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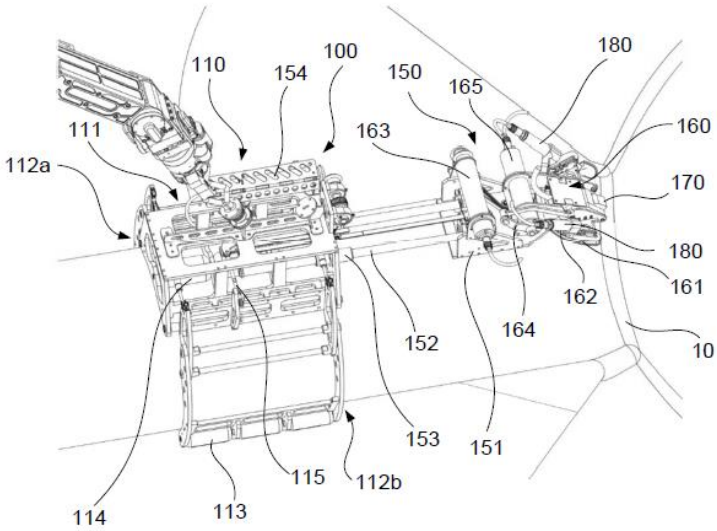
(73)	Proprietor	OCEANTECH INNOVATION AS, Skippergata 16, 7042 TRONDHEIM, Norge
(72)	Inventor	Ståle Karlsen, Ole Ross vei 58, 7092 TILLER, Norge Geir Ingar Bjørnsen, Selsbak Øvre nr. 4, 7027 TRONDHEIM, Norge Bernt Schjetne, Kringsjåveien 53, 7032 TRONDHEIM, Norge Kristian Ohr, Peder Falchs vei 8, 7042 TRONDHEIM, Norge
(74)	Agent or Attorney	CURO AS, Vestre Rosten 81, 7075 TILLER, Norge

(54) Title **Portable, controllable and autonomous subsea weld inspection tool**

(56) References Cited: US 4720213 A, GB 2182898 A, EP 0547685 A1, WO 2013076541 A1, WO 2018057250 A1

(57) Abstract

Portable, controllable and autonomous subsea weld inspection tool (100) for detachable attachment to a subsea structure (20), wherein it comprises an attachment assembly (110) for detachable attachment to the subsea structure (20), and an inspection probe holder assembly (150), wherein the inspection probe holder assembly (150) is arranged movable in longitudinal direction of the attachment assembly (110) and the attachment assembly (110) is arranged movable in circumferential direction of the subsea structure (20).



Portable, controllable and autonomous subsea weld inspection tool

The present invention is related to a portable, controllable and autonomous subsea weld inspection tool, according to the preamble of claim 1.

Background

It is a well-known fact that it is desired to detect fatigue fractures in offshore/subsea structures, and especially in welded joints thereof, where the load is highest.

An example where this is desired is in relation to lifetime extensions where it is desirable to determine status of a structure, and especially the welded joints, which is theoretically «expired» before approval of further operation is given.

From US 4720213 A is known an apparatus for inspecting, cleaning and/or performing other tasks in connection with a welded joint between intersecting tubular members of an offshore platform. The apparatus includes a support body adapted to be moved onto and removed from one of the tubular members, and a carrier rotatable about the body, when clasped about a tubular member, and having the task performing devices thereon for traversing the joint as the carrier is rotated.

In GB 2182898 A is described a robot, particularly for cleaning, inspection and/or repair of welds on underwater tubular steel sections of offshore platforms. The robot is carried by front and rear wheels and has at least one forwardly directed leg having an outer support roller. The legs are constructed and pivotally arranged such that the legs together with the body can retentively embrace more than half the perimeter of the tubular section on which the robot is placed.

From EP 0547685 A1 is known a remotely operated apparatus for inspection of and/or other work on a structure, for example a welded joint on an offshore platform, consisting of a support frame designed to be attached to and to move on the structure. An arm is mounted to rotate on the frame in both main directions in relation to the said frame. Furthermore, a steering carriage is mounted to rotate at the front end of the arm. One or more tools may be mounted on the carriage for the purpose of carrying out the required working operations.

In WO 2013076541 A1 is described a modular two-part welding and processing platform. A cart section is capable of rotating around objects, such as pipes and cylinders, or of linear travel along

plates or the like. The cart section reversibly couples to a processing section supplied for instance with welding apparatus, painting apparatus, cleaning means, analysis means or the like. By means of this two-part device, work pieces can be cleaned, welded, and inspected quickly and accurately. Special marks may be provided on the work piece, which in conjunction with sensors and motoring means on the cart, allow for precise positioning of the process head with respect to the work.

From WO 2018057250 A1 is known a system for underwater inspection including an inspection crawler, wherein the inspection crawler includes a housing having first and second sides, a power source, a controller, an inspection tool, at least two pairs of driving wheels, and a moveable center of gravity. It is also described a method for traversing a weld joint with the inspection crawler having a moving mass, wherein the crawler is parked proximate to the joint, and the mass is slid along a slide rail to the second end of the crawler distal to the joint. The first end of the crawler is then propelled over the joint and the mass is slid to the center of the crawler. A center portion of the crawler is then propelled over the joint and the mass is slid to the first end of the crawler. The second end of the crawler is then propelled over the joint.

Different probes for NDT (Non-Destructive Testing) of the mentioned welded joints can be used for this purpose. Welded joints of subsea structures may be tested using NDT techniques such as ultrasonic testing, magnetic particle inspection or via eddy current technology.

Common for most of these techniques for subsea applications is that the probe used for this would have to be positioned close to the weld and follow this.

Further, there exists no suitable solutions for automated inspection with probes of this kind for subsea use.

Presently, the inspection is mainly performed by the use of ROVs (Remotely Operated Vehicles) or divers. Divers is preferable to avoid due to HES (Health, Environment and Safety) and costs. It is further a problem that it is almost impossible to perform this operation with ROVs or divers in the splash zone due to high sea forces, resulting in that it is dangerous for divers to dive there, and ROV equipment will be destroyed.

There exist some solutions where fixed guiding rails have been attached to the subsea structures for arrangement of the probes. A disadvantage with these solutions is that they require accurate arrangement by a ROV and that they would have to be designed for each joint on the subsea structure, which is both expensive and challenging to achieve. There has also been developed some

magnetic crawlers for this inspection, but the manipulation of the probe movements is very difficult for a topside pilot under these conditions.

There is accordingly a need for a portable, controllable and autonomous subsea weld inspection tool that can follow the inspection curves and in a simple manner can be arranged to and removed from a subsea structure.

There is further a need for a portable, controllable and autonomous subsea weld inspection tool that can be reused for other subsea structures.

It is further a need for a portable, controllable and autonomous subsea weld inspection tool that provides control of an inspection probe in relation to a weld of a subsea structure to be inspected.

Object

The main object of the present invention is to provide a portable, controllable and autonomous subsea weld inspection tool partly or entirely solving the above-mentioned drawbacks of prior art.

An object of the present invention is to provide a portable, controllable and autonomous subsea weld inspection tool that can easily be attached and detached from subsea structures.

It is an object of the present invention to provide a portable, controllable and autonomous subsea weld inspection tool that provides control of an inspection probe in relation to a weld of a subsea structure to be inspected.

An object of the present invention is to provide a portable, controllable and autonomous subsea weld inspection tool enabling automated inspection of a weld of a subsea structure to be inspected.

It is an object of the present invention to provide a portable, controllable and autonomous subsea weld inspection tool that is more efficient, accurate and cost-saving in relation to prior art solutions.

Further objects of the present invention will appear from the following description, claims and attached drawings.

The invention

A portable, controllable and autonomous subsea weld inspection tool according to the present invention is disclosed in claim 1. Preferable features of the portable, controllable and autonomous subsea weld inspection tool are disclosed in the remaining claims.

A portable, controllable and autonomous subsea weld inspection tool according to the present invention comprises an attachment assembly for detachable attachment to a subsea structure, and a weld inspection probe holder assembly, wherein the weld inspection probe holder assembly is arranged movable in longitudinal direction of the attachment assembly and the attachment assembly is arranged movable in circumferential direction of the subsea structure.

The inspection probe holder assembly is according to a further embodiment of the present invention arranged for rotational or pivotable movement of an inspection probe arranged to the inspection probe holder assembly about a vertical axis of the inspection probe holder assembly and thus the portable, controllable and autonomous subsea weld inspection tool.

According to a further embodiment of the present invention, the inspection probe holder assembly is further arranged for tiltable movement of an inspection probe arranged to the inspection probe holder assembly in vertical direction in relation to the longitudinal direction of the portable, controllable and autonomous subsea weld inspection tool.

By the present invention is accordingly provided a solution for remote subsea weld inspection. The portable, controllable and autonomous subsea weld inspection tool according to the present invention provides controlling of an inspection probe in all 6 degrees of freedom, enabling the weld to be inspected by a pilot or inspector from topside.

Accordingly, the attachment assembly will retain the inspection probe holder assembly movably to the subsea structure and thus the inspection probe movable in relation to a weld is to be inspected.

The present invention will especially be suitable for inspection (scanning) of a weld in a joint between substructures of a main subsea structure, such as a joint between two substructures of a main subsea structure of a steel jacket of a platform used in connection with offshore oil production, offshore wind farms or fish farming structures.

According to the present invention, the controlling of the portable, controllable and autonomous subsea weld inspection tool for inspection of a subsea weld can be performed manually by means of a control unit or automatically by means of optical or laser reading of the weld by means of a vision system.

In relation to optical or laser reading of the weld, the portable, controllable and autonomous subsea weld inspection tool is provided with laser light sources or cameras for providing reference points and cameras for reading the reference points and controlling the portable, controllable and autonomous subsea weld inspection tool based on the readings. The portable, controllable and autonomous subsea weld inspection tool can then analyze the readings and automatically control the probe position at the weld and calculate the required movements, and then scan the weld configuration.

The portable, controllable and autonomous subsea weld inspection tool can according to the present invention be arranged to the subsea structure by means of rigging equipment, a splash zone access tool, or by a ROV (Remotely Operated Vehicle).

Accordingly, the portable, controllable and autonomous subsea weld inspection tool is arranged to the subsea structure, whereupon it can be controlled to position the inspection probe in relation to the weld to be inspected followed by inspection (scanning or “pick and place”) by movement in relation to the weld, continuously or in sections.

Further preferable features and advantageous details of the present invention will appear from the following example description, claims and attached drawings.

Example

The present invention will below be described in further detail with references to the attached drawings, where:

Fig. 1 is a principle drawing of a portable, controllable and autonomous subsea weld inspection tool according to the present invention arranged to an access tool,

Fig. 2 is a principle drawing of an embodiment of the portable, controllable and autonomous subsea weld inspection tool according to the present invention,

Fig. 3 is a principle drawing of degrees of freedom for an inspection probe holder according to the present invention,

Fig. 4 is a principle drawing of laser tagging of a weld, and

Fig. 5 is a principle drawing of laser light for optical reading of position according to the present invention.

Reference is now made to Figure 1, which is a principle drawing of a portable, controllable and autonomous subsea weld inspection tool 100 according to the present invention, arranged to an access tool 200, *known per se*, according to prior art. In the shown example, the access tool 200 is formed by a clamping device 210 for attachment to a subsea structure 20 and a controllable manipulator arm 220 arranged to the clamping device 210, which controllable manipulator arm 220 can be used to position the portable, controllable and autonomous subsea weld inspection tool 100 in vicinity of a weld 10 of a subsea structure 20 to be inspected. The access tool 200 is only one example of a system or device that can be used for positioning the portable, controllable and autonomous subsea weld inspection tool 100, and e.g. a ROV can be used for this, as well as rigging equipment, and other devices/systems, which will be within the knowledge of a skilled person.

Reference is now made to Figure 2 which is a principle drawing of an embodiment of the portable, controllable and autonomous subsea weld inspection tool 100 according to the present invention, and Figure 3 which is a principle drawing of degrees of freedom for an inspection probe holder 160 according to the present invention. The portable, controllable and autonomous subsea weld inspection tool 100 according to the present invention comprises an attachment assembly 110 and an inspection probe holder assembly 150.

The attachment assembly 110 is in the shown embodiment formed by a body 111, wherein controllable clamps 112a-b are arranged to each side of the body 111 such that the body 111 and thus attachment assembly 110 can be detachably attached to a subsea structure 20 by engagement of the clamps 112a-b from each side. In the example, the subsea structure 20 exhibits a tubular shape, and the body 111 preferably exhibits a mainly C-shape base adapted the curvature of the tubular subsea structure 20. The clamps 112a-b are preferably controllable by actuators and are in addition spring-loaded such that the clamps 112a-b will retain the attachment assembly 110 to the subsea structure 20 with a predefined force and allowing the attachment assembly 110 to be moved in circumferential direction of the subsea structure 20. The clamps 112a-b are further preferably

provided with rolls/wheels 113 with or without magnets for peripheral movement. In addition, also the main body 111 is preferably provided with rolls 114 at contact surfaces of the base with the subsea structure 20 for the same reason.

The clamps 112a-b are preferably further arranged to a controllable synchronization stay 115 for ensuring centralization in relation to the subsea structure 20 it is arranged to.

The inspection probe holder assembly 150 is formed by a main body 151, which is arranged movable in longitudinal direction of the attachment assembly 110 by at least one shaft 152 arranged movable in longitudinal direction of the body 111 by means of at least one actuator 153 driven by a motor 154, such as an electric, hydraulic or air driven motor.

The inspection probe holder assembly 150 is further provided with an inspection probe holder 160, controllably arranged to the far end of the main body 151 for arrangement of at least one inspection probe 170. The inspection probe holder 160 is arranged rotatable or pivotable about the vertical axis of the inspection probe holder assembly 150. This can e.g. be achieved by that the inspection probe holder 160 is arranged to travel on a C-shaped track 161 by means of at least one carriage 162, the C-shaped track 161 extending in transversal direction of the main body 151, in a parallel horizontal plane thereof, driven by an electric motor 163 via transmission means, such as belt and cogs.

According to the present invention, the inspection probe holder 160 is further preferably arranged tiltable in vertical direction of the main body 151. This can e.g. be achieved by that the inspection probe holder 160 is arranged to the at least one carriage 162 by a hinged connection at one side and wherein the other side is arranged to a manipulator arm 164 connected to an electric motor 165.

Accordingly, by the present invention is provided a portable, controllable and autonomous subsea weld inspection tool 100 capable of (see Figure 3):

- moving the inspection probe 170 in longitudinal direction (X-direction) of a subsea structure 20 in relation to a weld 10,
- moving the inspection probe 170 in vertical direction (Z-direction) of a subsea structure 20 and in relation to a weld 10,
- moving the inspection probe 170 about the vertical axis (Y-direction) of a subsea structure and in relation to a weld 10, and

- moving the inspection probe 170 about the longitudinal axis (X-direction) of a subsea structure and in relation to a weld 10.

The portable, controllable and autonomous subsea weld inspection tool 100 is accordingly controllable in all 6 degrees of freedom by pivotable, rotatable or tiltable movement about X-, Y- and Z-axis of the subsea structure 20, and movement in X-, Y- and Z-direction.

To be able to control the inspection probe 170 along a weld 10 one will be dependent to control 4 degrees of freedom at the same time. These are movement in X-direction, rotational or pivotable movement about the Y-axis, and tiltable movement about the Z-axis. The remaining two degrees of freedom will be locked according to the design of the portable, controllable and autonomous subsea weld inspection tool 100.

The portable, controllable and autonomous subsea weld inspection tool 100 can be controlled manually by a control unit based on that the portable, controllable and autonomous subsea weld inspection tool 100 is provided with cameras 180 and light sources. This will then depend on the skills of an operator to provide a successful inspection (scan).

The portable, controllable and autonomous subsea weld inspection tool 100 can be controlled in an automated manner, which will be described below, which will remove or partly remove the need for a skilled/trained operator.

Reference is now made to Figure 4 which is a principle drawing of laser tagging of weld and Figure 5 which is a principle drawing for optical reading of position according to the present invention.

The inspection probe holder assembly 150 will further be provided with at least one camera 180, in the shown embodiment two cameras 180, preferably with integrated lights sources (not shown).

By using laser tagging or photogrammetry tagging 190 of a weld 10 at each side of the inspection probe 170 one will get reference points 1, 2 that can be read optically by means of the cameras 180. The cameras 180 will read and process the several parameters that will be required for controlling the portable, controllable and autonomous subsea weld inspection tool 100, and thus provide an automated movement of the inspection probe 180 along a weld 10 to be inspected.

Control of movements by means of optical reading can be summarized as follows:

- Rotation about X-axis is performed with constant velocity and controlled by rotation of the attachment assembly 110 about the surface of the subsea structure 20.

- Movement in X-direction and rotation or pivoting about Y-axis is performed by reading of the mentioned reference points 1 and 2 by laser light. The reference points 1 and 2 will define the distances A and B. These two distances A and B should always be the same and controlled by rotation or pivoting about the Y-axis. In addition, the distances A and B will have a predefined distance that will control movement in the X-direction.

- Rotation or pivoting about the Z-axis is performed by optical reading of angle of the weld 10 in relation to the position of the inspection probe 170, ref. Figure 4.

The embodiment of the portable, controllable and autonomous subsea weld inspection tool 100 is shown attached to an access tool 200 with a controllable manipulator arm 220, which can be used to control the rotational or pivoting movement about the X-axis by controlling the manipulator arm 220 connected to the attachment assembly 110 for movement of the attachment assembly 110. The rotation or pivoting movement can also be provided by using a ROV with a manipulator arm or that the attachment assembly 110 is provided with means for rotation of the attachment assembly 110, such as rolls, wheels or belts with or without magnets or a C-ring system driven by an electrical motor or similar means, which enable rotation control by the inspection tool 100 itself.

The portable, controllable and autonomous subsea weld inspection tool 100 will further be provided with communication means for communication by wire or partly or entirely wireless with a control unit topside.

By the present invention is provided a portable, controllable and autonomous subsea weld inspection tool 100 that can be reused and easily moved from structure to structure without any special adaption to the structure.

By the portable, controllable and autonomous subsea weld inspection tool 100 according to the present invention one will have full control of the inspection probe at all time and the position of the inspection probe can be controlled according to the weld to be inspected, such that a scan of a sector or continuous scan of the weld can be performed with high accuracy and without any risk for personnel or equipment as the portable, controllable and autonomous subsea weld inspection tool 100 can be controlled manually or automated from topside.

Accordingly, the portable, controllable and autonomous weld inspection tool will be provided with a control unit that can read the weld and structure shape by use of sensors and from these data calculate the movements of the probe holder in an autonomous manner or partly autonomous manner.

Even though the present invention is especially suitable for inspection of welds in joints, the present invention can be used for inspection of any weld in relation to a subsea structure or any weld configuration where an inspection probe is to be guided along a weld, both above water or under water.

Modifications

The portable, controllable and autonomous subsea weld inspection tool 100 will or can further be provided with a control unit that can recognize weld shape against already modelled or read shapes (machine learning) and use this information to calculate the needed movement on the inspection scan.

Claims

1. Portable, controllable and autonomous subsea weld inspection tool (100) for detachable attachment to a subsea structure (20), comprising an attachment assembly (110) formed by a body (111) provided with controllable clamps (112a-b) arranged at each side of the body (111) for detachable attachment to the subsea structure (20), and an inspection probe holder assembly (150), wherein the inspection probe holder assembly (150) is arranged movable in longitudinal direction of the attachment assembly (110), **characterized in** that the clamps (112a-b) are arranged for retaining the attachment assembly (110) to the subsea structure (20) with a predetermined force and allowing the attachment assembly (110) with the inspection probe holder assembly (150) to be moved in circumferential direction of the subsea structure (20), wherein the inspection probe holder assembly (150) is formed by a main body (151) arranged movable in longitudinal direction of the attachment assembly (110) by means of at least one controllable shaft (152).

2. Portable, controllable and autonomous subsea weld inspection tool (100) according to claim 1, **characterized in** that inspection probe holder assembly (150) is provided with an inspection probe holder (160), controllably arranged to the far end of the main body (151) for arrangement of at least one inspection probe (170).

3. Portable, controllable and autonomous subsea weld inspection tool (100) according to claim 2, **characterized in** that the inspection probe holder assembly (150) is arranged for rotatable or pivotable movement of the inspection probe (170) arranged to the inspection probe holder assembly (150) about vertical axis of the inspection probe holder assembly (150) and thus the portable, controllable and autonomous subsea weld inspection tool (100).

4. Portable, controllable and autonomous subsea weld inspection tool (100) according to claim 3, **characterized in** that the inspection probe holder (160) is arranged to travel on a C-shaped track (161) by means of at least one carriage (162), the C-shaped track (161) extending in transversal direction of the main body (151), in a parallel horizontal plane thereof, driven by an electric motor (163) via transmission means.

5. Portable, controllable and autonomous subsea weld inspection tool (100) according to claim 2, **characterized in** that the inspection probe holder assembly (150) is arranged for tiltable movement of the inspection probe (170) arranged to the inspection probe holder assembly (150) in vertical

direction in relation to the longitudinal direction of the portable, controllable and autonomous subsea weld inspection tool (100).

6. Portable, controllable and autonomous subsea weld inspection tool (100) according to claim 5, **characterized in** that the inspection probe holder (160) is arranged to the at least one carriage (162) by a hinged connection at one side and wherein the other side is arranged to a manipulator arm (164) connected to an electric motor (165).

7. Portable, controllable and autonomous subsea weld inspection tool (100) according to any one of the preceding claims, **characterized in** that it is provided with at least one camera (180) and at least one light source, wherein the at least one light source is arranged for providing reference points that can be optically read by the at least one cameras (180), and used for automated control of the portable, controllable and autonomous subsea weld inspection tool (100) in relation to a weld (10).

8. Portable, controllable and autonomous subsea weld inspection tool (100) according to claim 1, **characterized in** that it comprises a control unit arranged to use sensors to collect data of a weld shape, and recognizing or reading the shape in such manner that the movements can be recognized or calculated by the portable, controllable and autonomous subsea weld inspection tool (100).

9. Portable, controllable and autonomous subsea weld inspection tool (100) according to claim 1, **characterized in** that the controllable clamps (112a-b) are provided with rolls or wheels (113) with or without magnets for peripheral movement and the body (111) is provided with rolls (114) at contact surfaces of the body (111) with the subsea structure (20).

10. Portable, controllable and autonomous subsea weld inspection tool (100) according to claim 1, **characterized in** that the controllable clamps (112a-b) are arranged to a controllable synchronization stay (115) for ensuring centralization in relation to the subsea structure (20).

11. Portable, controllable and autonomous subsea weld inspection tool (100) according to claim 1, **characterized in** that the controllable clamps (112a-b) are controllable by actuators and in addition spring-loaded such that the clamps (112a-b) are retaining the attachment assembly (110) to the subsea structure (20) with a predefined force.

12. Portable, controllable and autonomous subsea weld inspection tool (100) according any preceding claim, **characterized in** that it comprises a control unit that can recognize weld shape against already modelled or read shapes by machine learning and use this information to calculate the needed movement of the inspection probe holder assembly (150).

Patentkrav

1. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) for avtakbar festing til en undervannsstruktur (20), omfattende en festesammenstilling (110) dannet av en kropp (111) forsynt med styrbare klemmer (112a-b) innrettet på hver side av kroppen (111) for avtakbar festing til undervannsstrukturen (20), og en inspeksjonsprobe-holdersammenstilling (150), hvori inspeksjonsprobe-holdersammenstillingen (150) er innrettet bevegelig i lengderetning av festesammenstillingen (110), **karakterisert ved** at klemmene (112a-b) er innrettet for å holde festesammenstillingen (110) til undervannstrukturen (20) med en forhåndsbestemt kraft og tillate festesammenstillingen (110) med inspeksjonsprobe-holdersammenstillingen (150) å beveges i omkretsretning av undervannstrukturen (20), hvori inspeksjonsprobe-holdersammenstillingen (150) er dannet av en hovedkropp (151) innrettet bevegelig i lengderetning av festesammenstillingen (110) ved hjelp av minst en styrbar aksling (152).

2. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) i samsvar med krav 1, **karakterisert ved** at inspeksjonsprobe-holdersammenstillingen (150) er forsynt med en inspeksjonsprobeholder (160), styrbart innrettet til den fjerne enden av hovedkroppen (151) for innretning av minst en inspeksjonsprobe (170).

3. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) i samsvar med krav 2, **karakterisert ved** at inspeksjonsprobe-holdersammenstillingen (150) er innrettet for roterbar eller svingbar bevegelse av inspeksjonsproben (170) innrettet til inspeksjonsprobe-holdersammenstillingen (150) om vertikal akse av inspeksjonsprobe-holdersammenstillingen (150) og på denne måte det flyttbare, styrbare og autonome undervanns sveisinspeksjonsverktøyet (100).

4. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) i samsvar med krav 3, **karakterisert ved** at inspeksjonsprobeholderen (160) er innrettet for bevegelse på en C-formet bane (161) ved hjelp av minst en vogn (162), hvilken C-formet bane (161) strekker seg i tverrgående retning av hodekroppen (151), i et parallelt horisontalt plan derav, drevet av en elektrisk motor (163) via overføringsmidler.

5. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) i samsvar med krav 2, **karakterisert ved** at inspeksjonsprobe-holdersammenstillingen (150) er innrettet for vippbar bevegelse av inspeksjonsproben (170) innrettet til inspeksjonsprobe-holdersammenstillingen (150)

i vertikalretning i forhold til lengderetningen til det flyttbare, styrbare og autonome undervanns sveisinspeksjonsverktøyet (100).

6. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) i samsvar med krav 5, **karakterisert ved** at inspeksjonsprobeholderen (160) er innrettet til den minst ene vognen (162) gjennom en hengslet tilkobling på en side og hvori den andre siden er innrettet til en manipulatorarm (164) koblet til en elektrisk motor (165).

7. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) i samsvar med et av de foregående krav, **karakterisert ved** at det er forsynt med minst et kamera (180) og minst en lyskilde, hvori den minst ene lyskilden er innrettet for å tilveiebringe referansepunkter som optisk kan leses med det minst ene kameraet (180), samt brukes for automatisk styring av det flyttbare, styrbare og autonome undervanns sveisinspeksjonsverktøyet (100) i forhold til en sveis (10).

8. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) i samsvar med krav 1, **karakterisert ved** at det omfatter en styringsenhet innrettet for bruk av sensorer til å samle inn data om en sveisform, samt gjenkjenne eller lese formen på en slik måte at bevegelsene kan gjenkjennes eller beregnes av det flyttbare, styrbare og autonome undervanns sveisinspeksjonsverktøyet (100).

9. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) i samsvar med krav 1, **karakterisert ved** at de styrbare klemmene (112a-b) er forsynt med ruller eller hjul (113) med eller uten magneter for periferisk bevegelse og kroppen (111) er forsynt med ruller (114) ved kontaktflater av kroppen (111) med undervannsstrukturen (20).

10. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) i samsvar med krav 1, **karakterisert ved** at de styrbare klemmene (112a-b) er innrettet til et styrbart synkroniseringsstag (115) for å sikre sentralisering i forhold til undervannsstrukturen (20).

11. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) i samsvar med krav 1, **karakterisert ved** at de styrbare klemmene (112a-b) er styrbare gjennom aktuatorer og i tillegg fjærbelastet slik at klemmene (112a-b) holder festesammenstillingen (110) til undervannsstrukturen (20) med en forhåndsbestemt kraft.

12. Flyttbart, styrbart og autonomt undervanns sveisinspeksjonsverktøy (100) i samsvar med et av de foregående krav, **karakterisert ved** at det omfatter en styringsenhet hvilken kan gjenkjenne en sveisform mot allerede modellerte eller avleste sveiser gjennom maskinlæring og bruk av denne informasjonen til å beregne den krevde bevegelsen av inspeksjonsprobe-holdersammenstillingen (150).

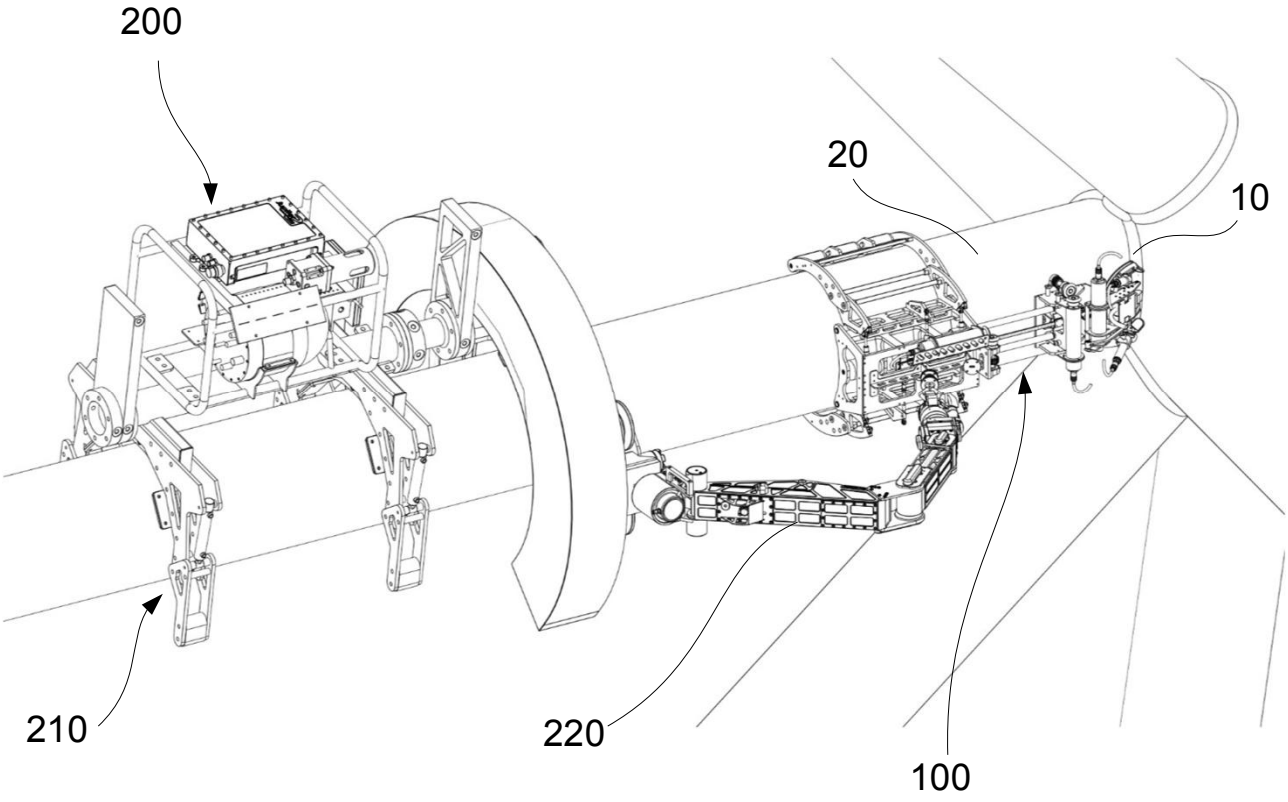

200
20
10
210
220
100

Fig. 1.

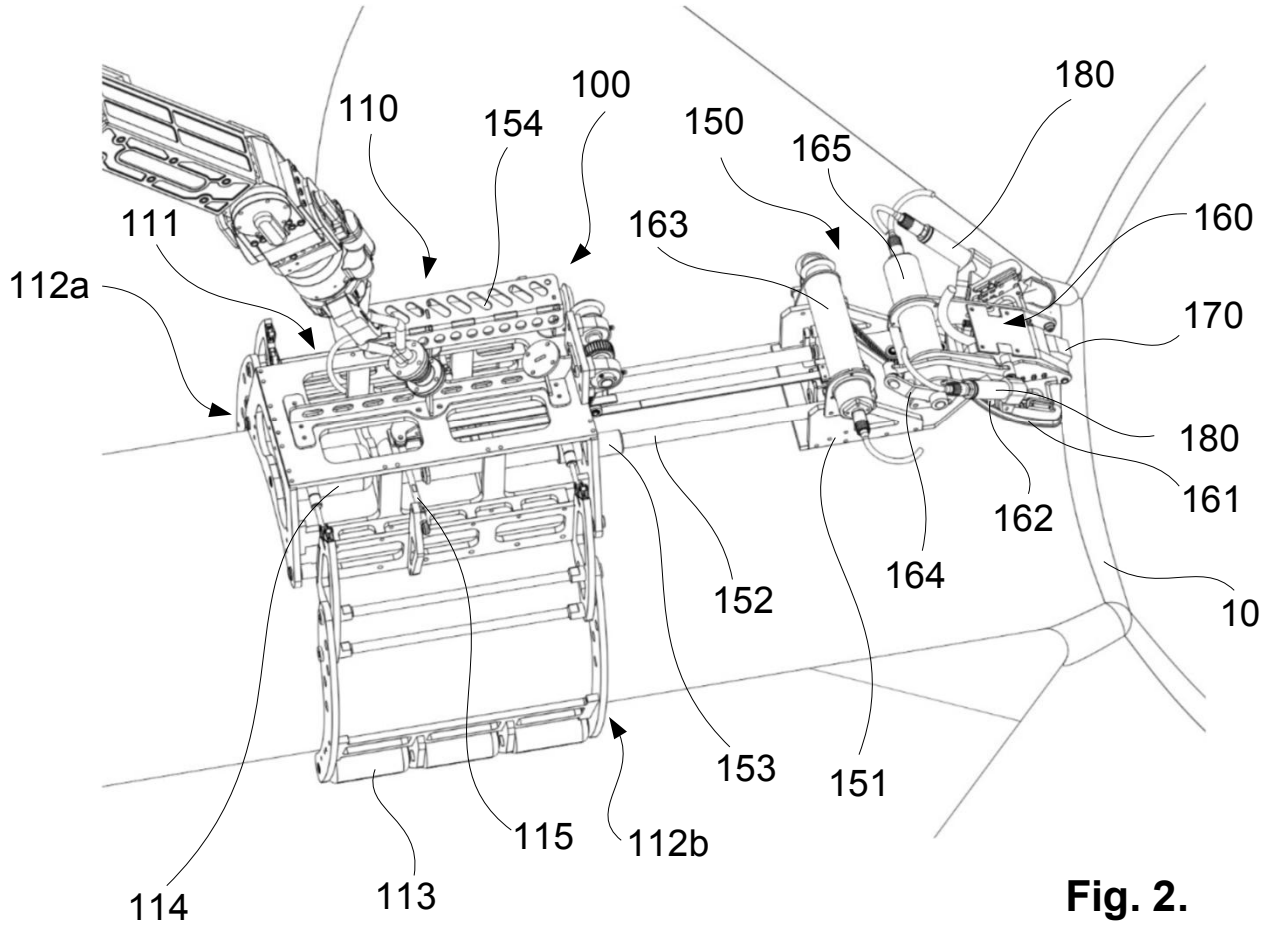

110
154
100
150
165
180
111
163
160
112a
170
180
161
162
164
152
10
153
151
115
112b
114
113

Fig. 2.

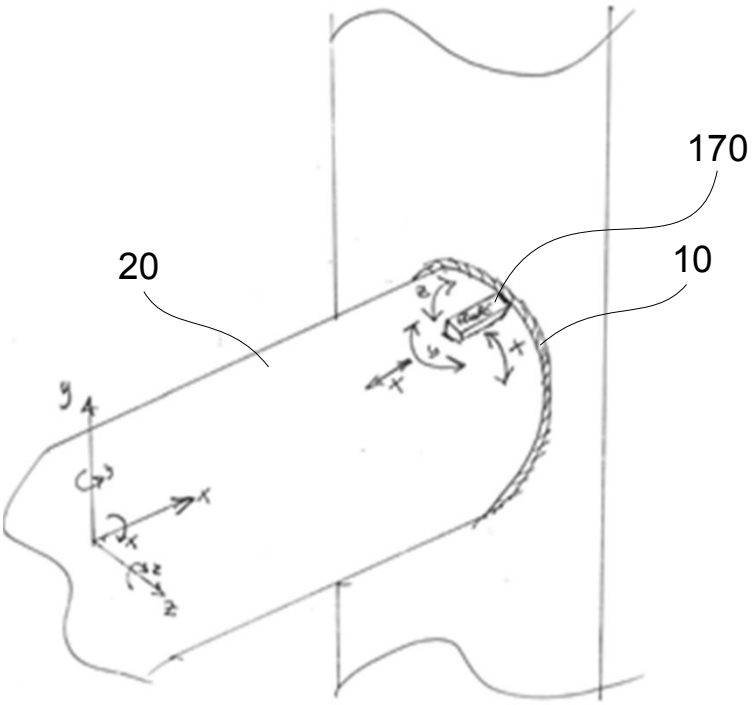


Fig. 3.

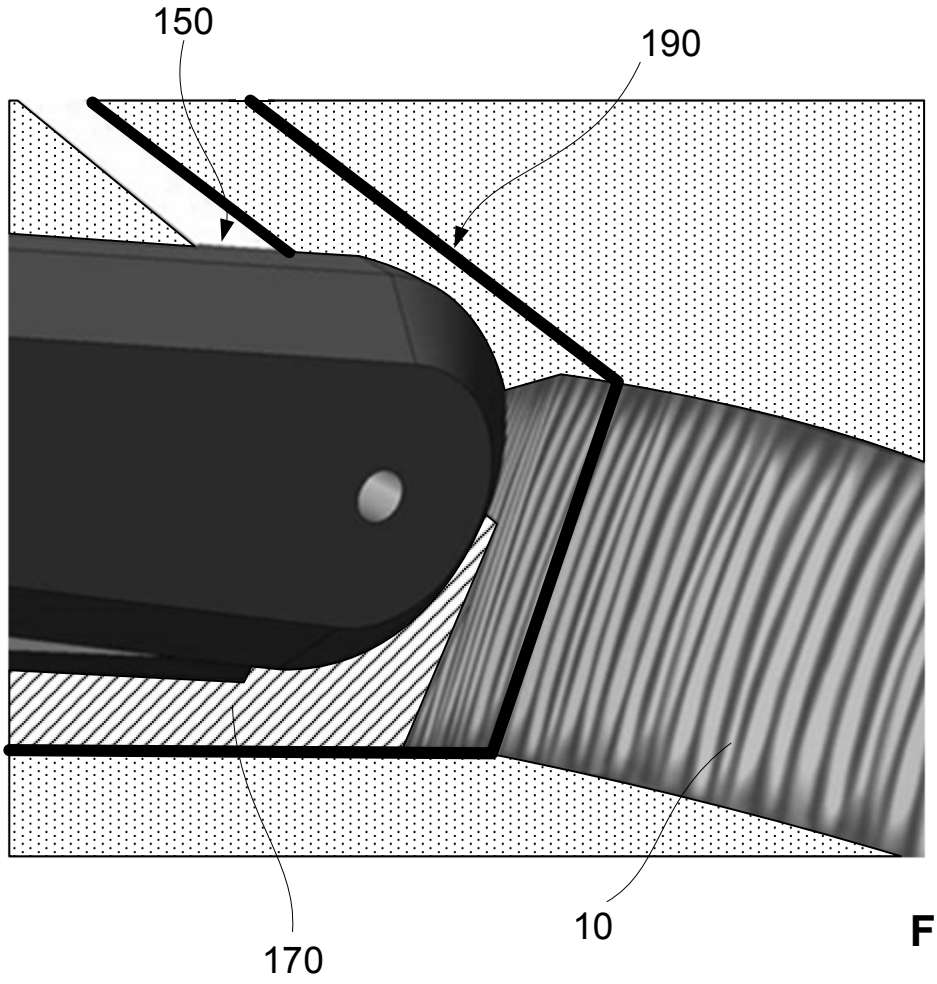


Fig. 4.

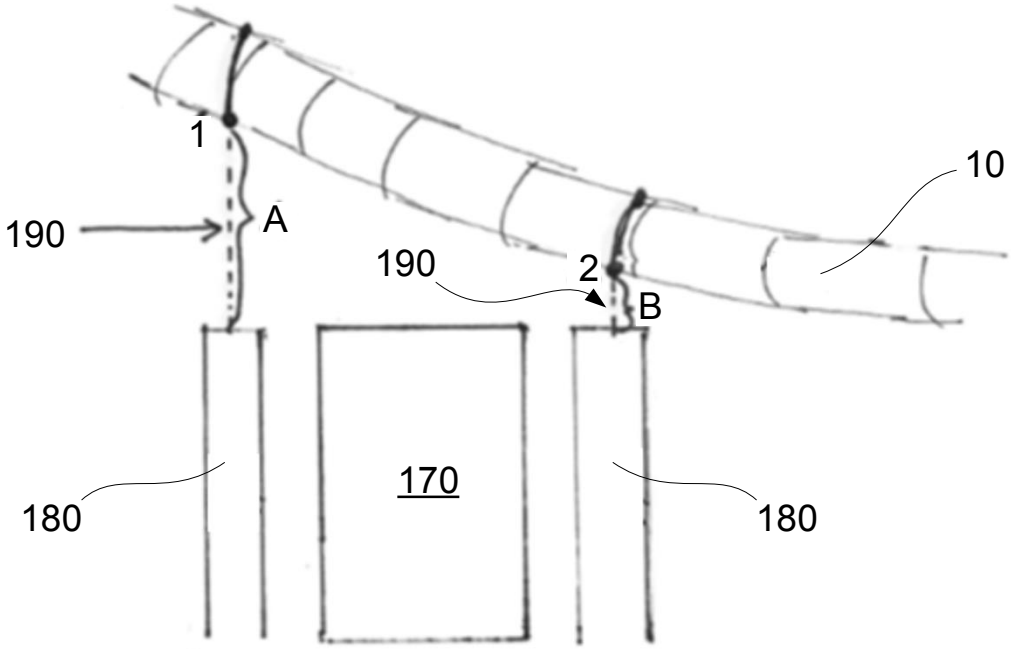


Fig. 5.