(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 February 2009 (05.02.2009)

PCT

(10) International Publication Number
WO 2009/016346 A2

(51) International Patent Classification:
E21B 17/01 (2006.01) *E21B 19/22* (2006.01)
E21B 19/00 (2006.01) *E21B 33/068* (2006.01)
E21B 19/14 (2006.01) *E21B 33/076* (2006.01)

(21) International Application Number: PCT/GB2008/002513

(22) International Filing Date: 24 July 2008 (24.07.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0714646.7 27 July 2007 (27.07.2007) GB
0811639.4 25 June 2008 (25.06.2008) GB

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

(54) Title: DEPLOYMENT SYSTEM

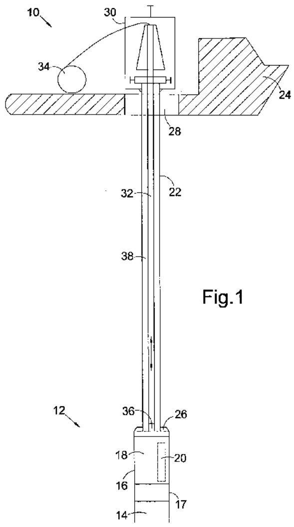

Fig.1

(57) Abstract: A downhole deployment system comprises a spoolable tubular member (76) adapted to be coupled to a subsea assembly and to extend to surface level. The deployment system also comprises a spoolable support member (96) adapted to extend through the spoolable tubular member (76) and into a wellbore. The spoolable tubular member (76) may define a conduit between the subsea assembly and the surface and the spoolable support member (96) may be utilised to extend through this defined conduit and into a wellbore, for example to deploy a tool into a wellbore, to engage a downhole tool or other object, for example for activation, retrieval or the like.

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DEPLOYMENT SYSTEM

FIELD OF THE INVENTION

The present invention relates to a deployment system, and in particular, but not exclusively, to a tool deployment system. The tool deployment system may form part of an intervention system.

BACKGROUND TO THE INVENTION

There are many well bore operations which require a tool to be delivered into a well bore to the required depth and subsequently be recovered after performing the desired operation. For example, tools may be deployed on wireline, coiled tubing or the like. However, it is often the case that a store of tools are required to be held on site to be ready for use as appropriate, which accordingly takes up valuable space.

Furthermore, many offshore wells are located in water depths exceeding several thousand metres and as such deploying tools through a subsea wellhead and into a wellbore first have to be tripped through the water depth within a marine riser. As such, the proportion of the total tripping time occupied by passing through the water depth can be significant.

Recent advances in the oil and gas industry relate to methods and apparatus of performing well intervention operations, and of particular interest are recent developments in subsea intervention operations. The present applicant has proposed a self-contained subsea intervention system which is capable of being mounted on an existing Christmas tree to perform various intervention operations within the well. More specifically, the applicant's system, such as is described in WO 2004/065757, includes a subsea assembly which includes a reel of wireline and a chamber within which a number of intervention tools are stored. The required tools are selected from the chamber, coupled to the wireline and subsequently run into the wellbore through the Christmas tree. Once the operation is completed the tools are retrieved and again stored.

However, many desired intervention operations, and indeed many other in-well operations, may require the use of coiled tubing instead of wireline, for example where the tool or process requires fluid to be delivered from surface or where particular forces are to be applied. That is, coiled tubing has the ability to support a degree of compressive forces which may be required to manipulate or actuate a downhole tool or process. The depth of most conventional wellbores, however, requires a significant length of coiled tubing to be available which thus requires substantial reels of the coiled tubing which would be extremely difficult to accommodate entirely within a subsea intervention system.

Furthermore, despite the advantages of providing a subsea intervention system with a selection of tools, there may be occasions where running a tool from surface level is still desired, for example where only a single tool is required. For this and other reasons, there may be circumstances where a contained conduit must be established between a wellhead and a surface vessel.. In such circumstances a marine riser may be installed, which typically involves coupling together multiple lengths of tubing with large diameters, normally using threaded connections. However, the connections are time consuming to make-up, and the marine riser formed in this manner is normally relatively stiff, thus minimising the degree of permitted deviation of a surface vessel. This in turn may require specialised vessels to be utilised, which may be difficult to obtain due to demand, and are expensive.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention there is provided a downhole deployment system comprising:

a spoolable tubular member adapted to be coupled to a subsea assembly and to extend to surface level; and

a spoolable support member adapted to extend through the spoolable tubular member and into a wellbore.

The spoolable tubular member may therefore define a conduit between the subsea assembly and the surface. The spoolable support member may be utilised to extend through this defined conduit and into a wellbore, for example to deploy a tool into a wellbore, to engage a downhole tool or other object, for example for activation, retrieval or the like. The spoolable tubular member may define a portion of the wellbore.

The deployment system may be adapted to be supported on a vessel, such as a ship, platform, barge or the like. The spoolable tubular member and spoolable support member may be spooled to and from respective reels mounted on the vessel. The spoolable tubular and support members may be adapted to be spooled through a vessel moonpool.

The spoolable tubular member may define a marine riser.

The spoolable tubular member may comprise coiled tubing, such as metal coiled tubing, composite coiled tubing or the like.

The spoolable tubular member may comprise a continuous length of tubing extending between the subsea assembly and the surface. This arrangement may therefore eliminate the requirement for multiple connections to be utilised. In alternative embodiments the spoolable tubular member may comprise two or more separate lengths adapted to be coupled together. This may permit the downhole deployment system to be readily installed and utilised in extreme water depths which may require a length of tubular beyond that which is conventionally provided in a single reel or spool. Furthermore, this arrangement may permit a length of tubing to be reused in deeper locations. The separate lengths of tubing may be coupled together by, for example, welding, threaded connections, quick-connect type connections and the like. The system may comprise a tubing connector adapted to couple separate lengths of tubing together. A connector as described in applicant's co-pending application of equal filing date may be provided.

The subsea assembly may form part of the deployment system. The subsea assembly may comprise a wellhead, a Christmas tree, a tool storage chamber adapted to contain at least one downhole tool, a well control apparatus, a manifold or the like, or any suitable combination thereof. In embodiments where a tool storage chamber is provided, the spoolable support member may be adapted to selectively engage a stored tool to deploy said tool into and from the wellbore.

The subsea assembly may comprise a tool deployment assembly, such as an intervention assembly, drilling assembly or the like.

The spoolable tubular member may be adapted to deploy at least a portion of a subsea assembly. For example, a component of a subsea assembly may be deployed on the spoolable tubular member and coupled to existing subsea infrastructure, such as a wellhead, Christmas tree, well control package, tool storage package or the like. This arrangement may permit installation of the subsea assembly to be completed simultaneously with installation of the spoolable tubular member. The spoolable tubular member may be adapted to deploy an emergency disconnect package. The emergency disconnect package may be adapted to sever the connection with the spoolable tubular member in an emergency situation, for example in adverse weather conditions or the like.

The spoolable support member may comprise coiled tubing, wireline, slickline or the like.

The deployment system may comprise a support assembly adapted to support the spoolable tubular member at an upper end thereof, preferably at surface level. The support assembly may be adapted to provide mechanical support to the spoolable tubular member. For example, the support assembly may be adapted to maintain a degree of tension in the spoolable tubular member.

The support assembly may be adapted to establish a seal against leakage of fluid or otherwise from the spoolable tubular member. The support assembly may comprise a tubing hanger. A tubing hanger as described in applicant's co-pending application of equal filing date may be provided.

The support assembly may comprise a compensation system adapted to compensate for surface motion and maintain the upper end of the spoolable tubular member at a substantially constant. height relative to the subsea assembly, irrespective of sea conditions and the like.

The compensation system may comprise a movement compensator. The movement compensator may be directly coupled to an upper end of the spoolable tubular member, for example directly through a tubing hanger.

Alternatively, the movement compensator may be indirectly coupled to an upper end of the spoolable tubular member. In one embodiment the support assembly may comprise a suspended structure, such as a frame, adapted to be suspended from a lifting member, such as a chain, wire or the like, wherein the movement compensator may be coupled to the lifting member. In this arrangement, an upper end of the spoolable tubular member may be secured relative to the suspended structure to thus be compensated. The movement compensator may be comprised in a compensator reel or winch which supports the lifting member. Accordingly, in this way, any compensation equipment and the like may be removed from the location of the upper end of the spoolable tubular member. Furthermore, a conventional compensator reel arrangement may be utilised to provide movement compensation for the spoolable tubular member. In embodiments of the present invention, the compensator reel may be adapted for deploying subsea equipment, and subsequently for providing compensated support for the spoolable tubular member. This therefore minimises the requirement to carry additional equipment on a vessel, where space is restricted.

The deployment system may comprise a tubing injector adapted to assist displacement of the spoolable tubular member relative to a reel. The tubing injector may be adapted to spool or displace the spoolable tubular member to be deployed subsea. The tubing injector may be adapted to be releasably coupled to a support assembly. The support assembly may comprise the support assembly for supporting the spoolable tubular member. By permitting the tubing injector to be releasably coupled, it is possible to install the spoolable tubular member between the subsea assembly and the surface, and then remove the tubing injector to provide access for the spoolable support member. The support assembly may be adapted to support the tubing injector when removed, for example in a storage position or configuration.

The tubing injector may be adapted to assist displacement of the spoolable support member relative to a reel. In this arrangement a single injector may be utilised for both the spoolable tubular member and the spoolable support member.

The tubing injector may comprise an access window adapted to provide access to a tubular member being deployed or retrieved through the tubing injector, without requiring the tubing injector to be removed. The access window may be adapted to permit the tubular member to be cut, for example when the required length has been deployed. The access window may permit a connection between separate sections of tubular member to be made, for example where significant lengths of tubing are required, to permit reattachment of a deployed length of tubing to a tubing spool for retrieval and the like.

The deployment system may comprise a spoolable support member injector adapted to displace the spoolable support member relative to a reel. The spoolable support member injector may be adapted to spool or displace the spoolable support member to be deployed through the spoolable tubular member. The spoolable support member injector may be adapted to be releasably coupled to an upper end region of the spoolable tubular member. The spoolable support member injector may be adapted to be mounted on a support assembly. The support assembly may comprise the support assembly for supporting the spoolable tubular member. The support assembly may be adapted to support the spoolable support member injector when removed. The support assembly may comprise a Blow Out Preventor (BOP) arrangement.

The deployment system may comprise a lubricator adapted to permit the sealed passage of the spoolable support member into the spoolable tubular member.

The deployment system may comprise an umbilical winder adapted to wind at least one umbilical around the outer surface of the spoolable tubular member while said member is being deployed. The at least one umbilical may comprise a tubular member, such as a hose, a wire, such as an electrically conducting wire, or the like. The umbilical winder may permit a degree of management over any umbilicals to extend subsea to be achieved, which is advantageous, particularly in deepwater environments where significant lengths of umbilicals may be required. The umbilical winder may comprise a reel adapted to spoolably support an umbilical, such that the umbilical may be paid out and in on the reel. The umbilical winder may comprise a rotatable platform comprising a central hole adapted to receive the spoolable tubular member therethrough, wherein the reel is mounted on the platform at a radial distance from the central hole. In this arrangement, rotation of the platform in combination with rotation of the reel will permit an umbilical to be wound around the length of the spoolable tubular member.

The umbilical winder may be adapted to be removable, for example to permit passage of components of a subsea assembly and the like. The umbilical winder may be adapted to be split and separated.

According to a second aspect of the present invention there is provided a method of deploying a support member into a wellbore, said method comprising the steps of:

spooling a tubular member from a first reel mounted on a vessel and securing a lower end of said tubular member to a subsea assembly connected to a wellbore; and

spooling a support member from a second reel mounted on the vessel through the tubular member and into the wellbore.

Accordingly, the tubular member may define a conduit adapted to provide a passage for the support member.

The tubular member may define a marine riser.

The tubular member may define part of a wellbore.

The method may comprise the step of coupling a tool to the support member and running the tool into the wellbore on the support member. The tool may be coupled to the support member at a surface location. Alternatively, or additionally, the tool may be coupled to the support member at a subsea location.

The method may comprise the step of locating a tool within the subsea assembly, and then coupling the tool to the support member. This arrangement may therefore permit a tool to be run into the wellbore without first having to be tripped through the tubular member.

The method may comprise the step of coupling at least a portion of the subsea assembly to a lower end of the tubular member at surface level, and then lowering said portion to a subsea location. Thus, the tubular member may be used to deploy at least a portion of the subsea assembly

The method may comprise the step of spooling the tubular member to a required length, and then cutting the tubular member. The tubular member may be cut at surface level. However, in alternative embodiments the tubular member may be cut at a subsea location. Accordingly, the required length of tubular member may be readily provided and directly installed from the reel to extend between the subsea assembly and the surface.

The method may comprise the step of joining separate sections of the tubular member together. This may be required in deepwater locations or the like.

The method may comprise the step of supporting the upper end of the tubular member. This upper end of the tubular member may be supported by a support assembly. The support assembly may comprise a tubing hanger.

A first injector assembly may be utilised to assist spooling of the tubular member from and to the first reel. The first injector assembly may be located on the vessel. The first injector assembly may permit access to the tubular member, for example through a work window. Access may be required for cutting the tubular member, joining separate sections of the tubular member or the like.

The first injector assembly may be utilised to assist spooling of the support member from and to the second reel.

Alternatively, a second injector assembly may be utilised to assist spooling of the support member to and from the second reel. In this embodiment the method may comprise the steps of removing the first infector assembly from the upper end of the tubular member, and then connecting the second injector assembly relative to the upper end of the tubular member.

A lubricator assembly may be utilised, for example to provide a dynamic seal against the outer surface of the support member while being spooled through the tubular member.

The method may comprise the step of providing movement compensation to at least the tubular member, and preferably to both the tubular member and the support member. The movement compensation may be provided to compensate for movement of the vessel, for example from wave motion and the like.

At least one or both of the tubular and support members may be secured relative to a suspended structure, such as a frame or the like. The suspended structure may be suspended from a lifting member, such as a chain, cable, wire, rope or the like. The lifting member may be spooled from a third reel. The third reel may comprise a movement compensator, such that movement compensation is indirectly provided via the lifting member and the suspended structure.

The third reel and lifting member may be utilised to deploy subsea equipment. Accordingly, the third reel may be utilised both for installing subsea equipment, such as portions of the subsea assembly to which the tubular member is connected, and then subsequently be used to provide compensation for one or both of the tubular and support members. In this way, the requirement to provide further dedicated compensation systems and arrangements is eliminated, which is advantageous on a vessel where space is limited.

The method may comprise the step of winding at least one umbilical around the outer surface of the tubular member while being deployed. Winding any umbilicals in this way permits the umbilicals to be effectively managed.

The method may comprise the step of retrieving the support member back to surface.

The method may comprise the step of retrieving the tubular member back to surface. In one embodiment an upper end of the deployed tubular member may be reattached to an end of a spooled tubular member, and then retrieved by spooling on to a reel, for example the first reel.

According to a third aspect of the present invention there is provided an offshore support system comprising a suspended structure adapted to support an assembly extending therefrom to a subsea location, and further adapted to be suspended by a winch assembly comprising a movement compensator.

Accordingly, the support system may be adapted to support the assembly and provide movement compensation to accommodate for heaving motion and the like.

Providing a separate winch assembly with a movement compensator eliminates the requirement to directly connect a movement compensator either to the assembly being supported or to the suspended structure. This also may permit an existing winch comprising a movement compensator to be utilised. For example, a winch comprising a movement compensator may be utilised to deploy subsea equipment. The winch may subsequently be used to support the suspended structure and assembly to provide the required or necessary compensation.

The assembly to be supported may comprise a single object, or multiple objects. The assembly to be supported may comprise a tubular member, wire member or the like, or any suitable combination thereof.

The suspended structure may comprise at least one injector assembly, adapted to assist spooling of an elongate or spoolable member from a vessel.

According to a fourth aspect of the present invention there is provided a method of supporting an assembly to extend to a subsea location from a vessel, said method comprising the steps of:

securing an assembly to be supported to a suspended structure; and

mounted said suspended structure from a winch assembly comprising a movement compensator.

According to a fifth aspect of the present invention there is provided an injector assembly comprising:

a support structure;

at least one injector mounted on the support structure and adapted to be moved between a storage position and a spooling position.

The injector may be adapted for use with an elongate member, such as a tubular member, wire or the like.

The at least one injector may be adapted to be releasably coupled to a hanger assembly. The hanger assembly may be adapted to provide support for an elongate member while or after extending through the injector.

The injector assembly may comprise two or more injectors mounted on the support structure.

The support structure may be suspended from a movement compensated winch and winch line.

According to a sixth aspect of the present invention there is provided a riser assembly comprising a spoolable tubular member extending between a subsea assembly and surface level to define a riser.

The riser may define a workover riser.

According to a seventh aspect of the present invention there is provided a method of installing a riser comprising the steps of:

spooling a tubular riser from a reel mounted on a vessel; and

securing said spooled riser between a subsea location and the vessel.

According to a eighth aspect of the present invention, there is provided a well bore tool deployment system comprising:

a subsea assembly adapted to be coupled to a wellhead and comprising a tool storage chamber containing at least one downhole tool;

a tubular member adapted to be coupled to the subsea assembly and to extend to surface level; and

a spoolable member adapted to extend through the tubular member and into the tool storage chamber of the subsea assembly to selectively engage the at least one downhole tool.

Accordingly, in use, the tubular member may be coupled to the subsea assembly to provide a conduit extending back to surface level, for example to a surface vessel. The conduit is adapted to accommodate the spoolable member to extend therethrough and into the tool storage chamber, wherein the at least one tool may be mounted on the spoolable member and then run into the wellbore through the wellhead. Accordingly, the present invention advantageously eliminates the requirement to store and run the required downhole tools from surface level which, as is well known in the art, requires specialised handling equipment and a significant amount of vessel space, which is at a premium.

Additionally, the present invention advantageously eliminates the requirement to transport or trip a downhole tool through the depth of the sea from surface level to the wellhead location, and vice versa, which in many cases can involve distances in excess of several thousand metres. As such, by eliminating the requirement to transport a tool through the sea depth the present invention significantly reduces the time required to trip downhole tools from a stored location to the required depth in the well, which provides associated benefits in terms of, for example, production down-time, vessel, equipment and personnel costs and the like.

The tubular member may comprise a single unit. Alternatively, the tubular member may comprise a plurality of individual tubular sub units coupled together. In this arrangement, the tubular sub units may be coupled together by welding, interference couplings, threaded couplings or the like. Advantageously, a tubular coupling may be utilised which defines a larger outer diameter than that of the tubular member given that embodiments of the invention do not require the tubular member to have a uniform diameter or a restricted diameter to permit the tubular member to be accommodated within an outer casing or the like.

The tubular member may comprise coiled tubing. The coiled tubing may be selected and cut to the required length to extend between the subsea assembly and surface level. In one embodiment, coiled tubing may be paid out from a surface located reel and coupled to the subsea assembly, and then cut to the desired length.

In one embodiment the spoolable member may comprise wireline, which may include an electrical conductor.

Alternatively, or additionally, the spoolable member may comprise coiled tubing adapted to be spooled through the tubular member from a reel provided at surface level. Accordingly, the spoolable member may be run into and pulled out of the tubular member and well bore by manipulation of the coiled tubing reel.

The spoolable member may be adapted to permit fluid communication therethrough such that fluid may be delivered from surface level to a downhole location, for example to actuate a downhole tool or the like.

An annulus may be defined between the tubular member and the spoolable member, wherein said annulus may permit fluid communication between the subsea assembly and surface level. For example, the annulus may provide a return flow path to permit fluid communicated into a well through the spoolable member to be returned to surface level. The cross sectional area of the annulus may be readily selected to provide a preferential flow regime in that particular larger dimensions of the tubular member are not dictated by large downhole tool diameters in that in a preferred embodiment of the invention the tools are not required to be accommodated within or through the tubular member.

The tubular member may be adapted to be coupled to a supporting assembly mounted on a surface vessel. The supporting assembly may comprise a lifting frame adapted to apply and maintain tension in the tubular member. This arrangement may prevent or minimise the risk of collapse or buckling of the tubular member.

The system may further comprise a compensator assembly adapted to compensate for heaving motion and unintended deviation of a surface vessel supporting the tubular member. The compensator system may be provided in combination with or as part of the supporting assembly.

The tool storage chamber may be adapted to be in fluid communication with the well bore, and specifically exposed to well bore conditions, such as fluid pressure.

In one embodiment of the invention the tubular member may be adapted to be fluidly isolated from the tool storage chamber. Alternatively, the tubular member may be adapted to be in fluid communication with the tool storage chamber.

A Blow Out Preventor (BOP) may be coupled to the first tubular member at surface level. The BOP may be provided with or as part of the supporting assembly.

The apparatus may further comprise a lubricator which may be coupled to the tubular member and adapted to permit or assist insertion of the spoolable member into the first tubular member and to provide a dynamic fluid seal between the tubular member and spoolable medium. Alternatively, or additionally, a lubricator may be coupled to the subsea assembly and adapted to permit insertion of the spoolable medium into the subsea assembly while providing a dynamic fluid seal between the subsea assembly and spoolable member.

The spoolable member may comprise a connector assembly. The connector assembly may be mounted at one end of the spoolable member and adapted to permit the at least one downhole tool to be coupled to said spoolable member.

The spoolable member may comprise a cable adapted to communicate power, signals or the like therethrough to the at least one intervention tool and/or other downhole equipment. Advantageously, the cable may be integrally provided as part of the spoolable member or alternatively may be separately formed and subsequently run in hole in combination with said spoolable member. The cable may incorporate an electrically conducting cable, fibre optic cable, hydraulic line or the like.

In one embodiment, the spoolable member comprises coiled tubing and a cable.

The subsea assembly may comprise a plurality of downhole tools, wherein each tool is adapted to be selectively presented to be engaged by the spoolable member. In embodiments of the invention the spoolable member may be adapted to engage more than one downhole tool. For example, a plurality of downhole tools may be assembled to provide a tool string which is engaged and manipulated by the spoolable member.

The tool storage chamber may be adapted to store downhole tools suitable for use in performing in-well operations. For example, the tool storage chamber may contain at least one intervention tool. Alternatively, or additionally, the tool storage chamber may contain a drilling tool or assembly, a tubing expansion tool, a fishing tool, a perforating tool or the like, or any suitable combination of tools as known in the art.

The subsea assembly may be adapted to be directly mounted on a wellhead. Alternatively, the subsea assembly may be adapted to be mounted on an existing subsea Christmas tree, such as a horizontal or vertical tree which is already coupled to the well head.

Advantageously, the tubular member may be adapted to be releasably coupled to the subsea assembly, for example via a latching mechanism or the like.

The subsea assembly may comprise a fluid control apparatus adapted to control fluid flow through the wellhead, while permitting passage of a downhole tool therethrough.

In embodiments of the present invention, the tool deployment system may be adapted to withdraw tools from the tool storage chamber to surface level, for example to be inspected, maintained or interchanged or the like.

A plurality of spoolable members may be provided and adapted to extend through the tubular member simultaneously.

According to a ninth aspect of the present invention, there is provided a method of deploying a tool into a wellbore, said method comprising the steps of:

providing a subsea assembly comprising a tool storage chamber containing at least one downhole tool and mounting said subsea assembly on a wellhead;

extending a tubular member from surface level and coupling said tubular member to the subsea assembly;

running a spoolable member through the tubular member and into the tool storage chamber of the subsea assembly;

coupling the at least one downhole tool to the spoolable member; and

running the at least one downhole tool into a wellbore on the spoolable member.

The tubular member may comprise coiled tubing and the method may comprise the step of cutting said coiled tubing to a required length to extend between the surface level and the subsea assembly.

The spoolable member may comprise coiled tubing and the method may comprise the step of running said coiled tubing from a reel through the tubular member, wherein the reel is preferably mounted at surface level.

In one embodiment the subsea assembly may comprise a plurality of downhole tools or tool assemblies and the method may comprise the step of selecting and coupling at least one of said plurality of downhole tools to the spoolable member.

The method may further comprise the step of ceasing production from the well bore prior to mounting the subsea assembly on the wellhead.

According to a tenth aspect of the present invention, there is provided a tool deployment installation comprising:

a subsea assembly coupled to a wellhead and comprising a tool storage chamber containing at least one downhole tool;

a tubular member coupled to the subsea assembly and extending to surface level; and

a spoolable member extending through the tubular member and adapted to extend into the tool storage chamber of the subsea assembly to selectively engage the at least one downhole tool.

Various aspects of the present invention have been defined above. However, it should be understood that one or more features from each individual aspect may be utilised in other aspects.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic representation of a tool deployment system in accordance with an embodiment of one or more aspects of the present invention;

Figures 2 to 5 are diagrammatic representations of stages in the installation of a subsea assembly;

Figure 6 shows a variation of an installed subsea assembly;

Figures 7 and 8 show stages in the deployment of a component of a subsea assembly, in combination with a spoolable riser;

Figure 9 is a diagrammatic representation of an installed spoolable riser being cut to a required length;

Figures 10 and 11 are diagrammatic representations of installing a coiled tubing workstring injector and BOP to an installed riser;

Figure 12 is a diagrammatic representation of an installed lubricator assembly for use with a wireline; and

Figure 13 is a diagrammatic representation of retrieving a spoolable riser.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the Figure 1, a tool deployment system according to an embodiment of an aspect of the present invention is shown diagrammatically. The tool deployment system, generally identified by reference numeral 10, includes a subsea assembly 12 mounted on an existing subsea wellhead 14. The subsea assembly 12 comprises a tool storage package 16 which defines a tool storage chamber 18 containing a plurality of downhole tools 20 (only one shown for clarity). The tool storage chamber 18 may contain intervention tools, drilling tools, logging tools or the like, or any suitable combination of tools selected from the art.

The system 10 further comprises a first tubular member 22 formed of a length of coiled tubing which extends from a surface vessel 24 and is secured at a lower end thereof to an upper portion of the tool storage package 16 via a latching mechanism 26. In one example, the coiled tubing used to define the first tubular member may describe an outer diameter of around 89mm (3½"). The first tubular member 22 is formed by running a length of coiled tubing from the surface vessel 24 and securing one end to the subsea assembly and then cutting the coiled tubing to the required length. In the embodiment shown the first tubular member 22 extends through a moonpool 28 of the vessel 24 and is supported by a lifting frame 30 which is adapted to maintain the first tubular member 22 in tension. This arrangement therefore assists to prevent collapse or buckling of the first tubular member 22.

The lifting frame 30 includes a compensator (not illustrated) adapted to compensate for heaving motion of the vessel 24 and for deviation of the vessel 24 from an intended location, to thus prevent failure of the tubular 22.

A BOP (not illustrated) is provided at an upper portion of the first tubular member 22 to isolate the internal passage defined by the first tubular member 22 from the environment.

The intervention system 10 further comprises a spoolable member in the form of a second tubular member 32 incorporating coiled tubing and provided from a vessel mounted coiled tubing reel 34. In one example, the coiled tubing used to define the second tubular member 32 may describe an outer diameter or around 60mm (2⅜ ") The second tubular member 32 extends from the tubing reel 34 and through the first tubular member 22 and into the tool storage package 16. A tool connector 36 is provided on an end of the second tubular member 32 which is adapted to be secured to a tool 20 contained within the tool chamber 18.

In use, the second tubular member 32 is run into and through the first tubular member 22 and into the tool storage package 16. The tool storage package 16 includes a mechanism (not shown) for selecting one or more tools 20 and presenting the selected tools 20 to be secured to the second tubular member 32 via the connector 36. The second tubular member 32 may then be run into the well bore through the well head 14 to the required depth to perform the intended downhole operation with the selected tool 20. The tool 20 may be adapted to be actuated hydraulically by fluid delivered from the surface vessel 24 through the second tubular member 32. Additionally, the second tubular member 32 may carry an electrical wire or wires (not shown) adapted to transmit power or control signals or the like to the selected tool or tools 20 or to a downhole location.

An annulus 38 is defined between the first and second tubular members 22, 32 which may be adapted to accommodate flow back to the vessel 24, which flow may be handled on the vessel 24 with suitable fluid handling equipment (not shown).

The subsea assembly 12 further comprises a well control package 17 positioned between the well head 14 and the tool storage package 16, wherein the well control package 17 includes valves and other flow control devices to control flow to and from the well head 14 while permitting passage of a tool or tools 20 therethrough.

Once the required operation has been performed with the selected tool or tools 20 the second tubular member 32 may be withdrawn through the first tubular member 22 to thus recover the tool or tools 20 back into the storage chamber 18 of the tool storage package 16. The tools 20 may be decoupled from the second tubular member 32 and moved to a storage position. Following this an alternative tool or tools 20 may be selected and then run into the well on the second tubular member 32. Alternatively, if the in well or downhole operations have been completed then the second tubular member 32 may be completely recovered to the surface vessel 24. Following this the first tubular member 22 may be released from the subsea assembly 12, the subsea assembly 12 may be released from the wellhead 14, and the well may be reconfigured to a production mode.

In embodiments of the invention the first tubular member 22 may be utilised again in a similar or shallower water depth or alternatively in deeper water through use of a coiled tubing connector, such as an outer diameter connector.

The present invention provides significant benefits over existing methods and systems of performing well bore intervention operations. For example, the present invention eliminates the necessity to accommodate the required intervention tools and associated equipment on the surface vessel. Additionally, by providing the intervention tools at a subsea location, and specifically at the location of the well head, the requirement to run the tools from surface level through the total sea depth is eliminated, thus significantly reducing the time to run in each tool to the required bore depth.

Further embodiments of aspects of the present invention will now be described with reference to Figures 2 to 13.

Referring initially to Figures 2 to 5 there is shown various stages of installation of a subsea assembly, specifically a subsea assembly for use in performing a workover operation within a wellbore. As will be described below, the subsea assembly is intended to be landed on top of an existing Christmas tree mounted on a wellhead.

The various components of the subsea assembly are deployed from a vessel 50, as demonstrated in Figure 2, in which a well control package 52 of a subsea assembly is shown being deployed. The well control package 52 comprises a number of valves and the like which are intended to control and contain well fluids and pressures when the subsea assembly is in operation. The well control package 52 is connected, via a connector head or running tool 54, to a lifting wire 56 which is spooled from a vessel mounted reel/winch (not shown). The reel/winch comprises a movement compensator (not shown) to compensate for heave motion and the like of the vessel 50 during the deployment operation.

The well control package 52 is lowered through a vessel moonpool 58 and an umbilical winder 60 is provided to wind required umbilicals 62 around the lifting wire 56 in order to manage the umbilicals 62. The umbilicals 62 may be provided to communicate power, such as electric or hydraulic power to, for example, the running tool 54. In the embodiment shown the umbilical winder 60 comprises a rotatable platform 64 defining a central bore 66 through which the lifting wire 56 and umbilicals 62 extend. Umbilical reels 68 are mounted radially outwardly from the central bore 66. In use, rotation of the platform 64 in combination with rotation of the reels 68 will permit the umbilicals 62 to be neatly wound round the lifting wire 56. When the umbilicals 62 are to be recovered, the platform 64 and reels 68 are rotated in reverse directions. It should be understood that a single reel 68 and umbilical 62 may be provided.

The umbilical winder 60 is adapted to be removable to permit passage of the subsea equipment, such as the well control package 52, into and through the moonpool 58. In the embodiment shown the umbilical winder 60 is adapted to be split.

As shown in Figure 3, the well control package 52 is landed on an existing wellhead Christmas tree 70, and once a connection has been established with the Christmas tree 70, the running tool 54 may be removed and retrieved to surface by the wire 56.

The lifting wire 56 and running tool 54 may then be used to deploy further components of the subsea assembly, such as a tool storage package 72, as shown in Figure 4. The tool storage package 72 comprises a number of wellbore tools, such as intervention tools, drilling tool, pills, logging tools and the like which may be required to be deployed into the wellbore to perform a desired operation. Once the tool storage package 72 is mounted and securely connected to the well control package 52, the lifting wire 56 and running tool 54 may be retrieved to surface.

Following this, as shown in Figure 5, a final subsea component, in this case an emergency disconnect package 74, is deployed and connected to an upper end of the tool storage package 72. It should be understood, however, that in alternative embodiments the tool storage package 72 may not be required, such that the emergency disconnect package 74 may be directly coupled to the well control package 52, as shown in Figure 6. The tool storage package 72 may not be required in circumstances where a tool is preferably run into the wellbore from surface level.

As shown in Figures 5 and 6, the emergency disconnect package 74 is deployed on the end of a spoolable tubular member, specifically coiled tubing 76. As will be described in further detail below, the coiled tubing 76 is intended to create a marine riser to provide a conduit extending between surface level and the subsea assembly, wherein said conduit provides a passage for a spoolable support member to extend therethrough and into the wellbore.

The emergency disconnect passage 74 is provided to permit the coiled tubing riser 76 to be quickly and safely disconnected from the subsea assembly in an emergency situation, for example when too much tension, bending loads and/or other forces are applied to the coiled tubing riser 76 by extreme weather conditions and heave of the surface vessel and the like.

Reference is now made to Figures 7, 8 and 9 in which various stages of deploying the emergency disconnect package 74 while simultaneously installing the coiled tubing riser 76 are shown.

Referring initially to Figure 7, a lifting frame 78 is suspended above the moonpool 58 by the running tool 54 and lifting wire 56. As will be described in further detail below, the lifting frame 78 provides support for the coiled tubing 76, and as such the lifting wire 56, through its associated winch and movement compensator (not shown), may provide movement compensation to the frame 78 and thus the coiled tubing 76. This arrangement therefore eliminates the requirement to provide a dedicated compensation system for the coiled tubing 76, permitting existing equipment to be utilised.

A tubing hanger 80 is mounted on the frame 78. In use, the tubing hanger 80 mechanically supports and seals the coiled tubing riser 76 once installed.

A coiled tubing riser injector head 82 is mounted on the frame 78, and specifically releasably mounted on the tubing hanger 80. The riser injector head 82 receives the coiled tubing 76 from a vessel mounted reel (not shown) and in use assists to deploy the tubing 76 from (and to) the reel.

A lower end of the coiled tubing riser 76 is secured to the emergency disconnect package 74 at surface level. Following this, as shown in Figure 8, the coiled tubing riser 76 may be spooled out by the injector head 82 and reel (not shown) to deploy the emergency disconnect package 74 through the moonpool 58 and into the sea 84 to the depth of the existing subsea installation. During deployment, the umbilical winder 60 may be employed to neatly wind the required umbilicals 62 around the coiled tubing riser 76. Furthermore, during deployment, heaving motion of the vessel may be compensated by the lifting wire 56 and associated compensator winch.

Once the required length of coiled tubing riser 76 has been spooled to permit the emergency disconnect package 74 to be connected to the subsea assembly, the coiled tubing 76 may then be cut, as shown in Figure 9. In this respect the riser injector head 82 comprises a work window 86 to permit working access to the coiled tubing riser 76, in this case to be cut from the tubing spool or reel. Once cut from the spool or reel, the coiled tubing riser 76 may be mechanically supported by the coiled tubing riser 76, for example via slips or the like.

It should be noted that Figure 9 also demonstrates a situation where the depth of the water is such that a single reel of coiled tubing, or a previously used section of coiled tubing, is of insufficient length. In this case the work window 86 may provide working access to respective ends of two sections of tubing 76 to be connected together to continue deployment. The connector used advantageously is adapted to extend through the tubing hanger 80.

Referring now to Figure 10, once the coiled tubing riser 76 has been cut, as shown in Figure 9, the riser injector head 82 may be removed from the tubing hanger 80 and moved to a storage position on the frame 78. The upper end of the tubing riser 76 may then be cut to its final length, dressed, and securely mounted and sealed within the hanger 80. Following this a Blow Out Preventor (BOP) and a workstring injector 90 may be moved to be positioned above the tubing hanger 80, and subsequently mounted on the tubing hanger 80, as shown in Figure 11. Hydraulic lines 92, 93, 94, such as kill lines, wellbore return lines and the like may then be secured to the BOP 88.

Once the BOP 88 and workstring injector head 90 are installed, a workstring 96, which in the embodiment shown in Figure 11 comprises coiled tubing, may be spooled from a vessel mounted reel (not shown) to be deployed through the coiled tubing riser 76 and into the wellbore. The coiled tubing workstring 96 may be connected to a tool at surface level to deploy said tool into the wellbore, or alternatively, or additionally, the workstring 96 may engage or pick-up a tool at a downhole location, for example from the tool storage package 72 (see Figure 5) or from within a cased wellbore or the like.

Some wellbore operations may require the use of a workstring which comprises wireline. This may be accommodate by the arrangement shown in Figure 12 in which the coiled tubing workstring injector head 90 is removed and stored on the frame 78 and a wireline lubricator 98 is then coupled to the BOP 88. In this way, wireline 100 may be run into the coiled tubing riser 76.

Once the required well operations have been performed the workstring and associated tools and the like may be retrieved. Following this, the coiled tubing riser 76 may be retrieved as shown in Figure 13. In this respect the riser injector head 82 may once again be mounted on the riser hanger 80, and an upper end 76a of the riser 76 connected to a free end 76b of tubing extending from a vessel mounted reel (not shown), with the connection being made with a conventional spoolable connector through the work window 86. Once the connection has been made the coiled tubing riser 76 may be spooled on to the reel to therefore retrieve the riser 76, and any connected equipment, back to surface.

It should be understood that the embodiments described herein are merely exemplary and that various modifications may be made thereto without departing from the scope of the invention. For example, the subsea assembly may be mounted on or comprise a subsea Christmas tree interposed between the well control package and the wellhead. Additionally, the intervention system may be adapted to withdraw tools from the tool storage chamber to surface level, for example to be inspected, maintained or interchanged or the like. Furthermore, additional coiled tubular members may be provided and run through the first tubular member simultaneously with the second tubular member. Further still, the intervention system may comprise wireline adapted to be run through the first tubular member to engage a tool to support and deliver said tool into a well bore.

Additionally, the riser may be utilised to extend between any subsea equipment and the surface. For example, the coiled tubing riser may be coupled directly to a wellhead, or to a Christmas tree or the like.

Furthermore, in some embodiments described above the various injector heads may be stored on the frame. However, while this provides significant advantages in terms of storage space, there may be occasions where the injector head is entirely removed from the frame.

In embodiments of the invention a single injector assembly may be used for the various spoolable members.

CLAIMS:

1. A downhole deployment system comprising:

a spoolable tubular member adapted to be coupled to a subsea assembly and to extend to surface level; and

a spoolable support member adapted to extend through the spoolable tubular member and into a wellbore.

2. The downhole deployment system according to claim 1, wherein the spoolable tubular member may define a marine riser.

3. The downhole deployment system according to claim 1 or 2, wherein the spoolable tubular member comprises coiled tubing.

4. The downhole deployment system according to claim 1, 2 or 3, further comprising a tubing connector adapted to couple separate lengths of tubing together.

5. The downhole deployment system according to any preceding claim, wherein the subsea assembly comprises at least one of a wellhead, a Christmas tree, a tool storage chamber adapted to contain at least one downhole tool, a well control apparatus and a manifold.

6. The downhole deployment system according to any preceding claim, wherein the spoolable support member is adapted to selectively engage a tool stored within the subsea assembly and to deploy said tool into and from the wellbore.

7. The downhole deployment system according to any preceding claim, wherein the spoolable tubular member is adapted to deploy at least a portion of a subsea assembly.

8. The downhole deployment system according to any preceding claim, further comprising a support assembly adapted to support the spoolable tubular member at an upper end thereof.

9. The downhole deployment system according to claim 8, wherein the support assembly comprises a tubing hanger.

10. The downhole deployment system according to any preceding claim, wherein the system comprises a movement compensation system.

11. The downhole deployment system according to claim 10, wherein the movement compensation system is indirectly coupled to the spoolable tubular member.

12. The downhole deployment system according to claim 10 or 11, when dependent on claim 8 or 9, wherein the support assembly comprises a suspended structure adapted to be suspended from a lifting member wherein the movement compensation system is coupled to the lifting member.

13. The downhole deployment system according to claim 12, wherein the movement compensation system is comprised in a compensator winch which supports the lifting member.

14. The downhole deployment system according to any preceding claim, further comprising a tubing injector adapted to assist displacement of the spoolable tubular member relative to a reel.

15. The downhole deployment system according to claim 14, wherein the tubing injector is adapted to be releasably coupled to a support assembly.

16. The downhole deployment system according to claim 15, wherein the support assembly is adapted to support the tubing injector in a storage position.

17. The downhole deployment system according to claim 14, 15 or 16, wherein the tubing injector comprises an access window adapted to provide access to a tubular member being deployed or retrieved through the tubing injector.

18. The downhole deployment system according to any preceding claim, further comprising a spoolable support member injector adapted to displace the spoolable support member relative to a reel.

19. The downhole deployment system according to claim 18, wherein the spoolable support member injector is adapted to be releasably coupled to an upper end region of the spoolable tubular member.

20. The downhole deployment system according to claim 18 or 19, wherein the spoolable support member injector is adapted to be mounted on a support assembly.

21. The downhole deployment system according to claim 20, wherein the support assembly is adapted to support the spoolable support member injector in a storage position.

22. The downhole deployment system according to any preceding claim, further comprising a lubricator adapted to permit the sealed passage of the spoolable support member into the spoolable tubular member.

23. The downhole deployment system according to any preceding claim, further comprising an umbilical winder adapted to wind at least one umbilical around the outer surface of the spoolable tubular member while said member is being deployed.

24. The downhole deployment system according to claim 23, wherein the umbilical winder is adapted to be removable.

25. The downhole deployment system according to claim 23 or 24, wherein the umbilical winder is adapted to be split and separated.

26. A method of deploying a support member into a wellbore, said method comprising the steps of:

spooling a tubular member from a first reel mounted on a vessel and securing a lower end of said tubular member to a subsea assembly connected to a wellbore; and

spooling a support member from a second reel mounted on the vessel through the tubular member and into the wellbore.

27. The method according to claim 26, further comprising the step of coupling a tool to the support member and running the tool into the wellbore on the support member.

28. The method according to claim 26 or 27, further comprising the step of locating a tool within the subsea assembly, and then coupling the tool to the support member.

29. The method according to claim 26, 27 or 28, further comprising the step of coupling at least a portion of the subsea assembly to a lower end of the tubular member at surface level, and then lowering said portion to a subsea location.

30. The method according to any one of claims 26 to 29, further comprising the step of spooling the tubular member to a required length, and then cutting the tubular member.

31. The method according to any one of claims 26 to 30, further comprising the step of joining separate sections of the tubular member together.

32. The method according to any one of claims 26 to 31, further comprising providing movement compensation to at least one of the tubular member and the support member.

33. The method according to any one of claims 26 to 32, further comprising the step of suspending a structure from a lifting member, and securing at least one of the tubular and support members relative to the suspended structure.

34. The method according to claim 33, wherein the lifting member is spooled from a third reel.

35. The method according to claim 34, comprising the step of providing movement compensation to the third reel such that movement compensation is indirectly provided via the lifting member and the suspended structure.

36. The method according to any one of claims 26 to 35, further comprising the step of retrieving at least one of the support member and tubular member back to surface.

37. An offshore support system comprising a suspended structure adapted to support an assembly extending therefrom to a subsea location, and further adapted to be suspended by a winch assembly comprising a movement compensator.

38. A method of supporting an assembly to extend to a subsea location from a vessel, said method comprising the steps of:

securing an assembly to be supported to a suspended structure; and

mounted said suspended structure from a winch assembly comprising a movement compensator.

39. An injector assembly comprising:

a support structure;

at least one injector mounted on the support structure and adapted to be moved between a storage position and a spooling position.

40. The injector assembly according to claim 39, comprising two or more injectors mounted on the support structure.

41. The injector assembly according to claim 39 or 40, wherein the support structure is suspended from a movement compensated winch and winch line.

42. A riser assembly comprising a spoolable tubular member extending between a subsea assembly and surface level to define a riser.

43. A method of installing a riser comprising the steps of:

spooling a tubular riser from a reel mounted on a vessel; and

securing said spooled riser between a subsea location and the vessel.

44. A well bore tool deployment system comprising:

a subsea assembly adapted to be coupled to a wellhead and comprising a tool storage chamber containing at least one downhole tool;

a tubular member adapted to be coupled to the subsea assembly and to extend to surface level; and

a spoolable member adapted to extend through the tubular member and into the tool storage chamber of the subsea assembly to selectively engage the at least one downhole tool.

45. A method of deploying a tool into a wellbore, said method comprising the steps of:

providing a subsea assembly comprising a tool storage chamber containing at least one downhole tool and mounting said subsea assembly on a wellhead;

extending a tubular member from surface level and coupling said tubular member to the subsea assembly;

running a spoolable member through the tubular member and into the tool storage chamber of the subsea assembly;

coupling the at least one downhole tool to the spoolable member; and

running the at least one downhole tool into a wellbore on the spoolable member.

46. A tool deployment installation comprising:

a subsea assembly coupled to a wellhead and comprising a tool storage chamber containing at least one downhole tool;

a tubular member coupled to the subsea assembly and extending to surface level; and

a spoolable member extending through the tubular member and adapted to extend into the tool storage chamber of the subsea assembly to selectively engage the at least one downhole tool.

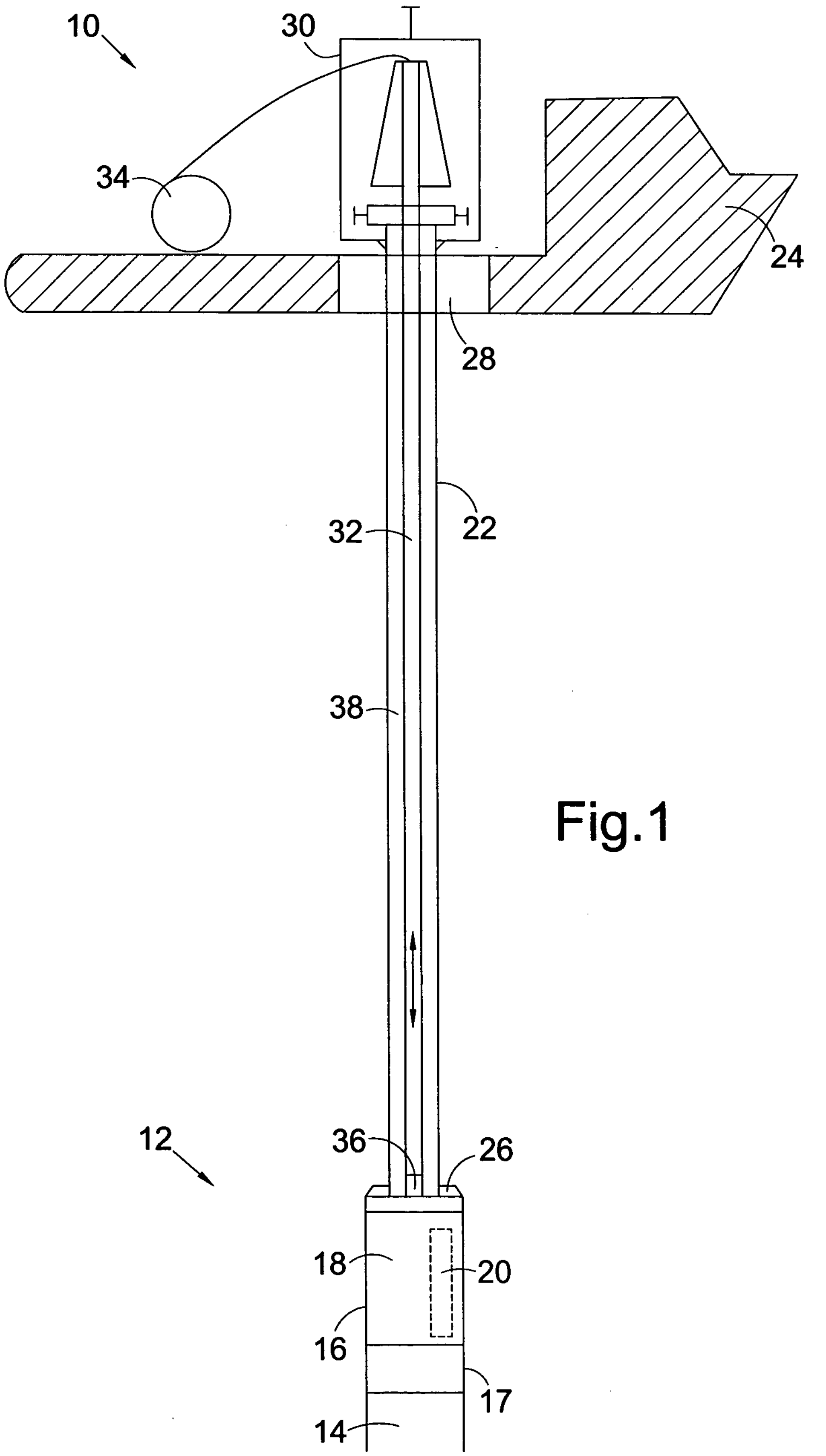

Fig.1

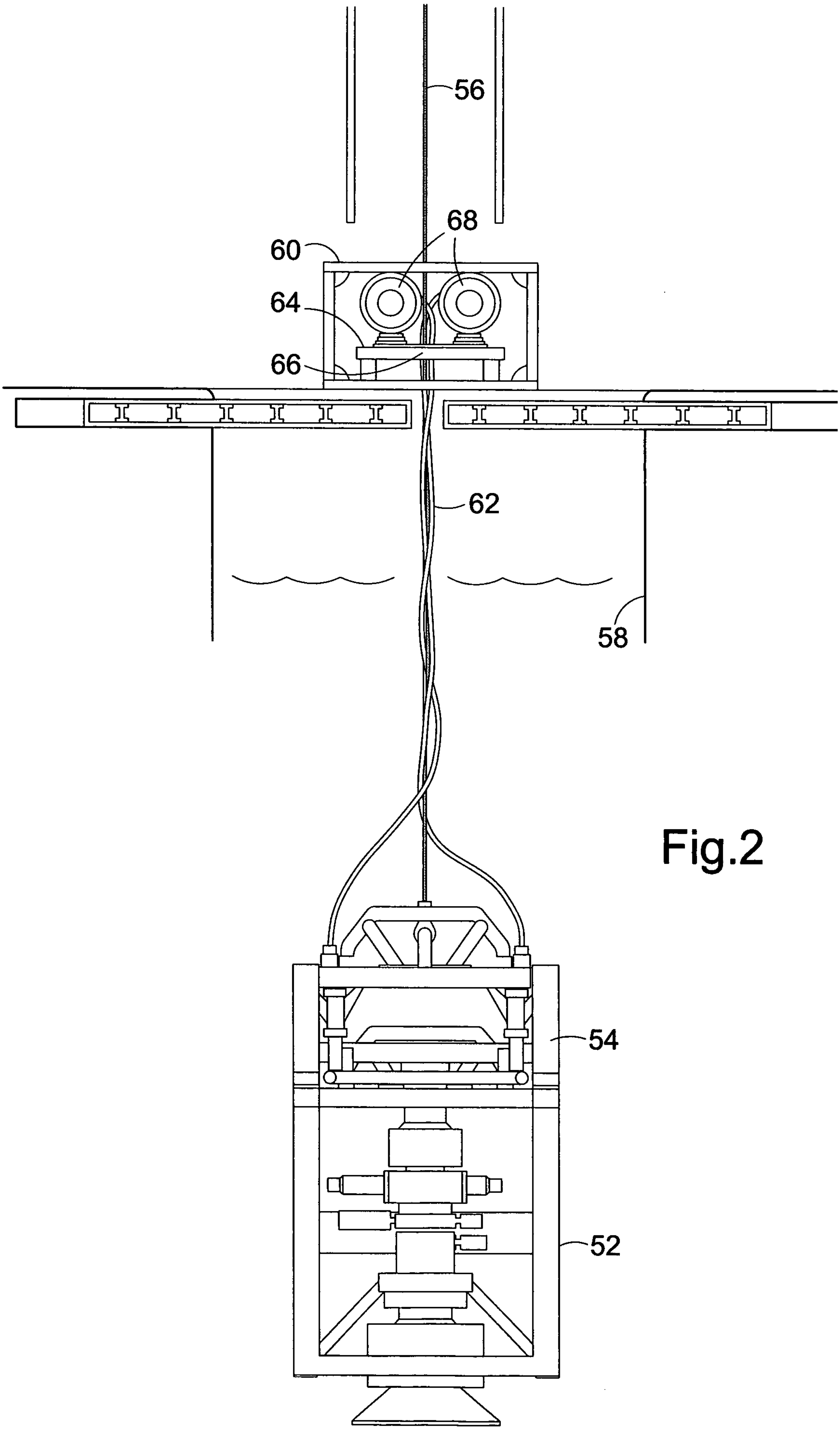

Fig.2

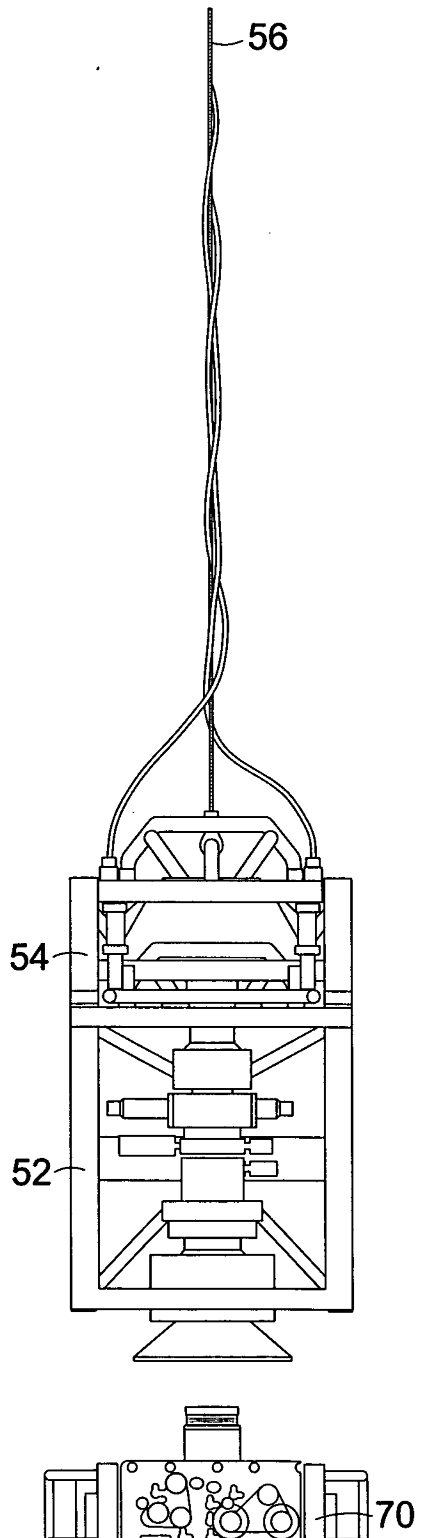

Fig.3

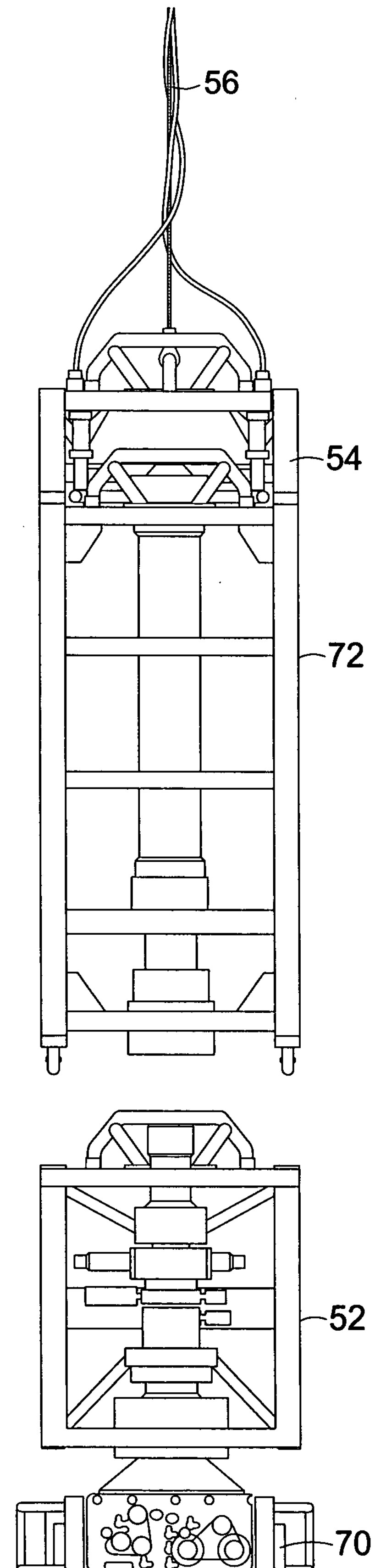

Fig.4

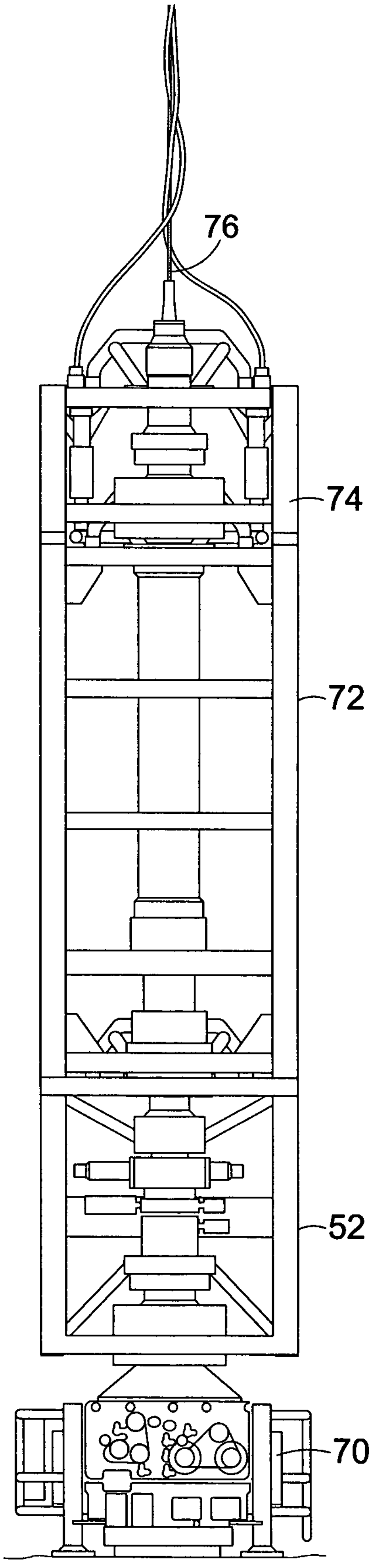

Fig.5

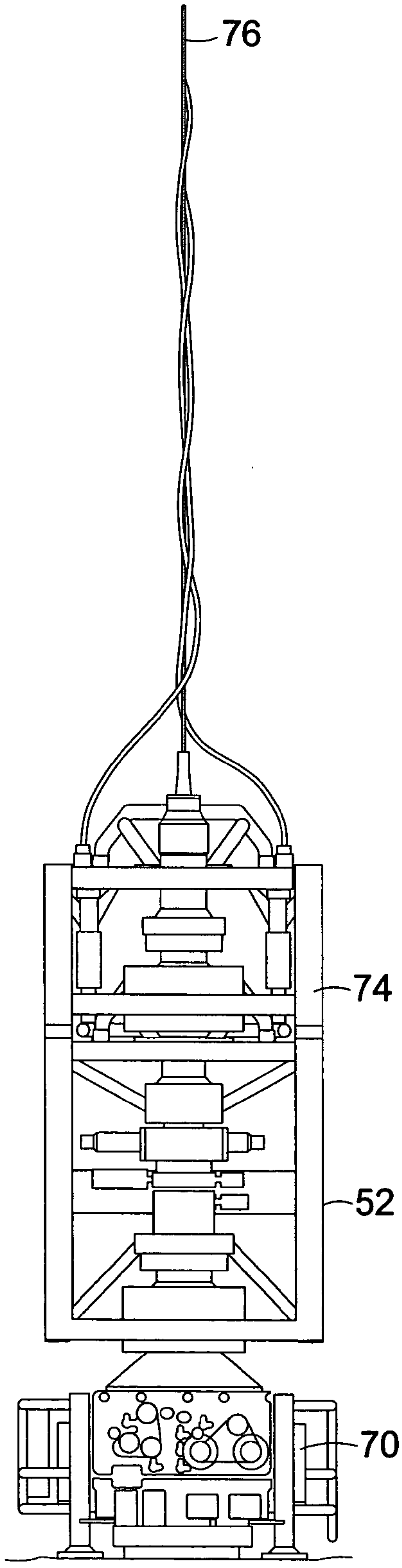

Fig.6

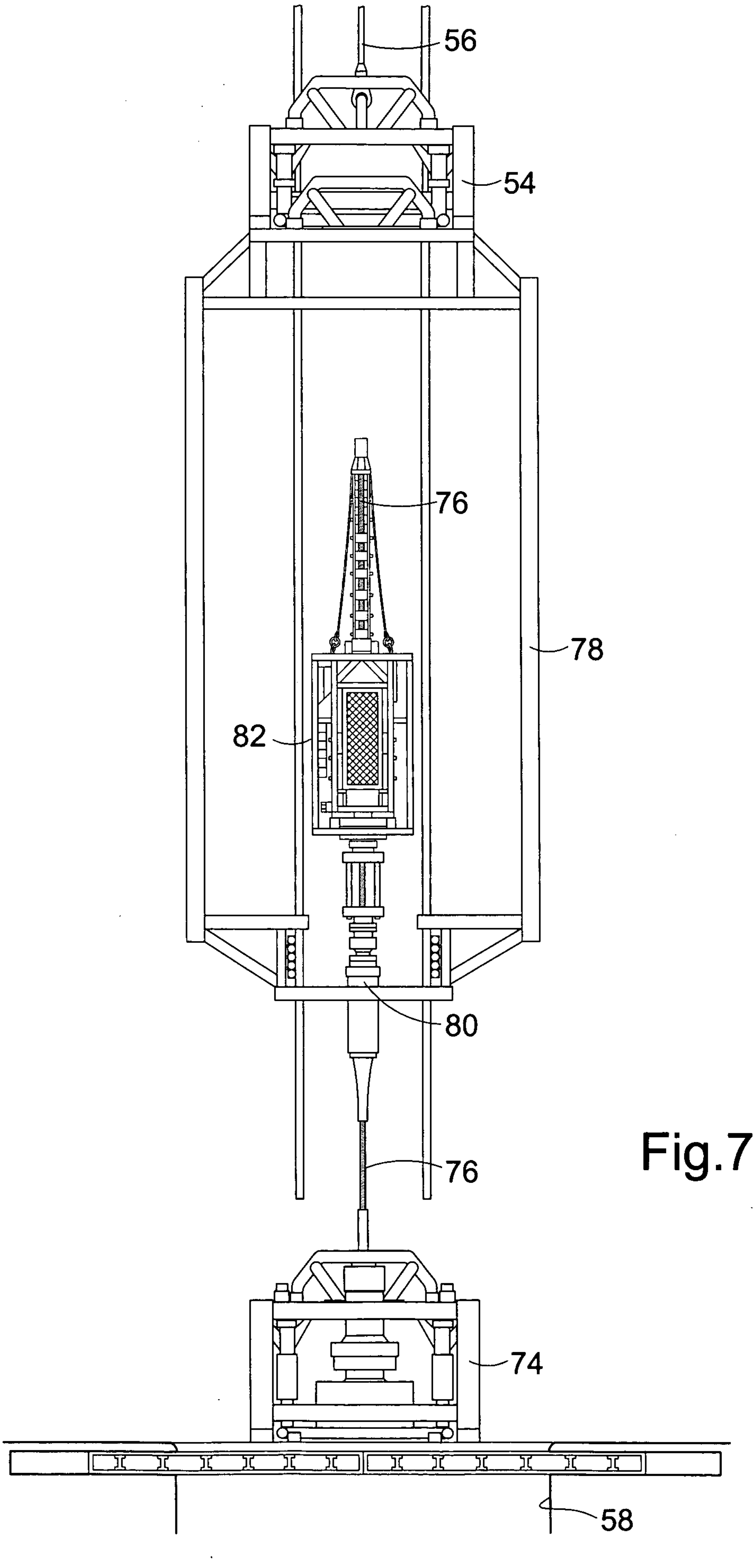

Fig.7

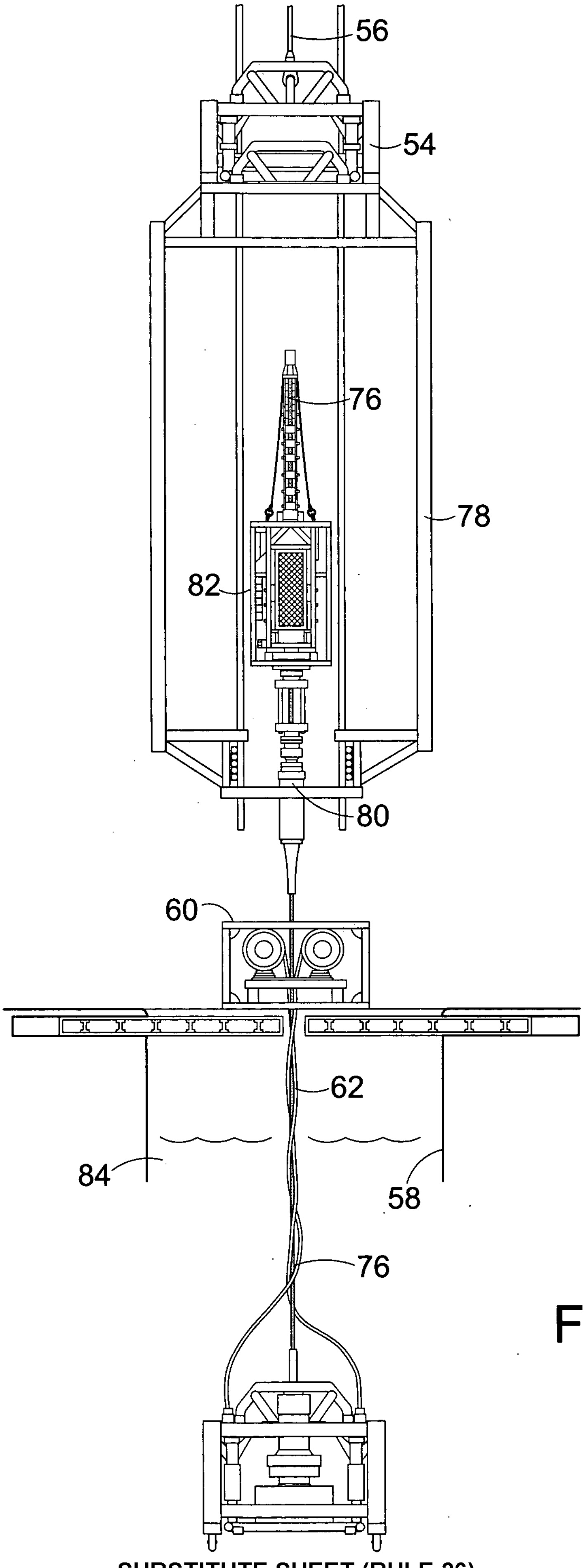

Fig.8

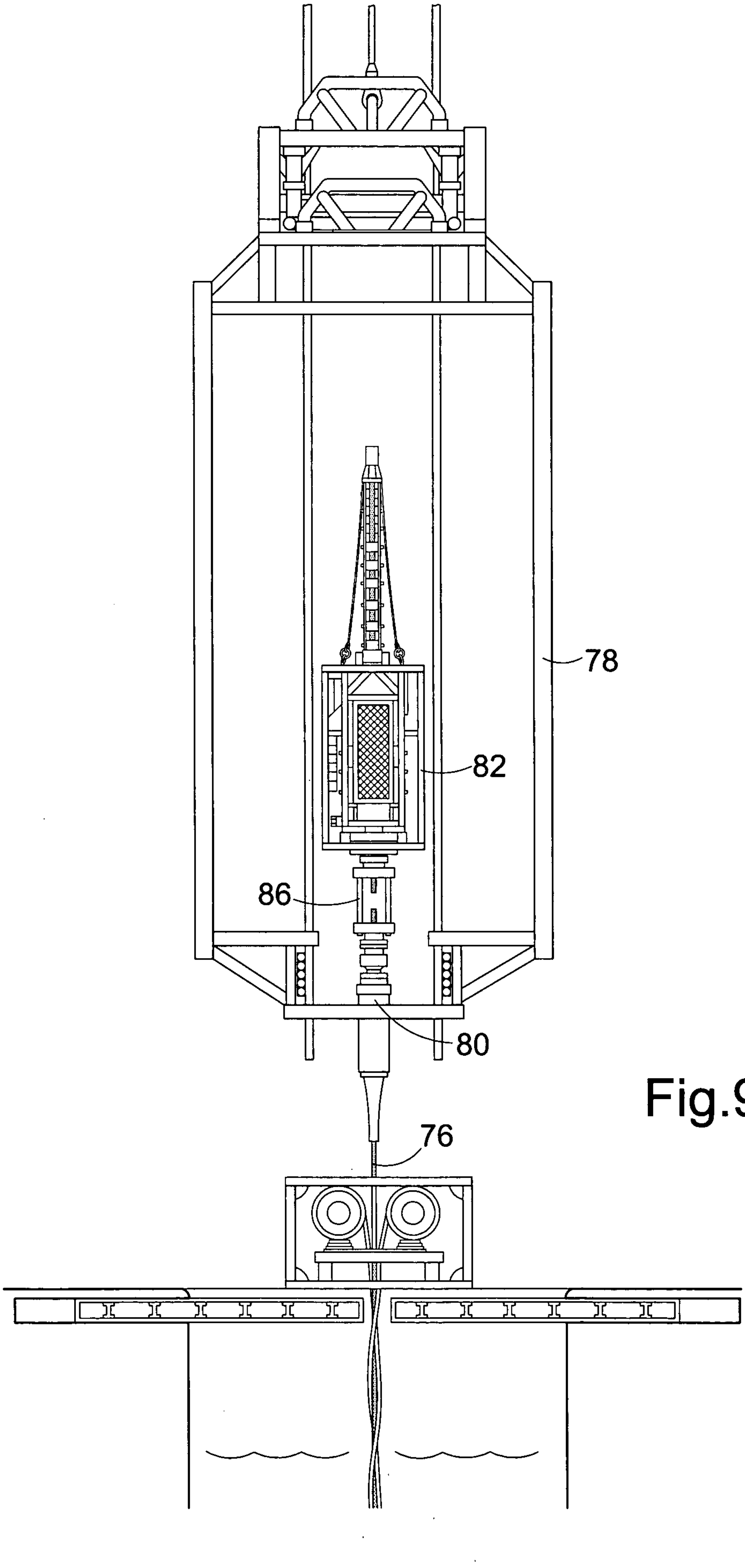

Fig.9

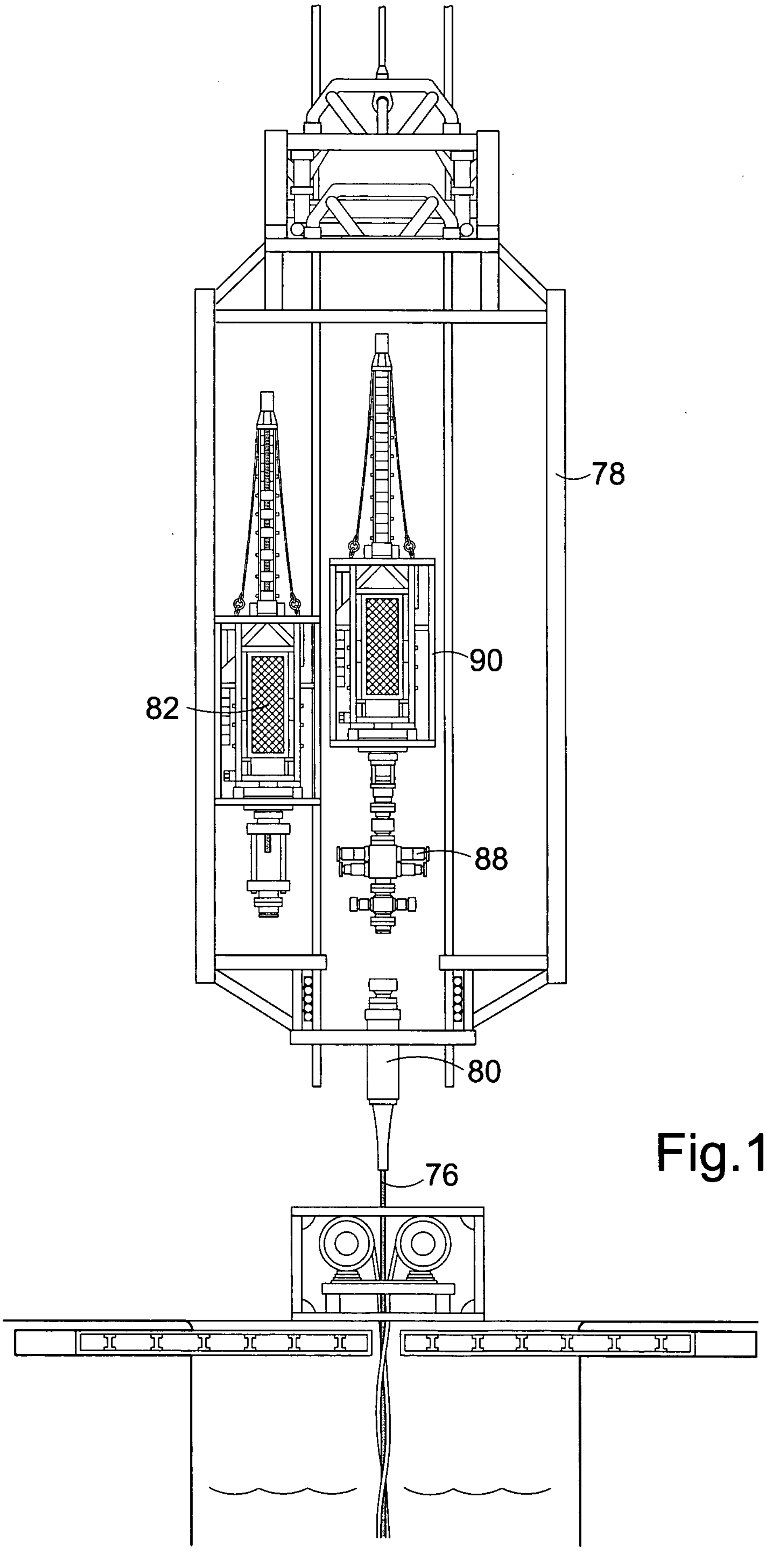

Fig.10

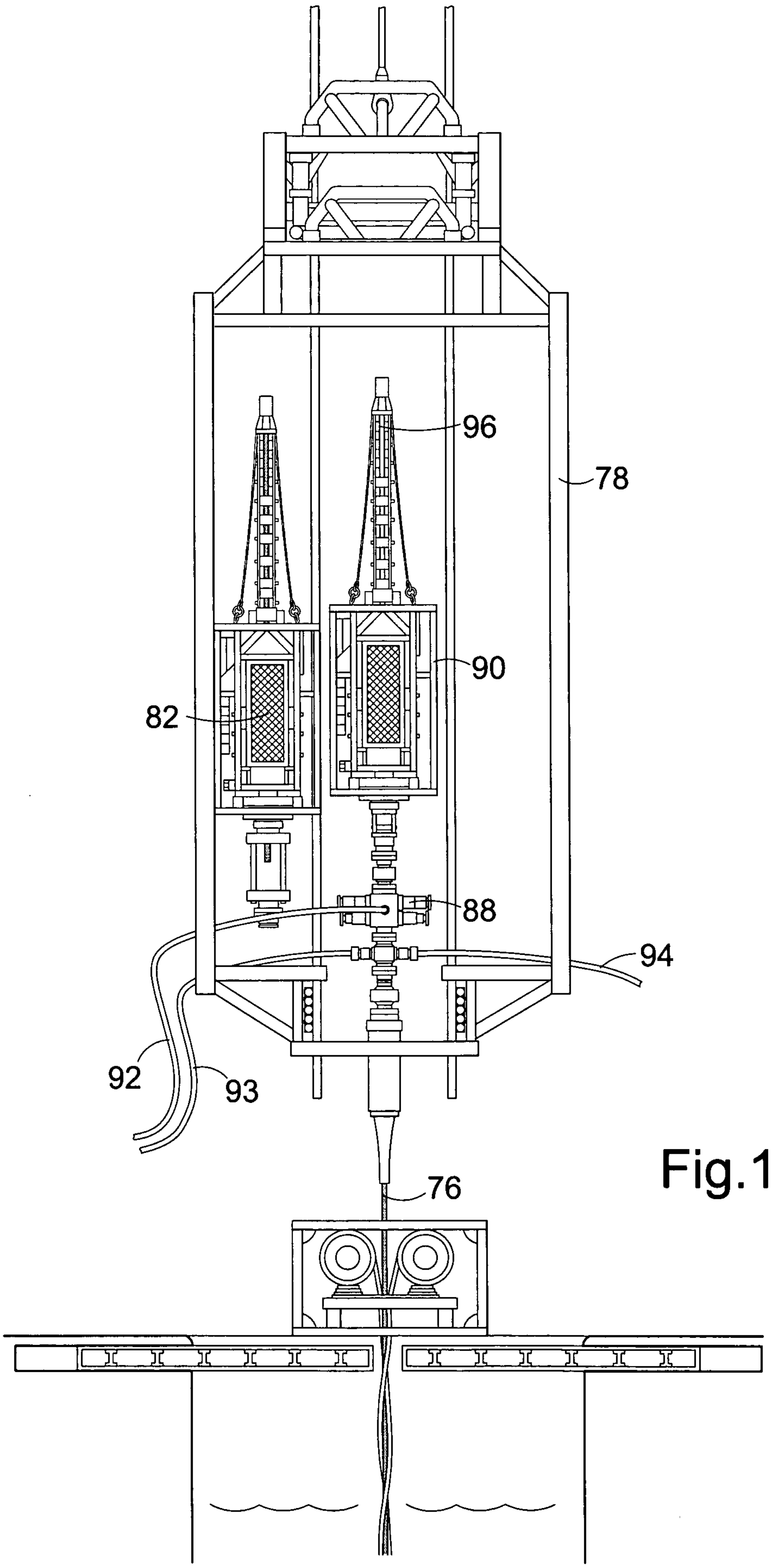

Fig.11

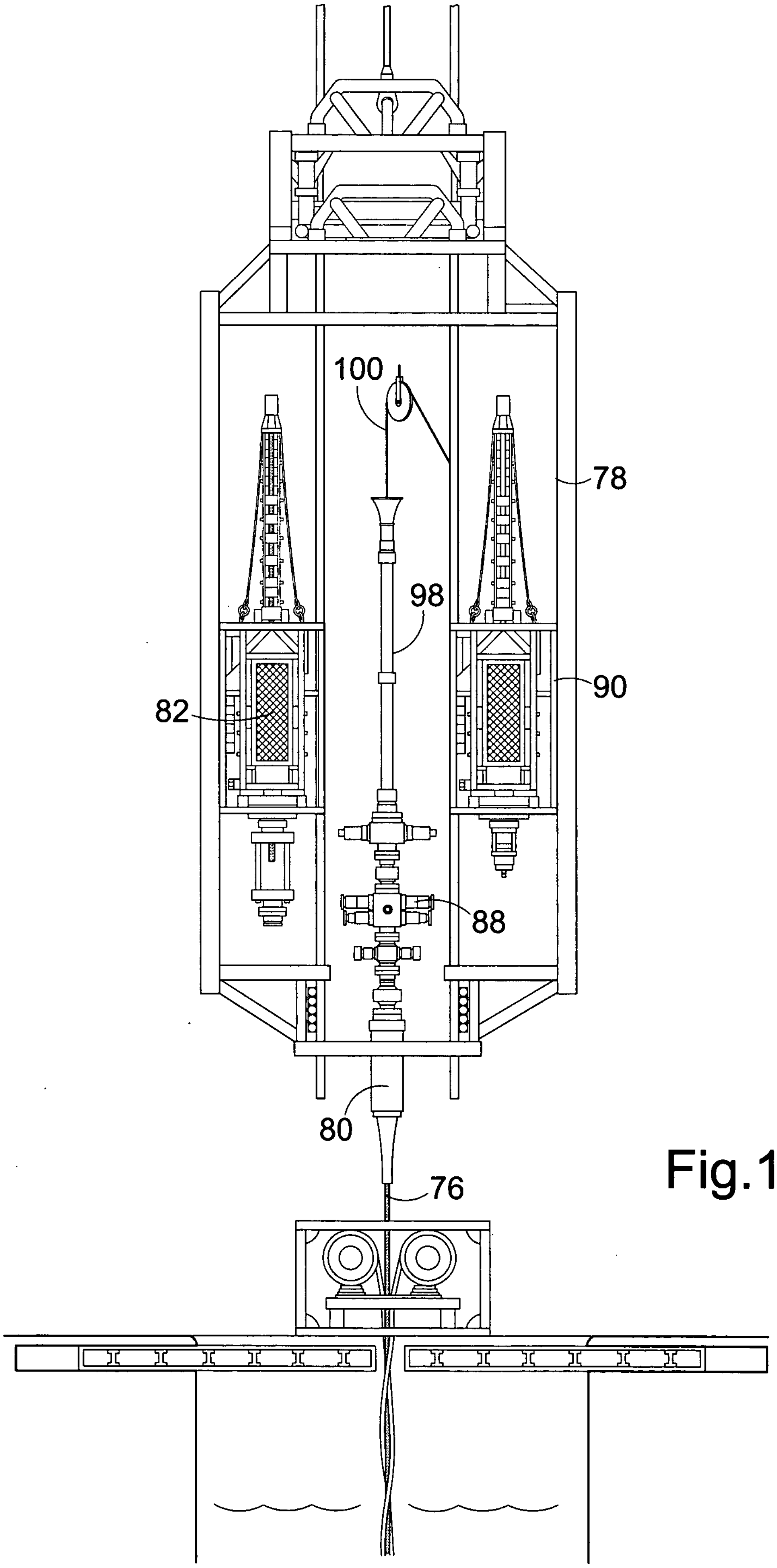

Fig.12

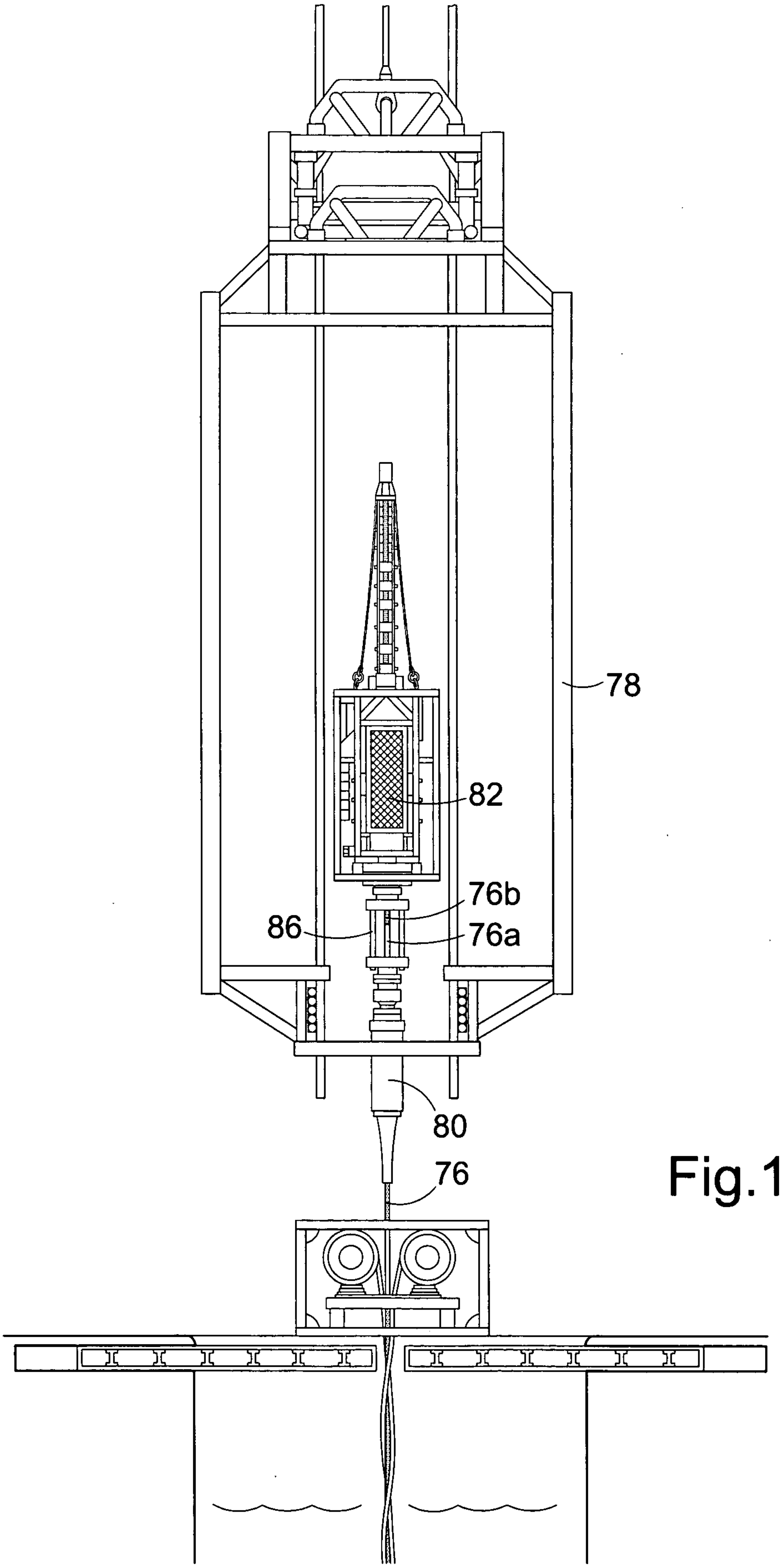

Fig.13