

(19)



(11)

EP 4 534 401 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.04.2025 Bulletin 2025/15

(51) International Patent Classification (IPC):
B63B 35/04 ^(2006.01) **B63B 79/10** ^(2020.01)

(21) Application number: **23306704.0**

(52) Cooperative Patent Classification (CPC):
B63B 35/04; B63B 79/10

(22) Date of filing: **04.10.2023**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(72) Inventors:
• **MORAND, Henri**
WEST PERTH, 6005 (AU)
• **SCHNEIDER, Matthew**
PERTH, 6000 (AU)

(74) Representative: **Lavoix**
2, place d'Estienne d'Orves
75441 Paris Cedex 09 (FR)

(71) Applicant: **TechnipFMC Subsea France**
92400 Courbevoie (FR)

(54) **A RECOVERY INSTALLATION TO RECOVER A SUBMARINE LINE IN A BODY OF WATER, AND CORRESPONDING RECOVERY METHOD**

(57) The installation comprises a line recovery system (32), to lift the submarine line (11) out of a body of water and a radiation detection unit (13), to detect a ionizing radiation emitted from the submarine line (11).

The line recovery system (32) defines a line circulation space (80) through which the submarine line (11) follows a linear path.

The detection unit (13) comprises :

- a stand (70) fixedly or adjustably mounted in the line recovery system (32), in the vicinity of the line circulation space (80);
- a radioactivity detector (72), carried by the stand (70) and configured to detect a radioactivity level in the line circulation space (80) at successive measurement times;
- a recording unit (74), connected to the radioactivity detector (72) to record the successive measurements of the radioactivity level at successive measurement times.

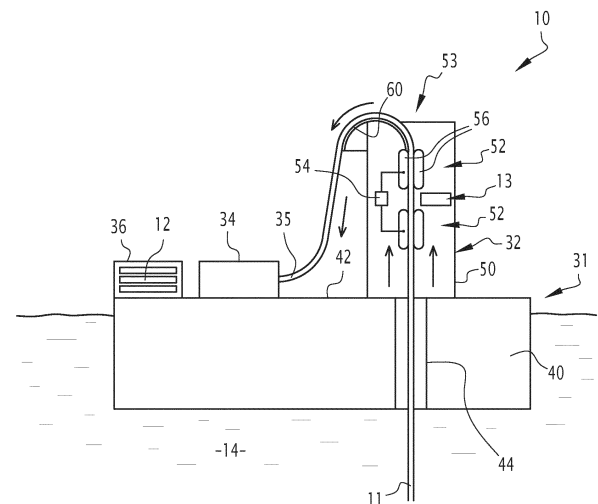


FIG.1

Description

[0001] The present invention concerns a recovery installation to recover a submarine line in a body of water, comprising:

- a vessel;
- a line recovery system, to lift the submarine line out of the body of water and recover the submarine line on the vessel;
- a radiation detection unit, to detect a ionizing radiation emitted from the submarine line.

[0002] The submarine line is for example a flexible line, in particular a flexible pipe, an umbilical, or a rigid pipeline.

[0003] The submarine line is in particular part of an offshore fluid production and/or fluid injection site, and/or power production site to be decommissioned.

[0004] The decommissioning of offshore sites, in particular fluid production and/or fluid injection sites after the termination of fluid production is currently a challenge for operators.

[0005] An offshore production or/and injection site generally comprises fluid collection equipment located at the bottom of a body of water. Numerous fluid injection and/or production lines extend from the fluid collection equipment to the surface, to transport fluids to be injected in the ground below the bottom of the body of water and/or to collect fluids produced from the ground.

[0006] For the decommissioning, the lines are disconnected or cut from the fluid collection equipment. The submarine lines are then lifted with a line recovery system mounted on an offshore vessel.

[0007] Thereafter, the terms "vessel", "offshore vessel" or "recovery vessel" are identical and can be used randomly to mean a floating structure on a body of water and equipped with a lay system to lay submarine lines on the floor of the body of water. The lay system is also able to recover the submarine lines resting in the body of water or on the floor of the body of water. Barge, boat, ship and FPSO (Floating Production Storage and Offloading) are encompassed into the term "vessel". Other floating structures not mentioned hereabove are also included in the scope of protection of the present invention.

[0008] The submarine lines are retrieved using vessels and are sometimes stored on the deck of the vessel, or onto reels or carousels installed on the deck of the vessel.

[0009] Alternatively, the submarine lines are cut into short sections. The submarine line sections in this case have a length ranging from 6 m to 20 m. The submarine line sections can then be processed offshore on the vessel or onshore at a deconstruction site.

[0010] The recovered submarine lines may comprise flexible production lines which have been used to carry fluids for long periods of times. A production line generally conveys not only production fluids such as oil and gas, but also materials from the reservoirs in which the pro-

duction fluids are extracted.

[0011] Most often, the materials comprise Naturally Occurring Radioactive Materials (hereafter referred to as "NORM") and/or other materials. The radionuclides are thus transported along the production or injection lines during operation. Consequently, as time elapses, materials such as scales, deposits, sand or sludge accumulate inside or on the inner layers of the production or injection lines. These accumulated materials may contain non-negligible levels of radionuclides.

[0012] Before the submarine lines recovery operations are started, the field operator usually carries out an inspection of the lines on the bottom of the body of water. In particular, potential accumulation of NORM in regions of the line are monitored to inform the decommissioning operator operating the decommissioning vessel of the potential for NORM occurrence when the line is recovered.

[0013] In some instances, the detection carried out at the bottom of the body of water is not possible or precise enough to certify that the line does not comprise significant amounts of NORM at least in some regions.

[0014] The method allows a detection of the presence of potential NORM in the line, even if these NORM have not been detected beforehand.

[0015] However, such a method is not entirely satisfactory to operate. Indeed, an operator must stand in the vicinity of the line at any moment to inspect the line. The operator may thus be exposed to radiation while controlling the line.

[0016] In addition, once NORM have been detected within the line, the method does not allow a precise determination of which region of the line comprise NORM as opposed to regions which do not comprise NORM. Thus, the recovery operations have to be stopped to monitor the line more precisely.

[0017] An object of the invention is thus to provide a submarine line recovery installation which is very safe to operate, even if the line contains NORM, and in which the line containing NORM can be processed safely and efficiently.

[0018] To this aim, the subject matter of the invention is a recovery installation of the above-mentioned type, characterized in that the line recovery system defines a line circulation space through which the submarine line follows a linear path, the detection unit comprising:

- a stand fixedly or adjustably mounted in the line recovery system, in the vicinity of the line circulation space;
- a radioactivity detector, carried by the stand and configured to detect a radioactivity level in the line circulation space at successive measurement times;
- a recording unit, connected to the radioactivity detector to record the successive measurements of the radioactivity level at successive measurement times.

[0019] The recovery installation according to the invention may comprise one or more of the following feature(s), taken solely, or according to any technical feasible combination:

- the radioactivity detector is positioned transverse to the linear path;
- the detection unit comprises a display unit to display values of the radioactivity level as a function of time;
- the recording unit is configured to record successive positional information on the submarine line recovered from the body of water of the successive measurements at the successive measurement times;
- the line recovery system comprises a recovered line length sensor configured to measure a length of recovered line at the successive measurement times, the recovered line length sensor being connected to the recording unit to provide the recording unit with lengths of recovered line at the successive measurement times and obtain the successive positional information at the successive measurement times;
- the line recovery system is a lay tower comprising at least one tensioner defining the linear path of the submarine line;
- the line recovery system comprises two successive tensioners, the stand being positioned at an intermediate level of the lay tower between the two successive tensioners or below the two successive tensioners;
- the detection unit comprises an alarm unit, directly or indirectly connected to the recording unit, the alarm unit being configured to trigger an alarm when the radioactivity level detected by the radioactivity detector is beyond a predetermined level;
- the ionizing radiation comprises alpha particles, beta particles, and/or gamma rays, advantageously emitted by radioactive material present in the submarine line.

[0020] The invention also concerns a recovery method to recover a submarine line in a body of water, comprising:

- lifting the submarine line out of the body of water with a line recovery system on a vessel, and recovering the submarine line on the vessel;
- detecting the presence of ionizing radiation emitted from the submarine line with a radiation detection unit;

characterized by :

- providing a stand fixedly or adjustably mounted in the line recovery system, facing a line circulation space through which the submarine line follows a linear path;
- detecting a radioactivity level in the line circulation

space with a radioactivity detector carried by the stand, at successive measurement times;

- recording the successive measurements of the radioactivity level at successive measurement times with a recording unit, connected to the radioactivity detector.

[0021] The recovery method according to the invention may comprise one or more of the following feature(s), taken solely, or according to any technical feasible combination:

- the detection unit comprises an alarm unit, directly or indirectly connected to the recording unit, the method comprising triggering an alarm when the radioactivity level detected by the radioactivity detector is beyond a predetermined level;
- the recovery method comprises recording successive positional information on the submarine line recovered from the body of water of the successive measurements at the measurement times with the recording unit and correlating the successive positional information of the successive measurements at the measurement times with the radioactivity levels measured by the radioactivity detector at corresponding measurement times;
- the recovery method comprises displaying values of the radioactivity level as a function of time on a display unit of the detection unit.

[0022] The invention will be better understood, based on the following description, given solely as an example, and made in reference to the appending drawings, in which:

- Figure 1 is a side cross-sectional view of a recovery installation according to the invention, equipped with a permanent radiation detection unit, during the recovery of a submarine line;
- Figure 2 is a schematic view of a line recovery system equipped with the radiation detection unit according to the invention;
- Figure 3 is a side view of the radioactivity detector of the radiation detection unit, measuring radioactivity produced by materials in a submarine line;
- Figure 4 is an example of flexible pipe potentially containing NORM.

[0023] A recovery installation 10, equipped with a radiation detection unit 13 according to the invention, to detect naturally occurring radioactive material (hereinafter "NORM"), is shown in figures 1 to 3.

[0024] The recovery installation 10 is intended to recover a submarine line 11.

[0025] Optionally, the recovery installation 10 is also configured to process the submarine line 11 in several line sections 12, although the processing can be carried out in another installation, for example onshore.

[0026] The recovery installation 10 is intended to be operated over a body of water 14 to recover the submarine line 11 in the body of water 14.

[0027] The body of water 14 is for example a sea, an ocean, a lake, and/or a river. Its depth is comprised generally between 10 m and 3000 m.

[0028] In the example of figure 1, the submarine line 11 has an axis and delimits a central passage for circulation of a fluid, advantageously a petroleum fluid.

[0029] The submarine line 11 is for example a flexible pipe, in particular built according with the standards API 17J (Specification for Unbonded Flexible Pipe, 4th edition - May 2014) and API RP 17B (Recommended Practice for Flexible Pipe, 5th edition - May 2014) established by the American Petroleum Institute.

[0030] In the example shown in figure 4, the submarine line 11 is an unbonded flexible pipe 16. At least two adjacent layers of the flexible pipe 16 are free to move longitudinally with respect to each other during flexure of the flexible pipe 16.

[0031] In the example of figure 4, the flexible pipe 16 has an axis A-A' and delimits a central passage 18 for circulation of a fluid, advantageously a petroleum fluid. The central passage diameter advantageously ranges from 15 cm to 60 cm.

[0032] The flexible pipe 16 comprises a plurality of concentric layers around the axis A-A'. The flexible pipe 16 includes at least one first tubular sheath 20 formed of a polymeric material. The first tubular sheath 20 is a pressure sheath.

[0033] The flexible pipe 16 further includes at least one layer of tensile armors 22, 23 positioned externally with respect to the first sheath 20.

[0034] The flexible pipe 16 further optionally includes an internal carcass 24 positioned inside the pressure sheath 20, and/or a pressure vault 25 inserted between the pressure sheath 20 and the layer(s) of tensile armors 22, 23. It also optionally comprises an external sheath 26, intended to protect the flexible pipe 16.

[0035] In a known way, the pressure sheath 20 is intended to tightly confine the fluid transported in the central passage 18. It is formed of a polymeric material, for example based on a polyolefin such as polyethylene, based on a polyamide such as PA11 or PA12, or based on a fluorinated polymer such as polyvinylidene fluoride (PVDF).

[0036] The thickness of the pressure sheath 20 is for example comprised between 5 mm and 20 mm.

[0037] When present, the carcass 24 is formed for example with a first helicoidally wound profiled interlocked metal strip 28.

[0038] The main function of the carcass 24 is to absorb the squeezing radial forces.

[0039] The carcass 24 is positioned inside the pressure sheath 20. It is able to come into contact with the fluid circulating in the pressure sheath 20.

[0040] The helical winding of the first profiled strip 28 forming the carcass 24 is with a short pitch, i.e. it has a

helix angle with an absolute value close to 90° in relation to the axis A-A', typically comprised between 75° and 90°.

[0041] When present, the pressure vault 25 is intended to absorb the radial forces related to the pressure prevailing inside the pressure sheath 20. For example it is formed with a helicoidally wound metal profiled wire around the sheath 20. The profiled wire generally has a complex geometry, in particular Z-shaped, T-shaped, U-shaped, K-shaped, X-shaped or I-shaped.

[0042] The pressure vault 25 is helicoidally wound with a short pitch around the pressure sheath 20, i.e. with a helix angle of an absolute value close to 90° in relation to the axis A-A', typically comprised between 75° and 90°.

[0043] In the example illustrated in figure 4, each layer of armors 22, 23 includes longitudinal armor elements 27 wound with a long pitch around the axis A-A' of the pipe.

[0044] The armor elements 27 of a first layer 22 are generally wound according to an opposite angle with respect to the armor elements 27 of a second layer 23.

Thus, if the winding angle of the armor elements 27 of the first layer 22 is equal to $+\alpha$, α being comprised between 25° and 55°, the winding angle of the armor elements 27 of the second layer of armors 23 positioned in contact with the first layer of armors 22 is for example equal to $-\alpha$.

[0045] The armor elements 27 are for example formed with metal wires, in particular steel wires, or with strips in composite material, for example strips reinforced with carbon fibers.

[0046] The external sheath 26 is intended to prevent ingress of fluid from the outside of the flexible pipe 10 towards the inside. It is advantageously made in a polymeric material, in particular based on a polyolefin, such as polyethylene, or on in a polyamide, such as PA11 or PA12.

[0047] The thickness of the external sheath 26 is for example comprised between 5 mm and 15 mm.

[0048] The flexible pipe 16 in some instances comprise accumulated solids 29 present in the central passage 18, in particular between the tubular sheath 20 and the carcass 24 or within the carcass 24.

[0049] In the example of figure 4, the accumulated solids 29 for example form an inside layer 30 within the carcass 24. The layer 30 can be solid, similar to a scale deposit or can be powdery, similar to sand.

[0050] The accumulated solids 29 result from materials such as scales, sand or sludge. Such material may contain radioactive elements, in particular uranium, thorium and decay products, or radium. These elements are Naturally Occurring Radioactive Materials (or "NORM").

[0051] The radioactive elements spontaneously emit ionizing radiations, for example alpha particles, beta particles, and/or gamma rays.

[0052] These accumulated deposits may also contain other hazardous substances such as mercury or hydrocarbons.

[0053] Alternatively, the submarine line 11 is a Hybrid Flexible Pipe (HFP), in particular built according with the standards DNV-ST-F119 (Thermoplastic Composite

Pipes, Edition September 2019) established by the DNV (Det Norske Veritas). The hybrid flexible pipe is advantageously an unbonded flexible pipe. At least two adjacent layers of the hybrid flexible pipe are free to move longitudinally with respect to each other during flexure of the pipe.

[0054] Alternatively, the submarine line 11 is another type of flexible pipe, such as a Fibre Reinforced 'composite' Pipe (FRP) or a bonded flexible pipe. The bonded flexible pipe is designed, manufactured and used according with the standards API RP 17B (Recommended Practice for Flexible Pipe, 5th edition - March 2014), API 7K (Drilling and Well Servicing Equipment, 6th edition - December 2015), API 16C (Choke and Kill Equipment, 3rd edition - March 2021) and API 17K (Specification for Bonded Flexible Pipe, 3rd edition - August 2017) established by the American Petroleum Institute.

[0055] Again alternatively, the submarine line 11 is an umbilical, as defined in ISO 13628-5 "Petroleum and natural gas industries - Design and operation of subsea production systems - Part 5: Subsea umbilicals" published in December 2009 by the International Organization for Standardization, API 17E "Specification for Subsea Umbilicals", 5th Edition - July 2017 and API RP 17A "Design and Operation of Subsea Production Systems - General Requirements and Recommendations", 6th Edition - May 2022, established by the American Petroleum Institute, and IEC60183:2015, January 2015, IEC60840:2020, May 2020 and/or IEC63026:2019, December 2019, established by the International Electrotechnical Commission (IEC), all provide standards for the design and manufacture of umbilicals and power cables. Umbilical includes for example steel/thermoplastic/composite tube electrohydraulic umbilical, Integrated Service/Production Umbilical (ISU™ / IPU™) and subsea power umbilical/cable.

[0056] Alternatively, again, the submarine line 11 is a single rigid metallic pipe including for example mechanically lined pipe (MLP) or polymer lined pipe (PLP), or is a rigid metallic pipe-in-pipe (PiP), as defined in the offshore standard DNV-ST-F101 "Submarine Pipeline Systems", August 2021, established by the DNV (Det Norske Veritas).

[0057] In the option in which the submarine line 11 is divided into line sections 12, the line sections 12 are obtained by successively transversely cutting the submarine line 11 into the line sections 12.

[0058] Each line section 12 has a length smaller than 25 m, advantageously comprised between 10 m and 20 m. Advantageously, the line sections 12 are transported from their offshore recovery site to an onshore decommissioning facility where they are deconstructed and their materials recycled. A decontamination of the line sections is carried out when NORM are present, before the line sections 12 are deconstructed.

[0059] In reference to figures 1 to 3, the recovery installation 10 comprises a recovery vessel 31, and a line recovery system 32, which, according to the inven-

tion, is equipped with the radiation detection unit 13.

[0060] In the option in which the submarine line 11 is divided into line sections 12, the recovery installation 10 further comprises a processing stage 34, to process an upper end region 35 of the submarine line 11 recovered with the line recovery system 32 into several line sections 12.

[0061] In this option, the recovery installation 10 further comprises, downstream of the processing stage 34, a handling and storage stage 36 to carry and store the line sections 12 processed in the processing stage 34.

[0062] The line recovery system 32, the radiation detection unit 13, the processing stage 34 and the handling and storage stage 36 when present are all carried by the recovery vessel 31.

[0063] In this example, the recovery vessel 31 is a ship floating on the surface of the body of water 14. In variant, the recovery vessel 31 is a platform, in particular a floating platform.

[0064] The recovery vessel 31 has a surface body, here a hull 40, floating on the surface of the body of water 14 and at least a deck 42 onto which the line recovery system 32, the processing stage 34, and the handling and storage stage 36 are positioned.

[0065] In the example of figure 1, the hull 40 has a moon pool 44 extending vertically through the deck 42 and through the hull 10 to provide a central vertical access in the body of water 14.

[0066] Alternatively, recovery operations can take place over the side or at the back of the vessel 31.

[0067] The line recovery system 32 is configured to vertically or horizontally lift the submarine line 11 above the surface of the body of water 14 to bring the upper end region 35 of the submarine line 11 above the deck 42 to the processing stage 34.

[0068] In the example of figure 1, the line recovery system 32 is a vertical lift system (VLS) configured to continuously lift a vertical section of the submarine line 11 and to redirect it above the hull 40. The vertical lifting system is configured to recover the submarine line 11 in a J shape configuration.

[0069] Optionally, the line recovery system 32 may comprise a tiltable lift system (i.e. not completely vertical and not completely horizontal) above the surface of the body of water 14, the line recovery system 32 being inclined over the side, at the middle or at the back of the vessel 31. Typically, tiltable lift systems are vertical or horizontal lay systems which are slightly inclined of a few degrees, for example between 10° and 45°, in relation to the deck 42 level of the recovery vessel 31.

[0070] Optionally again, when the submarine line 11 is a rigid line, the line recovery system 32 is a J-lay tower or a S-lay tower equipped preferably with tensioners.

[0071] In reference to figures 1 and 2, the line recovery system 32 comprises a tower 50 mounted on the deck 42, and tensioners 52 carried by the tower 50 to continuously lift the submarine line 11. The line recovery system 32 further comprises a redirecting mechanism 53 to bend

the submarine line 11 at the top of the tower 50 and redirect it towards the deck 42.

[0072] The tower 50 is here mounted above the moon pool 44. When the recovery vessel 31 does not comprise a moon pool 44, the tower 50 is advantageously mounted near a side of the hull 40 to lift the submarine line 11 from the side.

[0073] In the example of figure 1, the height of the tower, taken above the hull 40 is for example greater than 20 m, and is generally comprised between 20 m and 80 m.

[0074] In the example of figure 2, the line recovery system 32 comprises at least two tensioners 52, located one above the other along a vertical axis in the tower 50. Each tensioner 52 comprises at least a pair (2-track version), preferably two pairs (e.g. 4-track version), of facing gripping members 56 delimiting between them a vertical passage. Each gripping member 56 comprises a guide track for gripping and moving the submarine line 11.

[0075] The tensioners 52 can be operated continuously at a lifting velocity which can be controlled. The line lifting velocity is for example comprised between 1.0 m/min and 30 m/min, in particular between 1.5 m/min and 20.0 m/min.

[0076] The tower 50 here comprises a bottom floor 57 (see figure 2) located below the lower tensioner 52 around the top of the moon pool 44. The bottom floor 57 advantageously has retractable panels to let ancillary equipment, such as buoys or connectors, pass through and be dismantled on the bottom floor 57.

[0077] The tower 50 further comprises an intermediate floor 58 arranged between the lower tensioner 52 and the upper tensioner 52.

[0078] The line recovery system 32 comprises at least a sensor 54 to measure a length of submarine line 11 recovered from the body of water 14 as a function of time. The sensor 54 for example measures the numbers of rotations of the tensioners track rollers and converts it into a distance.

[0079] A correlation between the radiation level measured with the detecting unit 13 and the location along the submarine line 11 is thus allowed, using a time stamp or/and the length recovered through sensor 54 for example.

[0080] In reference to figure 1, the redirection mechanism 53 here comprises a curved guide chute 60 or a wheel, mounted at the top of the tower 50. The chute 60 is substantially U shaped and faces downwards. It defines a suitable bending radius for the submarine line 11.

[0081] This bending radius is greater than the Minimum Bending Radius (MBR) of the submarine line 11. It is configured to bend the submarine line 11 from an upper vertical trajectory to a downward trajectory directed towards the deck 42 while controlling the bending radius of the submarine line 11.

[0082] As shown in figures 2 and 3, the radiation detection unit 13 comprises a stand 70 permanently positioned

in the line recovery system 32, a radioactivity detector 72, reversibly mounted on the stand 70, and a control and recording unit 74, connected to the radioactivity detector 72.

[0083] The detecting unit 13 further comprising a display unit 76, connected to the control and recording unit 74 to show results of the detection by the radioactivity detector 72 and preferably, an alarm unit 78, also connected to the control and recording unit 74 to trigger an alarm when a radioactivity level detected by the radioactivity detector exceeds a predetermined level.

[0084] The stand 70 is fixedly or adjustably mounted in the line recovery system 32. It is preferably located adjacent to a line circulation space 80, through which the line 11 passes and follows a linear path along an axis A-A'.

[0085] In the example of figure 2, the stand 70 is for example permanently mounted on the intermediate floor 58 between the two tensioners 52. The line circulation space 80 extends vertically along the axis A-A' defined by the tensioners 52 through the intermediate floor 58.

[0086] The stand 70 is positioned at a position which allows the radioactivity detector 72 placed on the stand 70 to be at a distance of less than 1 m from the line 11.

[0087] As shown in figure 3, the radioactivity detector 72 has an end located less than 1 m from the line 11 circulating in the line circulation space 80. It extends along a longitudinal axis B-B' transverse to the line circulation axis A-A' along a generatrix of the line 11.

[0088] In this example, the radioactivity detector 72 has a cylindrical external housing 82 which contains a radioactivity sensor (not shown). It advantageously has a handle 84 to be carried by an operator when disconnected from the stand 70.

[0089] The radioactivity detector 72 is maintained on the stand 70 via detachable brackets 86 which, in this example, are located at the ends of the housing 82. The brackets 86 are reversibly detachable to let an operator seize the radioactivity detector 72 by the handle 84 and use it as a portable detector.

[0090] In a variant, the radioactivity detector 72 is also fluid tight. Its housing 62 is pressure resistant and configured to be also immersed in the body of water 14 to check the radioactivity along an immersed line 11 in the body of water 14, for example using a remotely operated vehicle (ROV).

[0091] As such, the radioactivity detector 72 may be used underwater. The fluid tightness also prevents grease deterioration of and/or water infiltration into the detector 72 due to the vicinity of the tensioners 52 and of the recovered line 11.

[0092] The radioactivity sensor contained in the radioactivity detector 72 is for example a Geiger counter. The Geiger counter is configured to receive counts of radioactive rays to determine a count rate and determine a received radiation dose. The counter is sensitive for example to γ radiation emitted from the NORM contained in the line 11 which is emitted through the layers 24, 20, 25,

22, 23, 26.

[0093] The control and recording unit 74 is connected to the radioactivity detector 72, for example by a wire connection, such as a cable 90. The cable 90 has for example a length greater than 1 m, for example greater than 10 m, and comprised between 12 m and 20 m.

[0094] The control and recording unit 74 comprises at least a processor and a memory comprising software modules configured to be executed by the processor to activate the radioactivity detector 72 and collect measurements from the radioactivity sensor of the radioactivity detector 72 at successive measurement times. It comprises a time stamping module configured to time stamp the radioactivity level measurements by the radioactivity detector 72 and store the time stamped measurements in the memory of the control and recording unit 74.

[0095] The frequency of the time-stamped measurements is for example greater than 0.01 Hz and is generally comprised between 0.01 Hz and 1 Hz.

[0096] As such, the radioactivity emitted along the submarine line 11 is accurately measured as a function of time.

[0097] In addition, the control and recording unit 74 is configured to recover a positional information on the submarine line 11 recovered from the body of water 14 of the successive measurements at the successive measurement times.

[0098] The positional information on the submarine line 11 recovered from the body of water 14 are for example obtained from the line length which has been recovered by the line recovery system 32, measured by the sensor 54 as a function of time.

[0099] The control and recording unit 74 is thus configured to correlate data of the radioactivity level to the actual recovered length to determine, at each point of the submarine line 11, the radioactivity level corresponding to this point.

[0100] The display unit 76 is connected to the control and recording unit 74 via an external cable 92. The cable 92 has a length greater than 10 m, for example comprised between 25 m and 75 m.

[0101] The display unit 76 comprises at least a computer configured to recover data obtained by the control and recording unit 74, the computer comprising at least a display generator configured to generate graphs of the radioactivity level versus time and advantageously, of the radioactivity level versus position in the submarine line 11.

[0102] The display unit 76 further comprises a display, such as a screen onto which the window generator is configured to display the graphs, and current values of the radioactivity level and recovered length of the submarine line 11. It is for example located into a vessel control room.

[0103] The alarm unit 78 is connected to the display computer 76 through another cable 94. It is for example located into the vessel control room. It comprises an alarm generator configured to emit a light, sound or/and

vibratory alarm when the radioactivity level measured by the radioactivity detector 72 exceeds a predetermined level, for example greater than 5 $\mu\text{Sv/h}$ on the surface of the submarine line 11.

[0104] Based on the alarm, the operators of the line recovery system 32 and of the processing stage 34 can anticipate the arrival of a region of the submarine line 11 which is contaminated with NORM and take the appropriate safety measures to process this region.

[0105] In this example, the processing stage 34 comprises a working section having a cutting system (not shown) configured to cut an upstream region 35 of the submarine line 11 retrieved with the line recovery system 32 into line sections 12 having a length advantageously comprised between 6 m and 20 m.

[0106] The handling and storage stage 36 comprise an appropriate and defined area to store the line sections 12 after they have been processed and a lifting device (not shown), such as a crane, configured to place at least a line section 12 into the said storage area.

[0107] For instance, the storage area comprises at least one container to store the line sections 12 previously cut. The at least one container is advantageously a flat rack to help sticking together the line sections 12.

[0108] In an alternative, instead of storing the line sections 12 into containers, the line sections 12 are rather dropped off on the deck 42 of the recovery vessel 31, in the appropriate and defined area.

[0109] The line sections 12 open ends are securely closed by appropriate solutions to avoid possible contamination of the deck and of the operators.

[0110] Alternatively, the recovery vessel 31 may comprises reel(s) or carrousel(s) configured to receive the submarine line 11 into a complete length to be further cut onshore or offshore at a separate time than the recovery. In that case, the recovery vessel 31 is not necessarily equipped with a processing stage 34 configured to divide the upper region 35 of the submarine line 11 recovered downstream of the line recovery system 32 in successive line sections 12.

[0111] A recovery method according to the invention will be now described.

[0112] Initially, a submarine line 11 is progressively lifted from the body of water 14 in the line recovery system 32.

[0113] The lifting is continuous, generally at a constant velocity advantageously comprised between 1.0 m/min and 30 m/min, in particular between 1.5 m/min and 20 m/min, except when a specific equipment located on the submarine line 11 needs to pass through the line recovery system 32.

[0114] A vertical lifted region 98 of the submarine line 11 is received between the gripping members 56 of the tensioners 52. It then runs through the redirection mechanism 53 to adopt a curved configuration in the curve guide chute 60.

[0115] An upstream region 35 of the submarine line 11 is then transported from the redirection mechanism 53 to

the processing stage 34.

[0116] In the option in which the submarine line 11 is divided into line sections 12, in the processing stage 34, the or each cutting system is activated to cut the upstream region 35 of the submarine line 11 in several submarine line sections 12. The submarine line sections 12 are temporarily retrieved in the processing stage 34 and are advantageously transported to the handling and storage stage 36 for storage.

[0117] During the lifting of the submarine line 11 in the tensioners 52, the line 11 circulates along a line circulation space 80, with a linear path between the tensioners 52 (which is vertical in the example of figure 2).

[0118] The radioactivity detector 72 has previously been mounted on the stand 70, for example after having been carried by the handle 84 and fixed with the brackets 86.

[0119] The control and recording unit 74 activates the radioactivity sensor of the radioactivity detector 72.

[0120] At regular measurement times, the radioactivity detector 72 determines the number of counts emitted from the submarine line 11 and received by the radioactivity sensor 72. It timestamps the measurements and record them in the memory of the control and recording unit 74.

[0121] Simultaneously, the sensor 54 provides data on the length of recovered submarine line 11 at each measurement time and thus a positional information of each measurement on the submarine line 11 recovered from the body of water 14.

[0122] The control and recording unit 74 then correlates each measurement of a radioactivity level by the radioactivity detector 72 with the positional information which is for example a length of recovered submarine line 11 which has been recovered by the line recovery system 32.

[0123] The data is then transmitted to the display computer 76 to be shown on a display, for example within the control room of the vessel.

[0124] Should the measured radioactivity level go beyond a predetermined threshold, the alarm generator of the alarm unit 78 triggers an alarm.

[0125] The operators of the processing stage are warned that a region of the submarine line 11 having NORM with a radioactivity level greater than the predetermined threshold arrives in the processing stage 34. They are able to equip themselves with protection gears and use a protective procedure to deal with the regions of the submarine line 11 having a radioactivity level beyond a predetermined threshold to be detected by the radioactivity detector 72.

[0126] Thanks to the provision of a radiation detection unit 13 comprising a stand 70 mounted at a fixed or adjustable position along the submarine line 11, in a line circulation space 80 in which the submarine line 11 follows a linear path, it is possible to place a radioactivity detector 72 at a predefined position which does not vary along time. This provides a very reliable and reproducible

measurement of the radioactivity level contained in the submarine line 11 at each measurement time.

[0127] The radioactivity level data versus time can be correlated with a positional information on the line 11 (for example data of the recovered length of the line 11 versus time), such that the radioactivity level at each point of the submarine line 11 can be detected along the submarine line 11.

[0128] When an abnormal radioactivity level is detected during the carrying out of the method according to the invention, an alarm can be triggered, and most importantly, the operators of the processing stage 34 can be warned and take appropriate protection measures.

[0129] The method according to the invention is thus safe and reliable to operate with very simple equipment.

[0130] In another variant, the stand 70 is placed on the bottom floor 57, and can be retracted when an equipment has to go through the bottom floor 57.

[0131] In a variant, the recording unit 74 of the detecting unit 13 is connected to the alarm unit 78, without passing through a display unit 76, and the detecting unit 13 may be without a display unit 76.

[0132] In another variant, the recording unit 74 of the detecting unit 13 is connected to the display unit 76, as shown above, but the detecting unit 13 is without an alarm unit 78.

Claims

1. A recovery installation (10) to recover a submarine line (11) in a body of water (14), comprising:

- a vessel (31);
- a line recovery system (32), to lift the submarine line (11) out of the body of water (14) and recover the submarine line (11) on the vessel (31);
- a radiation detection unit (13), to detect a ionizing radiation emitted from the submarine line (11);

characterized in that the line recovery system (32) defines a line circulation space (80) through which the submarine line (11) follows a linear path, the detection unit (13) comprising:

- a stand (70) fixedly or adjustably mounted in the line recovery system (32), in the vicinity of the line circulation space (80);
- a radioactivity detector (72), carried by the stand (70) and configured to detect a radioactivity level in the line circulation space (80) at successive measurement times;
- a recording unit (74), connected to the radioactivity detector (72) to record the successive measurements of the radioactivity level at successive measurement times.

2. The recovery installation (10) according to claim 1, wherein the radioactivity detector (72) is positioned transverse to the linear path.
3. The recovery installation (10) according to any one of the preceding claims, wherein the detection unit (13) comprises a display unit (76) to display values of the radioactivity level as a function of time. 5
4. The recovery installation (10) according to any one of the preceding claims, wherein the recording unit (74) is configured to record successive positional information on the submarine line (11) recovered from the body of water (14) of the successive measurements at the successive measurement times. 10 15
5. The recovery installation (10) according to claim 4, wherein the line recovery system (32) comprises a recovered line length sensor (54) configured to measure a length of recovered line at the successive measurement times, the recovered line length sensor (54) being connected to the recording unit (74) to provide the recording unit (74) with lengths of recovered line at the successive measurement times and obtain the successive positional information at the successive measurement times. 20 25
6. The recovery installation (10) according to any one of the preceding claims, wherein the line recovery system (32) is a lay tower comprising at least one tensioner (52) defining the linear path of the submarine line (11). 30
7. The recovery installation (10) according to claim 6, wherein the line recovery system (32) comprises two successive tensioners (52), the stand (70) being positioned at an intermediate level of the lay tower between the two successive tensioners (52) or below the two successive tensioners (52). 35 40
8. The recovery installation (10) according to any one of the preceding claims, wherein the detection unit (13) comprises an alarm unit (78), directly or indirectly connected to the recording unit (74), the alarm unit (78) being configured to trigger an alarm when the radioactivity level detected by the radioactivity detector (72) is beyond a predetermined level. 45
9. The recovery installation (10) according to any one of the preceding claims, wherein the ionizing radiation comprises alpha particles, beta particles, and/or gamma rays, advantageously emitted by radioactive material present in the submarine line (11). 50
10. A recovery method to recover a submarine line (11) in a body of water (14), comprising: 55

- lifting the submarine line (11) out of the body of

water (14) with a line recovery system (32) on a vessel (31), and recovering the submarine line (11) on the vessel (31);
 - detecting the presence of ionizing radiation emitted from the submarine line (11) with a radiation detection unit (13);

characterized by :

- providing a stand (70) fixedly or adjustably mounted in the line recovery system (32), facing a line circulation space (80) through which the submarine line (11) follows a linear path;
 - detecting a radioactivity level in the line circulation space (80) with a radioactivity detector (72) carried by the stand (70), at successive measurement times;
 - recording the successive measurements of the radioactivity level at successive measurement times with a recording unit (74), connected to the radioactivity detector (72).

11. The recovery method according to claim 10, wherein the detection unit (13) comprises an alarm unit (78), directly or indirectly connected to the recording unit (74), the method comprising triggering an alarm when the radioactivity level detected by the radioactivity detector (72) is beyond a predetermined level.
12. The recovery method according to any one of claims 10 to 11, comprising recording successive positional information on the submarine line (11) recovered from the body of water (14) of the successive measurements at the measurement times with the recording unit (74) and correlating the successive positional information of the successive measurements at the measurement times with the radioactivity levels measured by the radioactivity detector (72) at corresponding measurement times.
13. The recovery method according to claims 10 to 12, comprising displaying values of the radioactivity level as a function of time on a display unit (76) of the detection unit (13).

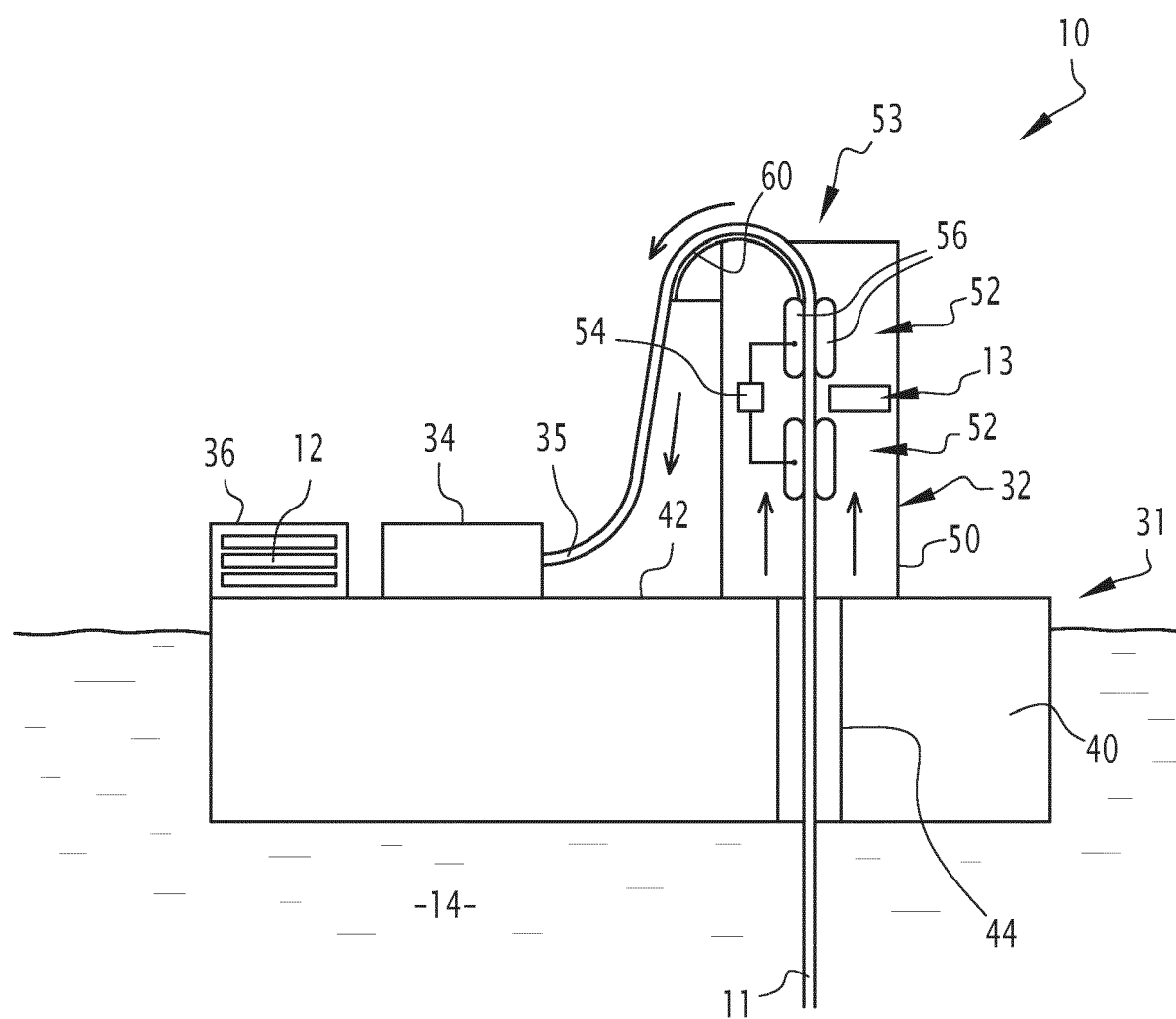


FIG.1

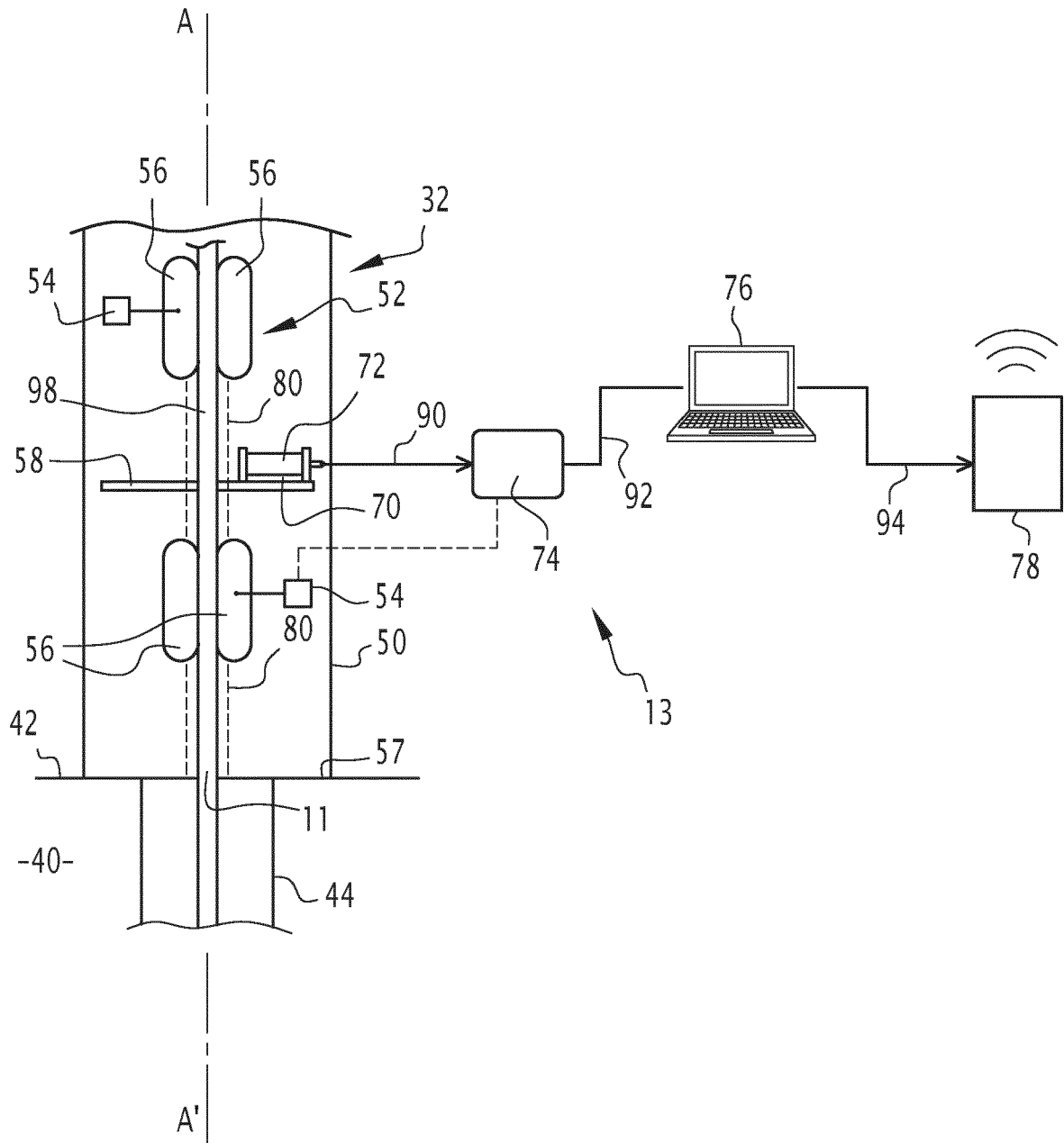


FIG. 2

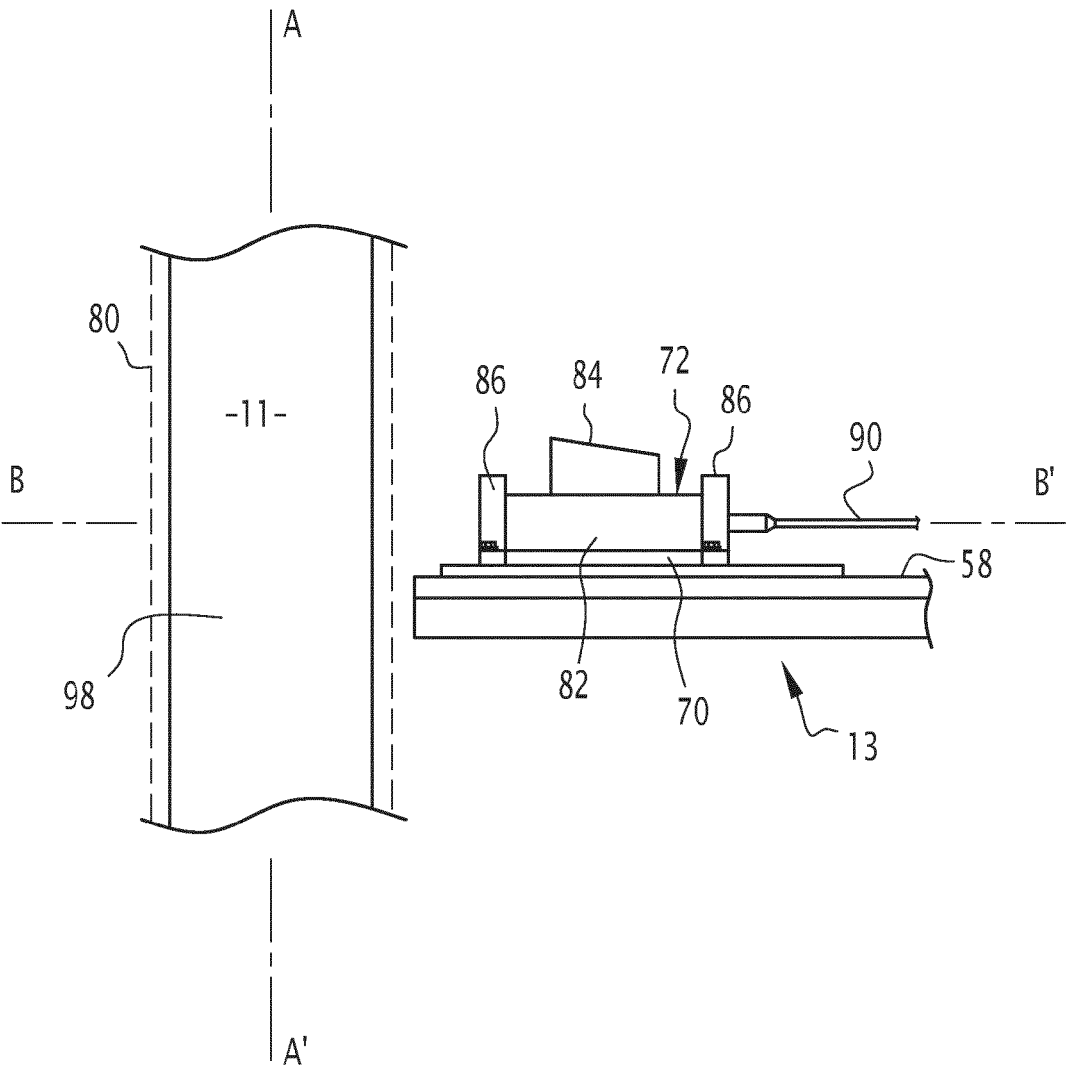


FIG.3

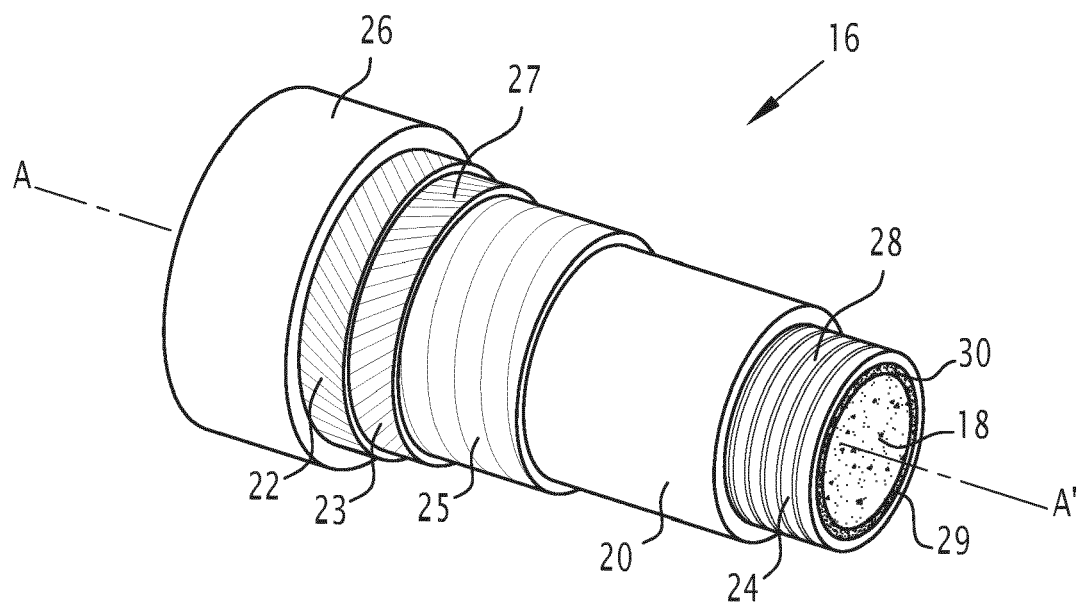


FIG.4



EUROPEAN SEARCH REPORT

Application Number

EP 23 30 6704

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2022/082182 A1 (JEAN SEBASTIEN [FR]) 17 March 2022 (2022-03-17) * the whole document * -----	1-13	INV. B63B35/04 B63B79/10
			TECHNICAL FIELDS SEARCHED (IPC) B63B
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		11 March 2024	Freire Gomez, Jon
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 23 30 6704

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

11-03-2024

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2022082182 A1	17-03-2022	AU 2019417977 A1	22-07-2021
		DK 3906375 T3	04-09-2023
		EP 3906375 A1	10-11-2021
		FR 3091326 A1	03-07-2020
		US 2022082182 A1	17-03-2022
		WO 2020141172 A1	09-07-2020

15

20

25

30

35

40

45

50

55

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Non-patent literature cited in the description

- Specification for Unbonded Flexible Pipe. May 2014 **[0029]**
- Recommended Practice for Flexible Pipe. American Petroleum Institute, May 2014 **[0029]**
- Recommended Practice for Flexible Pipe. March 2014 **[0054]**
- Drilling and Well Servicing Equipment. December 2015 **[0054]**
- Choke and Kill Equipment. March 2021 **[0054]**
- Specification for Bonded Flexible Pipe. American Petroleum Institute, August 2017 **[0054]**
- Petroleum and natural gas industries - Design and operation of subsea production systems - Part 5: Subsea umbilicals. ISO 13628-5. International Organization for Standardization, December 2009 **[0055]**
- Specification for Subsea Umbilicals. API 17E. July 2017 **[0055]**
- Design and Operation of Subsea Production Systems - General Requirements and Recommendations. API RP 17A. American Petroleum Institute, May 2022 **[0055]**
- IEC60183:2015, January 2015 **[0055]**
- IEC60840:2020, May 2020 **[0055]**
- IEC63026:2019. International Electrotechnical Commission (IEC), December 2019 **[0055]**
- Submarine Pipeline Systems. DNV-ST-F101. DNV (Det Norske Veritas), August 2021 **[0056]**