(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 528 069 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
26.03.2025 Bulletin 2025/13

(21) Application number: **23885235.4**

(22) Date of filing: **17.11.2023**

(51) International Patent Classification (IPC):
E21B 17/02 *(2006.01)* ***E21B 17/01*** *(2006.01)*
E21B 19/00 *(2006.01)* ***E21B 43/01*** *(2006.01)*
F16L 37/084 *(2006.01)* ***F16L 37/14*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
E21B 17/01; E21B 17/02; E21B 19/00; E21B 43/01;
F16L 37/084; F16L 37/14

(86) International application number:
PCT/IB2023/061657

(87) International publication number:
WO 2024/095248 (10.05.2024 Gazette 2024/19)

(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

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(54) MECHANISM FOR COUPLING AND SUPPORTING A BEND STIFFENER WITH SINGLE EXTERNAL ACTUATION

(57) The present invention is related to coupling/de-coupling and supporting mechanisms for connecting Bend Stiffeners to Bell Mouths and aims at optimizing pull-in and pull-out operations, reducing operational costs and time, and also completely replacing shallow diving with operations without associated MHER, such as those performed with remotely operated vehicles (ROVs). The proposed solution provides a coupling/de-coupling and supporting mechanism for Bend Stiffeners that comprises a front drive means, with the feature of being easily accessed and operated by ROVs, thus replacing the multiple tongue mechanisms previously used.

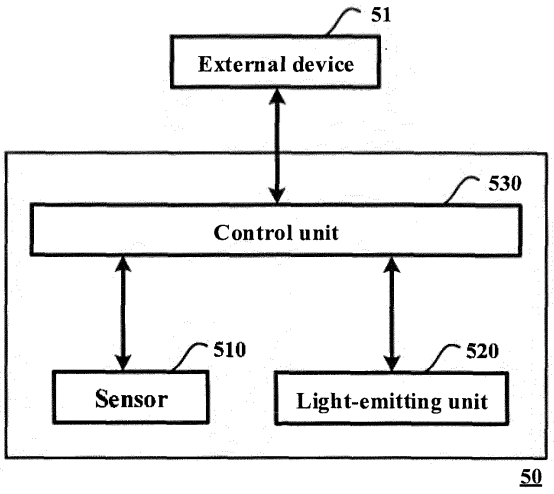

Fig. 5

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Description

Field of the invention:

[0001] The present invention is related to the oil and gas industry; more specifically, to the deepwater oil and gas production system. According to this system, technologies, mechanisms or devices that use risers in their compositions are used. In this way, the coupling process between risers and/or other structures is something of great relevance in this segment. Thus, more particularly, the present invention is related to coupling and supporting mechanisms for connecting Bend Stiffeners in Bell Mouths.

Background of the invention:

[0002] Flexible risers are usually connected to offshore oil production platforms by devices that decouple the riser's traction force from the lateral loads caused by displacements of the floating unit, with the traction being supported in a region close to the platform deck (Hang-off) and the lateral loads being transferred to a connection device located in a position close to the bottom of the platform hull, with a sliding coupling between such device and the riser. A typical example of this widely used connection device is the so-called Bell Mouth. The decoupling between the traction and lateral loads of flexible risers provides great operational benefits for riser technology, such as, for example, increasing their useful life, but not limited to this.

[0003] Although the post-installation configuration is quite favorable for the operational life of the flexible riser, the submerged condition of the Bell Mouth generates technical operational challenges for the pull-in and pull-out operation of risers. Among such challenges are the low operational efficiency in the riser installation steps and the unfavorable conditions for divers to work in terms of safety (MHER: man-hours exposed to risk).

[0004] Regarding low operational efficiency, when analyzing the main causes of non-productive time (NPT) of PLSVs (Pipe Laying Support Vessels), it was found that there was a great loss of time due to environmental conditions that prevented shallow diving during the pull-in operations, with the diving operation being necessary to ensure the correct connection of the Bend Stiffener in the Bell Mouth. In order to reduce the NPT, it was identified that one of the appropriate actions would be the development of a new Bell Mouth, in order to reduce the resistant force to the connection of the Bend Stiffener, increasing the reliability of this operation and eliminating the need for shallow diving in parallel with the PLSV.

[0005] As for the unfavorable conditions for divers to work, the Bell Mouth is usually positioned in a shallow water depth, in a region with strong influence from waves and flows induced by the movement of the production platform. In addition to diving being an inherently dangerous activity, the use of equipment that requires divers to work in this region, associated with high water mass movements, brings additional risks to the diver's physical integrity. It is important to note that shallow diving was recently mapped as one of the work activities with the greatest risk to the professional's physical integrity, with fatal accidents even being recorded in recent years.

State of the art:

[0006] The first Bell Mouths, as disclosed in document US5947642, used the philosophy of always requiring shallow diving during riser installation and uninstallation operations. Prior to the arrival of the PLSV and the subsequent transfer of the riser to the platform, diving was necessary to check the operation of the Bell Mouth locking mechanism.

[0007] During the transfer of the riser from the PLSV to the platform, shallow diving installed hoists, connecting the Bend Stiffener to the platform hull, to prevent the Bend Stiffener from falling in the event of a premature rupture of the pull-in fuse cables due to an overload due to excessive interference in the coupling of the riser to the Bell Mouth. After completion of the pull-in operation, the diver positioned the Bell Mouth Dogs in the locked position and removed the hoists that would prevent the Bend Stiffener from falling.

[0008] With the advent of the Diverless Bell Mouth (DLBM), as can be seen in document BR102018011452-2, the limitations listed above were overcome with the development of a locking mechanism using tongues, which eliminates the need for shallow diving during pull-in operations, with the locking step by divers no longer being necessary. Furthermore, the optimized geometry of the Bend Stiffener Shaft reduces the resistant forces during the coupling process, increasing the reliability of the fuse cable sizing and thus avoiding the need to install hoists.

[0009] Despite the advances listed above, the development of the DLBM prioritized the increase in operational efficiency during the pull-in operation. Regarding the aspects related to diver safety, despite the significant improvements made to the human-equipment interface, the DLBM still required shallow diving actuation during the riser disconnection (pull-out) operations.

[0010] To solve this problem, a hydraulic actuation system was developed whose unit is coupled to each of the tongue mechanisms, thus requiring up to 8 actuators per DLBM, whose hydraulic power is supplied, via control umbilical, by the platform's HPU system.

[0011] Even with the significant improvements, the set of solutions above (DLBM and Hydraulic Actuation) still has some gaps that can be improved, both from an economic point of view (reduction in equipment costs) and from a safety point of view, for example, by completely replacing shallow diving with operations without associated MHER, through the use of remotely operated vehicles (ROVs). Such improvements should be mainly

related to the following situations:
In the event of a hydraulic actuation failure by the platform, the handle mechanism (provided for in the DLBM) remains as a backup with diving, since the handles do not have optimized geometry for ROV operations. In addition, due to the typical size of ROVs and the limited reach when compared to human manipulation, some handles are not accessible by this actuation method. Therefore, there would be a need for diving support due to access limitations.

[0012] A significant reduction in the number of actuators/support components would allow only one actuation system, which could be mechanical or hydraulic, to open/close the Flexural Stiffener support system.

[0013] In this way, evaluating the disclosure above, it is clear that the points addressed to open space for solutions that mitigate such limitations, such as the difficulty of executing the operation of the handles by ROV, in case of failure, due to the location of the handles and the unification of the actuation system for support.

[0014] Thus, evaluating the general concept of the DLBM, together with the schematics of adjacent Bell Mouths, it is observed that, in case of failure of the hydraulic actuation by the platform, the operations of the handles by ROV would be difficult to execute, since such device was developed for human interface. In addition, some handles are located in an area that is difficult to access by ROV.

[0015] The State of the Art further discloses other documents related to the object of the present invention.

[0016] Document US7967070 discloses a connector to be used in subsea structures, which has a shaft, and comprises a funnel and a set of locks, one of the objectives being to inhibit unwanted movement between the set and its components. The set of locks includes a base plate, a cam plate and/or other components that operate to lock the set to the shaft. In particular, the cam plate only has a control function to lock or unlock locking dogs. Furthermore, the connector in one of its embodiments can be installed using a remotely operated vehicle (ROV) and without the use of divers.

[0017] Document US8573305 discloses an automatic release system for a riser, which includes a guide funnel assembly that receives a shaft coupled to the riser. The method proposed in this document foresees that the entire operation is handled by ROV.

[0018] Document PI1106877-9 discloses an accessory for installing and positioning lines connected to the hull of oil production units. The proposed technology ensures the coupling of the assembly formed by the Shaft and the Bend Restrictor to the Bell Mouth.

[0019] Document BR102018011452-2 discloses a coupling system between a Bend Stiffener and a Bell Mouth, which includes reliable automatic locking to the point that the shallow diving step is dispensed with in this operation. In this document, a coupling system between a Bend Stiffener and a Bell Mouth is disclosed, comprising a plurality of locking mechanisms wherein each locking mechanism is externally fixed to the Bell Mouth and comprises a movable tongue positioned in a downwardly inclined manner, wherein the tongue accesses the interior of the Bell Mouth and is actuated by an elastic element adapted to exert pressure on the tongue towards the interior of the Bell Mouth. In particular, the document does not present a mechanism compatible with pull-in/-pull-out operations by ROV.

[0020] Although the documents cited in the State of the Art disclose a matter related to the matter of the present invention, these documents disclose different applications, such as: the temporary pull-in connection between the Bend Stiffener and the Traction Head.

[0021] The proposed invention allows for the automatic coupling of the shaft-bend stiffener assembly with the Bell Mouth during the pull-in of the riser, an operation that includes considerably different particularities in relation to what was proposed in the State of the Art, notably due to the simplification of the Bell Mouth locking devices.

[0022] As the main innovation, for the procedure of disconnecting the riser, pull-out, the proposed invention allows for the decoupling of the Bend Stiffener from the Bell Mouth during the pull-out of the riser without the use of divers, since it would be fully operable through a remotely operable vehicle (ROV).

Objectives of the invention:

[0023] The present invention is related to coupling/decoupling and supporting mechanisms for connecting Bend Stiffeners to Bell Mouths and aims at reducing operational costs by reducing the acquisition cost of riser supports (simplification of components and reduction in the number of actuators) and also the total replacement of shallow diving with operations without associated MHER, such as with the use of a remotely operated vehicle (ROV). The proposed solution provides a coupling/decoupling and supporting mechanism for Bend Stiffeners that comprises a front drive means, with the feature of being easily accessed and operated by ROVs, thus replacing the multiple tongue mechanisms previously used.

Brief description of the figures:

[0024]

Figure 1 illustrates the coupling/decoupling and supporting mechanism for a Bend Stiffener containing the front drive means, according to the present invention.

Figure 2 illustrates the coupling/decoupling and supporting mechanism for a Bend Stiffener, identifying the structural body of the Bell Mouth, the Bend Stiffener Shaft, and the regions that are impacted by the locking mechanism.

Figures 3A and 3B illustrate the articulated yoke mechanism for supporting the Bend Stiffener Shaft

in the closed and open modalities respectively, according to the present invention.

Figure 4 illustrates four other possible variations of the Articulated Yoke mechanism that can be applied in the closed and open modalities, according to the present invention.

Figure 5 illustrates the Articulated Yoke mechanism for supporting the Bend Stiffener Shaft during the pull-in operation, according to the present invention.

Figure 6 illustrates the Articulated Yoke mechanism for supporting the Bend Stiffener Shaft in the closed position, according to the present invention.

Figure 7 illustrates the Articulated Yoke mechanism for supporting the Bend Stiffener Shaft in the open position during the pull-out operation, according to the present invention.

Detailed description of the invention:

[0025] An overview of the Bend Stiffener coupling and supporting mechanism proposed in this invention is shown in Figure 1. In general, the external geometry of the Bell Mouth is similar to that of the DLBM, although replacing the multiple tongue mechanisms with a front drive means M, with the feature of being easily accessed and operated by ROVs.

[0026] As previously mentioned, the structural body of the Bell Mouth 1, as well as the Bend Stiffener Shaft 2 change little in relation to that described in the DLBM (document BR102018011452-2), except in the regions impacted by the new locking mechanism proposed by the present invention and as represented by the region R highlighted in Figure 2.

[0027] The multiple DLBM tongues, responsible for supporting the Bend Stiffener Shaft 2, are replaced with an Articulated Yoke 3, pivoted on an Axis 4, with a fixed position in the Bell Mouth, as illustrated in Figures 3A and 3B. The natural position of the Articulated Yoke 3 is in the closed condition, that is, supporting the Shaft 2, as illustrated in Figure 3A. During the pull-in operation, Shaft 2 acts to open Articulated Yoke 3, allowing it to be coupled to the structural body of the Bell Mouth 1, as illustrated in Figure 3B. After connecting the Shaft 2, the Articulated Yoke 3 returns to its natural position with the aid of a Return Element 6, which may be a coil spring, as shown in Figure 3B.

[0028] The configuration shown in Figures 3A and 3B of the Articulated Yoke mechanism is the preferred solution for the mechanism. However, it is important to note that there are several other configurations for this solution, such as exemplified in Figure 4.

[0029] In order to guide the movement of the mechanism during the pull-in process, the structure of the Bell Mouth 1 is manufactured with Bearings 5 that are positioned at its interface with the Articulated Yoke 3. These bearings are selected with material with adequate tribological properties to support the weight of the Shaft 2 and allow the smooth movement of the Articulated Yoke 3 in a submerged environment, as illustrated in Figure 5.

[0030] After the pull-in process is completed, in order to avoid any spurious movement of the Articulated Yoke 3 during riser operation, a Safety Lock 8 must be installed, preferably by ROV, to kinematically prevent the movement of the Articulated Yoke 3 and avoid the risk of unintentional disconnection of the Bend Stiffener Shaft 2, as illustrated in Figure 6.

[0031] For the pull-out operation, the ROV couples a Drive Spindle 7 to the Articulated Yoke 3, so that the ROV itself exerts a force in the opposite direction to that exerted by the Return Element 6, allowing the disconnection of the Bend Stiffener Shaft 2, as illustrated in Figure 7.

[0032] As an alternative configuration, the Return Element 6 can be replaced with a hydraulic cylinder with spring return, which allows the disconnection of the Bend Stiffener Shaft 2 remotely by the platform. The spring return is necessary for the cylinder to act as described in Figure 7, that is, with automatic pull-in operation, without the need for hydraulic power.

[0033] In this alternative configuration, there are considerable gains due to the lack of need for ROV operation in pull-out operations. However, the possibility of using the Drive Spindle 7 must be maintained in the design, and there may be a need for back-up operation in the event of failure of the hydraulic cylinder.

[0034] Therefore, with the proposed modifications, the invention guarantees advantages in relation to the State of the Art, namely: reduction of the acquisition cost of riser supports, mainly with the simplification of components and reduction of the number of actuators; optimization of access to the equipment by ROV, reducing the time of operations; lower maintenance costs; compatibility of connection with the first generation DLBM Shaft; replacement of shallow diving operations with operations with ROV; reduction of the number of hydraulic systems that need to operate simultaneously, thus reducing the probability of overall failure of the mechanism, among others.

Claims

1. A coupling/decoupling and supporting mechanism for a Bend Stiffener with external drive, **characterized in that** it comprises:

   a drive means (M) consisting of an Articulated Yoke 3; and
   Bearings 5 that are positioned at the interface of the Bell Mouth 1 with the Articulated Yoke 3.

2. The mechanism according to claim 1, **characterized in that** the Articulated Yoke 3 pivots on an Axis 4 when varying between the closed position and the open position.

3. The mechanism according to claim 1, **characterized in that**, during the pull-in operation, the Shaft 2 acts

on the opening of the Articulated Yoke 3.

4. The mechanism according to claim 3, **characterized in that**, after the connection with the Shaft 2, the Articulated Yoke 3 returns to its natural position with the aid of a Return Element 6.

5. The mechanism according to claim 4, **characterized in that** the Return Element 6 can be a coil spring.

6. Mechanism according to claim 1, **characterized in that** the bearings are selected with material with tribological properties specific to the function.

7. The mechanism according to claim 1, **characterized in that** it further comprises a Safety Lock 8 installed on the Articulated Yoke 3.

8. The mechanism according to claim 1, **characterized in that**, for the pull-out operation, a Drive Spindle 7 is coupled to the Articulated Yoke 3.

9. The mechanism according to claim 5, **characterized in that** the Return Element 6 is replaceable with a spring-return hydraulic cylinder.

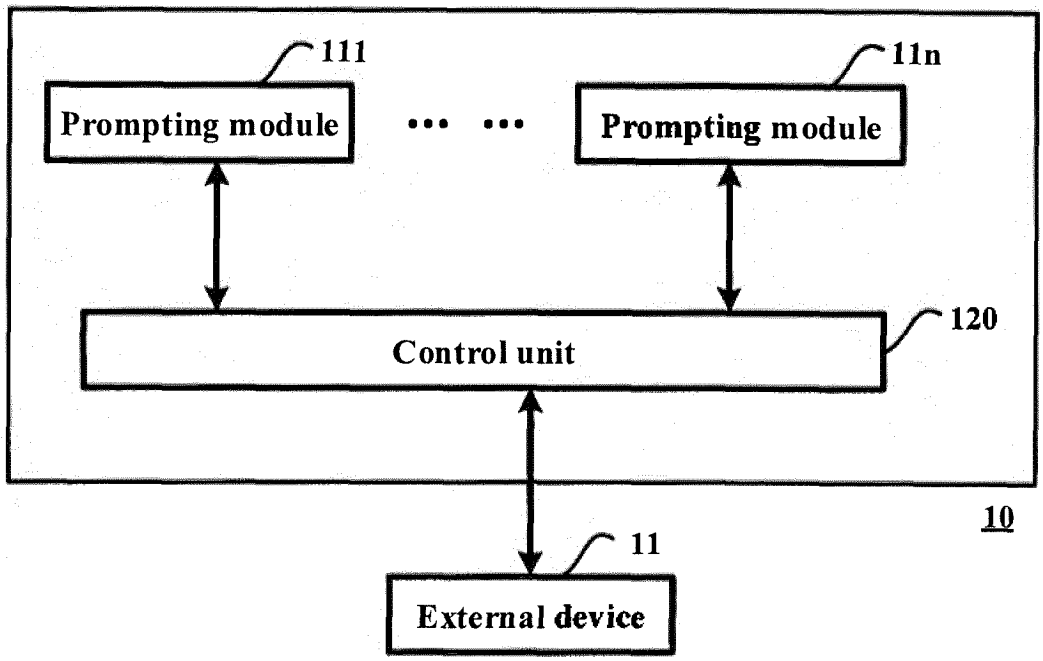
111
11n
Prompting module
Prompting module
Control unit
120
10
11
External device

Fig. 1

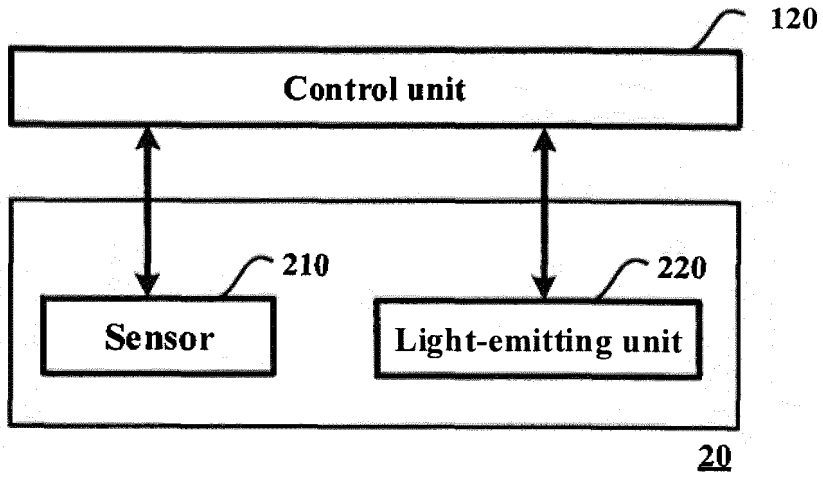

Fig. 2

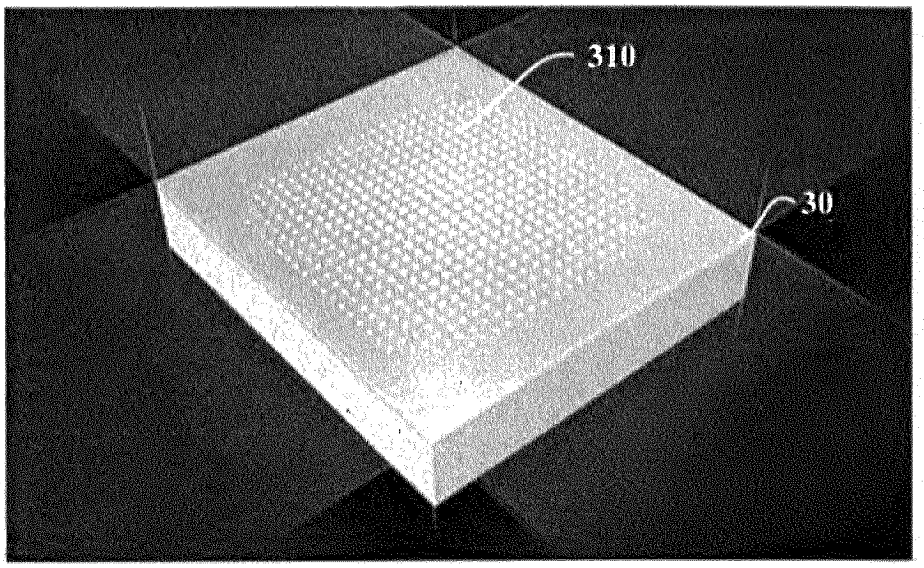

Fig. 3

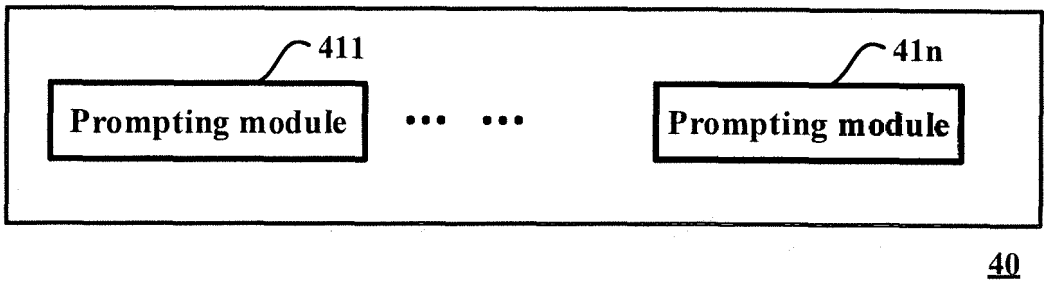
411
Prompting module
41n
Prompting module
40

Fig. 4

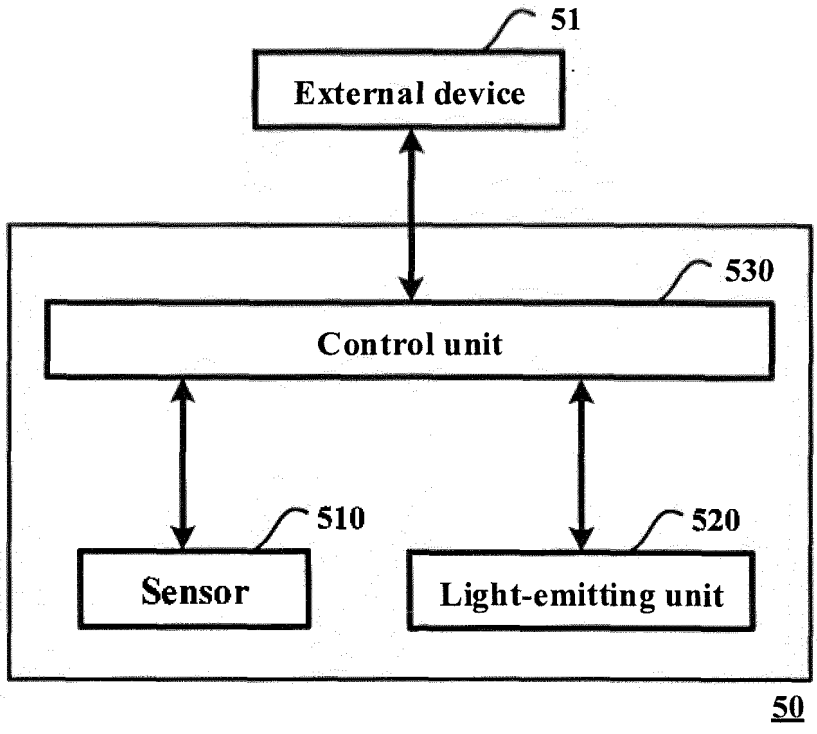
51
External device
530
Control unit
510
Sensor
520
Light-emitting unit
50

Fig. 5

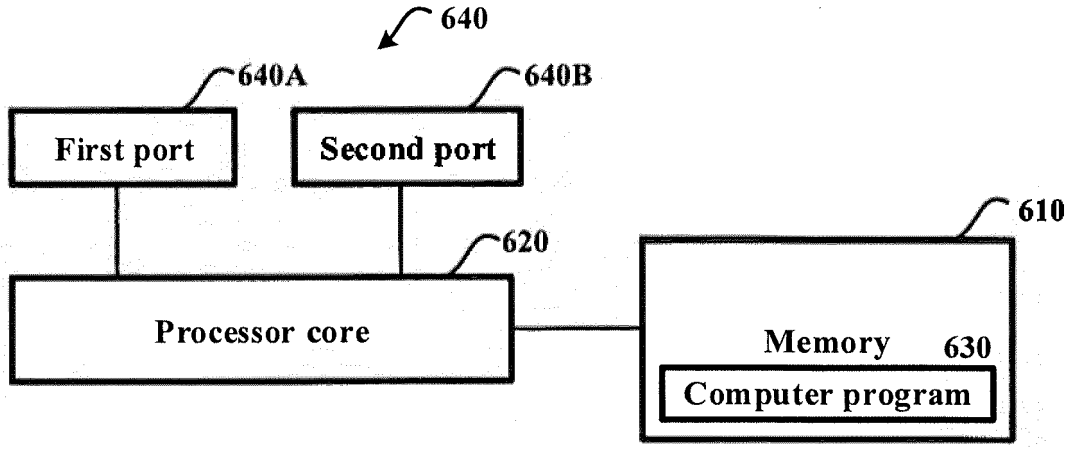
640
640A
640B
First port
Second port
610
620
Processor core
Memory
630
Computer program
60

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2023/061657

A. CLASSIFICATION OF SUBJECT MATTER

E21B 17/02(2006.01)i; ***E21B 17/01***(2006.01)i; **E21B 19/00**(2006.01)i; ***E21B 43/01***(2006.01)i; *F16L 37/084*(2006.01); *F16L 37/14*(2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B; F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Base de données INPI-BR

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Derwent Index Innovation

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 7967070 B2 (DEEP SEA TECHNOLOGIES INC [US]) 28 June 2013 (28.06.2013) The whole document	1-9
A	US 8573305 B2 (REDDY SANJAY K [US]) 05 November 2013 (05.11.2013) The whole document	1-9
A	WO 2019232605 A1 (PETROLEO BRASILEIRO SA PETROBRAS [BR]) 12 December 2019 (12.12.2019) The whole document	1-9
A	US 2014138095 A1 (VERGNE FREDERICK [FR]) 22 May 2014 (22.05.2014) The whole document	1-9
A	US 7293940 B1 (TECHNIP FRANCE [FR]) 13 November 2007 (13.11.2007) The whole document	1-9

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 April 2024 (17.04.2024)	23 April 2024 (23.04.2024)

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Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2023/061657

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	BR PI0913772 A2 (PETROLEO BRASILEIRO SA [BR]) 24 July 2012 (24.07.2012) The whole document	1-9
A	WO 2013097007 A1 (PETROLEO BRASILEIRO SA [BR]) 04 July 2013 (04.07.2013) The whole document	1-9

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/IB2023/061657

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				BR	102018011452	B1	10 de Agosto de 2021
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				BR	112013029286	B1	17 de Novembro de 2020
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				EP	2707567	B1	01 de Março de 2017
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				FR	2975121	B1	09 de Maio de 2014
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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- BR 1020180114522 **[0008] [0019] [0026]**
- US 7967070 B **[0016]**
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