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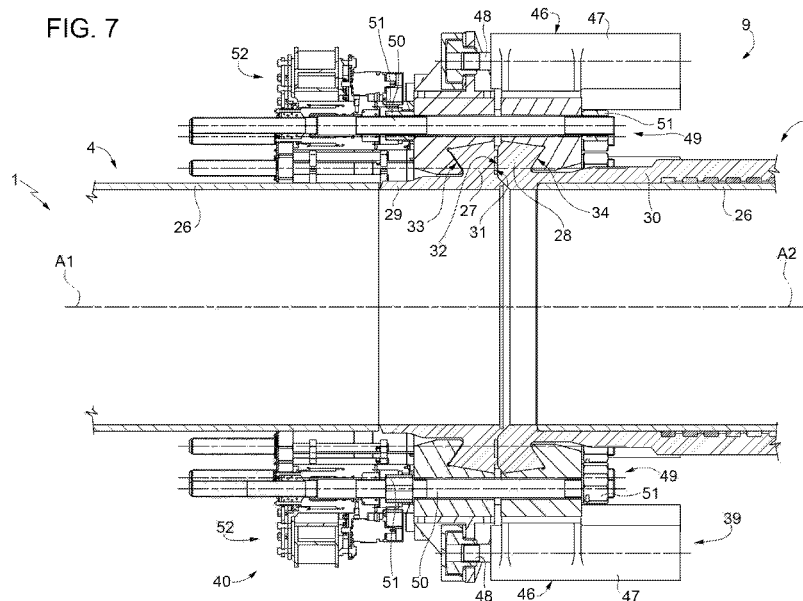
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(54) Title: JOINING DEVICE, SYSTEM AND METHOD FOR JOINING TWO FACING AND ALIGNED PIPELINE SECTIONS



(57) Abstract: A joining device (9) for joining two facing and aligned pipeline sections presents two coupling members (37, 38) selectively couplable to respective pipeline sections (4, 5) at two respective facing flanges (27, 28) located at the ends of respective pipeline sections (4, 5); a pulling mechanism (39) suitable to move the coupling members (37, 38) towards each other in abutment against the flanges (27, 28) and to temporarily tighten the flanges (27, 28) by moving the coupling members (37, 38) towards each other; and a tightening mechanism (40) suitable to definitively tighten the coupling members (37, 39) while the pulling mechanism (39) keeps the flanges (27, 28) tight.

**"JOINING DEVICE, SYSTEM AND METHOD FOR JOINING TWO FACING
AND ALIGNED PIPELINE SECTIONS"**

TECHNICAL FIELD

5 The present invention relates to a device for joining
two aligned and facing pipeline sections.

BACKGROUND ART

In general, for the purposes of the present invention
the definition "pipeline" means a pipeline, which, in use,
10 lies on the bed of a body of water or is partially buried
in the bed of the body of water and is intended to convey
gases and/or liquids, in particular hydrocarbons. A
pipeline of the type identified above can extend for
hundreds of kilometres, comprises sections of pipeline
15 joined to each other aboard a vessel, and launched into the
body of water from the vessel, and is laid on the bed of
the body of water by means of the advancement of the
vessel. Generally, each section of pipeline has a length of
12 metres, a relatively large diameter of between 0.2 and
20 1.5 metres, and comprises a steel cylinder; a protective
coating, which is made of polymeric material, is placed in
contact with the steel cylinder and protects the steel
cylinder from corrosion; and sometimes a weighing coat of
concrete or gunite is placed in contact with the protective
25 coating. The pipelines are usually buried in the bed near

the docks and in shallow waters to protect underwater pipelines from hydrodynamic stress, from temperature fluctuations, and from possible contact with foreign bodies which could jeopardise the integrity of said pipelines, including ice in extreme weather conditions. The burying of pipelines in the bed of the body of water or their covering by means of appropriate-sized rocky material is a widespread practice in shallow water, but is hard to execute and economically unsustainable in deep waters, where the risk profile for exposed pipes may be considered acceptable in first analysis. As a result, underwater pipelines placed on the bed of a body of water in deep water may be exposed to blunt objects such as containers falling from ships in transit or accidentally pulled behind the respective craft, literally "ploughing" the bed of the body of water and possibly damaging the pipeline as far as lacerating it. The frequency of these incidents is relatively low, but the damage caused is very high both in terms of the environmental damage which ensues, and in terms of the fact that the energy supply of many countries is closely related to the transport of hydrocarbons through underwater pipelines of the type identified above. As a result, when these incidents happen, action must be taken quickly to repair the pipeline and restore the hydraulic seal and mechanical characteristics of the same.

Methods have been proposed for such purpose which provide for carrying out all the repair phases in the body of water, and other methods which provide for performing certain repair phases above the body of water and other

5 repair phases in the body of water. One repair method described in the US patent 5,437,517 comprises steps of cutting a length of underwater pipeline containing the damaged area to define a first and a second section of underwater pipeline having respectively a first and a

10 second end; joining a first coupling head to the first section of underwater pipeline in the body of water; joining a second coupling head to the second section of underwater pipeline in the body of water; laying a telescopic sleeve with a third and a fourth coupling head

15 in the body of water and placing the telescopic sleeve between the first and second coupling head; aligning the first section of underwater pipeline, the second section of underwater pipeline and the telescopic sleeve in the body of water; adjusting the length of the telescopic sleeve in

20 the body of water; joining the telescopic sleeve to the first and second coupling head in the body of water. Subsequently, the telescopic sleeve is locked into the final position. All the above operations are performed in the body of water using scuba equipment controlled by

25 remote-controlled underwater vehicles (ROV: Remotely

Operated Vehicle) connected to a vessel via a cord (umbilical).

Other methods described in documents EP 2,430,346 and EP 2,430,347 are based on the use of telescopic sleeves and permit the repair of pipelines or merely the joining of sections of pipeline laid separately. Telescopic sleeves or other types of compensation sleeves create weakened zones of the pipeline and increase the number of operations to be performed and the complexity of the join.

10 DISCLOSURE OF INVENTION

One of the purposes of the present invention is to provide a joining device which is able to join two lengths of pipeline without the drawbacks of the prior art.

According to the present invention, a joining device is made for joining two facing and aligned pipeline sections, the joining device comprising two coupling members configured to be selectively coupled to respective pipeline sections in proximity of respective facing flanges located at the ends of respective pipeline sections; a pulling mechanism configured to move the coupling members towards each other so as to temporarily tighten the flanges to each other; and a tightening mechanism configured to definitively tighten the coupling members and the flanges, while the pulling mechanism maintains the flanges tight.

25 Thanks to the present invention, the pulling mechanism

is made so as to exert a very great force making it possible to pull into contact the sections of pipeline making them slide on the bed, and to tighten the flanges. There is no need to provide for sleeves or other lengths of pipe suitable to compensate the distance between the flanges. The compensation is provided by the elastic behaviour of the two lengths of pipeline.

The tightening mechanism instead is activated when the pulling mechanism holds the flanges temporarily tight to complete the closure and make it definitive. As a result, the tightening mechanism is sized to withstand the static force exerted by sections of pipeline once the pulling mechanism is released, upon completion of the joining operation. In particular, the pulling mechanism comprises hydraulic actuators making it possible to provide a very great tightening force, while the tightening mechanism comprises bolted joints. The bolted joints are in fact releasable but their tightening is considered definitive in that their release involves active intervention of unscrewing them.

The pulling mechanism makes it possible to screw the bolted joints with very limited torque values during the initial phase. High screwing torque values of the bolted joints are only required in the final phase of screwing to reach the desired preload tightening of the flanges in

mutual contact.

A further purpose of the present invention is to provide a joining method which is free of the drawbacks of the prior art.

5 According to the present invention a method is provided for joining two facing and aligned pipeline sections, the method comprising the steps of coupling two coupling members to respective pipeline sections in proximity of respective facing flanges located at the ends
10 of the respective pipeline sections; temporarily tightening the flanges by means of a pulling mechanism configured to move the coupling members towards each other; and definitively tightening the coupling members by means of a tightening mechanism, while the pulling mechanism keeps the
15 flanges tight.

In particular, the joining device is able to exert a tightening force greater than 1,000,000 N.

BRIEF DESCRIPTION OF THE DRAWINGS

Further features and advantages of the present
20 invention will be evident from the description below of a non-limiting embodiment with reference to the appended drawings, wherein:

-Figures 1 and 2 are side elevation views, with parts removed for clarity, of a joining system according to the
25 present invention;

-Figure 3 is a perspective view on an enlarged scale, with parts removed for clarity, of a joining device for joining two sections of pipeline made according to the present invention;

5 - Figure 4 is an elevation view, with parts removed for clarity and parts in cross-section, of the joining device in Figure 3 in a coupling step with the pipeline sections;

10 - Figure 5 is an elevation view, with parts removed for clarity and parts in cross-section, of the joining device in Figure 3 coupled to the pipeline in a further operating step; and

15 -Figures 6 and 7 are longitudinal cross-section views, with parts removed for clarity, of two operating steps of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

With reference to figures 1 and 2, reference numeral 1 globally denotes an underwater pipeline which, in use, is placed on the bed 2 of a body of water 3 to convey liquids or gases, in particular hydrocarbons. The underwater pipeline 1 comprises two separate sections 4 and 5 which must be joined. For simplicity of description and simplification of the drawings the bed 2 of the body of water 3 is flat, but it is understood that the underwater pipeline 1 may lie on tilted or variously rough beds. In

25

figures 1 and 2, in addition to the pipeline 1, a repair and/or joining system of the underwater pipeline 1 is shown in part. The system comprises a vessel 6; a remotely operated underwater vehicle 7 (Remotely Operated Vehicle: 5 ROV); two or more gantry cranes 8 suitable to be placed on the bed 2 of the body of water 3 to lift out of the bed 2 and retain the sections of pipeline 4 and 5 in a raised position from the bed 2; and a joining device 9.

The vessel 6 is designed to assemble underwater 10 pipelines on board the vessel 6 itself and to launch underwater pipelines into the body of water 3. The vessel 6 is also possibly used to flange the free ends of the pipeline sections 4 and 5 and to provide support to the joining operations of the pipeline sections 4 and 5. In the 15 present case illustrated, the vessel 6 comprises a floating structure and launching equipment 11, which in this case is a launching tower that extends in a substantially vertical launching direction, is fitted in an articulated manner to the floating structure, and is designed for J-type 20 launching to lay an underwater pipeline on the bed 2 of the body of water 3. The launching equipment 10 comprises an upper section 11, in which an assembly station is placed, not shown in the appended drawings; an intermediate section 12 in which a tensioning equipment is placed, not shown in 25 the appended drawings, and a lower section 13 in which a

recovery advancement device is placed, not shown in the appended drawings. The vessel 6 is equipped with at least one crane 14 to make a sea landing and recover the underwater vehicle 7, the gantry cranes 8 and other
5 equipment used in the repair of underwater pipelines 1; and with a winch 15, which is supported by the launching equipment 10 and is suitable to possibly recover the pipeline sections 4 and 5 to lift them from the bed 2 of the body of water 3 and to arrange them partly inside the
10 launching equipment 10 at the assembly station.

The underwater vehicle 7 is a vehicle controlled by the vessel 6 by means of an umbilical 16 and comprises a frame 17; a float 18; cameras not shown in the appended drawings; a group of propellers not shown in the appended
15 drawings; at least one manipulator arm 19, and a multifunctional attachment plate 20 suitable to be coupled to respective multifunctional attachment plates of underwater equipment suitable to carry out the operations described below. Depending on the operations performed in
20 the body of water 3 it is possible to use one or more underwater vehicles to speed up work on the underwater pipeline 1.

The gantry cranes 8 are placed astride the pipeline sections 4 and 5. Each gantry crane 8 comprises two portal
25 structures 21 rigidly connected together by transverse

beams 22 and a group of motorised carriages 23 connected to two jaws 24 suitable to grip the pipeline sections 4 and 5. The group of motorised carriages 23 makes it possible to move the jaws 24 along a system of Cartesian axes inside the gantry structures 21. Each gantry crane 8 comprises a multifunctional connection not shown in the appended drawings and suitable to be connected to the multifunctional attachment 20 of the underwater vehicle 7, which by means of such connection controls the actuation of the group of motorised carriages 23 and the jaws 24. Each portal structure 21 is provided with support plates 25 suitable to be placed so as to grip the bed 2 and define a precise position of the gantry crane 8.

With reference to Figure 6, each of the pipeline sections 4 and 5 comprises a metal cylinder 26, a protective coating not shown in the appended drawings and arranged around the metal cylinder 26 and made of deformable polymeric material. The term "protective coating" includes both anti-corrosive coatings, which are relatively thin (a few millimetres) made of PP (polypropylene) or PE (polyethylene), and insulation coatings, which add to the anti-corrosion characteristics those of thermal insulation. Insulating coatings reach thicknesses of tens of mm and are generally made of solid PU (polyurethane) or multilayer PP (polypropylene).

Sometimes, there is also a further weighing coating, not shown in the appended drawings, in concrete or gunite placed around the protective coating, not shown in the appended drawings. The pipeline sections 4 and 5 have two ends aligned and facing and two respective flanges 27 and 28 of the self-centering type. The pipeline sections 4 and 5 have respective longitudinal axes A1 and A2, which are substantially aligned at the flanged ends. In the case illustrated, the flange 27 is integral with a respective sleeve 29, which is joined to the metal cylinder 26 of the pipeline section 4. The flange 28 is integral with a sleeve 30 joined to the metal cylinder 26 of the pipeline section 5. The joining methods of the sleeves 29 and 30 to the respective metal cylinders comprise: welding, and plastic deformation. The flanges 27 and 28 comprise respective faces 31 and 32 configured to be placed in contact to make a hydraulic seal and define a self-centering of the pipeline sections 4 and 5. The flanges 27 and 28 comprise respective faces 33 and 34 opposite the respective faces 31 and 32 and configured to cooperate with the joining device 9. In the present case the flanges 27 and 28 form annular recesses along the faces 33 and 34.

With reference to the figures 3, 4, and 5, the joining device 9 comprises a frame 35; a multipurpose junction plate 36; two coupling members 37 and 38; a pulling

mechanism 39; and a tightening mechanism 40. The pulling mechanism 39 is mounted on the coupling members 37 and 38, and is suitable to move the coupling members 37 and 38 towards one another to place them in abutment against the flanges 27 and 28 and to tighten the flanges 27 and 28. The tightening mechanism 40 is mounted on the coupling members 37 and 38, and is configured to move the coupling members 27 and 28, while the pulling mechanism 39 keeps the flanges 27 and 28 tight.

The frame 35 is configured to support the coupling members 37 and 38 and comprises a longitudinal support 41 and two spacers 42 configured to be respectively coupled to the pipeline sections 4 and 5 so as to arrange the coupling members 37 and 38 at a distance determined by the two pipeline sections 4 and 5.

Each of the coupling members 37 and 38 is a ring shape, comprises two half-rings 43 pivoted and rotatable about a common hinge axis A3 (Figure 5) between an open position such as to allow the placing of the coupling members 37 and 38 about respective pipeline sections 4 and 5 and a closed position around the respective pipeline sections 4 and 5 at the respective flanges 27 and 28. The coupling members 37 and 38 are able to slide axially along the hinge axis A3 which, in use, is substantially parallel to the axes A1 and A2 of the pipeline sections 4 and 5. In

fact, the coupling members 37 and 38 are configured so as to form a shaped coupling with the flanges 27 and 28, which prevents a radial disengagement of the coupling members 37 and 38 as better illustrated in figure 7. In fact, the coupling members 37 and 38 engage the annular recesses of the respective flanges 27 and 28 along the faces 33 and 34.

The joining device 9 comprises a third mechanism 44 for selectively closing the half-rings 43 around the respective pipeline sections 4 and 5.

With reference to Figure 5, the joining device 9 also comprises a hydraulic circuit 45 to actuate the mechanisms 39, 40, 44, which, in particular, are of the hydraulic type.

With reference to Figure 3, the pulling mechanism 39 comprises a plurality of actuators 46, which connect the coupling members 37 and 38, are selectively activated to move the coupling members 37 and 38 towards each other, tighten the flanges 27 and 28, and tension the two pipeline sections 4 and 5. In the case shown, the actuators 46 are hydraulic actuators of the linear type and uniformly distributed around the coupling elements 37 and 38.

With reference to figure 6, each actuator 46 comprises a cylinder 47 mounted on a coupling member 38 and a rod 48 mounted on the other coupling member 37. The tightening mechanism 40 comprises a plurality of bolted joints 49,

which connect the coupling members 37 and 38 and can be selectively tightened to tighten the coupling members 37 and 38 against the flanges 27 and 28, while the pulling mechanism 39 holds the coupling members 37 and 38 tight
5 against the flanges 27 and 28, and the flanges 27 and 28 tightened to each other. The bolted joints 49 are evenly distributed along the coupling members 37 and 38. Each bolted joint 49 comprises a bar 50, which is threaded at the ends and is engaged in respective axial holes of the
10 coupling members 37 and 38. The threaded ends of the bar 50 protrude from opposite sides of the respective coupling members 37 and 38 and are engaged by respective nuts 51. The tightening mechanism 40 comprises a plurality of actuators 52, each of which is associated with a respective
15 bolted joint 49 and has the function of screwing a nut 51. The actuator 52 is of the rotary type operated hydraulically and is marketed by the company Hydratight.

With reference to figures 4 and 5, the coupling mechanism 44 comprises two hydraulic actuators 53 of the linear type,
20 each of which comprises one end connected to the frame 35 and one end connected to two half-rings 43 facing each other and belonging to the two coupling members 37 and 38.

In use, once the joining device 9 has been launched in the body of water 3 and coupled to the pipeline sections 4
25 and 5 as shown in figures 5 and 6, the coupling members 37

and 38 are moved together by the pulling mechanism 39 until the flanges 27 and 28 touch each other as shown in figure 7. At this stage, any small alignment errors of the axes A1 and A2 of the respective pipeline sections 4 and 5 are
5 corrected thanks to the flanges 27 and 28 of the self-centering type. The force exerted by the pulling mechanism 39 is very great and permits the elastic deformation of the pipeline sections 4 and 5 to compensate for the distance, generally a few centimetres, between the flanges 27 and 28.
10 This tightening force is transmitted from the vessel 6 to the flanges 27 and 28 via the umbilical 16, the underwater vehicle 7, and the pulling mechanism 39, according to the diagram shown in Figure 2. However, once the underwater vehicle 7 is uncoupled from the joining device 9, the
15 tightening force is released. Before releasing the tightening force, the tightening mechanism 40 is actuated to tighten the flanges 27 and 28 and the coupling members 37 and 38 in the tightened position. Once the flanges 27 and 28 and the coupling members 37 and 38 have been
20 tightened by tightening the nuts 51, the joining of the pipeline sections 4 and 5 is completed and the underwater vehicle 7 is uncoupled from the joining device 9.

It is evident that variations may be made to the embodiment described of the present invention while
25 remaining within the scope of the following claims.

CLAIMS

1. A joining device for joining two facing and aligned pipeline sections, the joining device (9) comprising two coupling members (37, 38) configured to be
5 selectively coupled to respective pipeline sections (4, 5) in proximity of respective facing flanges (27, 28) located at the ends of respective pipeline sections (4, 5); a pulling mechanism (39) configured to move the coupling members (37, 38) towards each other so as to temporarily
10 tighten the flanges (27, 28) to each other; and a tightening mechanism (40) configured to definitively tighten the coupling members (37, 38), while the pulling mechanism (39) maintains the flanges (27, 28) tight.

2. The joining device as claimed in Claim 1, wherein
15 the pulling mechanism (39) comprises a plurality of first actuators (46), which connect the coupling members (37, 38) and selectively activated for moving the coupling members (37, 38) toward each other in abutment against the flanges (27, 28), and tighten the flanges (27, 28).

20 3. The joining device as claimed in Claim 2, wherein the first actuators (46) are hydraulic actuators, in particular each actuator (46) comprises a hydraulic cylinder (47) mounted on a coupling member (38) and a rod (48) mounted on the other coupling member (37).

25 4. The joining device as claimed in Claim 2 or 3,

wherein the first actuators (46) are evenly distributed along the coupling members (37, 38).

5 5. The joining device as claimed in any one of the foregoing Claims, wherein the tightening mechanism (40) comprises a plurality of bolted joints (49), which extend through the coupling members (37, 38) and are selectively tightened so as to tighten the coupling members (37, 38) in abutment on the tight flanges (27, 28).

10 6. The joining device as claimed in Claim 5, wherein the bolted joints (49) are evenly distributed along the coupling members (37, 38).

15 7. The joining device as claimed in Claim 5 or 6, wherein the tightening mechanism (40) comprises a plurality of second actuators (52), each of which is coupled to a respective bolted joint (49) for selectively tightening the bolted joint (49).

20 8. The joining device as claimed in any one of the foregoing Claims, wherein each coupling member (37; 38) is annular and comprises two half-rings (43) hinged and pivotable around a hinge axis (A3) between an open position and such as to arrange the coupling members (37, 38) about the pipeline sections (4, 5) in proximity of the respective flanges (27, 28), and a closed position, in which each coupling member (37; 38) can slide along the respective
25 pipeline section (4; 5).

9. The joining device as claimed in Claim 8, and comprising a coupling mechanism (44) for selectively pivoting the half rings (43) about the hinge axis (A3).

10. The joining device as claimed in Claim 9, wherein
5 the coupling mechanism (44) comprises third actuators (53), in particular hydraulic actuators.

11. The joining device as claimed in any one of the foregoing Claims, and comprising a frame (35) configured for supporting the coupling members (37, 38), the pulling
10 mechanism (39), and the tightening mechanism (40).

12. The joining device as claimed in Claim 11, wherein the frame (35) comprises spacers (42) configured to be coupled respectively to the two pipeline sections (4, 5).

13. The joining device as claimed in Claim 11 or 12,
15 wherein the frame (35) comprises a multipurpose junction plate (36) for an underwater vehicle (7).

14. The joining device as claimed in any one of the foregoing Claims, and comprising a hydraulic circuit (45) for actuating the pulling mechanism (39), and the
20 tightening mechanism (40).

15. A system for joining two facing and aligned pipeline sections, the system comprising a joining device (9) as claimed in any one of the foregoing Claims; an underwater vehicle (7) configured to be operatively
25 connected to the joining device so as to control the

position and the actuation of the joining device (9); and cranes (8) configured for maintaining the free ends of the pipeline sections (4, 5) facing and raised from the bed of the body of water.

5 **16.** The system as claimed in Claim 15, and comprising a vessel (6) connected to the underwater vehicle (8) by means of an umbilical (16).

10 **17.** A method for joining two facing and aligned pipeline sections, the method comprising the steps of coupling two coupling members (37, 38) to respective pipeline sections (4, 5) in proximity of respective facing flanges (27, 28) located at the ends of the respective pipelines sections (4, 5); temporarily tightening the flanges (27, 28) by means of a pulling mechanism (39)
15 configured to move the coupling members (37, 38) towards each other; and definitively tightening the coupling members (37, 38) by means of a tightening mechanism (40), while the pulling mechanism (39) keeps the flanges (27, 28) tight.

20 **18.** The method as claimed in Claim 17, and comprising the step of moving closer the coupling members (37, 38) with a force greater than 1.000.000 N by means of said pulling mechanism (39).

25 **19.** The method as claimed in Claim 17 or 18, characterized by being implemented in the body of water.

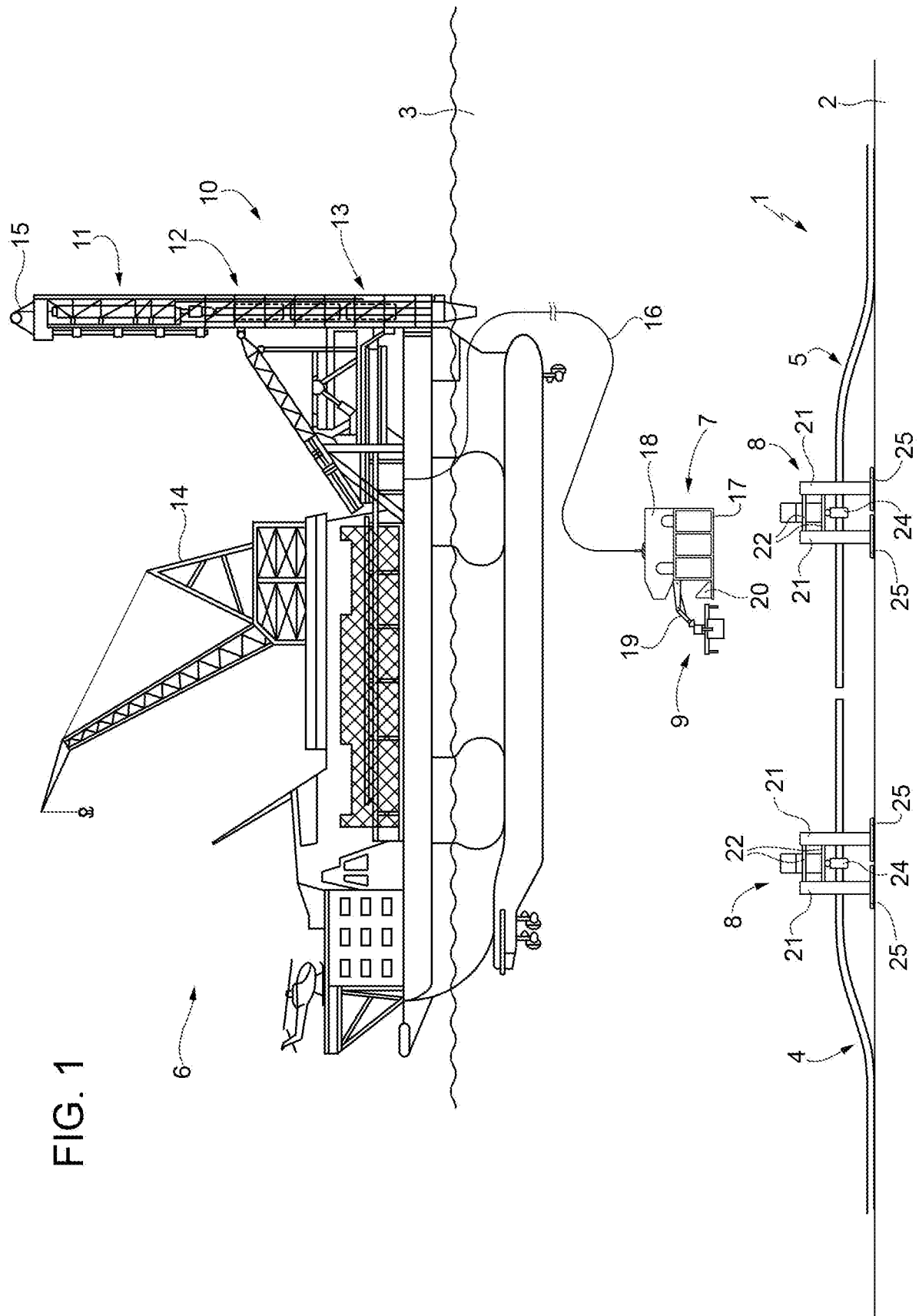
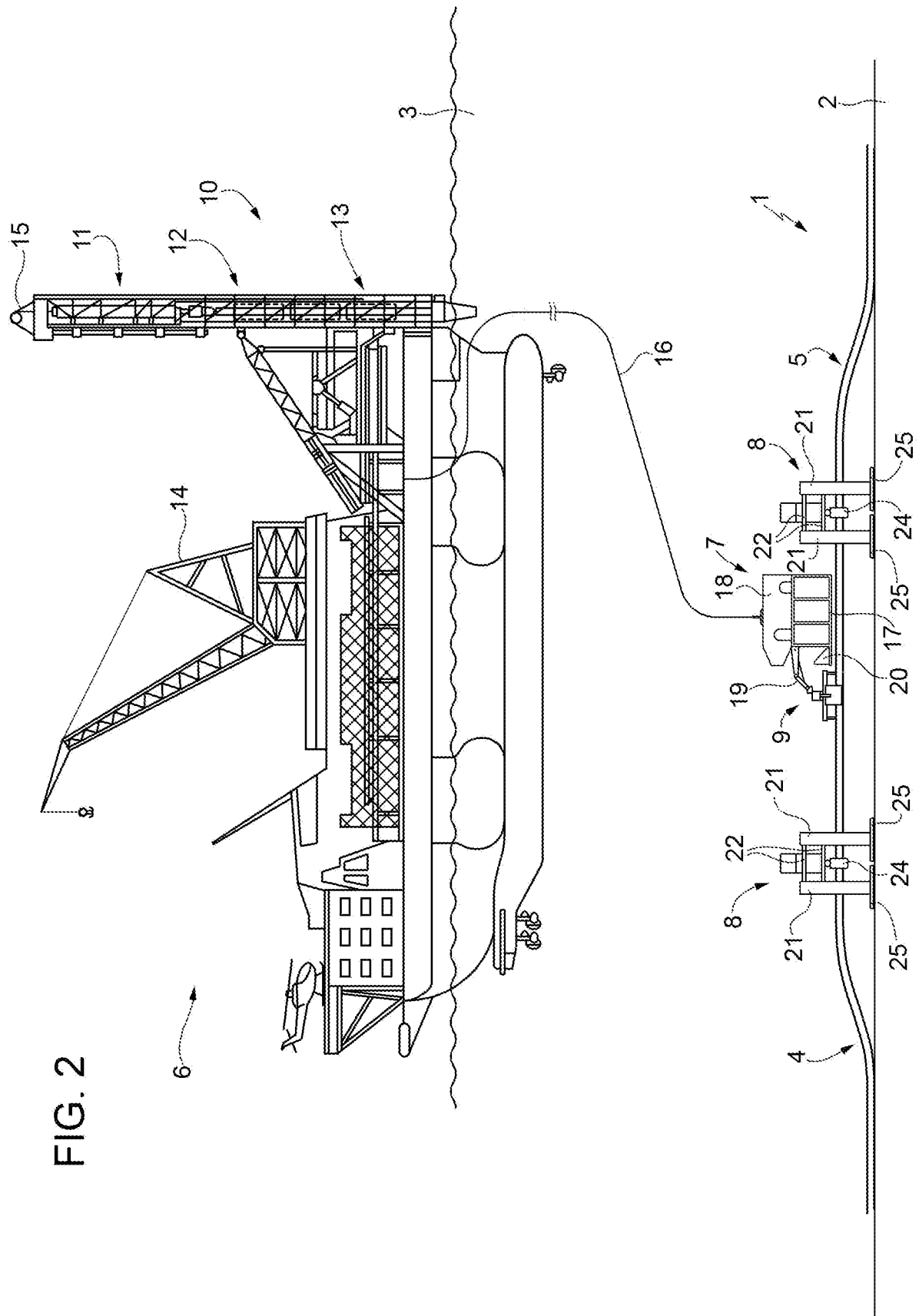


FIG. 2



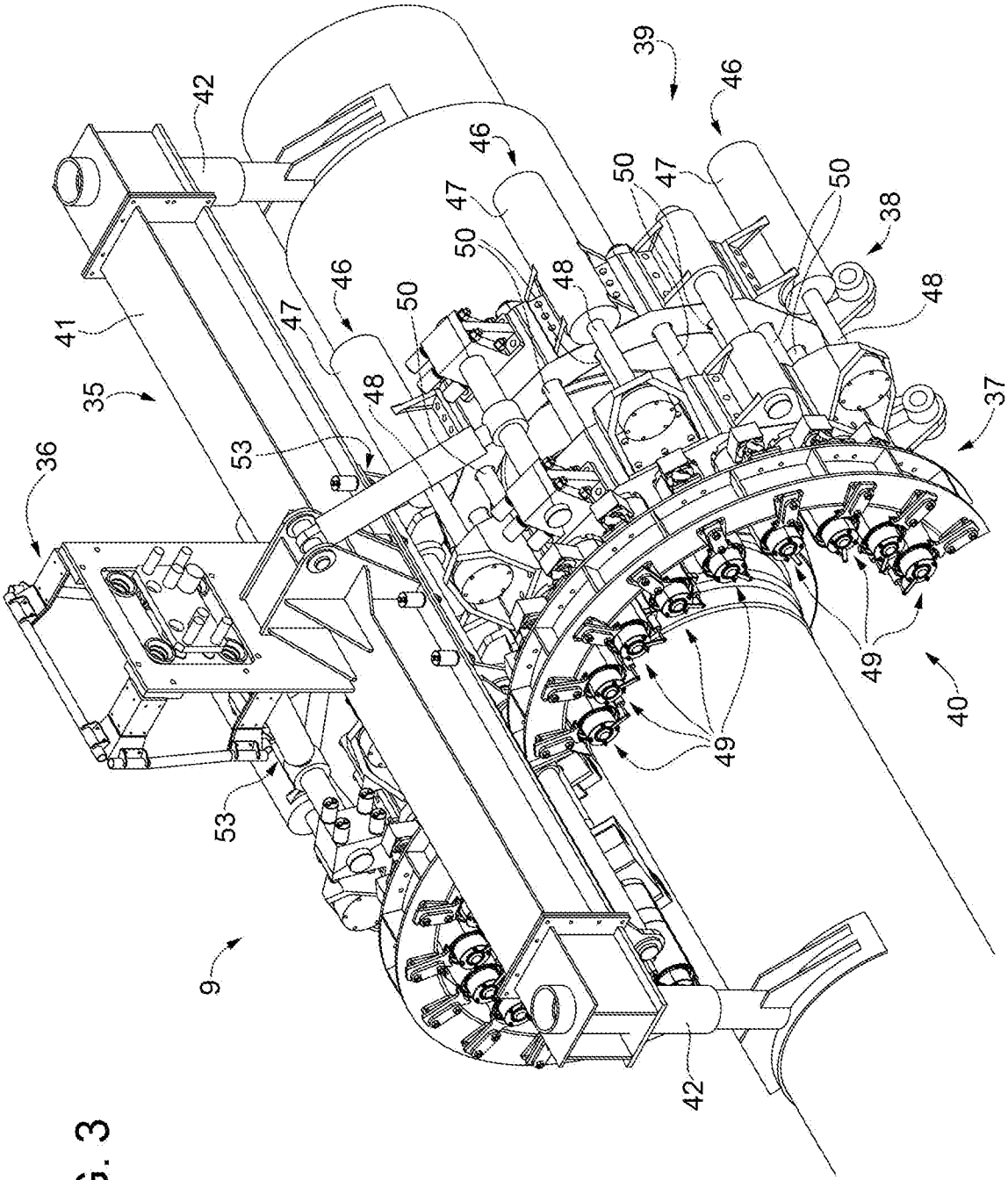


FIG. 3

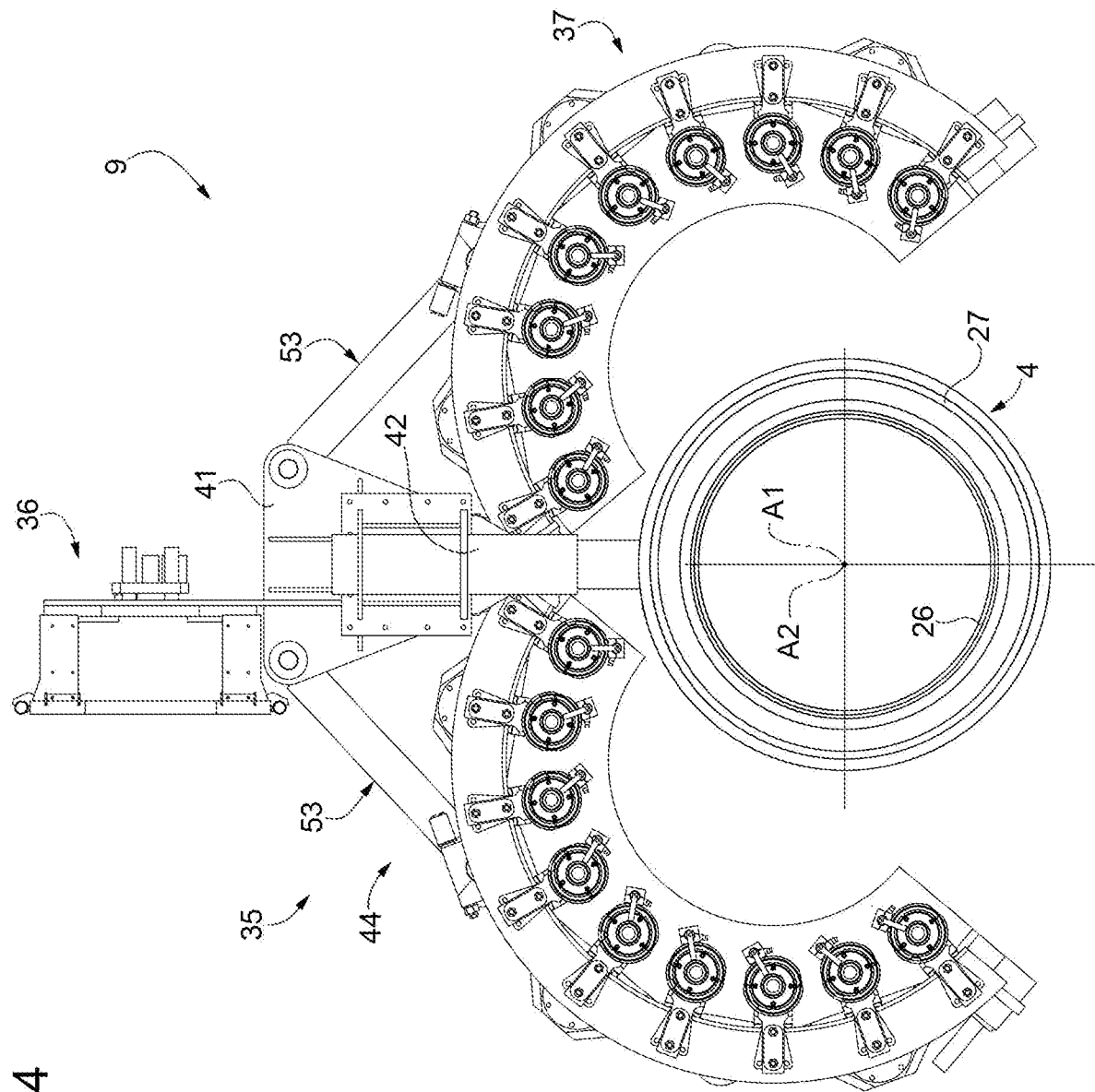


FIG. 4

FIG. 5

