



(51) International Patent Classification:

F03D 13/25 (2016.01) E02D 27/42 (2006.01)

E04H 12/08 (2006.01) F03D 13/20 (2016.01)

E04H 12/34 (2006.01)

(21) International Application Number:

PCT/EP2022/068373

(22) International Filing Date:

04 July 2022 (04.07.2022)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

2028735 15 July 2021 (15.07.2021) NL

(71) Applicant: ITREC B.V. [NL/NL]; 2, Admiraal Trompstraat, 3115 HH SCHIEDAM (NL).

(72) Inventor: WIJNING, Diederick Bernardus; c/o 2, Admiraal Trompstraat, 3115 HH SCHIEDAM (NL).

(74) Agent: EP&C; P.O. Box 3241, 2280 GE Rijswijk (NL).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH,

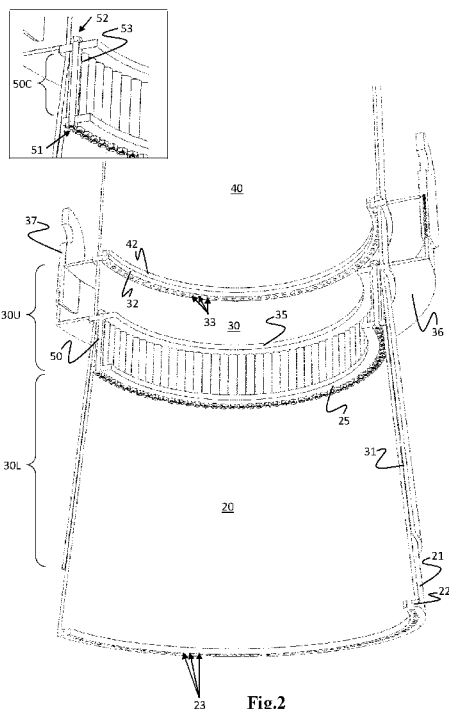
KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE

(54) Title: SLIP JOINT IN AN OFFSHORE WIND TURBINE



(57) Abstract: The invention relates to a slip joint for mounting an offshore wind turbine tower to an offshore foundation. The slip joint comprises an inner barrel and an outer barrel. The inner and outer barrels each comprise an inwardly protruding circumferential flange with bolt holes for receiving bolts connecting these flanges that are arranged vertically spaced from one another when the barrels are mated.

SLIP JOINT IN AN OFFSHORE WIND TURBINE

5 The present invention relates to the design and use of a slip joint for mounting of an offshore wind turbine tower onto an offshore foundation.

The tower may or may not include a transition piece.

10 The foundation may be of a type that is fixed to the seabed, e.g. a monopile, a jacket, etc. Fixed foundation offshore wind turbines are effective in relatively shallow waters. In deeper waters it is envisaged that floating foundation wind turbines will be most effective, e.g. economical. For example, the document WO2009/131826 discloses several designs of floating foundation wind turbines. A spar-type floating foundation or a tension-leg type floating foundation may also be envisaged as examples.

15

Nowadays, offshore wind turbines are enormous. Power ratings of over 9 MW, e.g. of about 15 MW, are rather common. This requires a very tall and larger diameter tower that is mounted onto the foundation.

20 In order to establish a connection between the tower and the foundation, it is known to provide a slip joint mounting. For example, the document WO2018/070868 discloses a slip-joint for this purpose.

25 An aim of the present invention is to provide an improved slip joint for mounting an offshore wind turbine tower, possibly including a transition piece, to the foundation.

The present invention provides a slip joint according to claim 1.

30 As will be explained herein, the provision of the first and second flanges and bolts may be advantageous when the slip joint is mated and as it later absorbs the enormous forces during operation of the wind turbine at sea. As explained herein, the inventive slip joint may also be of advantage in view of the de-installation of the wind turbine tower, for example in the de-installation of an entire offshore wind turbine, so including not only the tower but also nacelle and rotor blades as a unit from the (floating) foundation.

35

For installation and, possibly, de-installation of an offshore wind turbine provided with the inventive slip joint use may be made of a vessel and/or methods as described in non-prepublished patent applications NL2027279, NL2027489, NL2027788, NL2027280 and NL2027786, which are incorporated herein by reference.

5

Advantageously, the spaced apart first and second flanges provide two internally protruding structural elements which each belong to a respective barrel of the slip joint, are internally accessible, e.g. as personnel can enter the into this part of the foundation and/or into the tower, e.g. for mounting and tightening of the bolts, possibly also spacer bushing, and/or for the removal thereof and the placement of jacks.

10

As explained herein, the placement of jacks, e.g. single action hydraulic jacks, allows to move the first and second flanges (very) forcefully apart from each other and thereby cause or at least assist in the release of the frictional engagement between the barrels of the slip joint.

15

Advantageous embodiments of the slip joint are described in the subclaims.

The barrels may frictionally contact one another at one interface, but multiple interfaces vertically spaced from one another, e.g. having different cone angles, are also envisaged in the context of the present invention.

20

The invention furthermore relates to an offshore wind turbine comprising an offshore foundation and an offshore wind turbine tower, e.g. the tower including a transition piece, wherein the tower is mounted or mountable to the foundation by means of a slip joint as described herein.

25

The invention furthermore relates to a combination of an offshore wind turbine tower and the outer barrel of a slip joint as described herein which is configured to be mated to an inner barrel of the slip joint as described herein, which inner barrel is connected to an offshore foundation, e.g. a floating foundation.

30

The invention furthermore relates to a method for installing an offshore wind turbine tower on an offshore foundation, wherein use is made of the slip joint as described herein, the method comprising the steps of:

35

- mating the inner barrel of a slip joint with the outer barrel of the slip joint, e.g. by lowering the wind turbine tower provided with the outer barrel by means of a lifting device over the inner barrel that is connected to the foundation,

- 5 • arranging bolts through the bolt holes of the first and second flanges and tightening said bolts.

In an embodiment, the installation method further comprising the step of arranging spacer bushings between the first and second flanges, with at least one bolt extending through a
10 spacer bushing.

In an embodiment, the installation method comprises lowering the wind turbine tower provided with the outer barrel by means of a lifting device, e.g. as described in one or more of the mentioned non-published applications, over the inner barrel that is connected to the
15 foundation, which lifting involves connecting at least one attachment member, e.g. multiple attachment members distributed along the outer circumference, of the upper section with the lifting device, e.g. with a hoisting cable thereof.

For example, in an embodiment of the method according to the invention the outer barrel of
20 the slip joint and the tower are transferred by means of a vessel to the offshore location at which the offshore foundation is already installed, the foundation already being provided with the inner barrel.

The outer barrel is connected, e.g. on-board the vessel or already prior to said transfer, to the
25 tower via the respective upper connection member. Subsequently, the combination of the outer barrel and the tower, possibly fitted with nacelle and rotor blades, is engaged by a lifting device, e.g. of a crane vessel, for example involving engaging and connecting to the attachment member described in claim 6.

30 The installation may involve the step of firstly upending the tower, e.g. already provided with the outer barrel, into an upright orientation by means of the lifting device.

The installation may involve, lowering the outer barrel onto the inner barrel as the lifting device lowers the tower, e.g. the entire wind turbine. During this mating process, the guide
35 blocks described in claim 4 may be used for guiding the inner surface of the outer barrel into correct engagement with the outer surface of the inner barrel.

The bolts are then arranged through the aligned bolt holes in the first and second flanges. However, it may for example also be possible to arrange the bolts into the bolt holes of the second flange already prior to the mating process.

- 5 It is noted that due to the presence of a vertical spacing between the first and second flanges, some misalignment between the first and second flange bolt holes may be less critical compared to a situation wherein flanges are directly in contact with one another upon installation.
- 10 In case the spacer bushings are provided, these are preferably provided prior to the arrangement of the bolts through the bolt holes. The spacer bushings may, apart from defining the relative vertical spacing between the first and second flanges, advantageously also prevent the frictional engagement between the two barrels from becoming too tight, e.g. due to the weight, possibly aided by vibrations, of the wind turbine causing the upper barrel to
- 15 be pushed further downwards onto the lower barrel over time. Therewith the spacer bushings may advantageously facilitate a later controlled release of the slip joint.

The invention furthermore relates to a slip joint as described herein for mounting or actually mounting an offshore wind turbine tower to an offshore foundation.

20

The invention also relates to a method for de-installation of an offshore wind turbine tower from an offshore foundation, e.g. when repair of the wind turbine is required, wherein the tower is mounted to the foundation by means of a slip joint as described herein, wherein the de-installation method comprises:

25

- removal of the bolts connecting the first and second flanges, possibly also removal of the spacer bushings when present,
- placement of one or more jacks, e.g. hydraulic cylinders, between the first and second
- 30 flanges, e.g. the jacks being angularly spaced from one another, and driving the first and second flanges apart by extension of the one or more jacks, thereby releasing the frictional engagement between the inner surface of the outer barrel and the outer surface of the inner barrel.

35

The method allows for the removal of a tower, or entire wind turbine, from an offshore foundation by release of the slip joint as described herein. Such method may further comprise a placement of one or more jacks, e.g. hydraulic cylinders, vertically between the flanges e.g.

angularly spaced from one another, such as to enable driving the first and second flanges apart upon extension of the jacks, increasing the vertical spacing between the flanges and therewith releasing the engagement at the interface between the inner surface of the upper, outer barrel and the outer surface of the lower, inner barrel.

5

The placement of the jacks may e.g. be performed prior to prolonged use of the tower on the foundation, for later release of the joint after subsequent prolonged use of the tower on the foundation, for example for releasing the joint in order to perform subsequent servicing or replacement the tower. Alternatively, the placement may be performed after prolonged operation of the wind turbine, for example for releasing the slip joint in order to perform subsequent servicing or replacement the wind turbine or wind turbine tower.

10

The invention will hereinafter be described with reference to the appended figures. In the figures:

15

- figure 1 shows a slip joint according to the invention interconnecting a foundation and a tower, and a combination of the tower with the upper barrel of the slip joint,
- figure 2 shows in a side view onto a vertical cross-section, the slip joint with the barrels being engaged,
- 20 figure 3 shows in the same side view onto a vertical cross-section, the upper barrel of the slip joint,
- figure 4 shows in a perspective view the lower and upper barrel and the tower being disengaged and positioned above one another,
- figure 5 shows in a top, side, and front view a slip joint according to the invention,
- 25 figures 6A-C illustrate approaching and guiding of the upper barrel towards engagement with the lower barrel,
- figures 7A-C illustrate release of the engagement between the barrels by moving apart the first and second flanges, and thus release of the joint,
- figure 8 illustrates engagement of the barrels with bolts arranged through the first and second flange bolt holes, the bolts being fastened to secure the slip joint,
- 30 figures 9A-B illustrate extension of jacks between the first and second circumferential flanges, moving apart the first and second flanges, and releasing the slip joint.

The figures illustrate a slip joint 20,30 for mounting an offshore wind turbine tower 40 to an offshore foundation 10, e.g. a floating foundation.

35

The slip joint 20,30 comprises a lower, inner barrel 20, and an upper, outer barrel 30. See figure 1.

The outer barrel 30 is configured to slidably receive therein the inner barrel 20 from below, and to engage a conical outer surface 21 of the inner barrel 20 by a conical inner surface 31 of the outer barrel at an interface along a lower section 30L thereof that vertically overlaps with the received inner barrel, such that the outer barrel 30 is frictionally supported by the interface with an upper section 30U thereof still protruding above the inner barrel 20. See figures 2 and 8.

The inner barrel 20 comprises a first inwardly protruding circumferential flange 25 at an upper end thereof, comprising first angularly spaced bolt holes 24 for receiving bolts in a substantially vertical direction. See figures 2 and 4.

The upper section 30U of the outer barrel 30 comprises a second inwardly protruding circumferential flange 35, comprising second angularly spaced bolt holes 34 for receiving bolts in a substantially vertical direction. See figures 2 and 4.

In figures 2 and 8 it is best visible, that the second circumferential flange 35 is arranged above and vertically spaced from the first circumferential flange 21 of the received and engaged inner barrel 20, such, that bolts 50 can be arranged through the first and second bolt holes 24,34 with lower ends 51 thereof being received through the first bolt holes and with upper ends 52 thereof through the second bolt holes, with a center section 50C of the bolts 50 extending between the first and second circumferential flanges 25,35.

The inner barrel 20 further comprises, at a lower end thereof, a lower connection member 22,23 for connection to a top of the offshore foundation 10.

Figure 1 shows the interconnection, and figure 2 shows that the lower connection member is formed by a third inwardly protruding circumferential flange 22 at a lower end of the outer barrel 20, comprising third angularly spaced bolt holes 23 for receiving bolts in a substantially vertical direction, for joining the flange 22 with a circumferential flange of the foundation 10 at an upper end thereof.

The outer barrel 30 further comprises, at an upper end thereof, an upper connection member 32,33 for connection to a bottom 42 of the offshore wind turbine tower 40. As discussed, the tower may or may not include a transition piece. In an embodiment, the outer barrel is part of

the lower end of a transition piece. In another embodiment, a transition piece is absent. In yet another embodiment, a transition piece is present, with a first slip joint as described herein between the transition piece and the foundation and a second slip joint between the transition piece and the rest of the tower. In yet another embodiment of the invention, the transition piece is considered part of the foundation, e.g. provided at its upper end with an inner barrel of an inventive slip joint.

Figure 1 shows the interconnection, and figure 2 shows that the upper connection member is formed by a fourth inwardly protruding circumferential flange 32 at an upper end of the inner barrel 30, comprising fourth angularly spaced bolt holes 33 for receiving bolts in a substantially vertical direction, for joining the flange 32 with a circumferential flange of the offshore wind turbine tower 40 at a lower end thereof.

It is shown best in the magnified detail in figure 2, that the illustrated slip joint further comprises spacer bushings 53 through which bolts 50 extend, so as to circumferentially enclose respective ones of the bolts 50 along the vertical spacing between the first and second circumferential flanges 25,35, e.g. for maintaining a fixed distance therebetween.

Figures 6 - 9 show that guide blocks 60 are provided on the upper end of the lower, inner barrel 20, e.g. on top of the first inwardly protruding flange 25, of which an outer surface 61 forms an upward extension of the outer surface 21 of the inner barrel 20, slanting inwardly in the upward direction.

As is illustrated in figures 6A-6C, therewith, the outer surface 61 is configured to engage the inner surface 31 of the outer barrel 30 when it approaches the inner barrel 20 from above, and to guide the inner surface 31 into engagement with the outer surface 21 as the outer barrel 30 slides over the inner barrel 20.

Figures 6B-C show that when the barrels 20, 30 are vertically out of alignment, that is, the central longitudinal axes 30A and 20A of the respective barrels 20, 30 are not in line with each other, the guide member 60 shown leftmost in the figures, guides the inner surface 31 of the upper, outer barrel 30 over the outer surface 61 into alignment with the outer surface 21 of the lower, inner barrel 20.

The first and second circumferential flanges 25,35 are dimensioned and mutually vertically spaced, to enable placement of one or more jacks, in the form of hydraulic cylinders, vertically between the flanges 23,35.

The jacks are shown placed between the flanges 25,35, and engaging the flanges, in figures 9A - B. The hydraulic cylinders drive the flanges 25,35 apart upon extension thereof, increasing the vertical spacing between the flanges 25,35, and therewith releasing the engagement at the interface between the inner surface 31 of the upper, outer barrel 30 and the outer surface 21 of the lower, inner barrel 20.

The upper section 30U of the upper, outer barrel 30 further comprises, at an upper end of the outer barrel 30, multiple attachment members 37 in the form of eyelets distributed along the outer circumference. The eyelets 37 are configured for engagement by, and connection with, a lifting device, e.g. with a hoisting cable or object suspension device, e.g. a hook, thereof, for suspending at least the upper, outer barrel 30 from the lifting device by means of the attachment member 37.

The eyelets 37 are formed on an annular outward collar 36 from the upper section 30U, e.g. extending vertically along the outer side wall 36S thereof and protruding upwardly from the annular outward collar 36.

The outward collar is hollow with an internal space being provided between walls 36B, 36S, 36T thereof and an outer surface of the upper, outer barrel 30. A horizontal bottom wall 36B of the walls forms an extension of the second inwardly protruding circumferential flange 35 of the upper, outer barrel 30 and a horizontal top wall 36T of the walls forms an extension of the fourth inwardly protruding circumferential flange 32.

The shown slip joint 20,30 enables a method for installing the wind turbine tower 40 on the offshore foundation 10.

The method comprises slidably inserting a lower, inner barrel 20 of a slip joint 20,30 in an upper, outer barrel 30 of the slip joint 20,30, by receiving inner barrel 20 from below in the outer barrel 30. This is illustrated in figures 6A-C.

The method comprises after the insertion, engaging by the outer barrel 30 the conical outer surface 21 of the inner barrel 20 by the conical inner surface 31 of the outer barrel at an interface along a lower section 30L thereof that vertically overlaps with the received inner barrel, such that the outer barrel 30 is frictionally supported by the interface with an upper section 30U thereof still protruding above the inner barrel 20. This engagement is shown in

figures 2 and 8. Reaching the engagement is furthermore illustrated by the advancement from figure 7C to figure 7B and subsequently to figure 7A.

The method comprises arranging bolts 50 through the second bolt holes 33 with upper ends 52 thereof being received in the second bolt holes and arranging the bolts 50 through the first bolt holes 23 with lower ends thereof being received in the first bolt holes. The bolts are shown in this arrangement in figures 2 and 8. These show that the arranging of the bolts 50 through the first and second bolt holes 23,33 has been done such that the bolts 50 are arranged with a center section 50C of the bolts 50 extending between the first and second circumferential flanges 25,35 defining the vertical spacing therebetween.

The method comprises connecting the lower, inner barrel 20 at a lower end thereof to a top of the offshore foundation 10 by means of a lower connection member 22,23 of the inner barrel 20, and connecting the upper, outer barrel 30 at an upper end thereof to a bottom 42 of the offshore wind turbine tower 40 by means of an upper connection member 32,33 of the outer barrel 30.

The method may further comprise, prior to the step of arranging the bolts through the second bolt holes and/or the step of arranging the bolts through the first bolt holes, the step of arranging the spacer bushings 53 indicated in the magnified detail of figure 2 in the vertical spacing between the first and second circumferential flanges 25,35, and engaging the circumferential flanges at respective ends thereof around the bolt holes 23,33, for maintaining a fixed or defined (minimum) distance between the flanges 25,35.

The de-installation method may comprise the placement of one or more jacks, e.g. hydraulic cylinders, vertically between the flanges 23,35, e.g. angularly spaced from one another, such as to enable driving the flanges 25,35 apart upon extension of the jacks, increasing the vertical spacing between the flanges 25,35, and therewith releasing the engagement at the interface between the inner surface 31 of the upper, outer barrel 30 and the outer surface 21 of the lower, inner barrel 20. This is illustrated in figures 9A-B as explained before.

The installation and de-installation methods may further comprise connecting the eyelets 37 or the like with a lifting device, e.g. with a hoisting cable thereof, so as to suspend at least the upper, outer barrel 30 from the lifting device by means of the attachment member 37. The lifting may e.g. be done after the outer barrel 30 is connected to the tower 40 via the upper connection member 32, so that by said suspension, the combination of the outer barrel 30 and the tower 40 is suspended from the lifting device, e.g. a vessel mounted crane.

C L A I M S

1. Slip joint (20,30) for mounting an offshore wind turbine tower (40) to an offshore foundation (10),

5

the slip joint (20,30) comprising a lower, inner barrel (20) and an upper, outer barrel (30) configured to mated,

10 wherein the inner barrel (20) comprises a connection member (22,23) for connection to the offshore foundation (10),

wherein the outer barrel (30) comprises a connection member (32,33) for connection to the offshore wind turbine tower (40),

15 wherein – when in mated state of the slip joint - a conical outer surface (21) of the inner barrel (20) and a conical inner surface (31) of the outer barrel frictionally engage one another along a lower section (30L) of the outer barrel (30), and an upper section (30U) of the outer barrel (30) protrudes above the inner barrel (20),

20 wherein the inner barrel (20) comprises an inwardly protruding circumferential first flange (25) at or in proximity of an upper end thereof, which first flange (25) is provided with first bolt holes (24),

25 wherein the upper section (30U) of the outer barrel (30) comprises an inwardly protruding circumferential second flange (35), which second flange (35) is provided with second bolt holes (34),

30 wherein – in mated state of the inner and outer barrels of the slip joint – the first and second flanges (25,35) are vertically spaced above one another and the bolt holes (24, 34) of the first and second flanges (25,35) are aligned to allow for placement of bolts (50) through the aligned bolt holes (24, 34) in the first and second flanges (25,35).

2. Slip joint according to claim 1, wherein the connection member of the inner barrel comprises an inwardly protruding circumferential third flange (22) at a lower end of the inner barrel (20), the third flange (22) being provided with bolt holes (23) for receiving bolts for joining the third flange (22) to a circumferential flange of the foundation (10), and/or

35

wherein the connection member of the outer barrel comprises an inwardly protruding circumferential fourth flange (32) at an upper end of the outer barrel (30), the fourth flange being provided with bolt holes (33) for receiving bolts for joining the flange (32) to a circumferential flange of the offshore wind turbine tower (40) at a lower end thereof.

5

3. Slip joint according to claim 1 or 2, further comprising spacer bushings (53) to be placed between the first and second flanges (25,35) with at least one bolt extending through a spacer bushing.

10

4. Slip joint according to any one or more of the preceding claims, wherein one or more beveled guide blocks (60) are provided on the upper end of the inner barrel (20), e.g. on top of the first flange (25), said guide blocks (60) being configured to engage the inner surface (31) of the outer barrel (30) and to guide the inner surface (31) into engagement with the outer surface (21) as the outer barrel (30) slides over the inner barrel (20) in the mating process.

15

5. Slip joint according to any one or more of the preceding claims, wherein the first and second flanges (25,35) are configured, e.g. dimensioned and mutually vertically spaced, to enable placement of one or more jacks, e.g. hydraulic cylinders, between the first and second flanges (23,35) for driving the flanges (25,35) apart upon extension of the jacks, thereby increasing the vertical spacing between the first and second flanges (25,35) and releasing the frictional engagement at the interface between the inner surface (31) of the outer barrel (30) and the outer surface (21) of the inner barrel (20).

20

6. Slip joint according to any one or more of the preceding claims, wherein the upper section (30U) of the outer barrel (30) further comprises, e.g. at an upper end of the outer barrel (30), at least one attachment member (37), e.g. multiple attachment members (37) distributed along the outer circumference, e.g. eyelets or trunnions, the attachment member(s) (37) being configured for engagement by, and connection with, a lifting device, e.g. with a hoisting cable thereof, for suspending at least the outer barrel (30), e.g. the assembly of wind turbine tower and outer barrel, from the lifting device via the attachment member(s) (37),

25

30

e.g. wherein the attachment member (37) is formed on an annular outward collar (36) extending about the upper section (30U), e.g. extending vertically along an outer surface thereof and/or protruding upwardly from the annular outward collar (36), e.g. wherein the outward collar is hollow with an internal space being provided between walls thereof and an

35

outer surface of the outer barrel (30), e.g. wherein a horizontal bottom wall of the walls of the collar forms an extension of the second flange (35) of the outer barrel (30) and a horizontal top wall of the walls forms an extension of the fourth flange (32).

- 5 7. An offshore wind turbine comprising an offshore foundation (10) and an offshore wind turbine tower (40), wherein the tower is mounted or mountable to the foundation by means of a slip joint (20,30) according to any one or more of the claims 1 – 6, e.g. wherein the tower includes a transition piece
- 10 8. Combination (20,30,40) of an offshore wind turbine tower (40) and the outer barrel (30) of a slip joint (20,30) according to any one or more of the claims 1 – 6 which is configured to be mated to the inner barrel (20) of the slip joint (20,30) according to any one or more of the claims 1 – 6, which inner barrel is connected to an offshore foundation (10).
- 15 9. Method for installing an offshore wind turbine tower (40) on an offshore foundation (10), wherein use is made of the slip joint according to any one or more of claims 1 - 6.
10. Method for installing an offshore wind turbine tower (40) on an offshore foundation (10), wherein use is made of the slip joint according to any one or more of claims 1 – 6, the
20 method comprising the steps of:
- mating the inner barrel (20) of the slip joint (20,30) with the outer barrel (30) of the slip joint (20,30), e.g. by lowering the wind turbine tower provided with the outer barrel (30) by means of a lifting device over the inner barrel (20) that is connected to the foundation (10),
25
 - arranging bolts (50) through the bolt holes (24, 34) of the first and second flanges (25, 35) and tightening said bolts.
11. Method according to claim 10, further comprising the step of arranging spacer
30 bushings (53) between the first and second flanges (25,35), with at least one bolt extending through a spacer bushing.
12. Method according to claim 10 or 11, comprising lowering the wind turbine tower provided with the outer barrel (30) by means of a lifting device over the inner barrel (20) that
35 is connected to the foundation (10), which lowering involves connecting at least one attachment member (37), e.g. multiple attachment members (37) distributed along the outer

circumference, of the upper section (30U) with the lifting device, e.g. with a hoisting cable thereof.

13. Method for de-installation of an offshore wind turbine tower from an offshore

5 foundation, wherein the tower is mounted to the foundation by means of a slip joint (20,30) according to any one or more of the claims 1 – 6, wherein the method comprises:

- removal of the bolts (50) connecting the first and second flanges (25,35), possibly also removal of the spacer bushings (53) when present,

10

- placement of one or more jacks (70), e.g. hydraulic cylinders, between the first and second flanges (25,35), e.g. the jacks being angularly spaced from one another, and driving the first and second flanges (25,35) apart by extension of the one or more jacks, thereby releasing the frictional engagement between the inner surface (31) of the outer barrel (30)

15 and the outer surface (21) of the inner barrel (20).

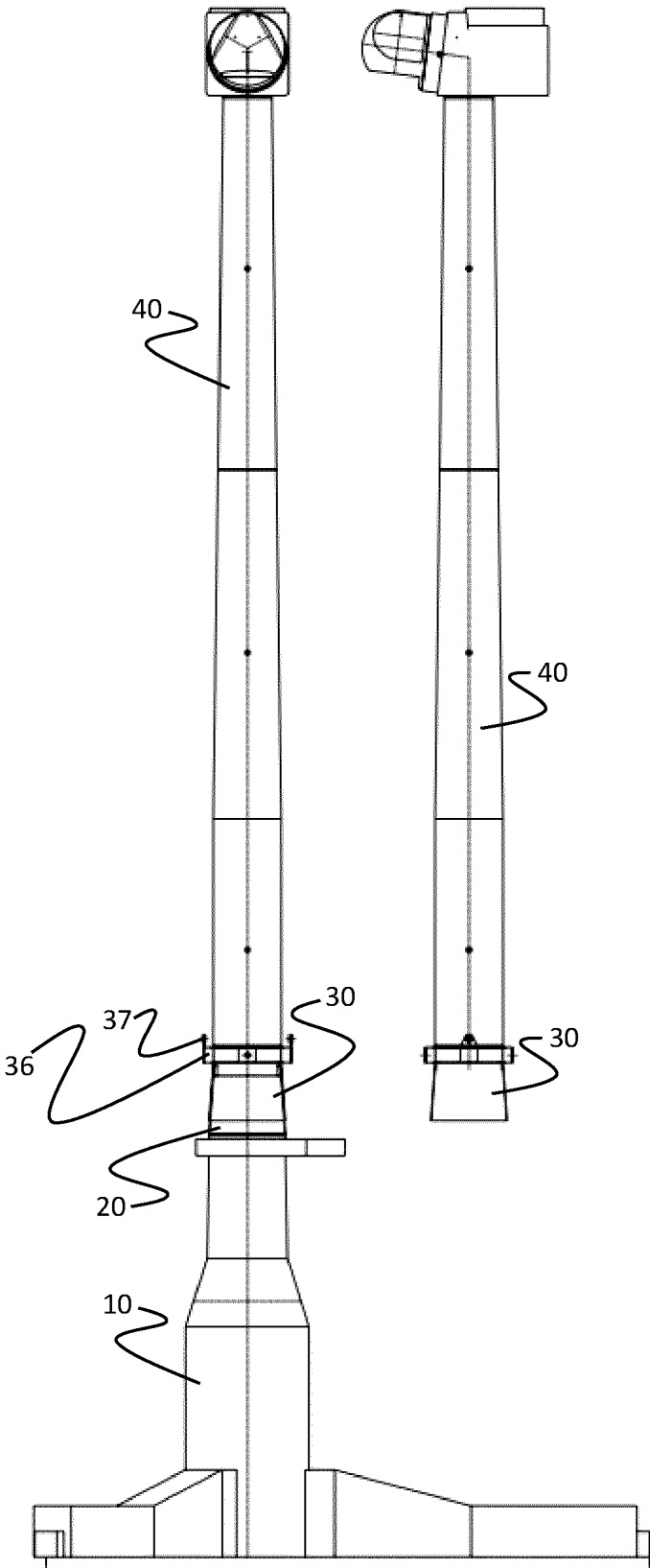
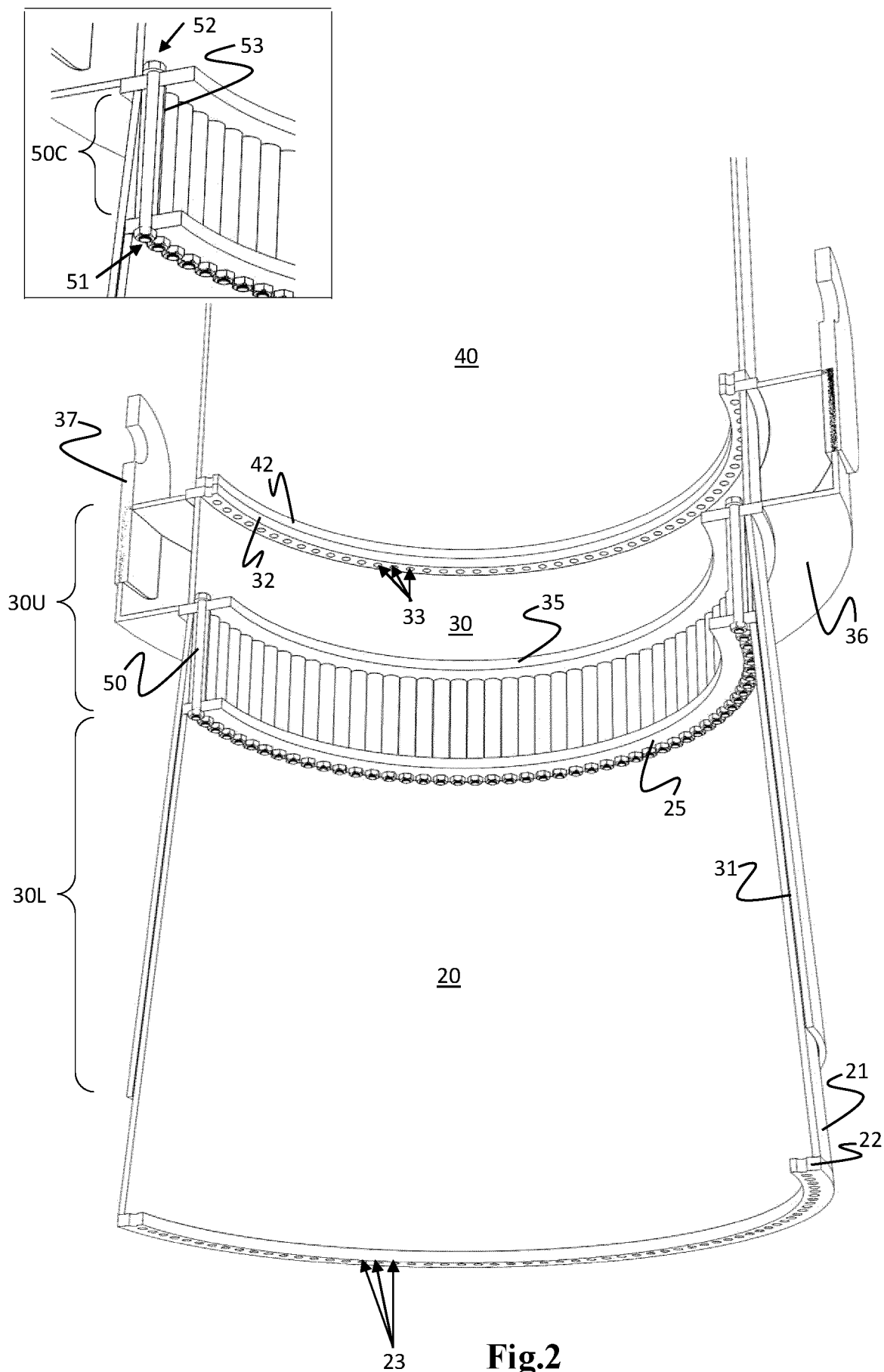
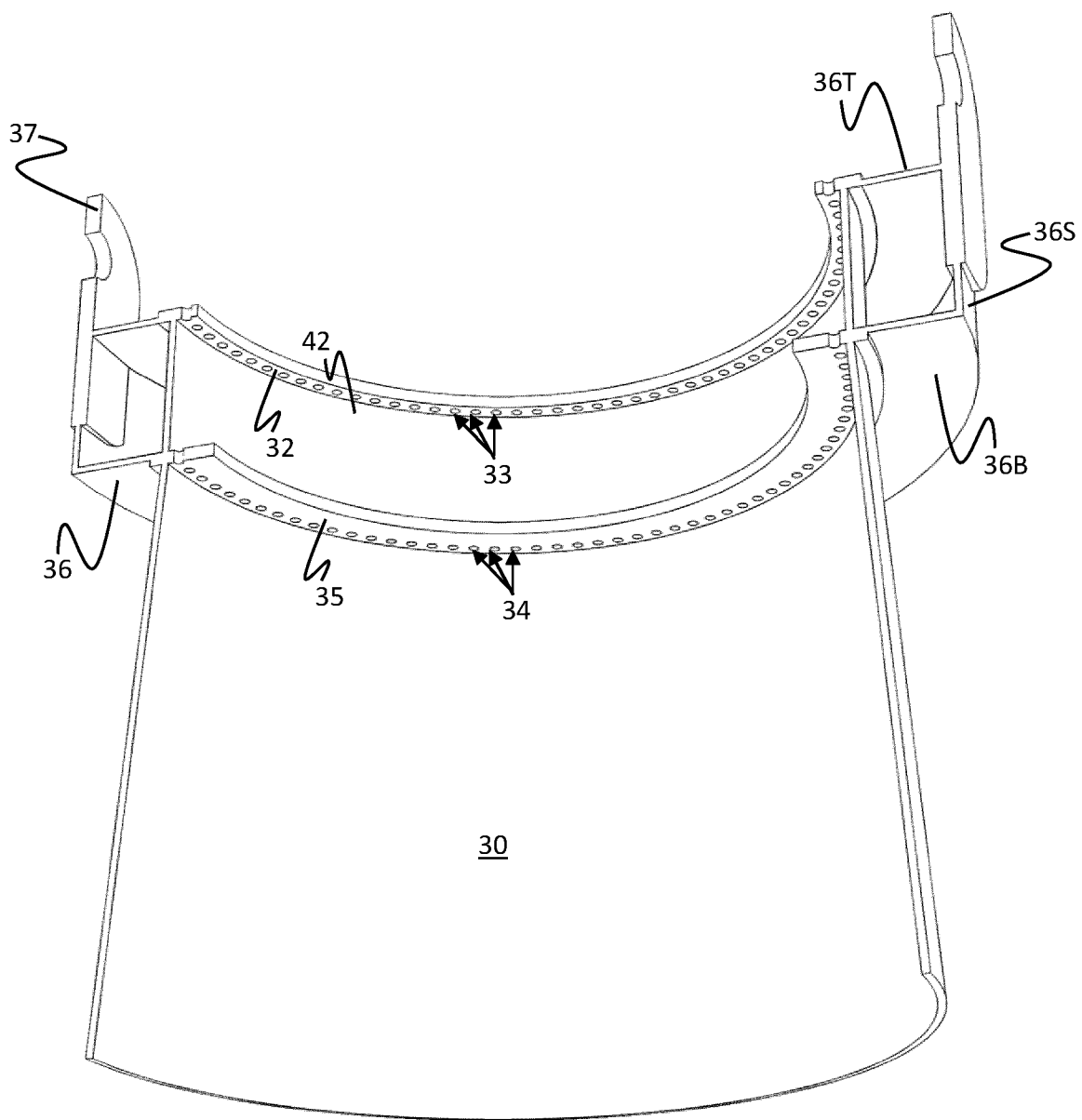
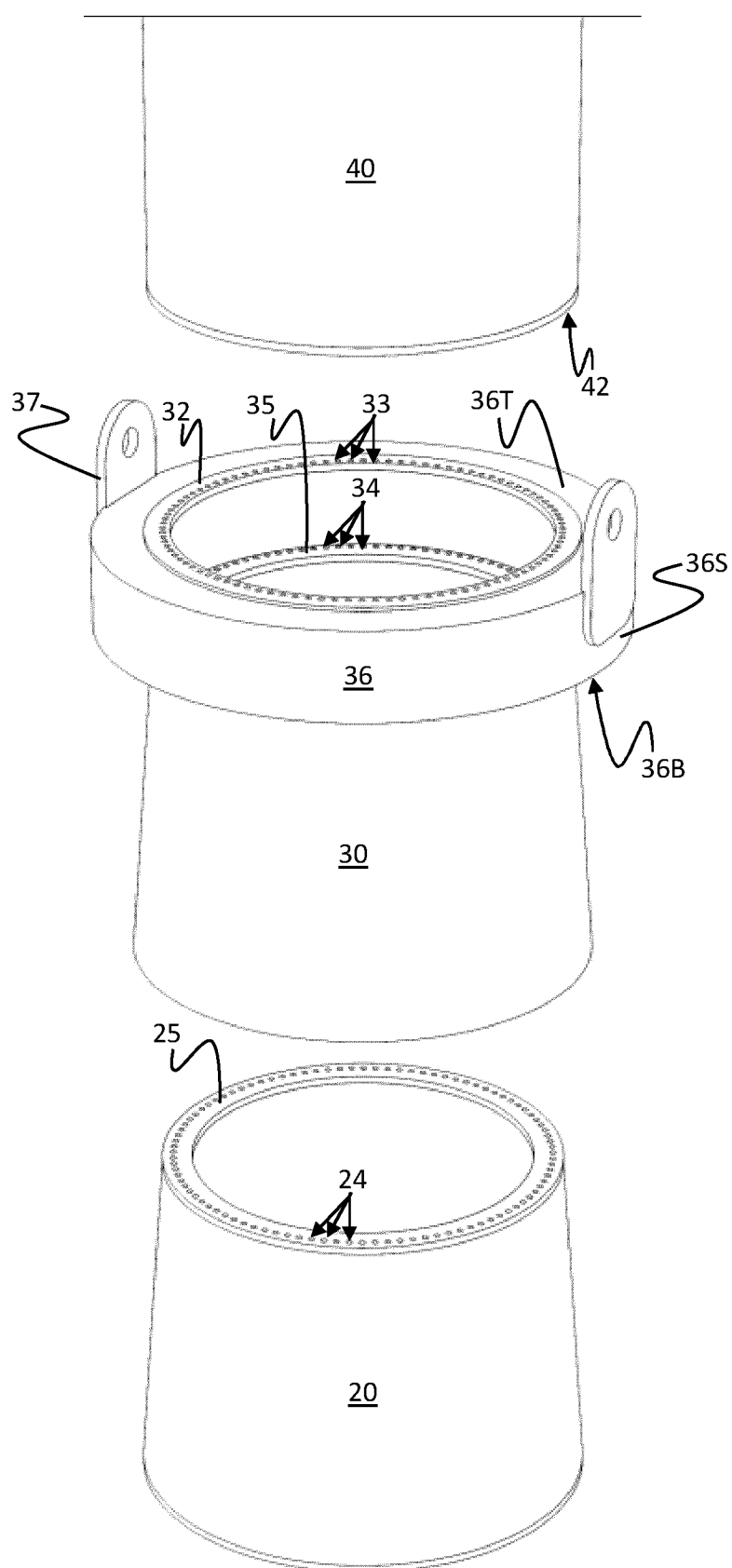
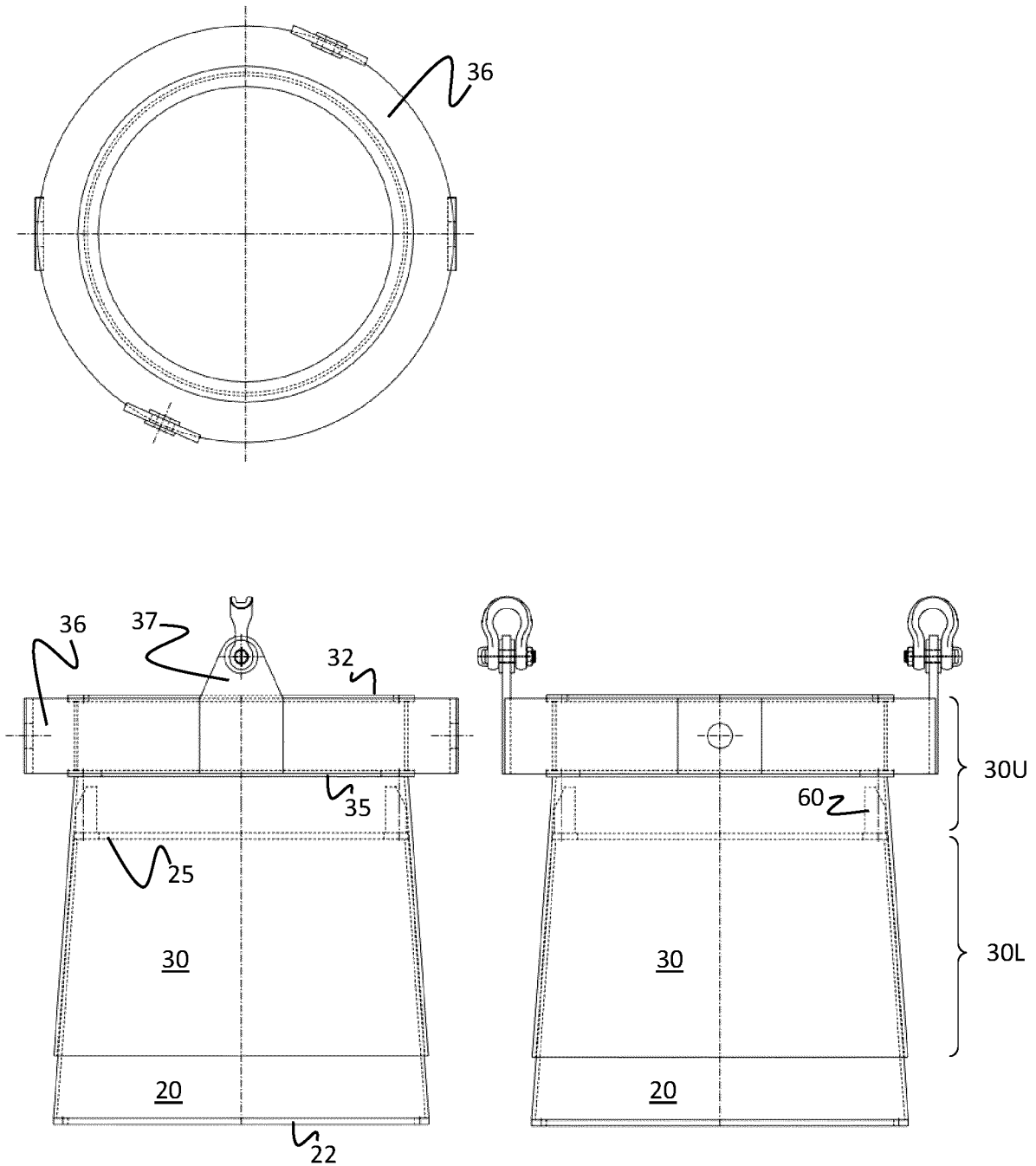


Fig.1



**Fig.3**

**Fig.4**

**Fig.5**

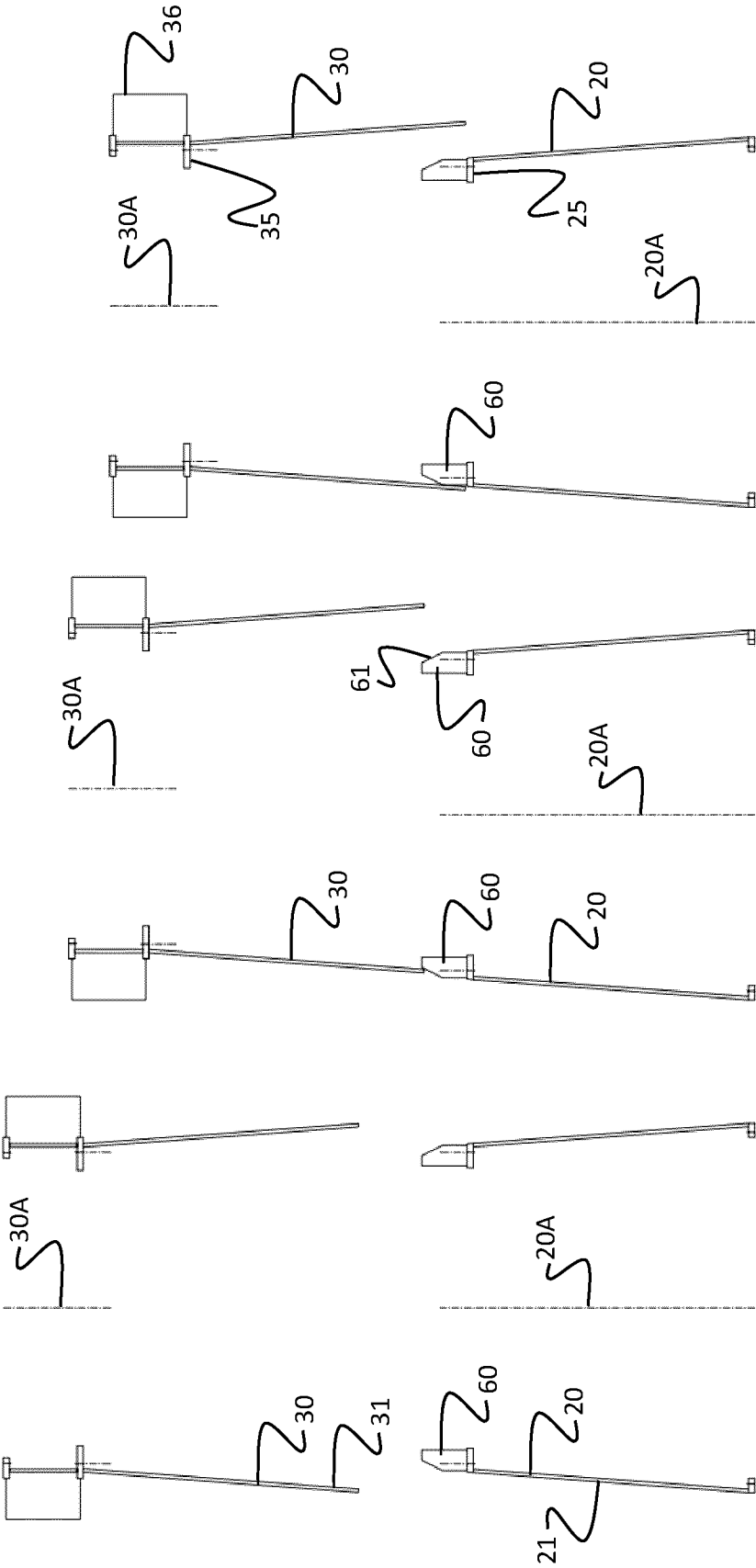


Fig.6C

Fig.6B

Fig.6A

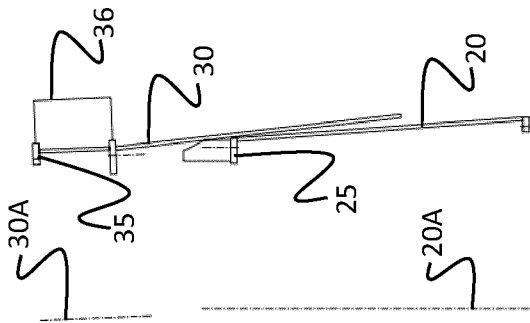


Fig.7C

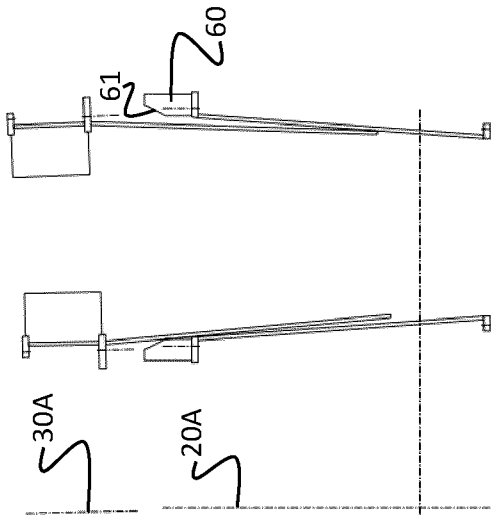


Fig.7B

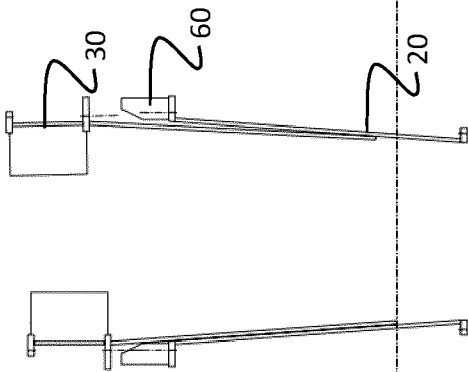
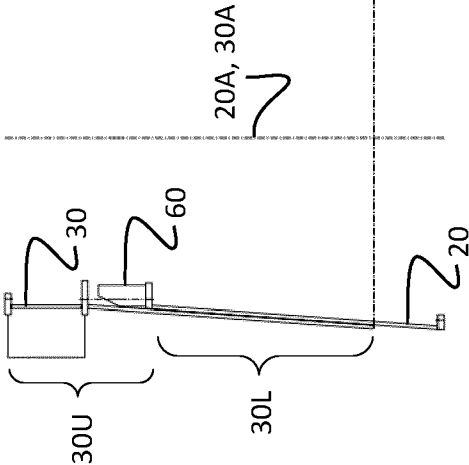


Fig.7A



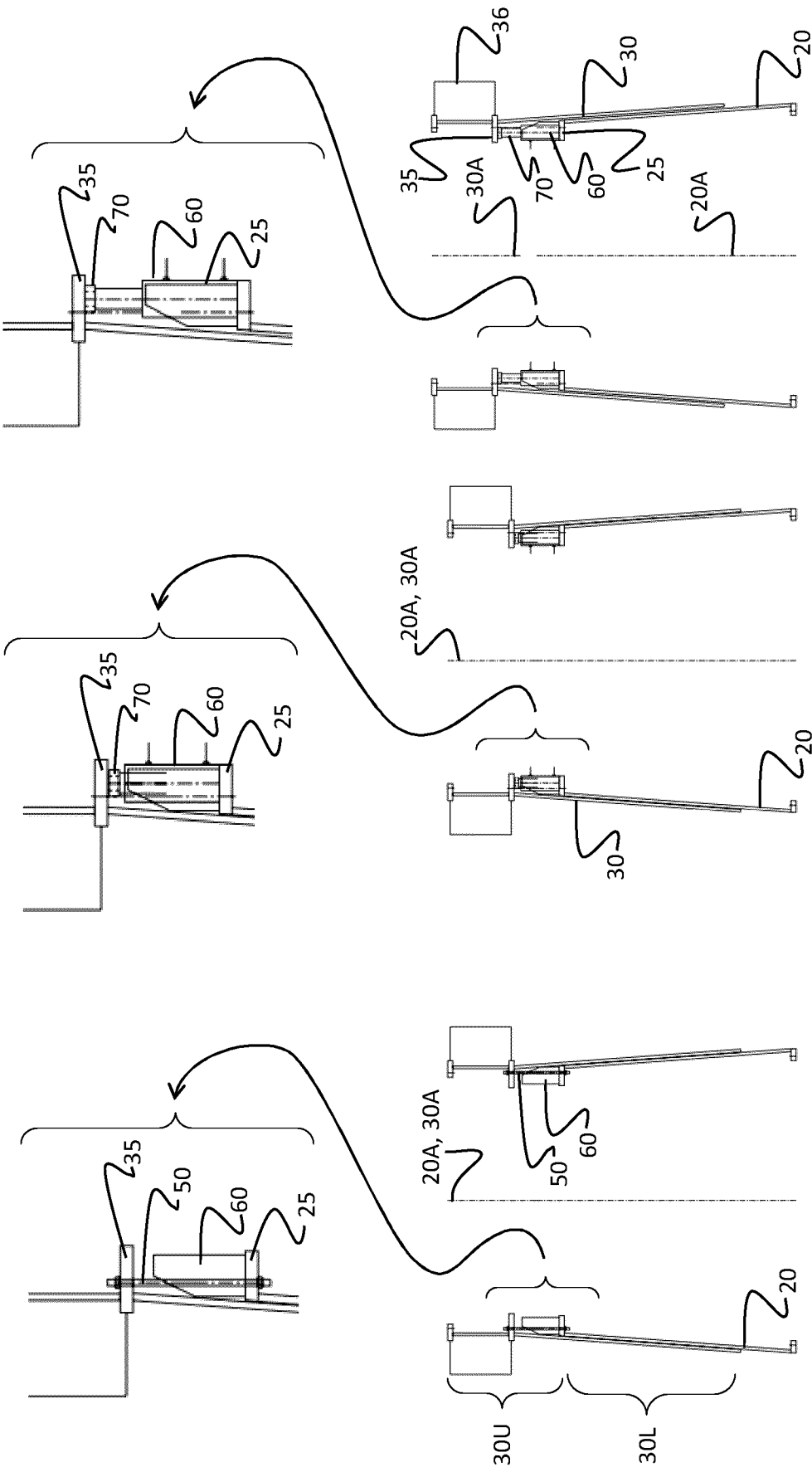


Fig.9B

Fig.9A

Fig.8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2022/068373

A. CLASSIFICATION OF SUBJECT MATTER INV. F03D13/25 E04H12/08 E04H12/34 E02D27/42 F03D13/20 ADD.		
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) F03D E04H E02D		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 10 704 220 B2 (WOBBEN PROPERTIES GMBH [DE]) 7 July 2020 (2020-07-07)	1,5-13
Y	column 5, line 65 - column 8, line 68 figures	1,9,13

X	DE 20 2006 011099 U1 (LIEBHERR WERK EHINGEN [DE]; CLEAN ENERGY FACTORY CO LTD [JP]) 5 July 2007 (2007-07-05)	1,5-13
	abstract figures paragraph [0017] - paragraph [0028]	

Y	WO 2020/106146 A1 (SIF HOLDING N V [NL]) 28 May 2020 (2020-05-28)	1,9,13
	page 6, line 28 - page 25, line 30 figures 3, 5-16	

	-/--	
☒ Further documents are listed in the continuation of Box C. ☒ 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 "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "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
16 September 2022		26/09/2022
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Rini, Pietro

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2022/068373

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 2 826 932 B1 (SIEGTHALERFABRIK GMBH [DE]) 28 September 2016 (2016-09-28) figures 1,2,3,7,8 -----	1-13
A	CN 112 502 908 A (UNIV CHONGQING) 16 March 2021 (2021-03-16) figures 1-11 -----	1-13
A	EP 2 910 686 A2 (KCI THE ENGINEERS B V [NL]) 26 August 2015 (2015-08-26) abstract figures -----	1-13
A	EP 3 771 825 A1 (SIEMENS GAMESA RENEWABLE ENERGY INC) 3 February 2021 (2021-02-03) abstract figures -----	1-13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2022/068373

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 10704220	B2	07-07-2020	AR 098811 A1 15-06-2016
		CA 2930787 A1 25-06-2015	
		CN 105829624 A 03-08-2016	
		DE 102013226536 A1 18-06-2015	
		DK 3092357 T3 22-06-2020	
		EP 3092357 A1 16-11-2016	
		ES 2792922 T3 12-11-2020	
		PT 3092357 T 08-06-2020	
		TW 201540921 A 01-11-2015	
		US 2016312431 A1 27-10-2016	
		WO 2015090861 A1 25-06-2015	

DE 202006011099	U1	05-07-2007	NONE

WO 2020106146	A1	28-05-2020	CA 3114880 A1 28-05-2020
		EP 3884111 A1 29-09-2021	
		JP 2022504053 A 13-01-2022	
		KR 20210093234 A 27-07-2021	
		US 2022018079 A1 20-01-2022	
		WO 2020106146 A1 28-05-2020	

EP 2826932	B1	28-09-2016	DE 102013213737 A1 15-01-2015
		EP 2826932 A2 21-01-2015	

CN 112502908	A	16-03-2021	NONE

EP 2910686	A2	26-08-2015	DK 2910686 T3 21-01-2019
		EP 2910686 A2 26-08-2015	

EP 3771825	A1	03-02-2021	CN 114144583 A 04-03-2022
		EP 3771825 A1 03-02-2021	
		EP 3980644 A1 13-04-2022	
		TW 202113227 A 01-04-2021	
		US 2022260061 A1 18-08-2022	
		WO 2021018855 A1 04-02-2021	
