0082] Alternatively, the riser system (100) may be used with any pumping method of upstream. In this case, the production of the oil is accomplished through a subsea pumping module coupled to the WCT, the aforesaid module being installed and retrieved via cable, as described in Applicant's Brazilian Patent application PI 0301255-7.

[0083] The advantages of the present riser system (100) include:

[0084] the possibility of lowering the WCT (20) utilizing the riser (50) itself;

[0085] the riser (50) is coupled to the WCT (20) and to the buoy assembly (60);

[0086] the terminal (700), permits workover the well, vertically, thereby dispensing with the need of removing/retrieving any components of the riser system (100);

[0087] the riser (50), being inside of the buoy assembly (60), simplifies the construction, assembly and installation of the riser system (100).

[0088] The characteristics of the instant riser system (100) permit its use up to water depths (WD) of 3,000 meters.

[0089] FIG. 5 shows an embodiment of a self-supported riser system consistent with the state of art.

[0090] In accordance to FIG. 5, the stability of the system, generally designated by the numeral (200), is provided by the pushing action provided by the buoy assembly (60) and applied to the upper end of the riser (50) by means of a tie (212). A flexible jumper (90) connects the end of the pipe (714) to the FPU. The lower end (213) of the riser (50) is connected to a foundation (210). A spool (211) is used to connect the extremity (213) to a pipe (214) installed at the seabed.

[0091] The embodiment (200) shown in FIG. 5 requires the construction of a foundation (210), whose function is solely to anchor the riser (50), thereby supporting the loads which the riser transmits. In the invention, it is not necessary to build a foundation (210), since the wellhead (10) itself is mechanically able to support and anchor the loads necessary to maintain the riser straight and stable.

[0092] In this way, the riser system (100) of the invention presents the following aspects which distinguish it from the state of art:

[0093] eliminates the need for constructing a foundation (210);

[0094] avoids the need to construct and install spools (211) interlinking the well to the base of the riser (50).

[0095] the riser (50) utilizes mechanical connectors and may be installed by the means of a rig during the lowering operation of the WCT (20);

[0096] the upper-end of the riser (50) possesses a subsea intervention unit (700) which permits the workover in the well while avoiding the need of removing the entire riser system (100);

- [0097] the upper-end of the riser (50) possesses a unit (700) which permits the retrieval of the jumper (90) for maintenance. The existing state of the art equipment does not permit the easy disconnection of the jumper (90);
- [0098] renders unnecessary the FPU with DP system and a rig for performing Long Duration Tests or Anticipated Production System procedures;
- [0099] the passage of the riser (50) through the buoy assembly (60) permits easy access to the upper-end of the riser (50), with the consequent benefit of direct and vertical access to the well and use of the unit (700).
- [0100] In another aspect, the invention contemplates a method of installing the riser system (100) which includes two embodiments.
- [0101] In accordance with the first embodiment, generally shown in FIGS. 6 to 18, the installation method of the riser system (100) comprises the following steps:
- [0102] a) hoisting the buoy assembly (60), by means of a crane (G), (FIG. 6), from a dock and placing it in a transportation raft (802). As an alternative, the buoy assembly may be placed on the raft by sliding it on the dock surface. Following the placement on the raft, sea fastening the buoy assembly to avoid dislocation of the buoy assembly on the raft during the oceanic transport;
- [0103] b) transporting the raft (802) and the buoy assembly (60), with the aid of a tug (803), (FIG. 7), to the location at which the riser system (100) is to be installed;
- [0104] c) in the proximity of a semi-submersible platform (804) for lowering the riser (50), (FIG. 8), connecting the buoy assembly (60): i) utilizing a cable (805) to a semi-submersible platform (804) and ii) utilizing a cable (806) connecting the buoy assembly to the tug (803).
- [0105] d) effecting a partial controlled submersion of one of the ends of the transportation raft (802) and displacing the buoy assembly (60) on the deck of the raft (802), while the tug (803) tractions the cable to ease the process of sliding the buoy assembly (60) onto the raft (802), (FIG. 9);
- [0106] e) separating and removing the transportation raft (802) from the location, after the free floating buoy assembly (60) is successfully connected to the semi-submersible installation platform (804) by the means of a cable (805) and to the tug (803) by another cable (806), (FIG. 10);
- [0107] f) effecting the process of keel hauling (cargo transfer) of the buoy assembly(60) under the semi-submersible platform (804) by appropriately maneuvering the cables (805) and (806) and an auxiliary cable (807) linked to the tug (803), which controls an anchor weight (808), connected to the lower end of the buoy assembly (60) such that at the end of the process the buoy assembly (60) will be sustained by the platform tower (804) through the cable (805) (FIG. 11);
- [0108] g) bringing the upper end of the buoy assembly (60) to the moon pool region of the semi-submersible platform (804) and proceeding to transfer the weight of the buoy assembly(60) to steel cables (809) of the tension system of the platform drilling assembly (804), (FIG. 12);
- [0109] h) following the disconnection of the cable (805), connecting and lowering the sections (810) whose conjoint forms the riser (50), inside the buoy assembly (60) until the required length of the riser (50) is reached. Attaching the upper-end of the riser (50) to the upper end of the buoy assembly (60) (FIGS. 13A and 13B);
- [0110] i) lowering the buoy assembly (60) to the operational depth by means of a service or maintenance pipe (811) of the semi-submersible platform (804) and then making a connection (812) of the lower end of the riser (50) to the wellhead (10) on the seabed (FIG. 14);
- [0111] j) injecting air into the chambers of the buoy assembly (60) and expelling the water from those chambers using a remote controlled subsea vehicle ROV (in order to effect a positive buoyancy in the buoy assembly(60), having determined the air volume required for riser stability (50);
- [0112] k) disconnecting the tubing (811) utilized for the lowering of the buoy assembly (60) and removing the semi-submersible platform (804) from the location;
- [0113] l) with the aid of a flexible line launch vessel (831) installing the production flexible jumper (90) and the Subsea Intervention Unit (700), which is to be coupled to the top of the buoy assembly (60), with the unit (700) being supported during its lowering by a cable (833) of the launch vessel (831), the Unit (700) being connected to the flexible production jumper (90) by interconnection to the Floating Production Unit (FPU); a subsea remotely controlled vehicle being utilized to aid the operation (FIG. 15);
- [0114] m) driving the flexible line launch vessel (831) to the Floating Production Unit (FPU) while unwinding the storage spool (B) of the flexible production jumper (90) (FIG. 16);
- [0115] n) transferring the end of the production flexible jumper (90) to the Floating Production Unit (FPU), utilizing auxiliary cables (841) and (842) for the interconnection operation (pull-in) (FIGS. 17 and 18);
- [0116] o) testing the riser system (100); and,
- [0117] p) operating the riser system (100).
- [0118] A second method of installation of the riser system (100) according to the invention involves individual buoys.
- [0119] According to this second embodiment, shown on FIGS. 19 to 21, the installation method of the riser system (100) of the following invention includes the following steps:
- [0120] a) mounting the WCT (20), the BOP preventor (30) and the connection tool (40) on a temporary support unit (901), located in the moon pool region (902) of the installation platform (804). Connecting the riser (50), formed of riser sections, to the connection tool (40), (FIG. 19A) and detail of joint (810) (FIG. 19B);

- [0121] b) connecting and lowering the sections (810), whose conjoint forms the riser (50), until the required length for the installation of the first buoys (60) is reached; maneuvering the buoy in the moon pool region (902) of the installation platform in order to enclose the riser sections (810) in the center of the buoy through use of the opening (903), so that the buoy (60) is attached to the riser sections (810), (FIG. 20A and detail in FIGS. 20B and 20C);
- [0122] c) connecting new riser sections (810) and repeating the same operation for the remaining buoys;
- [0123] d) lowering the buoy assembly (60) to operational depth through a pipe (811) of the semi-submersible platform (804) and then performing the connection of the lower end of the riser (50) to the wellhead (10) at the seabed, (FIG. 21);
- [0124] e) injecting air into the buoy assembly (60) expelling the water from within the buoy assembly with the aid of a remote controlled subsea vehicle —ROV (813) in order to produce a positive floatation of the buoy assembly (60), having determined the air volume required for riser (50) stability, (FIG. 21);
- [0125] f) disconnecting the pipes (811) utilized to lower the buoy assembly (60) from the buoy assembly, and removing the semi-submersible platform (804) from the location;
- [0126] g) with the aid of a flexible line launch vessel (831) installing the production flexible jumper (90) and the subsea intervention unit (700), which will be coupled to the buoy assembly (60), with the unit (700) being supported by a cable (833) of the launch vessel (831) during the lowering of the unit (700), and connected to the production flexible jumper (90) by interconnection to the Floating Production Unit (FPU); a subsea remotely controlled vehicle (834) being utilized to assist in the procedure (FIG. 15);
- [0127] h) driving the flexible lines launch vessel (831) to the Floating Production Unit (FPU) while unwinding the storage spool (B) of the flexible production jumper (90), (FIG. 16);
- [0128] i) transferring the end of the production flexible jumper (90) to the Floating Production Unit (FPU) utilizing auxiliary cables (841) and (842) for the interconnection operation (pull-in), (FIGS. 17 and 18);
- [0129] j) testing the riser system (100); and,
- [0130] k) operating the riser system (100).
- [0131] In both embodiments of the method of installing the riser system (100) of the invention the system test is an Anticipated System Production (ASP) Test.
- [0132] Alternatively, the test is a Long Duration Test (LDT).

What is claimed is:

1. A self-supported riser system for an Anticipated System Production (ASP) Test or a Long Duration Test (LDT) in subsea petroleum production utilizing a WCT coupled to a wellhead and a Floating Production Unit, said system comprising:

- a) a riser (50) formed of sections (810) linked one to another, with the lower end of the riser (50) being coupled to an ANM (20) or a manifold and the upper end being coupled to a buoy assembly (60) with control devices for variable buoyancy, said assembly of buoys (60) serving to traction a column of said riser (50), thereby maintaining said riser (50) erect and in an approximately vertical position;
 - b) a Subsea Intervention Terminal (700) for interconnecting a terminal (730) at the top of riser (50) and an Intervention rig (95);
 - c) a flexible jumper (90) disposed between the top of the riser (50) and Floating Production Unit (FPU), for production flow;
 - d) an umbilical (80) for controlling, monitoring and transmitting electrical and hydraulic energy; said umbilical linking the FPU to the WCT (20) and supported by the riser (50) or, alternately in a free catenary mode, wherein:
 - (i) the riser (50) is installed internally to the buoy assembly (60);
 - (ii) the coupling of the riser (50) to the Subsea Intervention Unit (700) with the aid of terminal (730) permits an access to a well in a vertical direction to perform maintenance operations; and
 - (iii) the riser (50) is used to lower and install the WCT (20), wherein a savings in rig time and number of operations is obtained.
2. The System according to the claim 1, wherein alternately the buoy assembly (60) is omitted, and the riser is utilized as a completion riser.
3. The System in accordance with claim 1, wherein the sections (810) may be connected by threads or mechanical connector.
4. The System according to the claim 1, wherein the unit (700) is formed with an upper funnel guide (710), being provided with an internal mandrel (711) for coupling an intervention tool and a passage (715), with an intervention valve (712) being located in a body of the unit (700) above the Y-shaped divider for a passage of production fluid flow and a production valve (713) being located in a production flow line and followed by a curved pipe section (714) in a gooseneck shape to promote production flow, said pipe section (714) being connected to a flexible jumper (90) through a connection device (720).
5. The System according to the claim 4, wherein the mandrel (711) is linked to a connector (717), wherein said connector (717) is provided with a funnel guide (718), said connector (717) interconnecting the unit (700) to the terminal (730) by the upper-end of the riser (50), being aided by the mandrel (732).
6. The System according to the claim 5, wherein a central part of the connector (717) is provided with a metal sealing ring (719) adapted to a recess (731) of complementary shape located in the mandrel (732) of the terminal (730), said mandrel (732) being interconnected to a isolation valve (734) of the riser (50) while a connection device (735) interconnects said valve (734) to the upper end of the riser (50).
7. The System according to the claim 6, wherein the valve (734) is destined to isolate the content of the riser (50), thus permitting removal of the unit (700) for maintenance.

8. The System according to the claim 1, wherein an umbilical (80) is supported by the riser (50).

9. The System according to the claim 1, wherein an umbilical (80) is coupled in a free catenary mode.

10. The System according to the claim 1, wherein said system is configured to facilitate surge production.

11. The System according to the claim 1, wherein alternatively production is effected with the aid of a subsea pumping module coupled to the WCT (20).

12. The System according to the claim 1, wherein the Floating Production Unit (FPU) is coupled to the said riser system rendering the use of a tower unnecessary.

13. The System according to the claim 1, wherein the FPU utilized is of the type FPSO (Floating Production Storage and Offloading).

14. The System according to the claim 13, wherein the FPSO is anchored.

15. The System according to the claim 13, wherein alternatively the FPSO is of the type DP (Dynamic Positioning).

16. The System according to the claim 15, wherein the FPSO of the type DP requires a presence of an unwinding device (swivel), in order to avoid a twisting of the arrangement of the flexible jumper (90)/riser (50) due to the possibility of the FPSO executing rotations around its own vertical axis.

17. The System according to the claim 1, wherein the system may be recovered at a low cost after the Anticipated System Production (ASP) Test or a Long Duration Test (LDT).

18. The System according to the claim 1, wherein during a workover operation (intervention), a valve (713) is closed, and any equipment is lowered or removed via riser (50) with a valve (712) in an open position.

19. An Installation method for the self supported riser system (100) of claim 1, said method comprising the following steps:

- a) transporting a buoy assembly (60) fastened to a transportation raft (802) to a location at which said riser system (100) is to be installed;
- b) proximate a semi-submersible platform (804) for lowering the riser (50), connecting said buoy assembly (60), with the assistance of a cable (805) to a semi-submersible platform (804) and connecting said buoy assembly (60) with the assistance of a cable (806) to a tug (803),
- c) effecting a partial controlled submersion of one of the ends of the transportation raft (802) and displacing the buoy assembly (60) over the raft deck while the tug (803) tractions the cable to ease the process of displacing the buoy assembly (60);
- d) separating and removing the transportation raft (802) from said location, after the free floating buoy assembly (60) is successfully connected to the semi-submersible installation platform (804) by the means of said cable (805) and to the tug boat (803) by said cable (806);
- e) keel hauling (cargo transfer) said buoy assembly (60) onto the semi-submersible platform (804) by appropriately maneuvering the cables (805) and (806) and of an auxiliary cable (807) linked to the tug (803), which controls an anchor weight (808) connected to the lower

end of the buoy assembly (60) such that at the completion of the process the buoy assembly (60) is supported by the platform tower (804) through the cable (805);

- f) bringing the upper end of the buoy assembly (60) to the moon pool region of the semi-submersible platform (804) and transferring the weight of the buoy assembly (60) to steel cables (809) which form part of the tension system of the platform drilling assembly (804);
 - g) after the disconnection of the cable (805), connecting and lowering the sections (810), whose interconnection forms the riser (50) assembly, inside the buoy assembly (60) until the required riser (50) length is reached;
 - h) lowering the buoy assembly (60) to an operational depth by means of a service pipe (811) of the semi-submersible platform (804) and making a connection (812) of the lower end of the riser (50) to the wellhead (10) on the seabed;
 - i) injecting air into the buoy assembly (60), expelling the water from within said assembly, aided by a remote controlled subsea vehicle ROV (813) in order to recover a buoyancy of the buoy assembly (60);
 - j) disconnecting the tubing (811), utilized for the lowering of the buoy system (60) and removing the semi-submersible platform (804) from the location;
 - k) with the aid of a flexible line launch vessel (831) installing the production flexible jumper (90) and the subsea Intervention unit (700), which is to be coupled to the top of the buoy assembly (60), with said unit (700) being supported by a cable (833) of the launch vessel (831) during a descent thereof, and further connected to the flexible production jumper (90) to form an interconnection with the Floating Production Unit (FPU);
 - l) driving the flexible line launch vessel (831) to the Floating Production Unit (FPU) while unwinding the stowing spool (B) of the flexible production jumper (90);
 - m) Transferring the end of the production flexible jumper (90) to the Floating Production Unit (FPU) utilizing auxiliary cables (841) and (842) for the interconnection operation (pull-in);
 - n) testing the self-supported riser system; and
 - o) operating the self-supported riser system.
20. The method in accordance with claim 19, wherein the test of step (n) is an Anticipated System Production (ASP) Test.
21. The method in accordance with claim 19, wherein the test of step (n) is a Long Duration Test (LDT).
22. The method in accordance with claim 19, wherein alternately the buoy assembly (60) is located on the transportation raft (802) using the alternate method of sliding the buoy system over the dock surface.
23. An installation method of the said self supported riser system (100) in accordance with claim 1, wherein said method alternatively comprises the following steps:
- a) mounting the WCT (20), the BOP preventor (30) and the connection tool (40) on a temporary support unit (901) located in the moon pool region (902) of the installation platform (804);

- b) connecting the production riser (50) constituted of riser sections (810), to a connection tool (40);
- c) connecting and lowering the sections (810) until the required length for the installation of the first buoy of the buoy assembly (60) is attained; maneuvering said buoy in the moon pool region (902) of the installation platform (804) so as to install the riser section at the center of the buoy aided by the opening (903), and connecting the buoy (60) to the riser section (810);
- d) connecting new riser section (810) and repeating the same operation for the remaining buoys;
- e) lowering the buoy assembly (60) to operational depth through a service pipe (811) of the semi-submersible platform (804) and then effecting a connection of the lower end of the riser (50) to the wellhead (10) at the seabed;
- f) injecting air into the buoy assembly (60) expelling the water within said buoy assembly, aided by a remote controlled subsea vehicle ROV (813);
- g) disconnecting the pipe (811) utilized during the lowering, from the buoy assembly (60), and removing the semi-submersible platform (804) from the location;
- h) with the aid of a flexible line launch vessel (831), installing the production flexible jumper (90) and the

subsea intervention unit (700), which will be coupled to the buoy assembly (60), said unit (700) being supported by a cable (833) of the launch vessel (831) during a lowering thereof, and said unit (700) being connected to the production flexible jumper (90) to form an interconnection to the Floating Production Unit (FPU);

- i) driving the flexible line launch vessel (831) to the Floating Production Unit (FPU) while unwinding the storage spool (B) of the flexible production jumper (90) from the vessel;
- j) transferring the end of the production flexible jumper (90) to the Floating Production Unit (FPU) utilizing auxiliary cables (841) and (842) for the interconnection operation (pull-in);
- k) testing the self-supported riser system; and
- l) operating the self-supported riser system.

24. A method in accordance with claim 23, wherein the test of step (k) is an Anticipated Production System (APS) Test.

25. A method in accordance with claim 23, wherein the test of step (k) is a Long Duration Production (LDP) Test.

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