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**METHOD AND APPARATUS FOR UNDERWATER CONNECTION
OF PIPE PIECES AND BOLT THEREFOR**

In order to enable the realization of nut and bolt connections, in particular deep under the water surface, the invention provides a method as stated in one or more of the claims 1-3, in addition to an apparatus as according to one or more of the claims 4, 6 and 8. The invention also provides a bolt as according to claim 9 designed specially for the application of the invented method.

In the drawings:

10 Figures 1-8 show successive steps of the underwater displacement of a pipe piece;

Figures 9 and 10 show respectively a top and side view of an apparatus according to the invention;

Figure 11 shows a nut magazine;

15 Figures 12 and 14 show side views of a preferred embodiment of the apparatus according to the invention in successive method steps;

Figures 13 and 15 show a top view of a fraction of figures 12 and 14 respectively;

20 Figure 16 shows fraction XVI of figure 10 on larger scale;

Figure 17 shows a section of fraction XVII of figure 16 on larger scale;

25 Figures 18 and 19 show views of fraction XIX of figures 14 and 23 on larger scale;

Figures 21 and 22 show views of fraction XXI of figure 10;

Figure 23 shows a section along the line XXIII-XXIII of figure 22 on larger scale;

30 Figure 24 shows fraction XXIV of figure 17 on larger scale; and

Figure 25 shows a section corresponding with figure 20 relating to a preferred embodiment of the apparatus according to the invention.

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In the method according to the invention, for instance two pipe pieces 100 which lie on a seabed 101 at a depth of for instance 1 km are displaced by means of yokes 106 (fig. 1-8) such that they come to lie mutually
5 in line and mutually connect with their flanges 102. One yoke 106 at a time is herein placed horizontally by means of its telescopic legs 103 provided with pivoting feet 105 (fig. 1, 2), a gripper frame 104 is displaced in transverse direction of pipe pieces 100 relative to yoke
10 106 by means of hydraulic cylinders 107 to a position above a pipe piece 100, the yoke 106 is moved downward, a gripper 108 supported by gripper frame 104 is closed round pipe piece 100 by means of a cylinder 109 and yoke 106 with pipe piece 100 is raised, whereafter pipe piece
15 100 is displaced.

These operations can be repeated, optionally while yoke 106 is moved in longitudinal direction of feet 105 and pipe piece 100 by means of hydraulic cylinders 110 (fig. 9).

20 When pipe pieces 100 lie mutually in line, which is controlled from an Remote Operated Vehicle (ROV) 111 (fig. 10), a positioning frame 112 lowered from a ship is placed above a pipe piece 100 on legs 113. Positioning frame 112 transports a nut wrench 2 and a bolt wrench 3
25 which are placed on pipe pieces 100. Positioning frame 112 further carries pump means for hydraulic fluid for driving the diverse hydraulic motors of wrenches 2 and 3.

Nut wrench 2 comprises an upper half 115 of a nut magazine 4 which is fixedly mounted on a wrench frame 114
30 and from which two lower quarters 116 are suspended by means of cylinders 117 for swivelling between the opened position of figure 11 and a closed position engaging round a pipe piece 100. Wrench frame 114 further supports on a pipe piece 100 via a saddle 118. Nut magazine 4 has
35 for instance 16 compartments 5 distributed over the periphery and having a hexagonal profile, in each of which compartments is received one nut 6 which is urged outward by a spring 119 but which is held so rigidly in its closely dimensioned compartment 5 by means of rubber

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friction rings 120 (fig. 18, 19) that spring 119 cannot overcome this friction.

The bolt wrench 3 (fig. 16) comprises a wrench frame 121 which is provided with floater bodies 122 and which
5 is lowered onto a pipe piece 100 by means of a saddle 123. A saddle-shaped supporting head 124 is slidable in axial direction relative to saddle 123 by means of hydraulic cylinders 125. Saddle 123 can be anchored to a
10 pipe piece 100 by means of hydraulically energized transverse pins 47. A frame 133 mounted to supporting head 124 by means of a ring bearing 127 is rotated into an angular position by means of a gear ring 128 and driving gear 129 such that four wrenches 30 mounted on frame 126 and
15 disposed in each case at mutual angular distances of 90° are situated opposite bolt holes 8 of flanges 102. The supporting head 124 is then displaced relative to wrench frame 121 until the bolts 9 protrude into bolt holes 8. Displacing of supporting head 124 is measured by means of
20 a wire 49 trained round a pick-up 48. In order to place bolt holes 8 of flanges 102 in line, the pipe pieces 100 are optionally twisted slightly by pivoting the yokes 106 (in which pipe pieces 100 are held) relative to each other using pipe pieces 100 as pivot axis.

Together with wrench frame 114, nut magazine 4 is
25 moved relative to saddle 118 toward bolts 8 by means of hydraulic cylinders 130 (fig. 14, 15) until a positioning cavity 131 of nut magazine 4 strikes against a positioning pin 132 of a flange 102. The compartments 5 with nuts 6 are hereby centered relative to bolt holes 8. Bolts 9
30 drive nuts 6 inside counter to spring action, whereby the friction of rings 120 is overcome.

Each wrench 30 comprises in a housing 7 a socket 32 which is urged by means of a spring 34 into the position shown in figure 17 on a nut 35 and which is driven by a
35 hydromotor 40 via its gear ring 37 and toothed wheels 38, 39. Each screw bolt 9 has a protruding grooved end 62 and a fixed ring 63 at a small distance from nut 35. Present in fig. 17 at the free end of the grooved end 62 is a welded clamp 64 consisting of a number of, for instance
40 three, clamping pieces 65 which have conical surfaces 67

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and 68. Surfaces 67 co-act with the conical surface 73 of a piston 69 of a double-action cylinder 70 which is fixed by means of bolts 66 to a piston piece 61. Surfaces 68 co-act with a conical surface 73 of the piston piece 61 of piston 74 of a hydraulic, double-action cylinder 72. Clamping pieces 65 are urged apart by tangential pressure springs 75 arranged in each case in each separating surface.

Piston 69 carries a bolt 77 which in the clamping position of clamping pieces 65 (also the clamping position of piston 69) lies opposite an electrical sensor 78 mounted on cylinder 70 and thus indicates the clamping position.

The ring 63 fixed for instance by glueing or locking comprises axial pins 81 which are urged away from nut 35 against stops 85 by springs 80 and received in continuous holes 83 and which, when energized by sliding sleeve 87 moves into arcuate recesses 89 of nut 35 (fig. 17, 24).

Piston 74 is sealed with at least one sealing ring relative to sliding sleeve 87 which is guided over threaded end 62 by means of a plastic lining 88.

Piston 74 is locked against rotation by means of axial rods 96.

During insertion of bolts 9 into flanges 102 (fig. 12) the clamps 64 are closed and the pins 81 of fixed ring 63 engage into nut 35.

During arranging of nuts 6 (fig. 14) clamps 64 are disengaged from bolts 9 and nuts 35 are driven by means of sockets 32 and motors 40 in order to rotate the bolts 9 which are coupled to nuts 35 via pins 81 and fixed rings 63 and thus screw them into the nuts 6.

When nuts 6 are screwed against a flange 102 the supporting head 124, and thus also housings 7, are moved away from flanges 102 by means of cylinders 125 so that the fixed rings 63 are moved away from nuts 35 and the disengaged nuts 35 move toward flanges 102 with further driving by motors 40.

While bolts 9 are held fast by clamps 64 and cylinders 72 are energized to place bolts 9 under axial ten-

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sion, nuts 35 are driven by means of motors 40 in order to screw the flanges 102 firmly against each other.

After release of clamps 64 the bolt wrench 3 can be removed, four other bolts 9 can be placed therein by means of the ROV and these can be inserted into flanges 102 in a different angular position of ring bearing 127 relative to supporting head 124.

Instead of using a nut wrench 2 a flange 102 can be provided at each bolt hole 8 with a nut compartment 10 mounted thereon (fig. 20) in which is situated a nut 6 urged toward flange 102 by a spring 119.

Although the described hydraulically driven clamp 64 is recommended, another, for instance mechanically driven, clamp can also be used.

A nut wrench 12 as in fig. 21-23 is preferably used. The wrench frame 13 thereof is placed on a pipe piece 100 by means of two saddles 14 and 15 which can each be clamped fixedly to pipe piece 100 by means of a hydraulically operated transverse pin 16 respectively 17. By fixedly clamping the saddle 14 displaceable relative to wrench frame 13 to pipe piece 100, the wrench frame 13 can be displaced relative to saddle 14 and, conversely, in the case of a fixedly clamped saddle 15 the saddle 14 is forward displaceable in order to perform the required step movements. (Wrench frame 14 of fig. 12 is also displaceable in the same manner).

The zero position of the angular displacement can be realized by means of a V-shaped angle section 22 which co-acts with a pin 23 welded to pipe piece 100. Because the weight of nut wrench 12 is compensated by a floater body 24, nut wrench 12 can be swivelled slightly relative to pipe piece 100 by means of the ROV.

A tool head 18 can be set in the required angular position by means of a ring bearing 25 mounted thereon, a gear ring 19 and a driving gear 20, wherein a plurality of, for instance four, nut wrenches 21 lie in line with bolt holes 8.

Each wrench 21 comprises a housing 26 and a nut magazine 27 mounted rotatably and slidably therein and urged toward flange 102 by a spring 28, which magazine is



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adapted to receive a plurality of, for instance four, nuts 6 (fig. 18, 19) and has for this purpose a hexagonal internal profile. Nut magazine 27 is driven via its gear ring 29 and a driving gear 31.

5 Hydraulic motors are present for the diverse drives.

Nut magazine 27 contains a push member 41 which is provided with three L-shaped leaf springs 42 which in the return direction act as pins, in addition to a rubber friction ring 43. When tool head 18 is in its starting position, the saddle 15 has axially in line with nut magazine 27 a pusher 44 which in each case is driven by a cylinder 45 and which shifts by one nut width at a time the push member 41, and the nuts 6 which are present.

In combination with this wrench 21 a wrench 46 is used in each case which is identical to wrench 30, except that the now superfluous fixed ring 63 is preferably omitted. Bolts 9 are inserted into holes 8, a nut 6 is screwed on in each case, a nut 35 is screwed in each case against a flange 102, bolts 9 are tightened by energizing cylinder 72 and nut 35 is screwed further to flange 102, all of this while the bolts 9 in question are held fast by means of clamps 64. Clamps 64 are thereafter released to remove wrenches 126 from bolts 9.

Wrenches 126 are once again filled with bolts 9 by means of the ROV and these are inserted into other holes 8 when wrenches 126 are swivelled through an angle, whereafter nuts 6 from nut wrenches 21 are screwed thereon from the other side.

In order to hold nuts 6 positioned in their compartment, instead of friction rings 120 on the nuts 6 rubber strips can be arranged on the inner walls of nut compartments 5, for instance in the middle of the hexagons in axial direction of nuts 6, which strips bring about a considerable friction between nuts 6 and the inner walls of compartments 5.

If only one nut and bolt connection has to be made, for instance because a bolt 9 must be replaced, the same wrench 3 can be used, wherein only one of the wrenches 6 is then driven. Control and driving of each wrench is dependent on the others for this purpose.

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CLAIMS

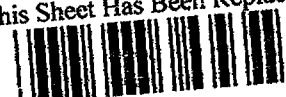
1. Method for underwater mutual connection with nut and bolt connections of two pipe pieces (100) provided with flanges (102), characterized in that a frame (126) of a bolt wrench (3) comprising a plurality of wrenches
5 (30) mounted on the frame (126) is positioned with bolts (9) received in the wrenches (30) relative to the bolt holes (8) of at least one flange (102), and that by means of the plurality of wrenches (30) the bolts (9) received therein are inserted into bolt holes (8) in the posi-
10 tioned situation of the frame (126), these bolts (9) are combined with nuts (6) to form nut and bolt connections and these nut and bolt connections are tightened.

2. Method for underwater mutual connection with nut and bolt connections of two pipe pieces (100) provided
15 with flanges (102), characterized in that nuts (6) are supplied and positioned by means of at least one nut wrench (2) which comprises at least one nut magazine (27) which is adapted to receive a plurality of nuts (6).

3. Method for assembling and/or disassembling at
20 least one pipe piece (100) located underwater, wherein nut and bolt connections of pipe flanges (102) are released and/or fastened by means of at least one wrench (2, 3), characterized in that at least one wrench (2, 3) is supported by a frame (13) having two supports (14, 15)
25 supporting at mutual axial distance on the pipe piece (100), and that the wrench (2, 3) is displaced in longitudinal direction of the pipe piece (100) by fixing only one (14) of the two supports (14, 15) to the pipe piece (100) in a displacement period, while the other support
30 (15) is displaced relative to the pipe piece (100).

4. Apparatus for performing the method as claimed in claim 1, 2 or 3, characterized by a frame (126) and a bolt wrench (3) comprising a plurality of wrenches (30) mounted on the frame, wherein each of said wrenches (30)
35 has a shaft for receiving a bolt (9) which is bounded by a socket (32) driven by drive means (38-40) and by a

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clamp (64) for opening and closing which is energized by tensioning means (69).

5. Apparatus as claimed in claim 4, characterized in that the shaft is also bounded by a ring (33) which is
5 fixedly connected to the housing (7) of the wrench (30) and which forms a stop for at least one pin (81) which is received slidably in a fixed ring (63) of a bolt (9) for mounting.

6. Apparatus for performing the method as claimed in
10 claim 2 comprising a nut wrench (21) for releasing and/or fastening a nut and bolt connection of flanges (102) of pipeline pieces (100) located underwater, characterized in that the wrench (21) comprises at least one nut maga-
zine compartment (5) which is adapted to receive a plu-
15 rality of nuts (6).

7. Apparatus as claimed in claim 6, characterized in that the spring force of spring means (28) urging a nut
(6) outward does not overcome the friction of friction
means (120) acting between a compartment and nut (6)
20 received therein.

8. Apparatus for performing the method as claimed in claim 3, characterized in that at least one wrench (2, 3, 12) comprises a frame (13) having two supports (14, 15) supporting at mutual axial distance on a pipe piece
25 (100), which supports (14, 15) are each provided with holding means (16, 17) for fixedly holding the relevant support (14, 15) on the pipe piece (100), that at least one of the two supports (14, 15) is displaceable relative to the frame (13) and that the supports (14, 15) are
30 mutually connected via driven pushing-off means (130).

9. Bolt (9) for a nut and bolt connection of pipe pieces (100) located underwater, which bolt (9) is provided with a ring (63) which is fixedly mounted thereon and in which at least one pin (81) which is longer than
35 the axial length of this ring (63) is arranged in a continuous hole (83), which pin (81) is provided between its ends with a shoulder (84) which co-acts on its one side with a spring (80) and co-acts on its other side with a stop (85).



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