

**IN THE UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF VIRGINIA
NORFOLK DIVISION**

LIFTWERX USA INC.,

Plaintiff,

v.

LIFTRA IP APS,

Defendant.

CASE NO. 2:25-cv-00679-EWH-LRL

JURY TRIAL DEMANDED

**LIFTRA IP APS’S ANSWER, AFFIRMATIVE DEFENSES, AND
COUNTERCLAIMS**

Liftra IP ApS (“Liftra”), by and through its undersigned attorneys respectfully submits its Answer and Defenses to LiftWerx USA Inc.’s (“LiftWerx”) Complaint and Counterclaims as follows:

Except as expressly admitted below, Liftra denies each and every allegation of the Complaint, and denies that Plaintiff is entitled to any relief. Liftra has included the headers and titles set forth in the Complaint below for ease of reference; however, Liftra expressly denies any implication based on such headers and titles.

ANSWER TO LIFTWERX’S COMPLAINT

1. The allegations in paragraph 1 include Plaintiff’s characterization of the claim in this action to which no response is required. To the extent a response is required, Liftra IP ApS (“Liftra”) denies the allegations in paragraph 1.
2. Liftra lacks knowledge or information sufficient to form a belief as to the truth of the allegations set forth in paragraph 2 and therefore denies them.

3. Responding to the allegations in paragraph 3, Liftra admits that it is a Danish company associated with Liftra USA, Inc. (d/b/a Liftra USA) and that Liftra IP ApS admits that Liftra IP ApS holds patents, including patents for technology related to up-tower wind turbine repairs. Liftra denies all remaining allegations in this paragraph.
4. Denied.

THE PARTIES

5. Liftra lacks knowledge or information sufficient to form a belief as to the truth of the allegations in paragraph 5 and therefore denies them.
6. Liftra admits that it is a company organized under the laws of Denmark with a principal place of business of Stationsmestervej 81, 9200 Aalborg SV, Denmark. To the extent there are any remaining allegations in paragraph 6 not addressed by the foregoing, Liftra denies them.

THE PATENTS-IN-SUIT

7. Responding to the allegations in paragraph 7, Liftra admits that U.S. Patent No. 10,378,518 (the “’518 Patent”) was validly issued by the U.S. Patent and Trademark Office (“USPTO”) on August 13, 2019, and is titled “Main Shaft Fixture” and that information relating to the priority date of the ’518 Patent is available on the face of the ’518 Patent. To the extent there are any remaining allegations in paragraph 7 not addressed by the foregoing, Liftra denies them.
8. Responding to the allegations in paragraph 8, Liftra admits that Liftra is the owner of all right, title, and interest in the ’518 Patent.
9. Responding to the allegations in paragraph 9, Liftra admits that U.S. Patent No. 12,104,578 (the “’578 Patent”) issued on October 1, 2024, and is titled “Main Shaft

Fixture” and that information relating to the priority date of the ’578 Patent is available on the face of the ’578 Patent. To the extent there are any remaining allegations in paragraph 7 not addressed by the foregoing, Liftra denies them.

10. Responding to the allegations in paragraph 10, Liftra admits that Liftra is the owner of all right, title, and interest in the ’578 Patent.

JURISDICTION AND VENUE

11. Paragraph 11 contains legal conclusions to which no response is required. To the extent any response is required, Liftra admits that LiftWerx’s allegations in its Complaint purportedly arise under the patent laws of the United States. Liftra denies all remaining allegations in paragraph 11.
12. Paragraph 12 contains legal conclusions to which no response is required. To the extent any response is required, Liftra admits that LiftWerx purports to establish subject matter jurisdiction in the United States District Court. Liftra denies all remaining allegations in paragraph 12.
13. Paragraph 13 contains legal conclusions to which no response is required. To the extent any response is required, Liftra does not contest personal jurisdiction under 35 U.S.C. § 293. Liftra denies all remaining allegations in paragraph 13.
14. Paragraph 14 contains legal conclusions to which no response is required. To the extent any response is required, Liftra does not contest venue in this District for purposes of this action only. Liftra denies all remaining allegations in paragraph 14.

THE CONTROVERSY BETWEEN THE PARTIES

15. Responding to the allegations in paragraph 15, Liftra admits that proceedings involving non-U.S. Liftra patents have been filed in jurisdictions outside the United States. Liftra denies all remaining allegations in paragraph 15.

16. Responding to the allegations in paragraph 16, Liftra admits that on or about September 20, 2024, Liftra filed a seizure request at the District Court of the Hague. Liftra admits that the application accompanying the request identified European Patent No. 3,204,639 B1 (the “EP ’639 Patent”). Liftra admits the respondents identified included Liftoff-MCE B.V., Meemaken B.V., Eager.one B.V., Kenz Cranes B.V., and Kenz Crane Services B.V. Liftra denies the Complaint’s characterization of the document as “the European Seizure Request.” To the extent there are any remaining allegations in paragraph 16 not addressed by the foregoing, Liftra denies them.
17. Liftra lacks knowledge and information sufficient to form a belief as to the truth of the allegations in paragraph 17 and therefore denies them.
18. Paragraph 18 contains legal conclusions to which no response is required. Liftra admits that EP 3,204,639 (“EP ’639 Patent”) is titled “Main Shaft Fixture” and cites PCT/DK2015/000040 on its face. Liftra denies that EP ’639 issued on July 12, 2022. To the extent there are any allegations remaining in paragraph 18 not addressed by the foregoing, Liftra denies them.
19. Admitted.
20. Responding to the allegations of paragraph 20, Liftra admits that Exhibit C of the Complaint is entitled “Statement Per Fenger” and states it is “intended for use as exhibit to [Liftra’s] request to the Patent Court of the Hague.” To the extent there are any allegations remaining in paragraph 20, Liftra denies them.
21. Responding to the allegations of paragraph 21, Liftra admits that Exhibit C of the Complaint is entitled “Statement Per Fenger” includes a paragraph labeled 2. To the

extent there are any allegations remaining in paragraph 21 not addressed by the foregoing, Liftra denies them.

22. Responding to the allegations of paragraph 22, Liftra admits that Exhibit C of the Complaint is entitled “Statement Per Fenger” includes a paragraph labeled 26. To the extent there are any allegations remaining in paragraph 22 not addressed by the foregoing, Liftra denies them.
23. Responding to the allegations of paragraph 23, Liftra admits that on or about September 27, 2024, Liftra received an order from the District Court of the Hague in response to its application. To the extent there are any allegations remaining in paragraph 23 not addressed by the foregoing, Liftra denies them.
24. Responding to the allegations of paragraph 24, Liftra admits that a writ of evidentiary seizure was served on Kenz Cranes B.V. and Kenz Crane Services, B.V. in November 2024. To the extent there are any allegations remaining in paragraph 24 not addressed by the foregoing, Liftra denies them.
25. Paragraph 25 contains legal conclusions to which no response is required. To the extent there are any allegations remaining in paragraph 25 not addressed by the foregoing, Liftra lacks knowledge or information sufficient to form a belief as to the truth of such allegations and therefore denies them.
26. Responding to the allegations of paragraph 26, Liftra admits that on or about March 21, 2025, a writ of summons issued for inspection of documents; on or about July 2, 2025, a judgement was issued relating to the writ of summons; and on or about July 29, 2025 a notice of appeal was filed. To the extent there are any allegations remaining in paragraph 26 not addressed by the foregoing, Liftra denies them.

27. Denied.
28. Denied.
29. Responding to the allegations of paragraph 29, Liftra admits that on or about July 18, 2025, Liftra, Liftra ApS, and Liftra USA Inc. filed a Statement of Claim in Federal Court in Canada and that the Statement of Claim named LiftWerx Solutions Inc., LiftWerx EU (CAN) Holdings Inc. and Liftoff-MCE B.V. and alleges infringement of Canadian Patent No. 2,963,016 (the “CA ’016 Patent”) (the “Statement of Claim”). Liftra denies any characterizations set forth in paragraph 29. To the extent there are any allegations remaining in paragraph 29 not addressed by the foregoing, Liftra denies them.
30. Responding to the allegations of paragraph 30, Liftra admits that the CA ’016 patent identifies PCT Pub. No. PCT/DK2015/000040 on its face. Liftra admits that each of the CA ’016 Patent and the ’518 Patent identify the same PCT Publication Number on their faces. To the extent there are any remaining allegations in paragraph 30 not addressed by the foregoing, Liftra denies them.
31. Admitted.
32. Responding to the allegations of paragraph 32, Liftra admits that Liftra alleges infringement of “claims 1 to 9 of Canadian Patent No. 2,963,016.” To the extent there are any remaining allegations in paragraph 32 not addressed by the foregoing, Liftra denies them.
33. Responding to the allegations of paragraph 33, Liftra admits that the Statement of Claim contains a paragraph labeled 26. To the extent there are any allegations remaining in paragraph 33, Liftra denies them.

34. Responding to the allegations of paragraph 34, Liftra admits that the Statement of Claim contains a paragraph labeled 30. To the extent there are any allegations remaining in paragraph 34, Liftra denies them.
35. Denied.
36. Responding to the allegations of paragraph 36, Liftra admits that each of the EP '639 Patent and the '518 Patent identify the same PCT Publication Number, PCT Pub. No. PCT/DK2015/000040, on their faces. Liftra denies any remaining allegations in this paragraph.
37. Responding to the allegations of paragraph 37, Liftra admits that each of the EP '639 Patent and the '518 Patent identify the same PCT Publication Number, PCT Pub. No. PCT/DK2015/000040, on their faces. Liftra denies any remaining allegations in this paragraph.
38. Paragraph 38 contains legal conclusions to which no response is required. Liftra denies any remaining allegations in this paragraph.
39. Paragraph 39 contains legal conclusions to which no response is required. Liftra denies any remaining allegations in this paragraph.
40. Paragraph 40 contains legal conclusions to which no response is required. Liftra denies any remaining allegations in this paragraph.
41. Responding to the allegations of paragraph 41, Liftra admits that the Statement of Claim asserts infringement of the '016 Patent.
42. Responding to the allegations of paragraph 42, Liftra admits that each of the CA '016 Patent and the '518 Patent identify the same PCT Publication Number, PCT Pub. No.

PCT/DK2015/000040, on their faces. Liftra denies any remaining allegations in this paragraph.

43. Responding to the allegations of paragraph 43, Liftra admits that each of the CA '016 Patent and the '518 Patent identify the same PCT Publication Number, PCT Pub. No. PCT/DK2015/000040, on their faces. Liftra denies any remaining allegations in this paragraph.
44. Paragraph 44 contains legal conclusions to which no response is required. Liftra denies any remaining allegations in this paragraph.
45. Paragraph 45 contains legal conclusions to which no response is required. Liftra denies any remaining allegations in this paragraph.
46. Paragraph 46 contains legal conclusions to which no response is required. Liftra denies any remaining allegations in this paragraph.
47. Liftra lacks knowledge or information sufficient to form a belief as to the truth of the allegations set forth in paragraph 47 and therefore denies them.
48. Liftra lacks knowledge or information sufficient to form a belief as to the truth of the allegations set forth in paragraph 48 and therefore denies them.
49. Liftra lacks knowledge or information sufficient to form a belief as to the truth of the allegations set forth in paragraph 49 and therefore denies them.
50. Liftra lacks knowledge or information sufficient to form a belief as to the truth of the allegations set forth in paragraph 50 and therefore denies them.
51. Denied.

52. In response to the allegations of paragraph 52, Liftra admits that Exhibit C of the Complaint is entitled “Statement Per Fenger” includes a paragraph labeled 26. Liftra denies any remaining allegations in this paragraph.

53. Denied.

54. Denied.

55. Responding to the allegations of paragraph 55, Liftra admits that a controversy exists between the parties concerning LiftWerx’s infringement of at least the ’518 and ’578 Patents. Liftra denies the remaining allegations of paragraph 55.

FIRST COUNT FOR RELIEF

(Declaratory Judgment of NonInfringement of the '518 Patent”)

56. Liftra repeats and incorporates by reference its responses to paragraphs 1-55 as if fully set forth herein.

57. Responding to the allegations in paragraph 57, Liftra admits that a controversy exists between the parties concerning LiftWerx’s infringement of the ’518 Patent. To the extent there are any remaining allegations in paragraph 57, Liftra denies them.

58. Denied.

59. Denied.

60. Denied.

61. Denied.

62. Denied.

63. Denied.

64. Denied.

65. Denied.

66. Denied.,

67. Denied

68. Denied.

69. Denied.

**SECOND COUNT FOR RELIEF(Declaratory Judgment of NonInfringement of the '578
Patent")**

70. Liftra repeats and incorporates by reference its responses to paragraphs 1-69 as if fully set forth herein.

71. Responding to the allegations in paragraph 71, Liftra admits that a controversy exists between the parties concerning LiftWerx's infringement of the '578 Patent. To the extent there are any remaining allegations in paragraph 71, Liftra denies them.

72. Denied.

73. Denied.

74. Denied.

75. Denied.

76. Denied.

77. Denied.

78. Denied.

79. Denied.

80. Denied.

81. Denied

82. Denied.

83. Denied.

84. Denied.

85. Denied.

86. Denied.

87. Denied.

88. Denied.

89. Denied.

90. Denied.

91. Denied.

92. Denied.

Answer to LiftWerx's Prayer for Relief

Liftra denies that LiftWerx is entitled to any of the relief requested in its Complaint, or any other remedy or relief whatsoever.

Defendant's Affirmative Defenses

Without conceding that any of the following necessarily must be pleaded as an affirmative defense, or that any of the following is not already at issue by virtue of the foregoing responses, and without prejudice to Defendant's right to plead additional defenses as discovery into the facts and circumstances of the matter warrants, Defendant, Liftra, asserts the following affirmative defenses:

First Affirmative Defense: Failure to State a Claim

The Complaint, including Plaintiff's claim for declaratory judgment of non-infringement, fails to state a claim upon which relief can be granted. By asserting this defense, Liftra does not admit that Plaintiff has adequately pleaded any claim and does not waive any right to move to dismiss any claim under Federal Rule of Civil Procedure 12(b)(6).

Second Affirmative Defense: Infringement

Plaintiff's claim for declaratory judgment of non-infringement of U.S. Patent No. 10,378,518 and U.S. Patent No. 12,104,578 fails because Plaintiffs infringe the '518 and '578 patents directly and indirectly in violation of 35 U.S. C. § 271(a)-(c). Liftra's infringement allegations are detailed below in Counterclaims I-III.

Third Affirmative Defense: No Attorneys' Fees

LiftWerx is precluded from recovering attorneys' fees and/or costs under 35 U.S.C. § 285.

Fourth Affirmative Defense: No Costs

LiftWerx is precluded from recovering costs.

Fifth Affirmative Defense: Additional Defenses or Claims

Liftra reserves all defenses available under the Federal Rules of Civil Procedure and the U.S. Patent laws and any additional defenses or claims that discovery may reveal.

DEFENDANT'S COUNTERCLAIMS

In accordance with Rule 13 of the Federal Rules of Civil Procedure, Counterclaim Plaintiff Liftra IP ApS ("Counterclaim Plaintiff" or "Liftra"), by and through its undersigned attorneys, alleges as follows:

Parties

1. Counterclaim-Plaintiff Liftra IP ApS is a Danish company with its principal place of business of Stationsmestervej 81, 9200 Aalborg SV, Denmark. Liftra USA, Inc.
2. On information and belief, LiftWerx USA Inc. ("Counterclaim-Defendant" or "LiftWerx") is a Delaware corporation with a principal place of business at 2510 Dickinson Avenue, Dickinson, Texas 77539.

Jurisdiction and Venue

3. These counterclaims arise under the patent laws of the United States, 35 U.S.C. § 1 et seq.
4. This Court has subject-matter jurisdiction under 28 U.S.C. §§ 1331 and 1338(a).
5. This Court has personal jurisdiction over LiftWerx at least because LiftWerx purposefully availed itself of the rights and privileges of this forum by initiating this action in this District.
6. This Court further has personal jurisdiction over LiftWerx because it has, directly and/or through its agents and/or intermediaries, committed acts and continues to commit acts of patent infringement by making, selling, offering for sale, importing, and/or using the Accused Products within this District giving rise to this action and has established minimum contacts with this District such that the exercise of jurisdiction would not offend traditional notions of fair play and substantial justice.
7. Venue is proper in this District because LiftWerx brought this civil action in this District and pursuant to 28 U.S.C. §§ 1391(b) and (c) and 1400(b).

Patents

7. U.S. Patent No. 10,378,518 (“the ’518 Patent”) is titled “Main Shaft Fixture.” Liftra is the sole owner by assignment of all right, title, and interest, including the right to recover for past, present, and future infringement.
8. U.S. Patent No. 12,104,578 (“the ’578 Patent”) is titled “Main Shaft Fixture.” Liftra is the sole owner by assignment of all right, title, and interest, including the right to recover for past, present, and future infringement.
9. U.S. Patent No. 12,473,179 (“the ’179 Patent”) is titled “Base for Supporting a Portable Crane and a Method for Removing a Main Bearing of a Wind Turbine.” Liftra is the sole

owner by assignment of all right, title, and interest, including the right to recover for past, present, and future infringement.

The Accused Products

10. On information and belief, LiftWerx employs multi-crane systems (the “Accused Products”) that it describes as follows:

RotorHook, GenHook, Heli-Hook. The RotorHook crane is part of a five-crane system. It is assembled by a GenHook crane, which itself is assembled by a Heli-Hook crane, which is assembled by two small service cranes. All of these cranes comprise a complex crane system which is now in use by our sister company LiftWerx in North America. You could compare the assembly of the RotorHook with a Russian matryoskha, a doll inside a doll inside a doll.

<https://eager.one/the-rotorhook-has-arrived/#:~:text=All%20of%20these%20cranes%20comprise%20a%20complex,doll%20inside%20a%20doll%20inside%20a%20doll.>

11. On information and belief, WO2021168549A1, titled “Multiple up-tower lifting appliances on wind turbines” describes the infringing features of LiftWerx’s multi-crane system.
12. On information and belief, the described multi-crane system includes at least the HeliHook, GenHook, and RotorHook depicted below.



LiftWerx HeliHook. https://www.linkedin.com/posts/liftwerx-solutions-inc-_heres-a-glimpse-of-our-heli-hook-crane-activity-7320041987150135297-qtOw



LiftWerx GenHook <https://liftwerx.com/news/the-genhook-is-launched/>



LiftWerx RotorHook <https://liftwerx.com/our-cranes/>

13. The Accused Products includes a “rotor lock” and a “main shaft clamp” for “preventing rotational and translational movement of the main shaft during an installation or repair procedure of a wind turbine component.” WO2021168549A1 at 9:3-5. On information and belief, the rotor lock employed in LiftWerx products is similar to that described in European Patent 3,824,180, titled Rotor Lock for Wind Turbine.

14. On information and belief, the LiftWerx attachment system includes a pivotal connection as described in WO2021168549A at 18:16-23. The beam-shaped brackets extend on each side of the main shaft from one stable structural part to another. WO2021168549A1 at 6:29-7.

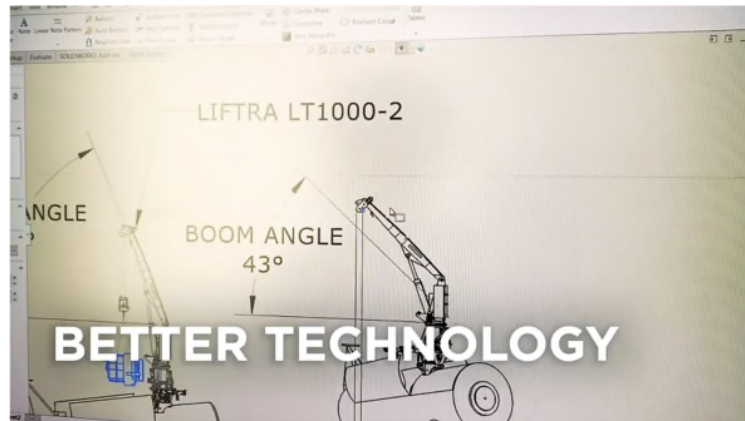
First Counterclaim (Infringement of U.S. Patent No. 10,378,518)

15. Liftra restates and incorporates by reference the allegations set forth in each of paragraphs 1–14 of the Counterclaims as if fully set forth herein.
16. U.S. Patent No. 10,378,518 (“the ’518 Patent”) is titled “Main Shaft Fixture.” Liftra is the sole owner by assignment of all right, title, and interest, including the right to recover for past, present, and future infringement. The ’518 Patent was duly and legally issued by the United States Patent and Trademark Office on August 13, 2019. A true and correct copy of the ’518 Patent is attached as Exhibit A.
17. LiftWerx has infringed and continues to directly infringe, literally and/or under the doctrine of equivalents, one or more claims of the ’518 Patent by making, using, offering for sale, selling, and/or importing the Accused Products without authorization.
18. LiftWex has been and is now directly infringing, literally and/or under the doctrine of equivalents, at least claim 2 of the ’518 Patent.
19. On information and belief, the Accused Products are designed and adapted to lift, among other things, wind turbine main shafts, rotors, gearboxes, and generators in connection with installation, removal, and repair of heavy components. The Accused Products include structures and components meeting the limitations of one or more asserted claims of the ’518 Patent. By way of illustration only, a claim chart showing the Accused Products meet each and every element of claim 2 of the ’518 Patent is attached as Exhibit B.

20. On information and belief, LiftWerx has directly infringed, literally and/or under the doctrine of equivalents, the '518 Patent under 35 U.S.C. § 271(a), including by making, using, selling, offering for sale in the United States, and/or importing into the United States, products that contain the features disclosed in the '518 Patent and continues to do so. On information and belief, LiftWerx has used and uses the patented system, as it, for example, provides services to its customers.
21. LiftWerx has had knowledge of the '518 patent from a date no later than the date of the filing of its Complaint in the present action. On information and belief, Liftwerx had knowledge of the '518 Patent prior to the date of the filing of this Counterclaim Complaint by virtue of, for example, prior business dealings between LiftWerx and Liftra.
22. On information and belief, LiftWerx had knowledge of the of the '518 Patent since at least Jul. 26, 2022, including by virtue of filing U.S. Patent Application 17/795,334. On Jul. 26, 2022, LiftWerx's patent prosecution counsel filed an Information Disclosure Statement related to U.S. Patent Application 17/795,334 that specifically identified Liftra's '518 Patent.
23. On information and belief, LiftWerx actively induces and has induced infringement of the '518 Patent under 35 U.S.C. § 271(b), either literally or under the doctrine of equivalents, and continues to do so.
24. On information and belief, LiftWerx directs and/or authorizes others, *e.g.*, its agents, customers, and/or field teams to make, use, sell, offer for sale and/or import into the United States, the Accused Products.

25. On information and belief, LiftWerx encouraged and facilitated infringement with specific intent and continue to encourage and facilitate infringement with specific intent, by, for example, providing instructions, manuals, training, and on-site supervision regarding the use of the Accused Products in a manner that infringes at least one claim of the '518 Patent. For example, LiftWerx is and has been aware that the features claimed in the '518 Patent are features in the Accused Products and are features used by those that use the Accused Products and, therefore, that users of the Accused Products have infringed and will infringe the '518 Patent.
26. LiftWerx has been and is now contributing to the infringement of the '518 Patent under 35 U.S.C. § 271(c), either literally or under the doctrine of equivalents, and continues to do so.
27. LiftWerx has actively, knowingly, and intentionally contributed to and continues to actively, knowingly and intentionally contribute to the infringement of the '518 Patent by, for example, importing in to the United States and/or using in the United States, the Accused Products with knowledge that the infringing technology is especially made and/or especially adapted for use in infringement of the '518 Patent, is a material part of the patented invention, and with knowledge that the Accused Products are not a staple article or commodity of commerce suitable for substantial non-infringing use and with knowledge that others, including users of the Accused Products, do not have any substantial non-infringing uses. On information and belief, LiftWerx has such knowledge at least because LiftWerx is aware that the claimed features of the '518 Patent are used in the United States.

28. LiftWerx has and continues to willfully infringe the '518 Patent. On information and belief, LiftWerx has known of the '518 Patent and has continued to infringe the patent in an egregious and wanton manner that LiftWerx knew or should have known amounted to infringement of the patent. On information and belief, LiftWerx's infringement of the '518 Patent has been and continues to be willful and deliberate. Liftra is a pioneer in its field with whom LiftWerx is familiar. On information, LiftWerx, *e.g.*, knowingly has imported, used, and continues to use the Accused Products in an infringing manner that was known to LiftWerx or was so obvious that LiftWerx should have known of its infringement.
29. On information and belief, Liftra has intended that its customers, field teams, and contractors use the Accused Products in a manner that infringes the '518 Patent.
30. On information and belief, LiftWerx's infringement of the '518 Patent has been egregious, willful, deliberate, and undertaken with objectively reckless disregard for Liftra's rights. After acquiring at least two Liftra LT1000 cranes as a customer, LiftWerx obtained detailed technical and engineering information regarding Liftra's LT1000 and its main shaft fixture. *See* Statement of Per Fenger, Sept. 8, 2024, Exhibit C to Complaint. In LiftWerx's own publicly disseminated promotional video, it prominently includes a screenshot showing a Liftra technical drawing—specifically, a proprietary SOLIDWORKS drawing of the Liftra LT1000-2—while a voiceover falsely and misleadingly claims that LiftWerx's "talented team of engineers and technicians created the cutting-edge technology in up-tower lifting solutions we use today." A screen capture from the LiftWerx promotional video at approximately 0:20 is shown below.



Screen capture from LiftWerx promotional video at 0m20s
<https://youtu.be/uFjCEjJWavg?si=WvI972dCNbuFkBJq>

31. On information and belief, LiftWerx knew of or was willfully blind to the '518 Patent and the high risk that its conduct infringed at least one claim of the '518 Patent, yet intentionally continued its infringing activities and actively encouraged others to use the Accused Products in an infringing manner.
32. LiftWerx's actions have caused Liftra to suffer irreparable harm resulting from the loss of its lawful patent rights and the loss of its ability to exclude others from making, using, selling, offering for sale and importing the inventions of the '179 Patent. On information and belief, LiftWerx will continue these infringing acts unless enjoined by this Court.
33. Liftra has been and continues to be damaged by LiftWerx's infringement of the '518 Patent, including at least in the form of lost sales, price erosion, and/or irreparable harm.

Second Counterclaim (Infringement of U.S. Patent No. 12,104,578)

34. Liftra repeats and incorporates paragraphs 1–33.
35. U.S. Patent No. 12,104,578 (“the '578 Patent”) is titled “Main Shaft Fixture.” Liftra is the sole owner by assignment of all right, title, and interest, including the right to recover for past, present, and future infringement. The '578 Patent was duly and legally issued by the

United States Patent and Trademark Office on October 1, 2024. A true and correct copy of the '578 Patent is attached as Exhibit C.

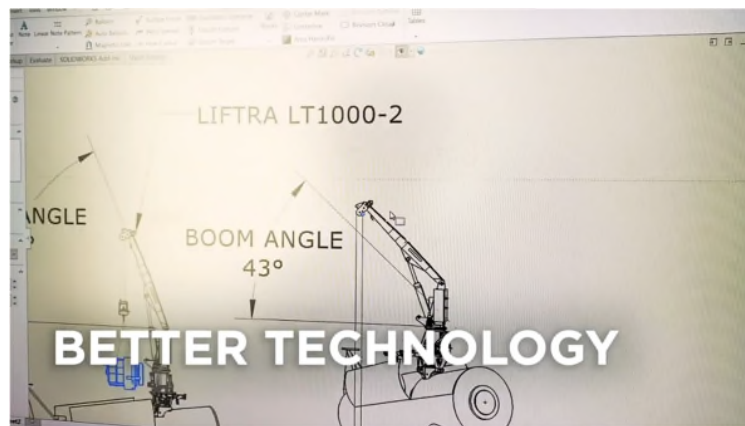
36. LiftWerx has infringed and continues to directly infringe, literally and/or under the doctrine of equivalents, one or more claims of the '578 Patent by making, using, offering for sale, selling, and/or importing the Accused Products without authorization.
37. LiftWex has been and is now directly infringing, literally and/or under the doctrine of equivalents, at least claim 1 of the '578 Patent.
38. On information and belief, the Accused Products are designed and adapted to lift, among other things, wind turbine main shafts, rotors, gearboxes, and generators in connection with installation, removal, and repair of heavy components. The Accused Products include structures and components meeting the limitations of one or more asserted claims of the '578 Patent. By way of illustration only, a claim chart showing the Accused Products meet each and every element of claim 1 of the '578 Patent is attached as Exhibit D.
39. On information and belief, LiftWerx has directly infringed, literally and/or under the doctrine of equivalents, the '578 Patent under 35 U.S.C. § 271(a), including by making, using, selling, offering for sale in the United States, and/or importing into the United States, products that contain the features disclosed in the '578 Patent and continues to do so. On information and belief, LiftWerx has used and uses the patented system, as it, for example, provides services to its customers.
40. LiftWerx has had knowledge of the '578 patent from a date no later than the date of the filing of its Complaint in the present action. On information and belief, Liftwerx had knowledge of the '578 Patent prior to the date of the filing of this Counterclaim

Complaint by virtue of, for example, prior business dealings between LiftWerx and Liftra.

41. On information and belief, LiftWerx had knowledge of the of the '578 Patent since at least Jul. 26, 2022, including by virtue of filing U.S. Patent Application 17/795,334. On Jul. 26, 2022, LiftWerx's patent prosecution counsel filed an Information Disclosure Statement related to U.S. Patent Application 17/795,334 that specifically identified Liftra's '518 Patent. The '518 is in the same family as the '578 patent.
42. On information and belief, LiftWerx actively induces and has induced infringement of the '578 Patent under 35 U.S.C. § 271(b), either literally or under the doctrine of equivalents, and continues to do so.
43. On information and belief, LiftWerx directs and/or authorizes others, *e.g.*, its agents, customers, and/or field teams to make, use, sell, offer for sale and/or import into the United States, the Accused Products.
44. On information and belief, LiftWerx encouraged and facilitated infringement with specific intent and continue to encourage and facilitate infringement with specific intent, by, for example, providing instructions, manuals, training, and on-site supervision regarding the use of the Accused Products in a manner that infringes at least one claim of the '578 Patent. For example, LiftWerx is and has been aware that the features claimed in the '578 Patent are features in the Accused Products and are features used by those that use the Accused Products and, therefore, that users of the Accused Products have infringed and will infringe the '578 Patent.

45. LiftWerx has been and is now contributing to the infringement of the '578 Patent under 35 U.S.C. § 271(c), either literally or under the doctrine of equivalents, and continues to do so.
46. LiftWerx has actively, knowingly, and intentionally contributed to and continues to actively, knowingly and intentionally contribute to the infringement of the '578 Patent by, for example, importing in to the United States and/or using in the United States, the Accused Products with knowledge that the infringing technology is especially made and/or especially adapted for use in infringement of the '578 Patent, is a material part of the patented invention, and with knowledge that the Accused Products are not a staple article or commodity of commerce suitable for substantial non-infringing use and with knowledge that others, including users of the Accused Products, do not have any substantial non-infringing uses. On information and belief, LiftWerx has such knowledge at least because LiftWerx is aware that the claimed features of the '578 Patent are used in the United States.
47. LiftWerx has and continues to willfully infringe the '578 Patent. On information and belief, LiftWerx has known of the '578 Patent and has continued to infringe the patent in an egregious and wanton manner that LiftWerx knew or should have known amounted to infringement of the patent. On information and belief, LiftWerx's infringement of the '578 Patent has been and continues to be willful and deliberate. Liftra is a pioneer in its field with whom LiftWerx is familiar. On information, LiftWerx, *e.g.*, knowingly has imported, used, and continues to use the Accused Products in an infringing manner that was known to LiftWerx or was so obvious that LiftWerx should have known of its infringement.

48. On information and belief, Liftra has intended that its customers, field teams, and contractors use the Accused Products in a manner that infringes the '578 Patent.
49. On information and belief, LiftWerx's infringement of the '578 Patent has been egregious, willful, deliberate, and undertaken with objectively reckless disregard for Liftra's rights. After acquiring at least two Liftra LT1000 cranes as a customer, LiftWerx obtained detailed technical and engineering information regarding Liftra's LT1000 and its main shaft fixture. *See* Statement of Per Fenger, Sept. 8, 2024, Exhibit C to Complaint. In LiftWerx's own publicly disseminated promotional video, it prominently includes a screenshot showing a Liftra technical drawing—specifically, a proprietary SOLIDWORKS drawing of the Liftra LT1000-2—while a voiceover falsely and misleadingly claims that LiftWerx's "talented team of engineers and technicians created the cutting-edge technology in up-tower lifting solutions we use today." A screen capture from the LiftWerx promotional video at approximately 0:20 is shown below.



Screen capture from LiftWerx promotional video at 0m20s
<https://youtu.be/uFjCEjJWavg?si=WvI972dCNbuFkBJq>

50. On information and belief, LiftWerx knew of or was willfully blind to the '578 Patent and the high risk that its conduct infringed at least one claim of the '578 Patent, yet

intentionally continued its infringing activities and actively encouraged others to use the Accused Products in an infringing manner.

51. LiftWerx's actions have caused Liftra to suffer irreparable harm resulting from the loss of its lawful patent rights and the loss of its ability to exclude others from making, using, selling, offering for sale and importing the inventions of the '578 Patent. On information and belief, LiftWerx will continue these infringing acts unless enjoined by this Court.
52. Liftra has been and continues to be damaged by LiftWerx's infringement of the '578 Patent, including at least in the form of lost sales, price erosion, and/or irreparable harm.

Third Counterclaim (Infringement of U.S. Patent No. 12,473,179)

53. Liftra repeats and incorporates paragraphs 1–52.
54. U.S. Patent No. 12,473,179 (“the '179 Patent”) is titled “Base for Supporting a Portable Crane and a Method for Removing a Main Bearing of a Wind Turbine.” Liftra is the sole owner by assignment of all right, title, and interest. The '179 Patent was duly and legally issued by the United States Patent and Trademark Office on November 18, 2025. A true and correct copy of the '179 Patent is attached as Exhibit E.
55. LiftWerx has infringed and continues to directly infringe, literally and/or under the doctrine of equivalents, one or more claims of the '179 Patent by making, using, offering for sale, selling, and/or importing the Accused Products without authorization.
56. LiftWex has been and is now directly infringing, literally and/or under the doctrine of equivalents, at least claim 2 of the '179 Patent.
57. On information and belief, the Accused Products are designed and adapted to lift, among other things, wind turbine main shafts, rotors, gearboxes, and generators in connection with installation, removal, and repair of heavy components. The Accused Products include structures and components meeting the limitations of one or more asserted claims

of the '179 Patent. By way of illustration only, a claim chart showing the Accused Products meets each and every element of claim 1 of the '179 Patent is attached as Exhibit F.

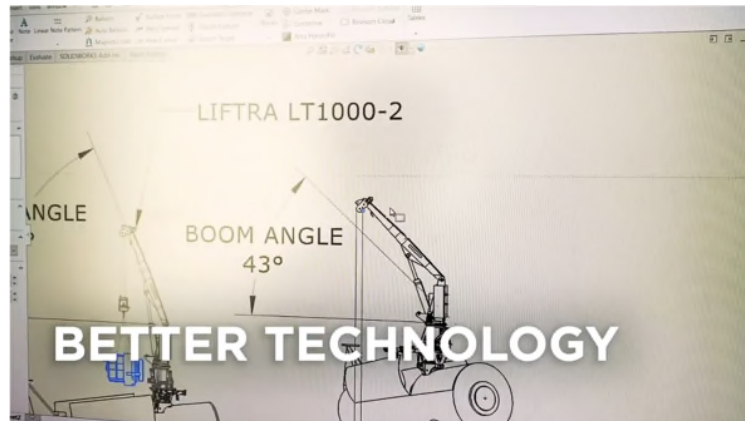
58. On information and belief, LiftWerx has directly infringed, literally and/or under the doctrine of equivalents, the '179 Patent under 35 U.S.C. § 271(a), including by making, using, selling, offering for sale in the United States, and/or importing into the United States, products that contain the features disclosed in the '179 Patent and continues to do so. On information and belief, LiftWerx has used and uses the patented system, as it, for example, provides services to its customers.
59. LiftWerx has had knowledge of the '179 patent from a date no later than the date of the filing of its Complaint in the present action. On information and belief, LiftWerx regularly monitors Liftra's patent activity. On Nov. 18, 2025, the USPTO published the '179 patent. On information and belief, Liftwerx had knowledge of the '179 Patent prior to the date of the filing of this Counterclaim Complaint by virtue of, for example, prior business dealings between LiftWerx and Liftra.
60. On information and belief, LiftWerx actively induces and has induced infringement of the '179 Patent under 35 U.S.C. § 271(b), either literally or under the doctrine of equivalents, and continues to do so.
61. On information and belief, LiftWerx directs and/or authorizes others, *e.g.*, its agents, customers, and/or field teams to make, use, sell, offer for sale and/or import into the United States, the Accused Products.
62. On information and belief, LiftWerx encouraged and facilitated infringement with specific intent and continue to encourage and facilitate infringement with specific intent,

by, for example, providing instructions, manuals, training, and on-site supervision regarding the use of the Accused Products in a manner that infringes at least one claim of the '179 Patent. For example, LiftWerx is and has been aware that the features claimed in the '179 Patent are features in the Accused Products and are features used by those that use the Accused Products and, therefore, that users of the Accused Products have infringed and will infringe the '179 Patent.

63. LiftWerx has been and is now contributing to the infringement of the '179 Patent under 35 U.S.C. § 271(c), either literally or under the doctrine of equivalents, and continues to do so.
64. LiftWerx has actively, knowingly, and intentionally contributed to and continues to actively, knowingly and intentionally contribute to the infringement of the '179 Patent by, for example, importing in to the United States and/or using in the United States, the Accused Products with knowledge that the infringing technology is especially made and/or especially adapted for use in infringement of the '179 Patent, is a material part of the patented invention, and with knowledge that the Accused Products are not a staple article or commodity of commerce suitable for substantial non-infringing use and with knowledge that others, including users of the Accused Products, do not have any substantial non-infringing uses. On information and belief, LiftWerx has such knowledge at least because LiftWerx is aware that the claimed features of the '179 Patent are used in the United States.
65. LiftWerx has and continues to willfully infringe the '179 Patent. On information and belief, LiftWerx has known of the '179 Patent and has continued to infringe the patent in an egregious and wanton manner that LiftWerx knew or should have known amounted to

infringement of the patent. On information and belief, LiftWerx's infringement of the '179 Patent has been and continues to be willful and deliberate. Liftra is a pioneer in its field with whom LiftWerx is familiar. On information, LiftWerx, *e.g.*, knowingly has imported, used, and continues to use the Accused Products in an infringing manner that was known to LiftWerx or was so obvious that LiftWerx should have known of its infringement.

66. On information and belief, Liftra has intended that its customers, field teams, and contractors use the Accused Products in a manner that infringes the '179 Patent.
67. On information and belief, LiftWerx's infringement of the '179 Patent has been egregious, willful, deliberate, and undertaken with objectively reckless disregard for Liftra's rights. After acquiring at least two Liftra LT1000 cranes as a customer, LiftWerx obtained detailed technical and engineering information regarding Liftra's LT1000 and its main shaft fixture. *See* Statement of Per Fenger, Sept. 8, 2024, Exhibit C to Complaint. In LiftWerx's own publicly disseminated promotional video, it prominently includes a screenshot showing a Liftra technical drawing—specifically, a proprietary SOLIDWORKS drawing of the Liftra LT1000-2—while a voiceover falsely and misleadingly claims that LiftWerx's "talented team of engineers and technicians created the cutting-edge technology in up-tower lifting solutions we use today." A screen capture from the LiftWerx promotional video at approximately 0:20 is shown below.



Screen capture from LiftWerx promotional video at 0m20s
<https://youtu.be/uFjCEjJWavg?si=WvI972dCNbuFkBJq>

68. On information and belief, LiftWerx knew of or was willfully blind to the '179 Patent and the high risk that its conduct infringed at least one claim of the '179 Patent, yet intentionally continued its infringing activities and actively encouraged others to use the Accused Products in an infringing manner.
69. LiftWerx's actions have caused Liftra to suffer irreparable harm resulting from the loss of its lawful patent rights and the loss of its ability to exclude others from making, using, selling, offering for sale and importing the inventions of the '179 Patent. On information and belief, LiftWerx will continue these infringing acts unless enjoined by this Court.
70. Liftra has been and continues to be damaged by LiftWerx's infringement of the '179 Patent, including at least in the form of lost sales, price erosion, and/or irreparable harm.

PRAYER FOR RELIEF ON COUNTERCLAIMS

Liftra respectfully requests that the Court enter judgment in its favor and against LiftWerx as follows:

- a. A judgment that LiftWerx has infringed one or more valid and enforceable claims of the '518 Patent;

- b. A judgment that LiftWerx has infringed one or more valid and enforceable claims of the '578 Patent;
- c. A judgment that LiftWerx has infringed one or more valid and enforceable claims of the '179 Patent;
- d. A permanent injunction enjoining LiftWerx and all entities in active concert or participation with it from further acts of infringement of the '518, '578, and '179 Patents;
- e. An award of damages adequate to compensate Liftra for LiftWerx's infringement, in no event less than a reasonable royalty, together with pre- and post-judgment interest, in accordance with 35 U.S.C. § 284;
- f. A finding that this is an exceptional case under 35 U.S.C. § 285 and an award to Liftra of its costs, expenses and reasonable attorneys' fees;
- g. A finding of willful infringement and trebled damages under 35 U.S.C. § 284;
- h. An award of Liftra's reasonable attorneys' fees, costs, and expenses incurred in this action;
- i. An assessment of pre-judgment and post-judgment interest and costs against LiftWerx, together with an award of such interest and costs, in accordance with 35 U.S.C. § 285; and
- j. Such other and further relief that this Court may deem proper, including, but not limited to, any enhanced damages for any of the aforementioned Counterclaims.

JURY DEMAND

Liftra, under Rule 38 of the Federal Rules of Civil Procedure, requests a trial by jury of any issues so triable by right.

RESERVATION OF RIGHTS

Liftra reserves all rights to amend its defenses and counterclaims as discovery progresses and consistent with the Scheduling Order.

Respectfully Submitted,

Dated: January 9, 2026

/s/ Robert A. Angle

Robert A. Angle (VSB No. 37691)
TROUTMAN PEPPER LOCKE LLP
1001 Haxall Point
Richmond, VA 23219
Phone: (804) 697-1200
Fax: (804) 698-5124
Email: Robert.Angle@Troutman.com

William Belanger (VSB No. 37438)
Troutman Pepper Locke LLP
111 Huntington Avenue
Boston, Massachusetts 02129
Tel: 617.204.5100
Fax: 617.227.4420
Email: William.Belanger@Troutman.com

Kimberly Coghill (*pro hac vice* to be filed)
Kevin X. Kuhn (*pro hac vice* to be filed)
TROUTMAN PEPPER LOCKE LLP
401 9th Street, N. W., Suite 1000
Washington, D.C. 20004
Tel: 202.220.1200
Fax: 202.274.2994
Email: Kimberly.Coghill@Troutman.com
Kevin.Kuhn@Troutman.com

Exhibit A

US010378518B2

**(12) United States Patent
Fenger****(10) Patent No.: US 10,378,518 B2****(45) Date of Patent: Aug. 13, 2019****(54) MAIN SHAFT FIXTURE****(71) Applicant: LIFTRA IP APS, Aalborg SV (DK)****(72) Inventor: Per E. Fenger, Terndrup (DK)****(73) Assignee: LIFTRA IP APS, Aalborg (DK)****(*) Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 23 days.**(21) Appl. No.: 15/517,288****(22) PCT Filed: Oct. 6, 2015****(86) PCT No.: PCT/DK2015/000040**

§ 371 (c)(1),

(2) Date: Apr. 6, 2017**(87) PCT Pub. No.: WO2016/055065****PCT Pub. Date: Apr. 14, 2016****(65) Prior Publication Data**

US 2017/0306930 A1 Oct. 26, 2017

(30) Foreign Application Priority Data

Oct. 7, 2014 (DK) 2014 00573

Sep. 4, 2015 (DK) 2015 00527

(51) Int. Cl.**F03D 80/50** (2016.01)**B23B 31/10** (2006.01)

(Continued)

(52) U.S. Cl.CPC **F03D 80/50** (2016.05); **B23B 31/101**
(2013.01); **F03D 13/10** (2016.05); **B23B 31/16**
(2013.01);

(Continued)

(58) Field of Classification SearchCPC . B23B 31/101; B23B 31/16; B23B 2260/008;
B23B 2260/0082; B23B 2260/0085;
B23B 2260/16287; B23B 2215/76; B23B
31/16287; Y10T 279/1986; Y10T 279/19;
Y10T 279/3462; Y10T 279/1274; Y10T
279/1291; Y10T 279/17752; Y10T279/17666; Y10S 279/903; F05B
2230/61; F05B 2240/60; F05B 2230/80;
F03D 80/50; F03D 13/10
See application file for complete search history.**(56) References Cited**

U.S. PATENT DOCUMENTS

1,152,271 A * 8/1915 Bisbee A01K 89/033
188/186
1,853,255 A * 4/1932 Borden B23B 31/101
279/110

(Continued)

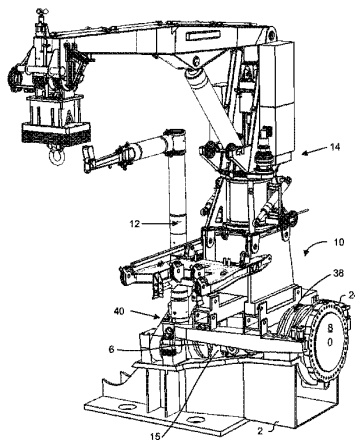
FOREIGN PATENT DOCUMENTS

DE 10 2006 013 539 A1 9/2007
EP 1101934 A2 * 5/2001 B66C 23/207

(Continued)

Primary Examiner — Eric A Gates*Assistant Examiner* — Chwen-Wei Su**(74) Attorney, Agent, or Firm** — David S. Safran; Roberts
Mlotkowski Safran Cole & Calderon, P.C.**(57) ABSTRACT**

A main shaft fixture for fixing a main shaft on a wind turbine during installation and repair work on heavy parts of the wind turbine nacelle, in the case where the fixture is formed of several sections for mounting on stable structural parts in the nacelle, including the nacelle's bottom frame. The main shaft fixture has adjustable pressure mandrels with tap shoes, which cause the fixture to be usable regardless of the turbine main shaft geometry, such that it can be mounted without fixing the rotor. The main shaft fixture also has facilities for mounting of a lightweight crane and a self-hoisting crane with a ground-based winch, respectively, as well as a rotor lock which, in combination with actuators of the main shaft fixture, enables the main shaft and the main shaft bearing to be sufficiently displaced vertically from its bearing in the nacelle to service or replace the bearing.

8 Claims, 5 Drawing Sheets

US 10,378,518 B2

Page 2

- | | | |
|------|---|--|
| (51) | Int. Cl.
F03D 13/10 (2016.01)
B23B 31/16 (2006.01)
F03D 80/70 (2016.01)
F16C 35/06 (2006.01) | 4,631,995 A * 12/1986 Vroenen B23B 31/101
82/164
5,015,003 A * 5/1991 Ramunas B23B 31/16275
269/284
7,759,815 B2 7/2010 Christensen
2002/0092395 A1 * 7/2002 Emilian B23B 5/163
83/452
2010/0021278 A1 * 1/2010 Stegemann B66C 23/06
414/629
2010/0139069 A1 * 6/2010 Daniels F03D 1/00
29/402.01
2012/0141292 A1 * 6/2012 Signore B66C 1/108
416/244 R
2012/0217089 A1 * 8/2012 Fenger F03D 80/50
182/2.1 |
| (52) | U.S. Cl.
CPC <i>F03D 80/70</i> (2016.05); <i>F05B 2230/60</i>
(2013.01); <i>F05B 2230/61</i> (2013.01); <i>F05B</i>
<i>2230/80</i> (2013.01); <i>F05B 2240/60</i> (2013.01);
<i>F05B 2260/30</i> (2013.01); <i>F16C 35/062</i>
(2013.01); <i>F16C 2360/31</i> (2013.01); <i>Y02E</i>
<i>10/722</i> (2013.01); <i>Y02P 70/523</i> (2015.11);
<i>Y10T 279/1274</i> (2015.01); <i>Y10T 279/1291</i>
(2015.01); <i>Y10T 279/1986</i> (2015.01) | |
| (56) | References Cited
U.S. PATENT DOCUMENTS
3,494,230 A * 2/1970 Gast, Jr. B23B 31/16012
279/66
4,623,157 A * 11/1986 Rohs B23B 31/102
279/123 | FOREIGN PATENT DOCUMENTS
EP 1 617 075 A1 1/2006
EP 1748182 A2 * 1/2007 F03D 13/10
JP 61-54846 A 3/1986
WO 2014/103018 A1 7/2014
* cited by examiner |

U.S. Patent

Aug. 13, 2019

Sheet 1 of 5

US 10,378,518 B2

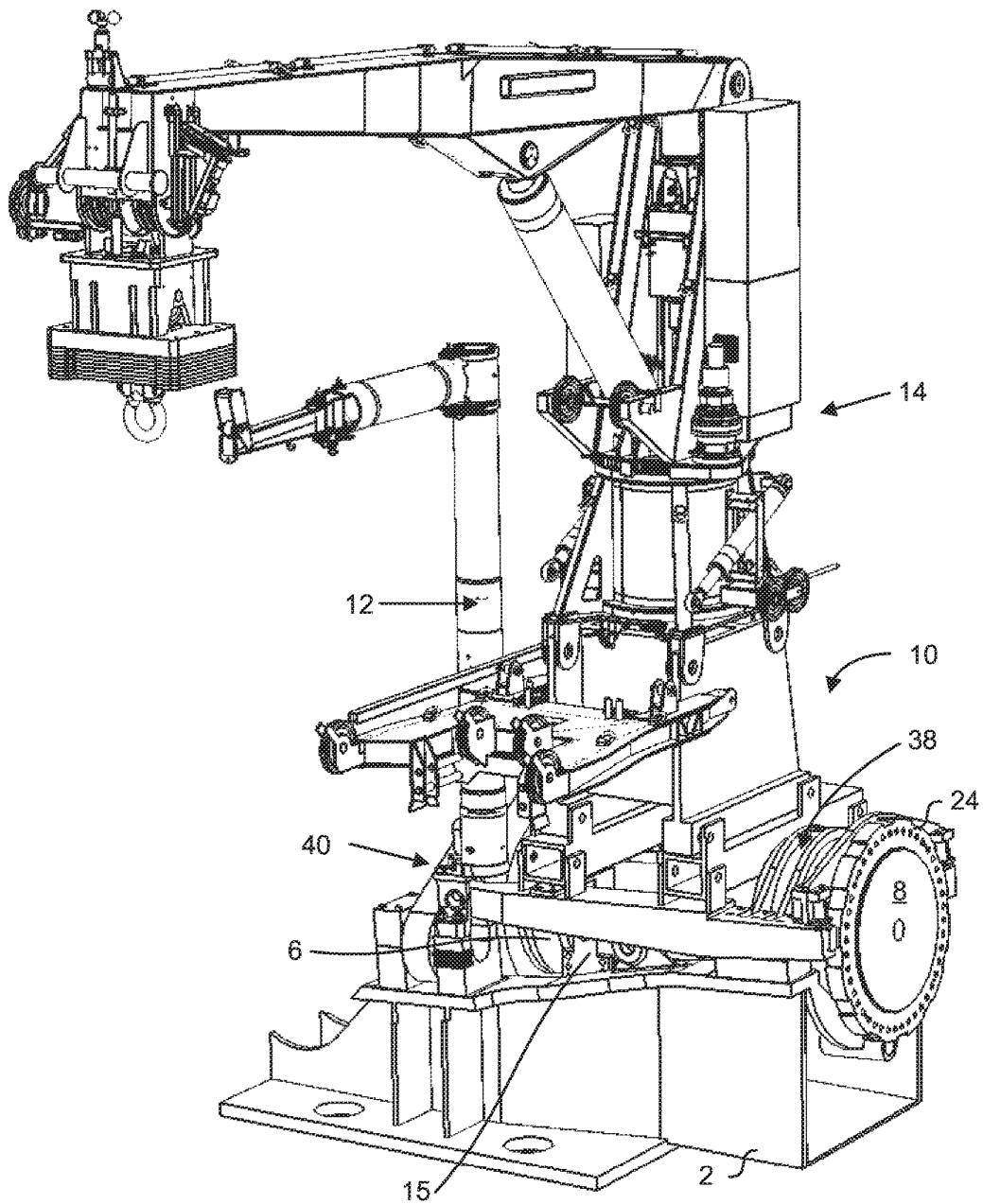


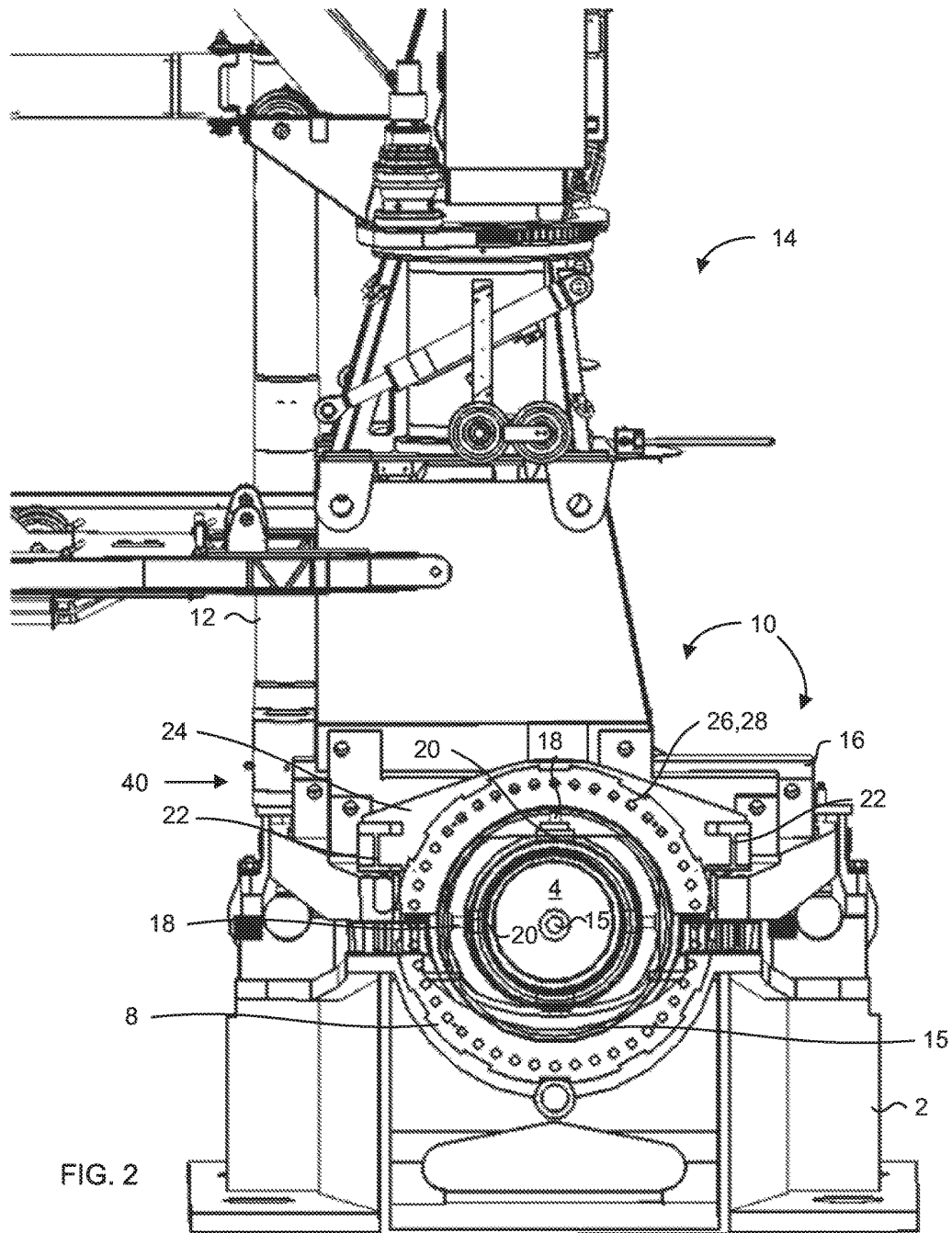
FIG. 1

U.S. Patent

Aug. 13, 2019

Sheet 2 of 5

US 10,378,518 B2

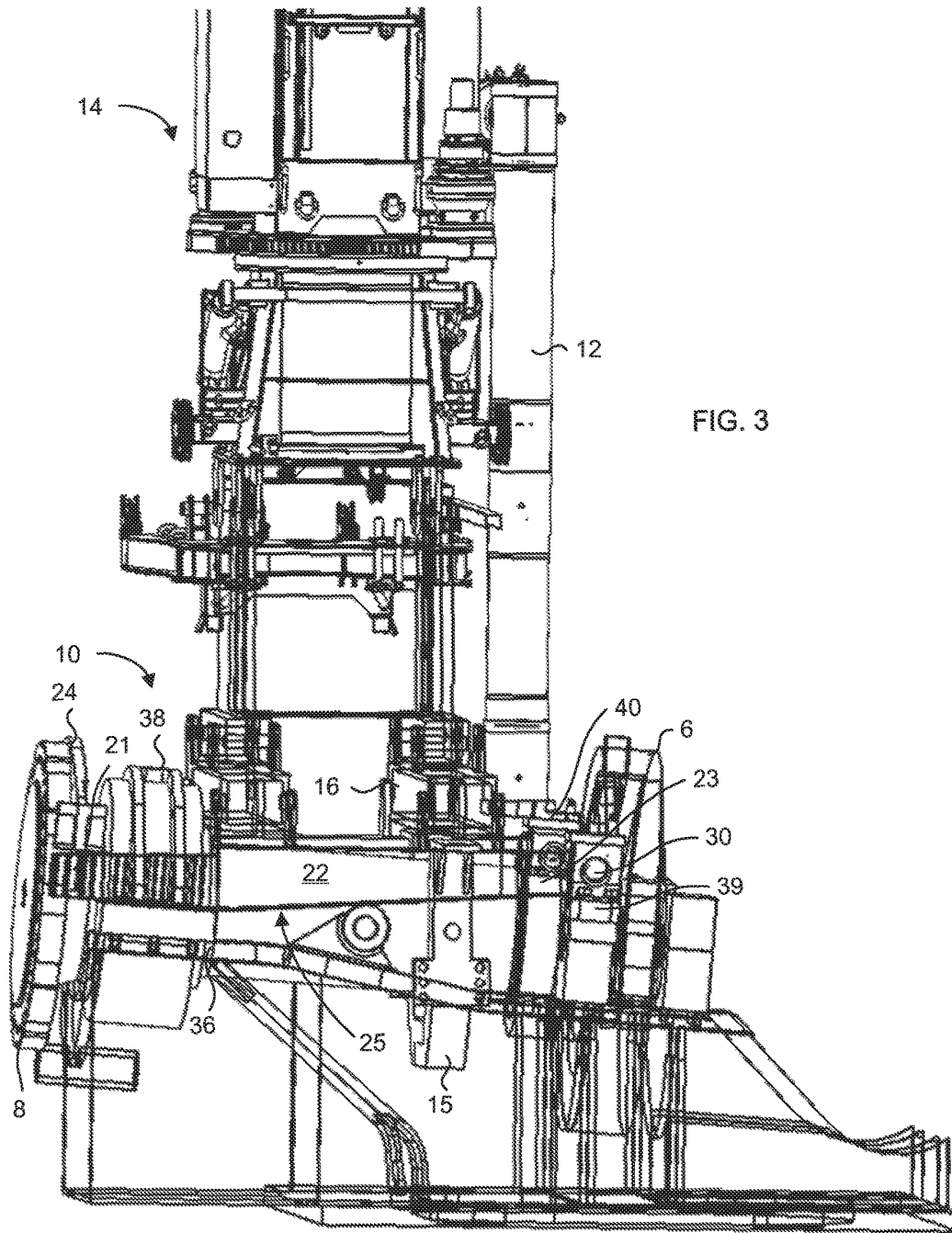


U.S. Patent

Aug. 13, 2019

Sheet 3 of 5

US 10,378,518 B2



U.S. Patent

Aug. 13, 2019

Sheet 4 of 5

US 10,378,518 B2

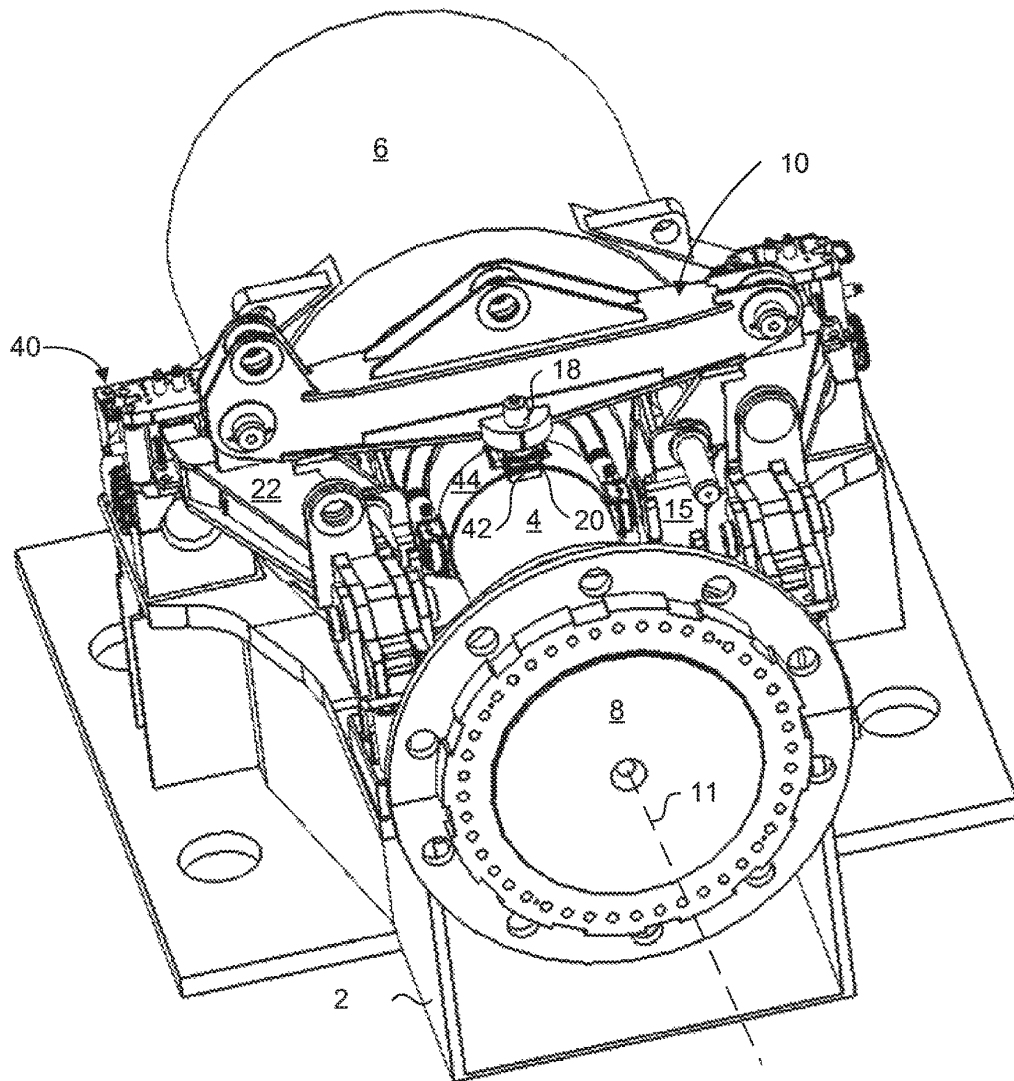


FIG. 4

U.S. Patent

Aug. 13, 2019

Sheet 5 of 5

US 10,378,518 B2

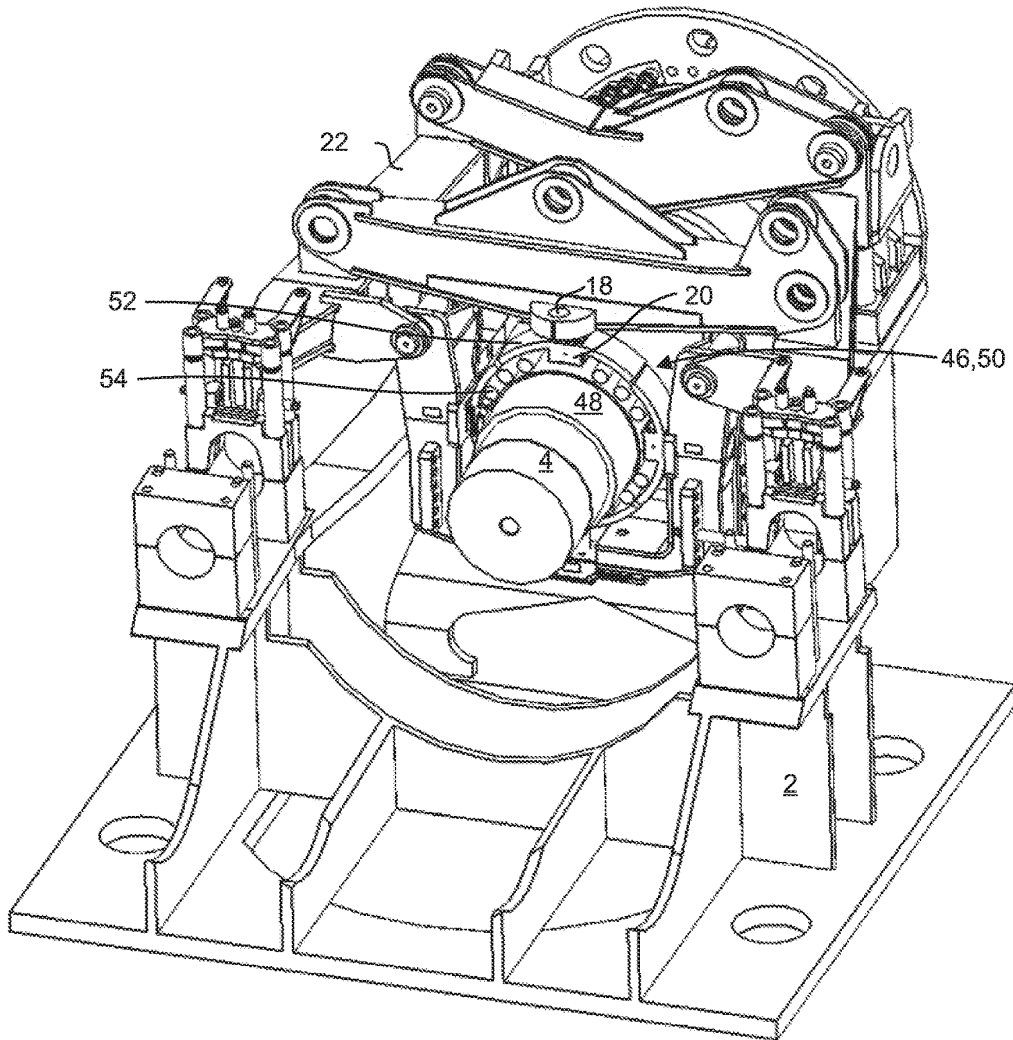


FIG. 5

US 10,378,518 B2

1

MAIN SHAFT FIXTURE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a main shaft fixture for the fixing of a main shaft on a wind turbine during the execution of installation and repair work in heavy parts of a wind turbine arranged in a nacelle on wind turbines, with the fixture being divided up into a number of sections for installation on stable structural parts in a nacelle in a wind turbine, including the nacelle's bottom frame.

Description of Related Art

During installation and repair work on the nacelle of wind turbines there is often a need to perform fixing of the main shaft of the wind turbine, for example, with the replacement and servicing of a wind turbine gear box, generator or with the replacement of its main bearing, or other heavy structural parts present in the nacelle of the wind turbine. The stated components, which are mutually conjoined and anchored to the nacelle's bottom frame, are stable in an assembled state, but when separation needs to be undertaken during repairs and servicing of the turbine, static instability and imbalance arises, which can lead to the turbine's structural parts being damaged, so that there is a need to fix the wind turbine main shaft.

German Patent Application DE 102006013539 A1 (NORDEX ENERGY GMBH) discloses a main shaft fixture for fixing the main shaft on a wind turbine during the execution of installation and repair work on heavy parts that are arranged in the nacelle on wind turbines, with the fixture being divided up into a number of sections for installation on stable structural parts that are found on a wind turbine nacelle, including the bottom frame of the nacelle.

Up to now it has been necessary to halt the turbine, i.e., brake it and fix the rotor with a rotor lock, and then mount an actual fixture to firmly hold the main shaft, subsequent to which servicing of the components in the wind turbine nacelle is able to take place. However, it is inappropriate to have to halt the operation of the wind turbine while the mounting of the main shaft fixture is taking place, as the standstill of the wind turbine during the time that is spent to install the fixture involves a not insignificant operating loss in the form of a lack of energy produced (power). Furthermore, the known main shaft fixtures are relatively inflexible in relation to shaft geometry, which means that in practice nearly just as many different fixtures need to be built and stored as there are shaft geometries that exist, which is inappropriate. In addition, the use of self-hoisting cranes, whose winches are placed on the ground surface near the turbine's tower, is increasing, because the use of such involves large savings in the level of expenses for servicing of wind turbines since the use of large mobile cranes for handling the above-mentioned large and heavy components is made superfluous. This causes however a need for facilities for anchoring the self-hoisting crane with the ground-based winch in the nacelle. However, the self-hoisting winch requires furthermore the presence of a lightweight crane, for the hoisting of snatch blocks, etc., that are to be anchored on/in the nacelle or on the blades of the wind turbine, which poses requirements concerning the facilities for mounting the lightweight crane.

In the event of servicing in particular large wind turbines, it may however be inappropriate to block the main shaft's

2

rotation with an actual rotor lock, but rather be appropriate to simply retain the shaft in position and permit a certain rotation of the shaft, which is possible by turning the blades/nacelle out of the wind so that the shaft via the effects of the wind on the blades only rotates very slowly, or not at all, whereby it is acceptable in terms of safety, to perform service work in the nacelle of the wind turbine concerned.

SUMMARY OF THE INVENTION

Thus, it is the purpose of the invention to specify a main shaft fixture that provide a more universal application in relation to shaft geometry, which moreover does not require halting and fixing of the wind turbine main shaft, but which may however comprise the means for such.

It is further the purpose of the invention to provide a main shaft fixture that in addition offers facilities for the mounting of a self-hoisting crane, with a ground-based winch.

It is by the invention realized that this is possible by a main shaft fixture of the nature specified in the introduction, which is characterised by that the main shaft fixture comprises at least three radial displaceable pressure mandrels, substantially symmetrical located around the centre axis of the main shaft, the ends of said pressure mandrels facing the main shaft are furnished with a tap shoe, and said pressure mandrels being displaceable between a passive, withdrawn lockable position where the tap shoes are configured to be located at a distance from the surface of the main shaft and an advanced lockable position where the tap shoes are configured to be engaged with the main shaft.

Considerable flexibility is hereby attained with respect to the main shaft fixture's use for the fixing of main shafts with different geometries on wind turbines, since solely the degree of mobility of the pressure mandrels and the size of the main shaft fixture pose limiting factors for the usability of such. The main shaft fixture is thus both usable for fixing of cylinder-shaped shafts with different diameters and for the fixing of shafts with conical shapes. The main shaft fixture according to the invention is multi-part, and may be mounted on permanent structural parts, preferably the bottom frame of the nacelle, while the rotor of the wind turbine is in operation.

With the intent of being able to use a self-hoisting crane with a ground-based winch together with the main shaft fixture according to the invention, it may comprise mounting facilities for a self-hoisting crane whose winch is placed on the ground surface ground near the foot of the wind turbine.

The advance thereof is that the establishment of facilities for the fixing of the wind turbine's main shaft, as well as the establishment of mounting facilities for the self-hoisting crane with a ground-based winch, take place simultaneously, which saves work processes, and space, which are of great importance, as the space in the nacelle in a wind turbine are most often narrow, and furthermore the main shaft fixture as well as the mounting facilities for a self-hoisting crane in the nacelle normally utilise the same permanent structural parts in the nacelle for anchoring.

With the intent of ensuring easy and rapid establishment of the self-hoisting crane, which requires the hoisting of snatch blocks with wires originating from the ground-based winch with a lightweight crane which is mounted on stable structural parts in the nacelle, the main shaft fixture may comprise mounting facilities for a lightweight crane.

For the purpose of securing the rapid fixing of the main shaft using the main shaft fixture according to the invention, the pressure mandrels may be provided with actuators for displacing and retaining the tap shoes in the passive position

US 10,378,518 B2

3

and the active position, respectively, alternatively in a selectable position between the passive and the active position.

Time is thereby saved in the displacement of the tap shoes between the passive position, and the active position pressed against the main shaft's surface.

In a more simple form of embodiment of the main shaft fixture according to the invention, the pressure mandrels may be comprised of threaded bolts whose free ends facing the main shaft are furnished with tap shoes, where the threaded bolts work together with threaded holes in relevant sections of the fixture. The pressure mandrels with the tap shoes are hereby displaced by manual turning of the threaded bolts between the passive position and the active position.

With the intent of being able to permit rotation of the main shaft during performance of servicing of a relevant wind turbine and in order to protect the main shaft and the main shaft fixture, slide plates may exist between the opposing sides of the main shaft's surface and the tap shoes.

This enables the main shaft to be fixed in its position by the main shaft fixture, but with the main shaft being permitted to rotate without it being damaged due to the presence of the slide plates.

In a first embodiment of the slide plates, this could comprise the free ends of tap shoes facing against the main shaft being furnished with slide plates, which in the active extended position are engaged with the main shaft.

In a further embodiment, the main shaft fixture may according to the invention comprise a multi-part slide plate working in conjunction with the main shaft to be mounted on the main shaft, where the multi-part slide plate in its mounted state on the main shaft cooperates with the tap shoes.

This enables the tap shoes on the main shaft fixture's pressure mandrel to slide directly on the multi-part slide plate, in the event of a possible rotation of the main shaft caused by the effects of wind on the blades. The tap shoes on the main shaft fixture's pressure mandrels may cooperate with the multi-part slide plate on the main shaft, with or without slideway linings on the opposing sides of the tap shoes facing the main shaft.

In a further embodiment of the main shaft fixture as per the invention, it may comprise a multi-part needle bearing, roller bearing, ball bearing, consisting of a, multi-part inner ring, fastened on the main shaft, and a therewith cooperating multi-part outer ring consisting of a number of bowed sub segments according to the number of tap shoes mounted on the opposing side of the tap shoes facing the multi-part inner ring, which in the advanced active position of the pressure mandrels form the outer ring at a distance from the external periphery of the multi-part inner ring, and where a suitable number of needle rollers, rollers or balls are placed between the inner ring and outer ring, and where means are present for retaining the needles, rollers, or balls in position between the inner ring and outer ring.

An actual temporary bearing connection is hereby formed between the main shaft fixture and the main shaft, about which the main shaft is able to rotate.

With the intent of being able to fix the rotor on the wind turbine after it has been braked to a stop, the main shaft fixture according to the invention, may comprise a rotor lock, for fixing the wind turbine rotor.

In a preferred embodiment of the rotor lock, it is comprised of a flange, whose bolt circle geometry corresponds to a bolt circle geometry on the rotor, said flange element being fastened at the ends to the first end of two first beam-shaped brackets extending parallel with, and on each

4

side of the main shaft, said beam shaped brackets belonging to the main shaft fixture, and where the other end of the brackets are pivotally mounted with horizontally oriented bolt connections, on other brackets belonging to the main shaft fixture, which are anchored on the bottom frame of the nacelle.

It is hereby achieved that the rotor can be fixed by introducing a bolt through one or more of the overlapping holes in the bolt circles on the flange fastened to the bottom frame and the bolt circle on the rotor, respectively.

With the intent of being able to perform replacement of the shafts main bearing, without being forced to dismount the main shaft, the main shaft fixture may furthermore comprise at least a second actuator, between the nacelle's bottom frame and the opposing side of the first beam-shaped brackets facing such and the nearest rotor lock, where the other actuator is movable between a first passive outer position and an active outer position whereby the flange element is moved vertically.

This enables the main shaft to be able to be raised from its bearing hanging in the rotor lock, such that the main bearing of the shaft can be replaced or serviced without the necessity of removing the shaft from the nacelle.

The invention is explained in further detail in the following with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of parts of a wind turbine nacelle, presenting the nacelle bottom frame, the wind turbine main shaft, and a main shaft fixture according to the invention, with a lightweight crane and a self-hoisting crane mounted,

FIG. 2 is a more detailed perspective view from another angle of what is shown in FIG. 1, where the main shaft is made transparent, presenting the pressure mandrel with tap shoe belonging to the main shaft fixture according to the invention,

FIG. 3 is a more detailed perspective view from another angle of what is shown in FIG. 1, presenting the actuators for raising the main shaft, where the main shaft is made transparent,

FIG. 4 is a detailed perspective view of the main shaft fixture for a wind turbine, where the tap shoes and the main shaft are furnished with slide plates, and

FIG. 5 is a detailed perspective view or the main shaft fixture for a wind turbine, where the slide plates are replaced by a multi-part needle bearing/roller bearing/ball bearing formed of a multi-part inner ring fastened to the main shaft and a therewith cooperating multi-part outer ring consisting of bowed sub-segments of the number of tap shoes mounted on the opposing side of the tap shoes facing the inner ring.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a bottom frame 2 in a nacelle (not shown) on a wind turbine (not shown), where the main shaft 4 of the turbine, with a gear box 6 and a rotor 8, and where the main shaft fixture 10 according to the invention is shown in the mounted state, bearing a lightweight crane 12 and a self-hoisting crane 14 with a ground-based winch (not shown), respectively. The bottom frame 2 has for reasons of clarity been made transparent.

In the illustrated embodiment, the main shaft fixture 10 is anchored to the bottom frame 2 near the gear box 6 and near the rotor 8, and comprises a multi-part frame 14, which

US 10,378,518 B2

5

together with a cross member 16 fastened on it encloses a part of the main shaft 4 between the rotor 8 and the gear box 6. The multi-part frame 14 is anchored on the bottom frame 2.

FIG. 2 shows what is seen in FIG. 1, but in an end view, seen from the rotor side of the shaft 4, and where the rotor 8 for reasons of clarity has been made transparent. As it appears from FIG. 2, the multi-part frame 14 and cross member 16 comprise in total four pressure mandrels 18 symmetrically placed around the main shaft 2, with tap shoes 20 that are engaged onto the main shaft 4 in order to fix it in place.

The pressure mandrels 18 may be comprised of hydraulically driven pistons whose free ends comprise the tap shoes 20, but may also be executed in other manners, where they are moved manually between the active position where the tap shoes 20 are engaged with the main shaft 4 and the passive, withdrawn position.

As it appears from FIG. 3, the main shaft fixture 10 comprises two parallel passing first beams 22, one on each side of the main shaft 4. In first ends of each first beam 22 nearest to the rotor 8, a rotor lock is fastened in the form of a flange element 24, the hole circle geometry 26 of which is similar to the hole circle geometry 28 of the rotor 8 over part of the periphery of the rotor. For locking of the rotor 8, the holes 7 in the rotor 8 and the holes 9 in the flange element 24 are brought to overlap, and subsequently, bolts are inserted through the overlapping holes, which are tightened with nuts, after which the rotor 8 is fixed/locked by the flange element 24.

The other end of the parallel passing first beams 22 (that nearest to the gear box 6) are pivotally anchored on horizontally oriented bearing bolt 30, on a bracket 32, which is fastened to the bottom frame 2. The parallel passing first beams 22 are mutually connected with second cross members 34, on which bracket facilities 23 are seen for a self-hoisting crane 14 with a ground-based winch (not shown).

As it appears in FIGS. 1 & 3, an actuator 36 is located between the bottom frame 2 and the parallel passing first beams 22. Activation of the actuator 36 will result in a change of the distance between the bottom frame 2 and the first beams 22, in which the flange element 24 is suspended, which will cause the flange element 24 and the rotor 8 and thereby the main shaft 4 to be raised, which will result in the possibility to replace the main shaft's bearing 38 without the necessity of hoisting the main shaft 4 down to the ground, which is quite time-saving when the main shaft bearing 38 has to be repaired or replaced.

In FIG. 1, it is moreover shown how the main shaft fixture 10 comprises mounting facilities 40 for the lightweight crane 12.

FIG. 4 shows an embodiment of the main shaft fixture according to the invention, which is specially suited for use for fixing the wind turbine main shaft 4 in position on the nacelle, but where rotation of the main shaft 4 is possible, in the active position of the pressure mandrels/tap shoes (18, 20), engaged with the main shaft.

As shown in FIG. 4, a slideway 42, 44 is located between the opposing sides of the tap shoes 20 facing the surface of the main shaft 4.

The slideway may be comprised of slide plates 42 that are fastened to the opposing free ends of the tap shoes 20 facing the main shaft 4, which in their active advanced position are engaged with the main shaft 4, but which alternatively may comprise a multi-part slide plate 44 cooperative working with the main shaft 4, for mounting on the main shaft 4, said

6

multi-part slide plate 44 in its mounted state on the main shaft 4 cooperates with the tap shoes 20. It must be stated that the presence of the multi-part slide plate 44 on the main shaft 4 does not necessarily exclude the presence of the slide plates 42 and the tap shoes 20.

In a further embodiment, the main shaft fixture 10 is comprised of a multi-part needle bearing/roller bearing/ball bearing 46, formed of a multi-part inner ring 48 fastened on the main shaft as well as, a cooperating multi-part outer ring 50 formed of bowed sub-segments 52 equal to the number of tap shoes mounted on the opposing side of the tap shoes 20 facing the inner ring 48, which in the advanced position of the pressure mandrels form the outer ring 50 at a distance from the outer periphery of the multi-part inner ring 48, and where an appropriate number of needle rollers, rollers, or balls 54 (in the shown embodiment rollers 54) are arranged between the inner ring 48 and the outer ring 50, and where means (not shown) are present for retaining the needles/rollers or balls (54) in position between the inner ring 48 and outer ring 50.

The means mentioned for fastening of needle rollers/rollers/balls 54 may be formed of cooperating edge delimiters in opposing sides of the inner ring 48 and the outer ring 50, alternatively as a means for holding between which the needle rollers/rollers/balls 54 are fastened.

The presence of the slide plates 42, 44, alternatively the multi-part needle bearing, roller bearing, ball bearing 46, involves the main shaft 4 being permitted to rotate, simultaneously with it being fixed in its position during servicing of the wind turbine, which can serve a purpose namely for larger wind turbines.

The inventor has recognised that the main shaft fixture 10 can assume other embodiments than disclosed in the preceding and shown in the figures, however such do not change the inventive aspect that is comprised of specifying a main shaft fixture 10 of the given type that comprises adjustable pressure mandrels 18 with tap shoes 20, which causes the fixture 10 to be usable regardless of the geometry of the main shaft 4 on a wind turbine, and thus that such can be mounted without fixing the rotor 8 in place, and furthermore of combining the main shaft fixture with facilities 40 for mounting of a lightweight crane 12 and a self-hoisting crane 14 with a ground-based winch, respectively, as well as a rotor lock 24 and finally of furnishing the main shaft fixture 10 with actuators 36, enabling the main shaft 4 and the main shaft bearing 38 to be raised sufficiently from its bearing in the nacelle that it can be serviced or replaced.

The invention claimed is:

1. A main shaft fixture (10) for fixation of a main shaft (4) on a wind turbine during execution of installation and repair work on heavy parts of a wind turbine, where the fixture (10) is divided up into a number of sections for mounting on stable structural parts (2) in a nacelle in a wind turbine, including the bottom frame (2) of the nacelle, wherein the main shaft fixture (10) comprises at least three radially displaceable pressure mandrels (18), substantially symmetrical located around a centre axis (11) of the main shaft, first ends of said pressure mandrels (18) face the main shaft (4) and are furnished with a tap shoe (20), and wherein said pressure mandrels (18) are displaceable between a passive, withdrawn lockable position where the tap shoes (20) are configured to be located at a distance from the surface of the main shaft (4) and an advanced lockable position where the tap shoes (20) are configured to be engaged with the main shaft (4), further comprising a rotor lock (24) for fixation of the rotor (8) of the wind turbine, further comprising one of a multi-part needle bearing, roller bearing, or ball bearing

US 10,378,518 B2

7

(46) comprised of a multi-part inner ring (48) fastened to the main shaft (4), and a therewith cooperating multi-part outer ring (50) comprised of bowed sub-segments (52) corresponding to the number of tap shoes, mounted on the opposing side of the tap shoes (20) facing the inner ring (48), which in the advanced active position of the pressure mandrels form the outer ring (50) at a distance from the outer periphery of the multi-part inner ring (48), and where a plurality of needle rollers, rollers, or balls (54) are arranged between the inner ring (48) and the outer ring (50), and where means are present for retaining the needles, rollers, or balls (54) in position between the inner ring (48) and outer ring (50).

2. A main shaft fixture (10) for fixation of a main shaft (4) on a wind turbine during execution of installation and repair work on heavy parts of a wind turbine, where the fixture (10) is divided up into a number of sections for mounting on stable structural parts (2) in a nacelle in a wind turbine, including the bottom frame (2) of the nacelle, wherein the main shaft fixture (10) comprises at least three radially displaceable pressure mandrels (18), substantially symmetrical located around a centre axis (11) of the main shaft, first ends of said pressure mandrels (18) face the main shaft (4) and are furnished with a tap shoe (20), and wherein said pressure mandrels (18) are displaceable between a passive, withdrawn lockable position where the tap shoes (20) are configured to be located at a distance from the surface of the main shaft (4) and an advanced lockable position where the tap shoes (20) are configured to be engaged with the main shaft (4), further comprising a rotor lock (24) for fixation of the rotor (8) of the wind turbine, wherein the rotor lock (24) is comprised of a flange element, with a bolt circle geometry (26) that corresponds to a bolt circle geometry (28) on the rotor, said flange element (24) being fastened at the ends to a first end (21) of two first beam-shaped brackets (22) extending parallel with each other, and being located on each side of the main shaft, said beam shaped brackets (22)

8

forming part of the main shaft fixture, and where a second end (23) of the brackets (22) is pivotally mounted with horizontally oriented bolt connections (30) on other brackets (39) that form parts of the main shaft fixture (10) and which are anchored on the bottom frame (2) of the nacelle.

3. The main shaft fixture (10) according to claim 2, further comprising mounting facilities (40) for a lightweight crane (12).

4. The main shaft fixture (10) according to claim 2, wherein the pressure mandrels (18) are provided with actuators for displacing and retaining the tap shoes (20) in the passive position and the active position, respectively, alternatively in a selectable position between the passive and the active position.

5. The main shaft fixture (10) according to claim 2, wherein slide plates (42, 44) are located between the opposing sides of the surface of the main shaft and tap shoes.

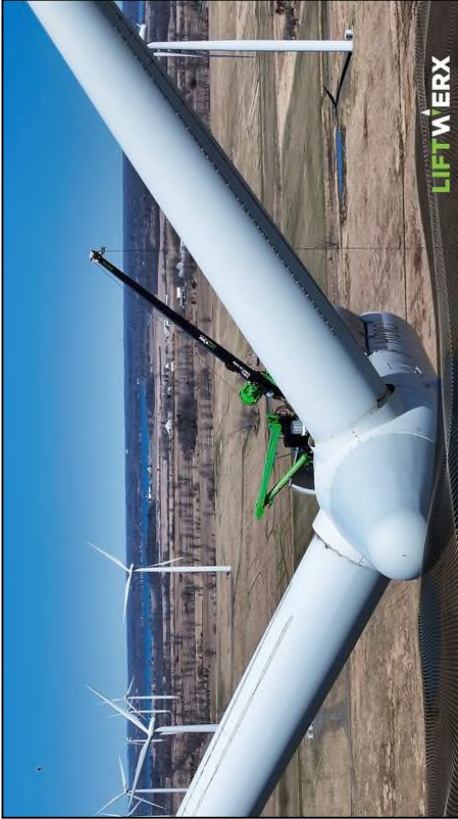
6. The main shaft fixture (10) according to claim 5, wherein the slide plates are configured so that the opposing free ends of the tap shoes (20) facing the main shaft (4) are provided with a one of the slide plates (42) which in the active advanced position is engaged with the main shaft (4).

7. The main shaft fixture (10) according to claim 5, wherein one of the slide plates is a multi-part slide plate (44) cooperating with the main shaft (4) for mounting on the main shaft (4), where the multi-part slide plate (44) in a mounted position on the main shaft (4) cooperates with the tap shoes (20).

8. The main shaft fixture (10) according to claim 2, wherein at least one actuator (36) is located nearest the rotor lock (24) between the bottom frame (2) of the nacelle and an adjacent side (25) of the first beam-shaped brackets (22) facing the bottom frame (2), and wherein said at least one actuator (36) is displaceable between a first passive outer position and an active outer position by which the flange element (24) is displaced vertically.

* * * * *

Exhibit B

U.S. Patent No. 10,378,518	Claim Language	Infringement Analysis
2(pre)	A main shaft fixture (10) for fixation of a main shaft (4) on a wind turbine during execution of installation and repair work on heavy parts of a wind turbine,	The Accused Product includes a main shaft fixture for fixation of a main shaft on a wind turbine during execution of installation and repair work on heavy parts of a wind turbine. LiftWerx describes a five-crane system: “RotorHook, GenHook, Heli-Hook. The RotorHook crane is part of a five-crane system. It is assembled by a GenHook crane, which itself is assembled by a Heli-Hook crane, which is assembled by two small service cranes. All of these cranes comprise a complex crane system which is now in use by our sister company LiftWerx in North America. You could compare the assembly of the RotorHook with a Russian matryoshka, a doll inside a doll inside a doll.” https://eager.one/the-rotorhook-has-arrived/#:~:text=All%20of%20these%20cranes%20comprise%20a%20complex,doll%20inside%20a%20doll%20inside%20a%20doll. WO2021168549A1, titled “Multiple up-tower lifting appliances on wind turbines” describes this same multi-crane system.  LiftWerx HeliHook. https://www.linkedin.com/posts/liftwerx-solutions-inc-_heres-a-glimpse-of-our-heli-hook-crane-activity-7320041987150135297-qtOw

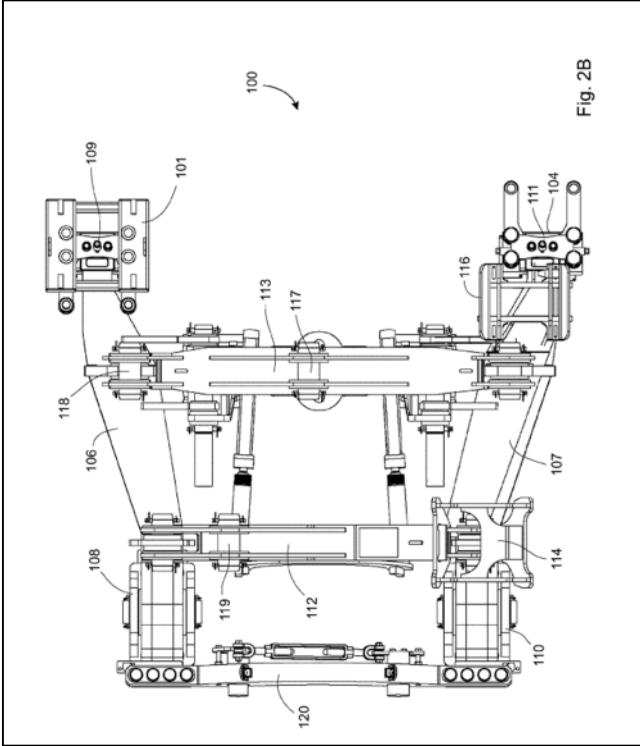


LiftWerx GenHook <https://liftwerx.com/news/the-genhook-is-launched/>

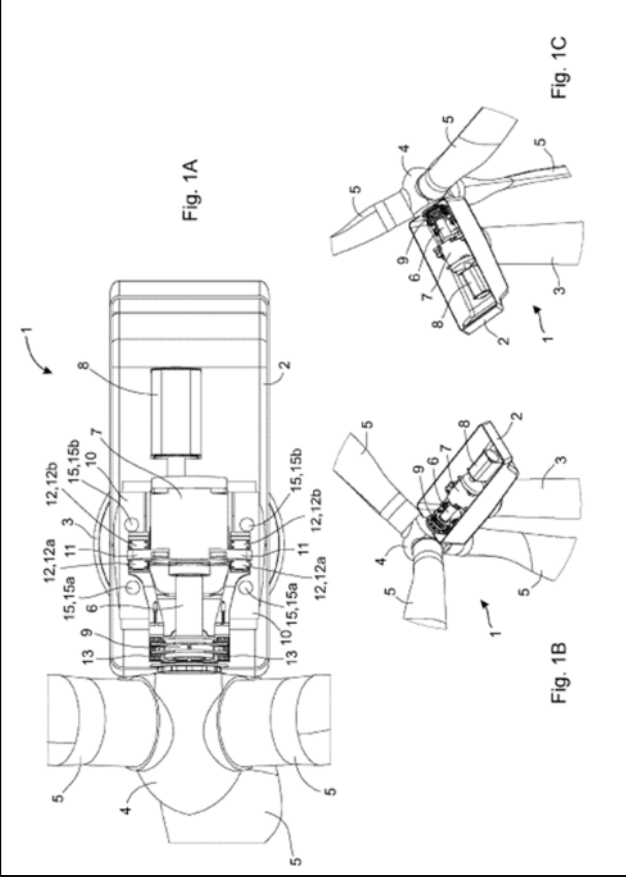


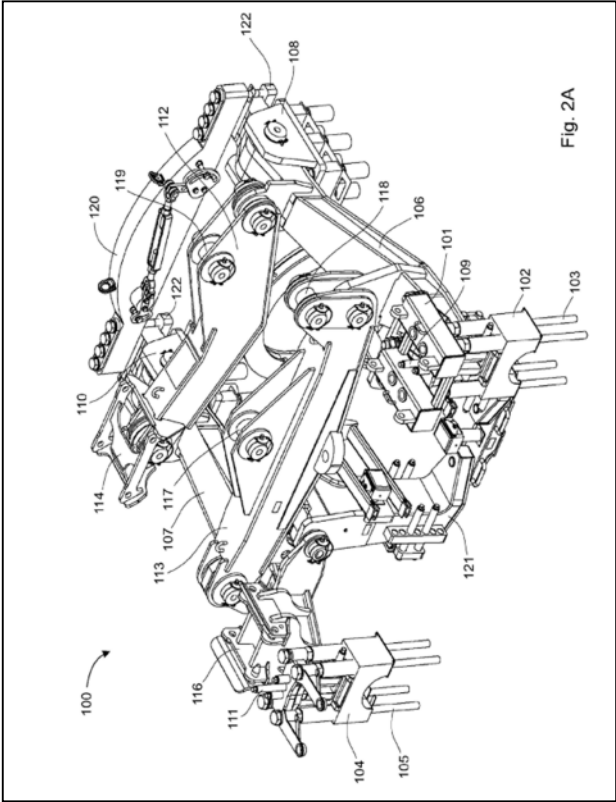
LiftWerx RotorHook <https://liftwerx.com/our-cranes/>

See also [WO2021168549A1](#), at abstract (“The first and second lifting appliances share one or both of the main bearing housing securements and the gearbox pillow blocks. The system permits having multiple lifting appliances mounted at the same in the restricted space of the nacelle.”; at 2[0015] (“The lift system is therefore capable of being used for a variety of different lifting tasks from the nacelle of the wind turbine, including but not limited to installation, removal and repair of wind turbine components such as the main bearing, the main shaft, the gearbox, the generator, the yaw drives and the rotor blades.”).

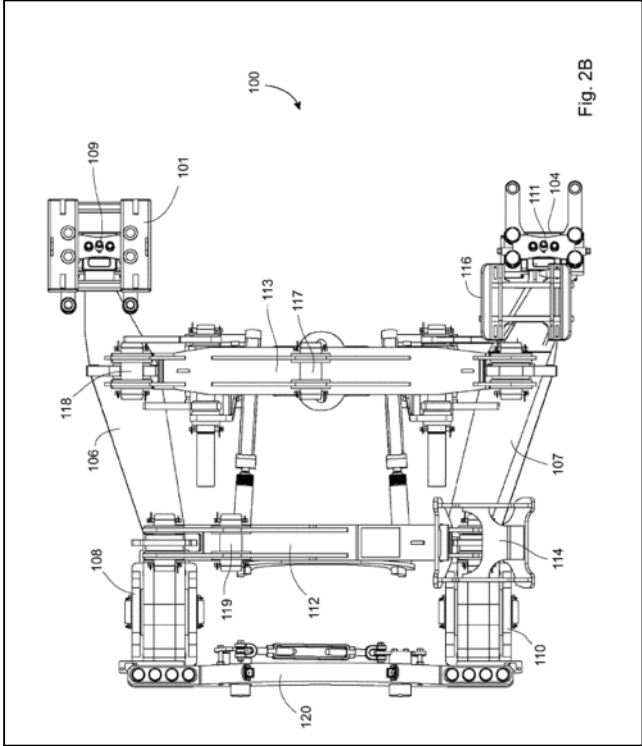
	U.S. Patent No. 10,378,518 Claim Language	Infringement Analysis
		The Accused Products include a “rotor lock 120 and a main shaft clamp 121 for preventing rotational and translational movement of the main shaft during an installation or repair procedure of a wind turbine component.” WO2021168549A1 at 9:3-5. WO2021168549A1 Fig. 2B, 8:16-23 (“The lifting appliance support base 100 further comprises a front transverse beam 112 and a rear transverse beam 113. The front transverse beam 112 rests on top of and straddles the first and second longitudinal beams 106, 107, respectively, at a location to the rear of the first and second main bearing supports 108, 110, respectively. The rear transverse beam 113 rests on top of and straddles the first and second longitudinal beams 106, 107, respectively, at a location forward of the first and second pillow block bridges 102, 104, respectively. A hydraulic power unit 114 to permit mounting of a hydraulic power unit to operate the lifting appliances is mounted on the second longitudinal beam 107 forward of the front transverse beam 112 and over the second main bearing support 110.”).  WO2021168549A1 Fig. 2B

	U.S. Patent No. 10,378,518 Claim Language	Infringement Analysis
2(a)	where the fixture (10) is divided up into a number of sections for mounting on stable structural parts (2) in a nacelle in a wind turbine, including the bottom frame (2) of the nacelle,	The Accused Product include a “number of sections” for mounting on stable structure parts in a nacelle in a wind turbine, including the bottom frame of the nacelle. WO2021168549A1 at 6:29-7:5 (“Inside the nacelle 2, the main bearing 9 and the gearbox 7 are supported on a bedplate 10. Torque arms 11 connected to the gearbox 7 and the bedplate 10 at the right and left sides of the gearbox 7 stabilize the gearbox 7 against twisting forces. The torque arms 7 are reinforced by gearbox pillow blocks 12 attached to the bedplate 10 in front of and behind the torque arms 7. The gearbox pillow blocks 12 comprise forward gearbox pillow blocks 12a and rearward gearbox pillow blocks 12b. The main bearing 9 is housed in a main bearing housing secured to the bedplate 10 by main bearing housing securements 13 at the right and left sides of the main bearing 9. The bedplate 10 further comprises lifting lugs 14 attached to the right and left sides of the bedplate 10. The nacelle 2 is rotatable atop the tower 3 by virtue of yaw drives (not shown) seated in yaw drive pockets 15 in the bedplate 10. The yaw drive pockets 15 comprise forward yaw drive pockets 15a and rearward yaw drive pockets 15b.”).

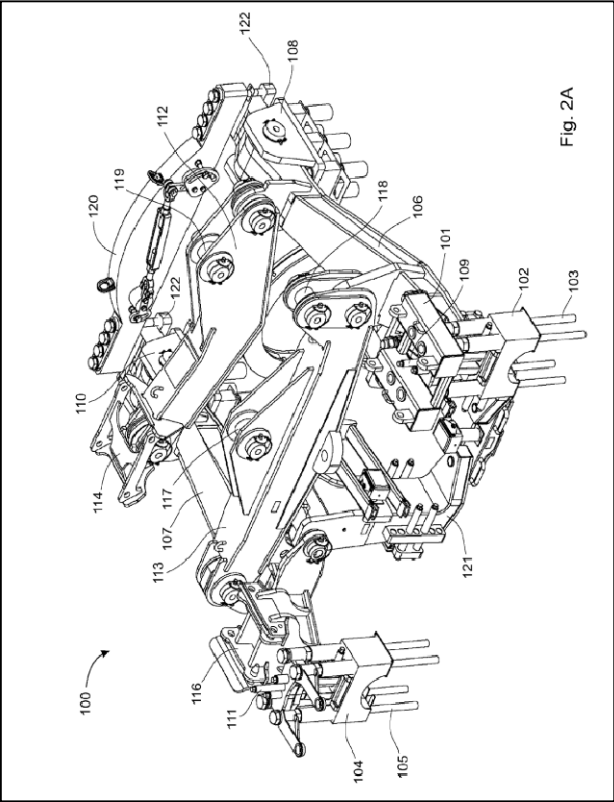
	U.S. Patent No. 10,378,518	Infringement Analysis
	Claim Language	 WO2021168549A1 Fig. 1C
2(b)	wherein the main shaft fixture (10) comprises at least three radially displaceable pressure mandrels (18), substantially symmetrical located around a centre axis (11) of the main shaft,	The Accused Products include at least three radially displaceable mandrels substantially symmetrical located around a centre axis of the main shaft. See, e.g., WO2021168549A1 at 9:3-5 (“rotor lock 120 and a main shaft clamp 121 for preventing rotational and translational movement of the main shaft during an installation or repair procedure of a wind turbine component”).

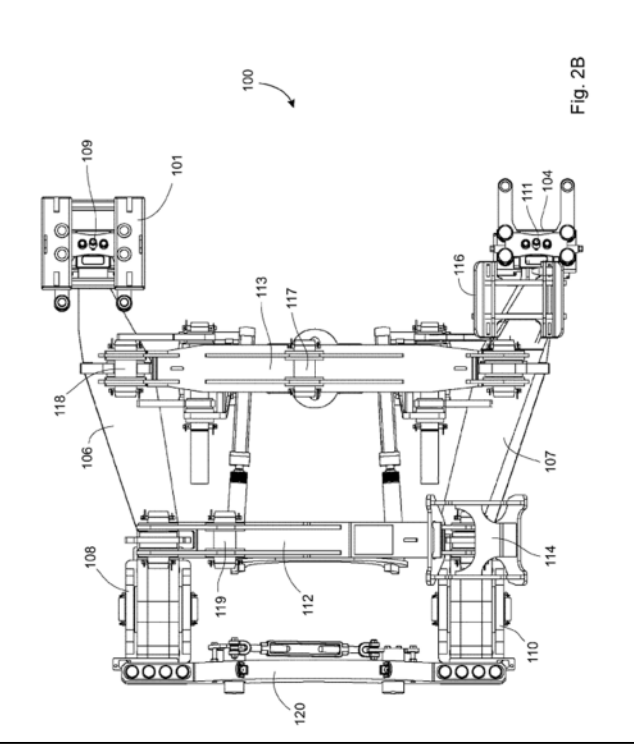


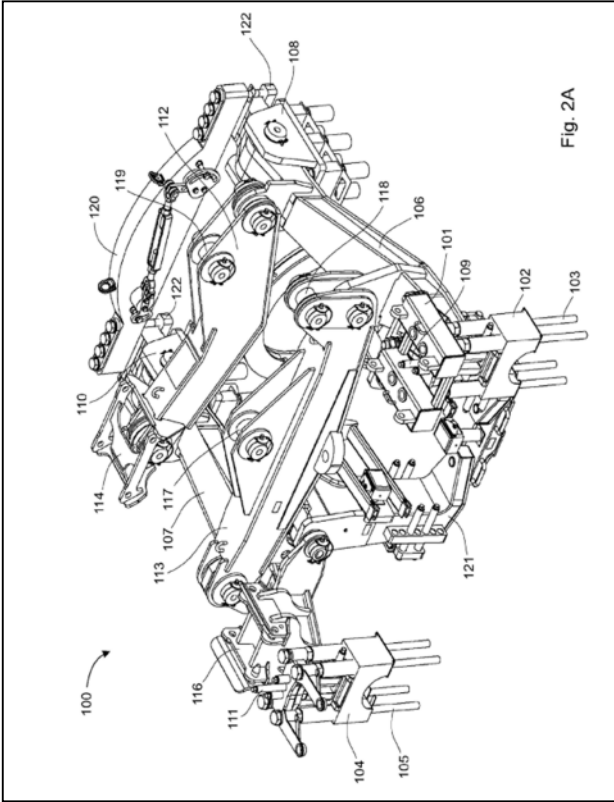
WO2021168549A1 Fig. 2A



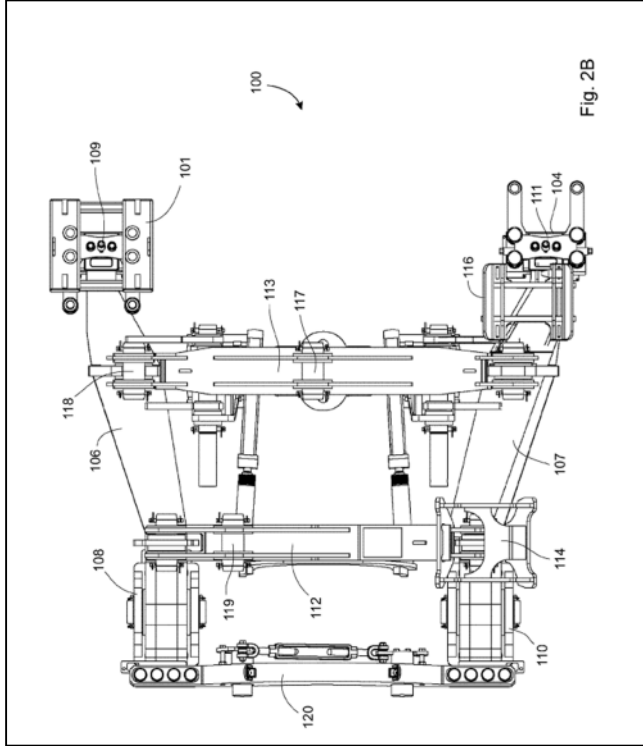
WO2021168549A1 Fig. 2B

	U.S. Patent No. 10,378,518 Claim Language	Infringement Analysis
2(c)	first ends of said pressure mandrels (18) face the main shaft (4) and are furnished with a tap shoe (20),	In the Accused Products, the first ends of said pressure mandrels face the main shaft and are furnished with a tap shoe. See WO2021168549A1 at Fig. 2A and 2B (item 121 is the “main shaft clamp”).  WO2021168549A1 Fig. 2A

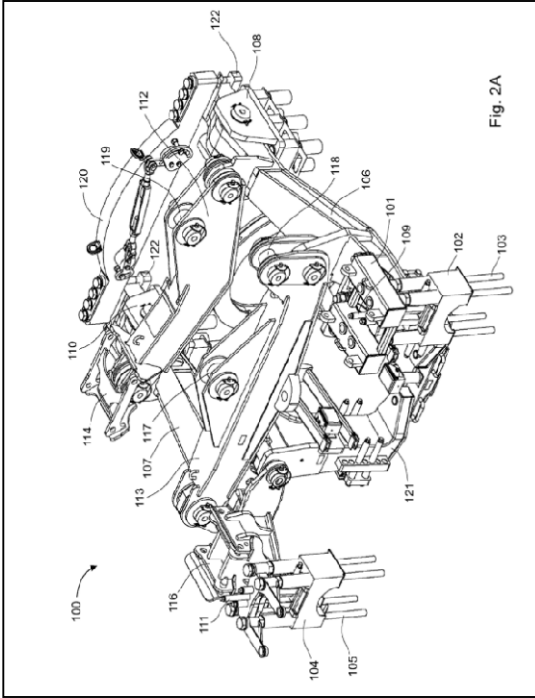
U.S. Patent No. 10,378,518 Claim Language	Infringement Analysis
	 WO2021168549A1 Fig. 2B
2(d) and wherein said pressure mandrels (18) are displaceable between a passive, withdrawn lockable position where the tap shoes (20) are configured to be located at a distance from the surface of the main shaft (4) and an advanced lockable position where the tap shoes (20) are configured to be engaged with the main shaft (4),	The Accused Products include pressure mandrels displaceable between a passive and withdrawn lockable position where the tap shoes are configured to be located at a distance from the surface of the main shaft and an advanced lockable position where the tap shoes are configured to be engaged with the main shaft. as components of the <i>See, e.g.</i>, WO2021168549A1 at 9:3-5, Figs. 2A and 2B (“rotor lock 120 and a main shaft clamp 121 for preventing rotational and translational movement of the main shaft during an installation or repair procedure of a wind turbine component.”).



WO2021168549A1 Fig. 2A



WO2021168549A1 Fig. 2B

	U.S. Patent No. 10,378,518 Claim Language	Infringement Analysis
2(e)	further comprising a rotor lock (24) for fixation of the rotor (8) of the wind turbine,	The Accused Products include a rotor lock for fixation of the rotor of the wind turbine. See, e.g., WO2021168549A1 at 9:3-5, Figs. 2A and 2B (“rotor lock 120 and a main shaft clamp 121 for preventing rotational and translational movement of the main shaft during an installation or repair procedure of a wind turbine component”). “The rotor lock 120 is mounted at the front ends of the longitudinal beams 106, 107 using clamps 122, and the main shaft clamp 121 is mounted proximate rear ends of the longitudinal beams 106, 107 using pinned connections.” <i>Id.</i> at 9:25-28.  Fig. 2A WO2021168549 Fig. 2A

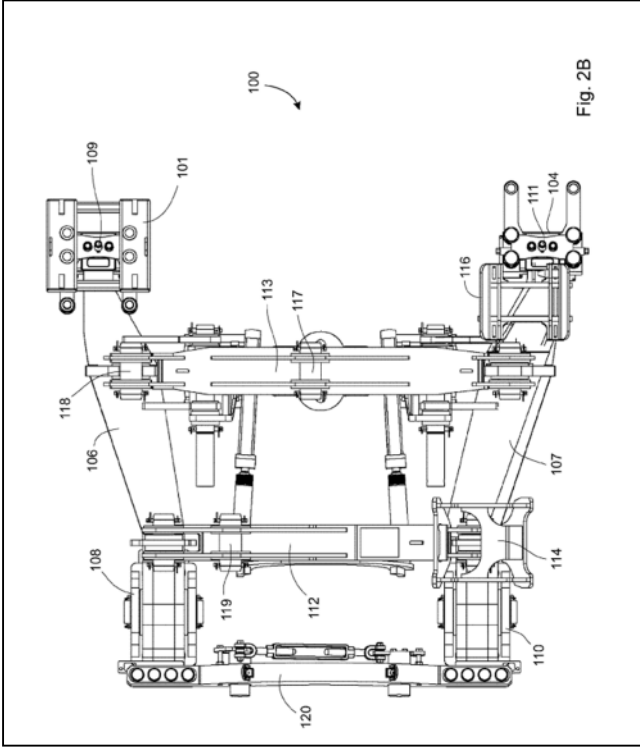


Fig. 2B

WO2021168549A1 Fig. 2B

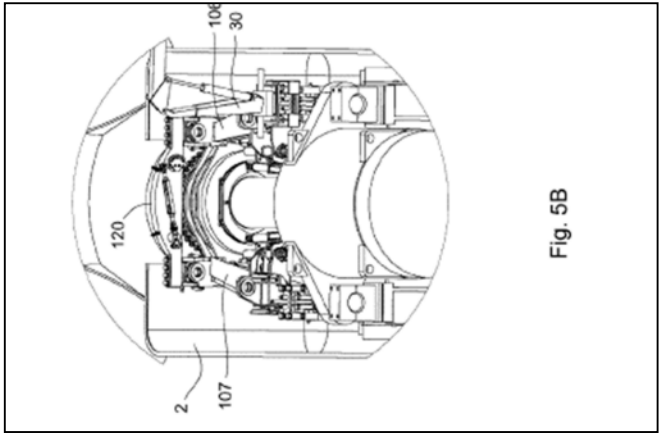
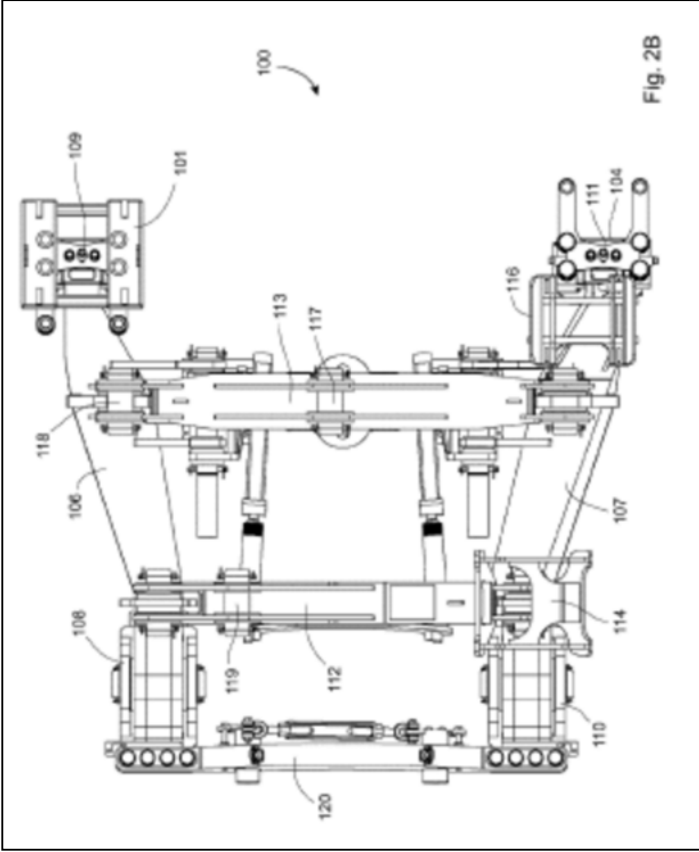
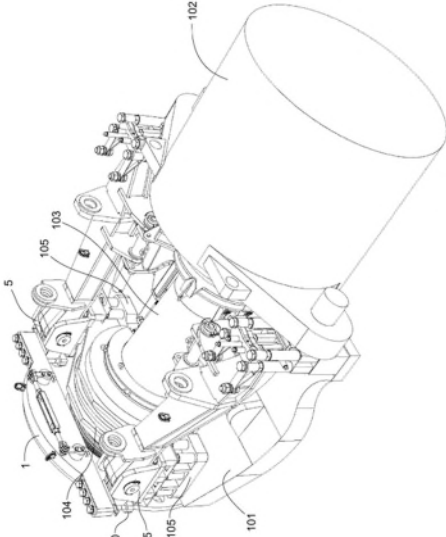
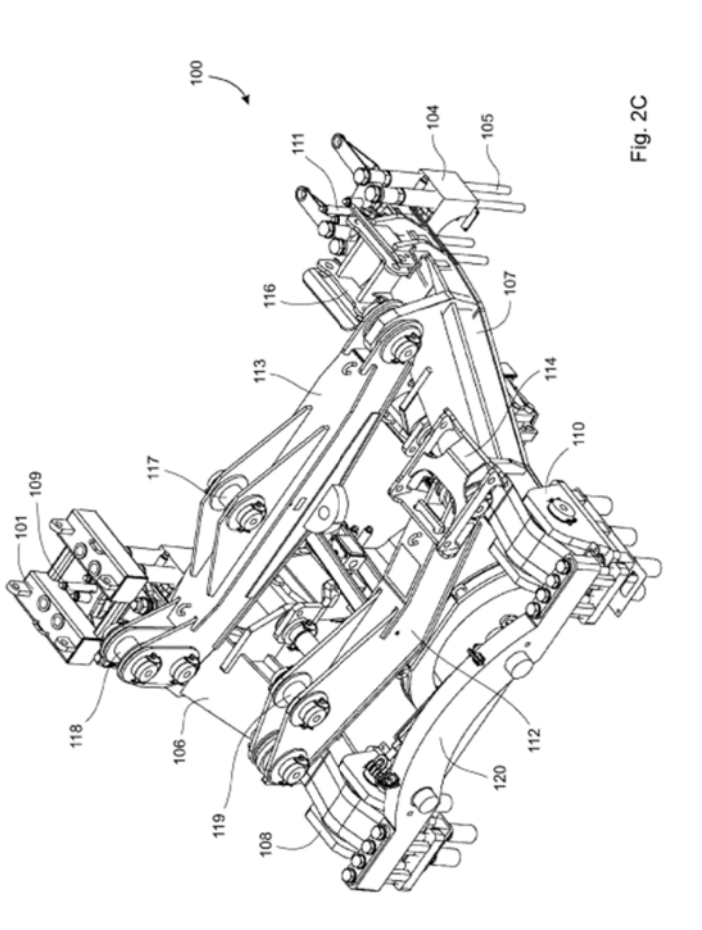


Fig. 5B

WO2021168549 Fig. 5B

	U.S. Patent No. 10,378,518 Claim Language	Infringement Analysis
2(f)	wherein the rotor lock (24) is comprised of a flange element, with a bolt circle geometry (26) that corresponds to a bolt circle geometry (28) on the rotor,	 1WO2021168549A1 Fig. 2B The rotor lock of the Accused Products is comprised of a flange element, with a bolt circle geometry, that corresponds to a bolt circle geometry on the rotor. See, e.g., Figs. 2B and 2C of WO2021168549A1 and LiftWerx's European Patent EP3824180B1 "Rotor lock for wind turbine." EP '180 at [0017] "Referring to Fig. 1, a nacelle of a wind turbine houses a bed plate 101, a gear box 102, a main rotor shaft 103, a main bearing 104, main bearing supports 105 and a rotor hub flange 106 having a plurality of rotor lock apertures 107 (only one labeled), as is known in the prior art." "Fig. 2 depicts a rear perspective view of the

	U.S. Patent No. 10,378,518 Claim Language	Infringement Analysis
		nacelle of Fig. 1 further showing a rotor lock of the present invention supported on the main bearing supports;” EP 3 824 180 B1  Fig. 2 EP '180 Fig. 2

	U.S. Patent No. 10,378,518 Claim Language	Infringement Analysis
2(h)	and where a second end (23) of the brackets (22) is pivotally mounted with horizontally oriented bolt connections (30) on other brackets (39) that form parts of the main shaft fixture (10) and which are anchored on the bottom frame (2) of the nacelle.	 WO2021168549A1 Fig. 2C In the Accused Products, the second end of the brackets is pivotally mounted with horizontally oriented bolt connections on other brackets that form parts of the main shaft fixture. See, e.g., WO2021168549A1 at 8:16-23 (“The lifting appliance support base 100 further comprises a front transverse beam 112 and a rear transverse beam 113. The front transverse beam 112 rests on top of and straddles the first and second longitudinal beams 106, 107, respectively, at a location to the rear of the first and second main bearing supports 108, 110, respectively. The rear transverse beam 113 rests on top of and straddles the first and second

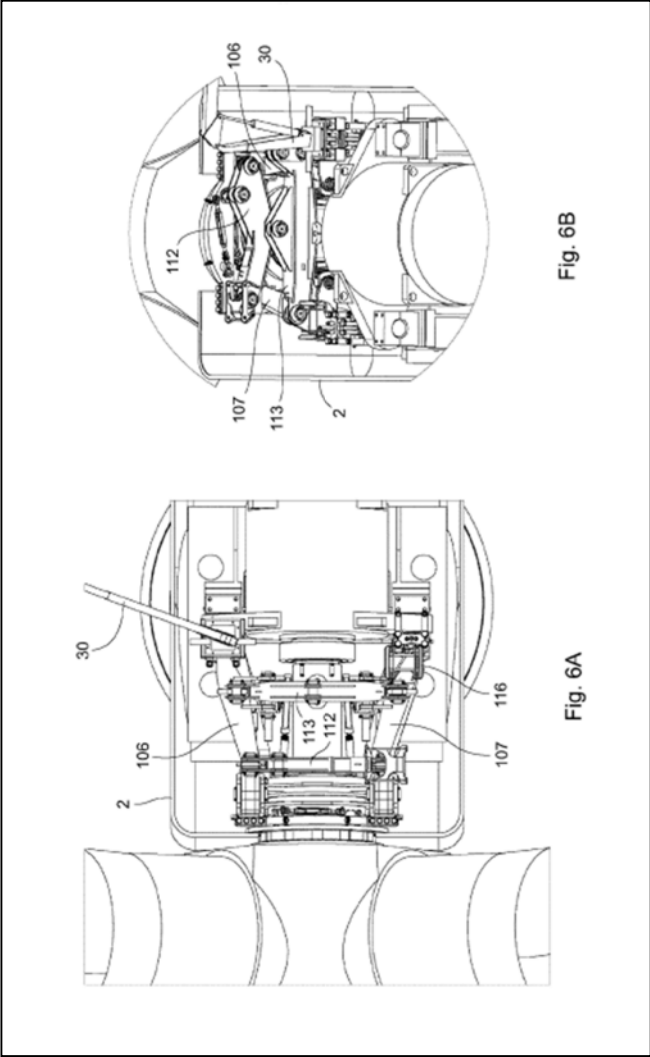
	U.S. Patent No. 10,378,518 Claim Language	Infringement Analysis
		longitudinal beams 106, 107, respectively, at a location forward of the first and second pillow block bridges 102, 104, respectively.”).  Fig. 6A Fig. 6B WO2021168549A1 Figs. 6A and 6B

Exhibit C

(12) **United States Patent**
Fenger

(10) **Patent No.:** **US 12,104,578 B2**
(45) **Date of Patent:** **Oct. 1, 2024**

(54) **MAIN SHAFT FIXTURE**

(71) Applicant: **LIFTRA IP APS**, Aalborg (DK)

(72) Inventor: **Per E. Fenger**, Terndurp (DK)

(73) Assignee: **LIFTRA IP APS**, Aalborg (DK)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **18/420,859**

(22) Filed: **Jan. 24, 2024**

(65) **Prior Publication Data**
US 2024/0209842 A1 Jun. 27, 2024

Related U.S. Application Data

(60) Continuation of application No. 16/452,617, filed on Jun. 26, 2019, now abandoned, which is a division of (Continued)

(30) **Foreign Application Priority Data**
Oct. 7, 2014 (DK) PA 2014 00573
Sep. 4, 2015 (DK) PA 2015 00527

(51) **Int. Cl.**
F03D 80/50 (2016.01)
B23B 31/10 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **F03D 80/50** (2016.05); **B23B 31/101** (2013.01); **F03D 13/10** (2016.05); **F03D 13/139** (2023.08);
(Continued)

(58) **Field of Classification Search**
CPC F03D 80/50; F03D 80/70; F03D 13/10; F03D 13/139; B23B 31/101; B23B 31/16;
(Continued)

(56) **References Cited**
U.S. PATENT DOCUMENTS
1,152,271 A 8/1915 Bisbee
1,853,255 A 4/1932 Borden
(Continued)
FOREIGN PATENT DOCUMENTS
DE 102006013539 A1 9/2007
EP 1101934 A2 5/2001
(Continued)
Primary Examiner — Stephen A Vu
(74) *Attorney, Agent, or Firm* — Bookoff McAndrews, PLLC

(57) **ABSTRACT**
A main shaft fixture for fixing a main shaft on a wind turbine during installation and repair work on heavy parts of the wind turbine nacelle, in the case where the fixture is formed of several sections for mounting on stable structural parts in the nacelle, including the nacelle's bottom frame. The main shaft fixture has adjustable pressure mandrels with tap shoes, which cause the fixture to be usable regardless of the turbine main shaft geometry, such that it can be mounted without fixing the rotor. The main shaft fixture also has facilities for mounting of a lightweight crane and a self-hoisting crane with a ground-based winch, respectively, as well as a rotor lock which, in combination with actuators of the main shaft fixture, enables the main shaft and the main shaft bearing to be sufficiently displaced vertically from its bearing in the nacelle to service or replace the bearing.

17 Claims, 5 Drawing Sheets

A detailed technical drawing of a main shaft fixture for a wind turbine nacelle. The drawing shows a complex mechanical assembly with various components labeled with numbers. A crane arm is mounted on top of the fixture, and a large gear or pulley is visible on the side. The fixture is designed to hold and adjust a main shaft within the nacelle.

[Page 62 of 113]

Liftra 2004
LiftWerx v Liftra
IPR2026-00102

US 12,104,578 B2

Page 2

Related U.S. Application Data

application No. 15/517,288, filed as application No. PCT/DK2015/000040 on Oct. 6, 2015, now Pat. No. 10,378,518.

Y10T 279/1291; Y10T 279/1986; Y02E 10/72

See application file for complete search history.

(56)

References Cited

U.S. PATENT DOCUMENTS

(51) **Int. Cl.**

F03D 13/10 (2016.01)
B23B 31/16 (2006.01)
F03D 80/70 (2016.01)
F16C 35/06 (2006.01)

(52) **U.S. Cl.**

CPC *B23B 31/16* (2013.01); *F03D 80/70* (2016.05); *F05B 2230/60* (2013.01); *F05B 2230/61* (2013.01); *F05B 2230/80* (2013.01); *F05B 2240/60* (2013.01); *F05B 2260/30* (2013.01); *F05B 2260/31* (2020.08); *F16C 35/062* (2013.01); *F16C 2360/31* (2013.01); *Y02P 70/50* (2015.11); *Y10T 279/1274* (2015.01); *Y10T 279/1291* (2015.01); *Y10T 279/1986* (2015.01)

(58) **Field of Classification Search**

CPC F05B 2230/60; F05B 2230/61; F05B 2230/80; F05B 2240/60; F05B 2260/30; F05B 2260/31; F16C 35/062; F16C 2360/31; Y02P 70/50; Y10T 279/1274;

3,494,230	A	2/1970	Gast, Jr.	
4,623,157	A	11/1986	Rohs	
4,631,995	A	12/1986	Vroenen	
5,015,003	A	5/1991	Ramunas	
7,759,815	B2	7/2010	Christensen	
10,378,518	B2 *	8/2019	Fenger	 F03D 13/10
10,502,195	B2	12/2019	Thomas et al.	
2002/0092395	A1	7/2002	Emilian	
2010/0021278	A1	1/2010	Stegemann et al.	
2010/0139069	A1	6/2010	Daniels et al.	
2012/0141292	A1	6/2012	Signore et al.	
2012/0217089	A1	8/2012	Fenger	
2018/0313330	A1	11/2018	Vanderwalker et al.	
2019/0017552	A1	1/2019	Vanderwalker et al.	

FOREIGN PATENT DOCUMENTS

EP	1617075	A1	1/2006
EP	1748182	A2	1/2007
JP	S6154846	A	3/1986
WO	2014103018	A1	7/2014

* cited by examiner

U.S. Patent

Oct. 1, 2024

Sheet 1 of 5

US 12,104,578 B2

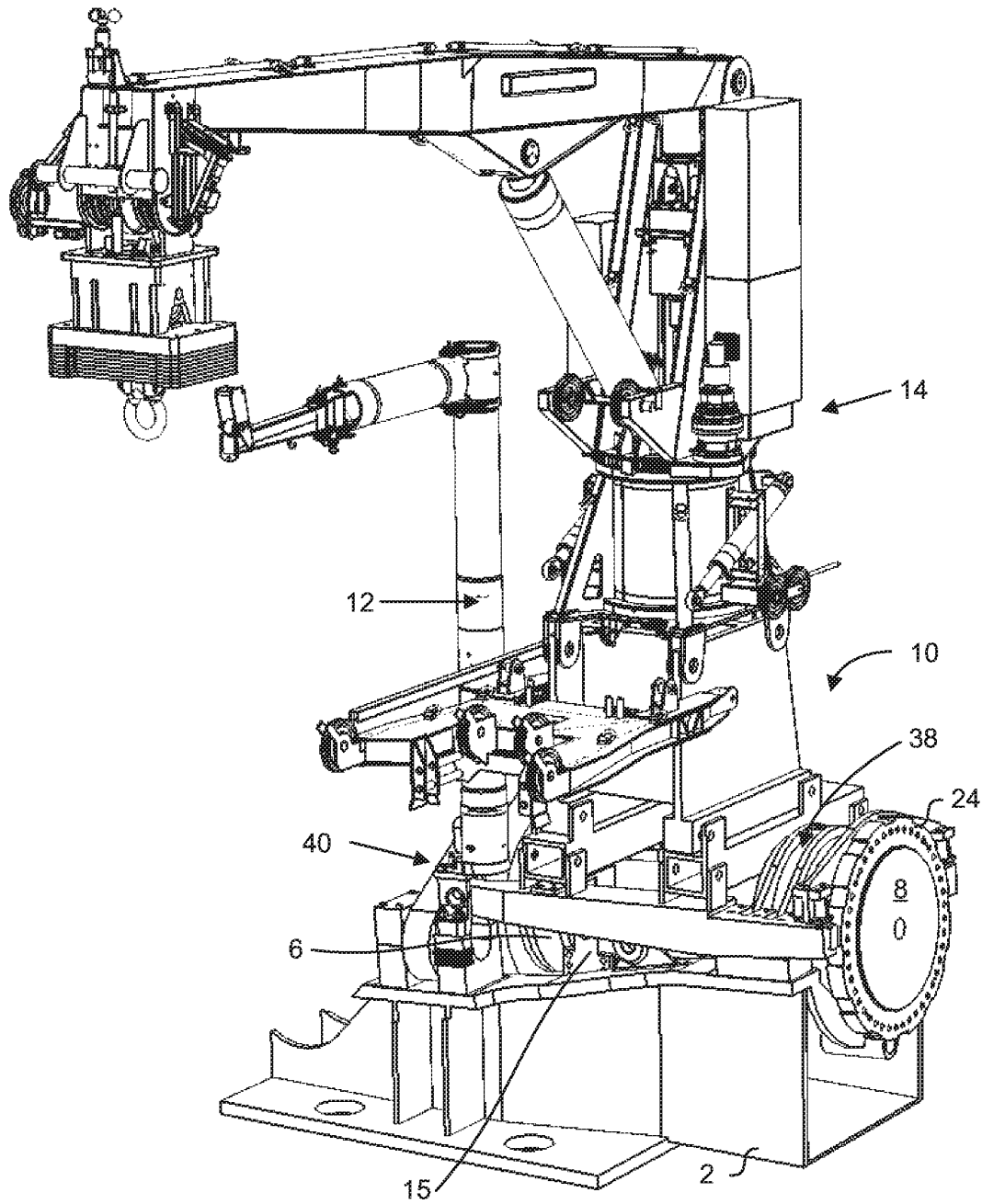


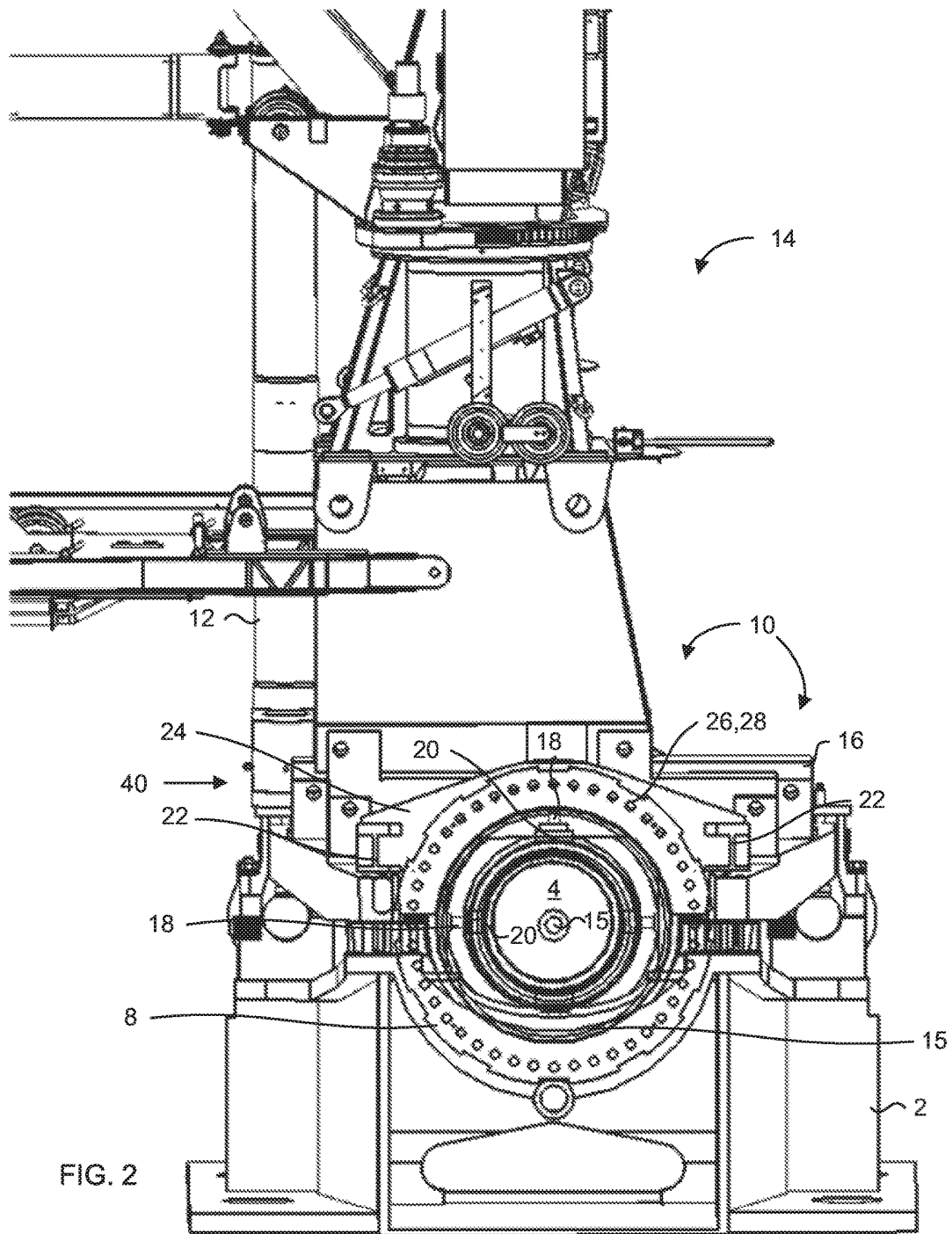
FIG. 1

U.S. Patent

Oct. 1, 2024

Sheet 2 of 5

US 12,104,578 B2

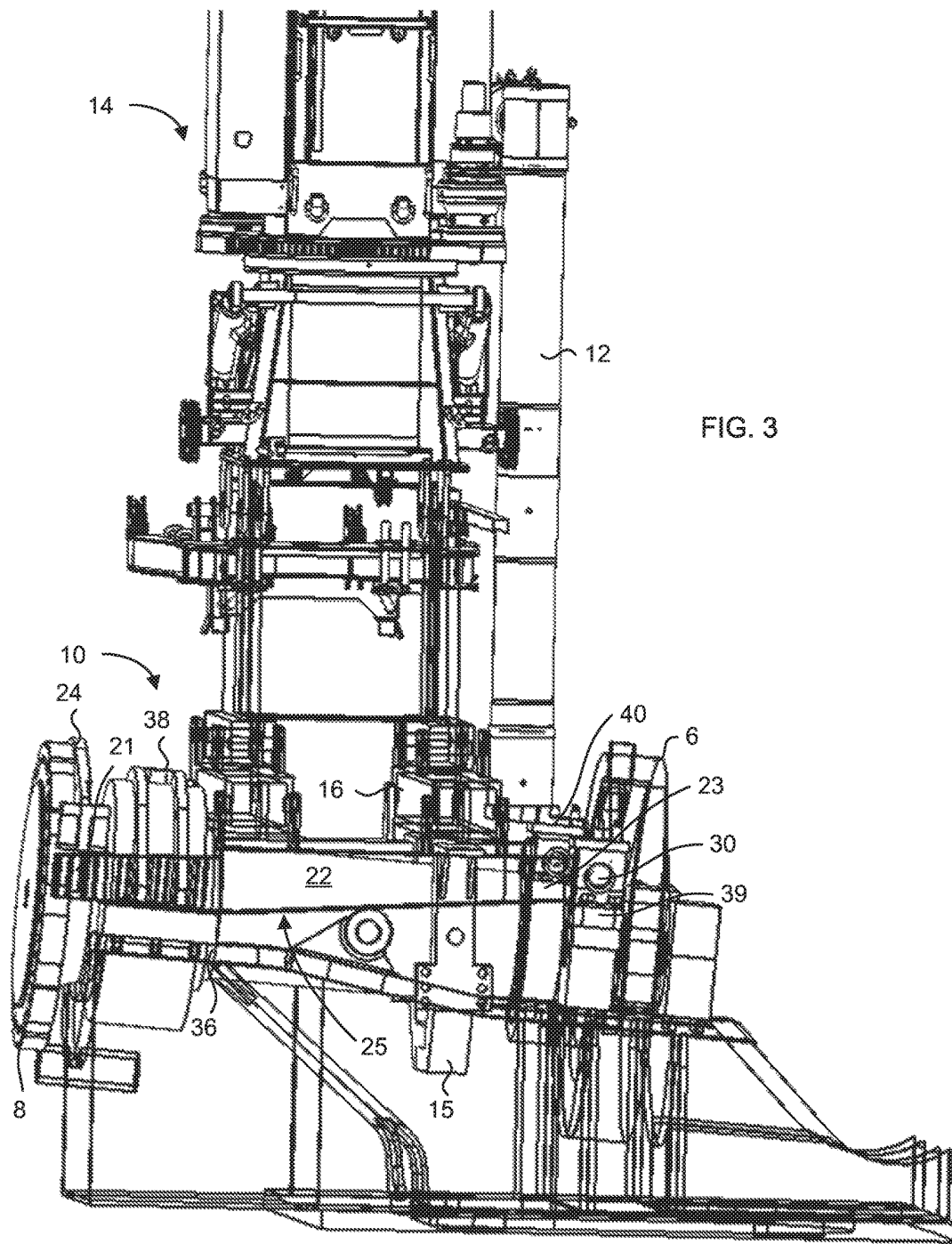


U.S. Patent

Oct. 1, 2024

Sheet 3 of 5

US 12,104,578 B2



U.S. Patent

Oct. 1, 2024

Sheet 4 of 5

US 12,104,578 B2

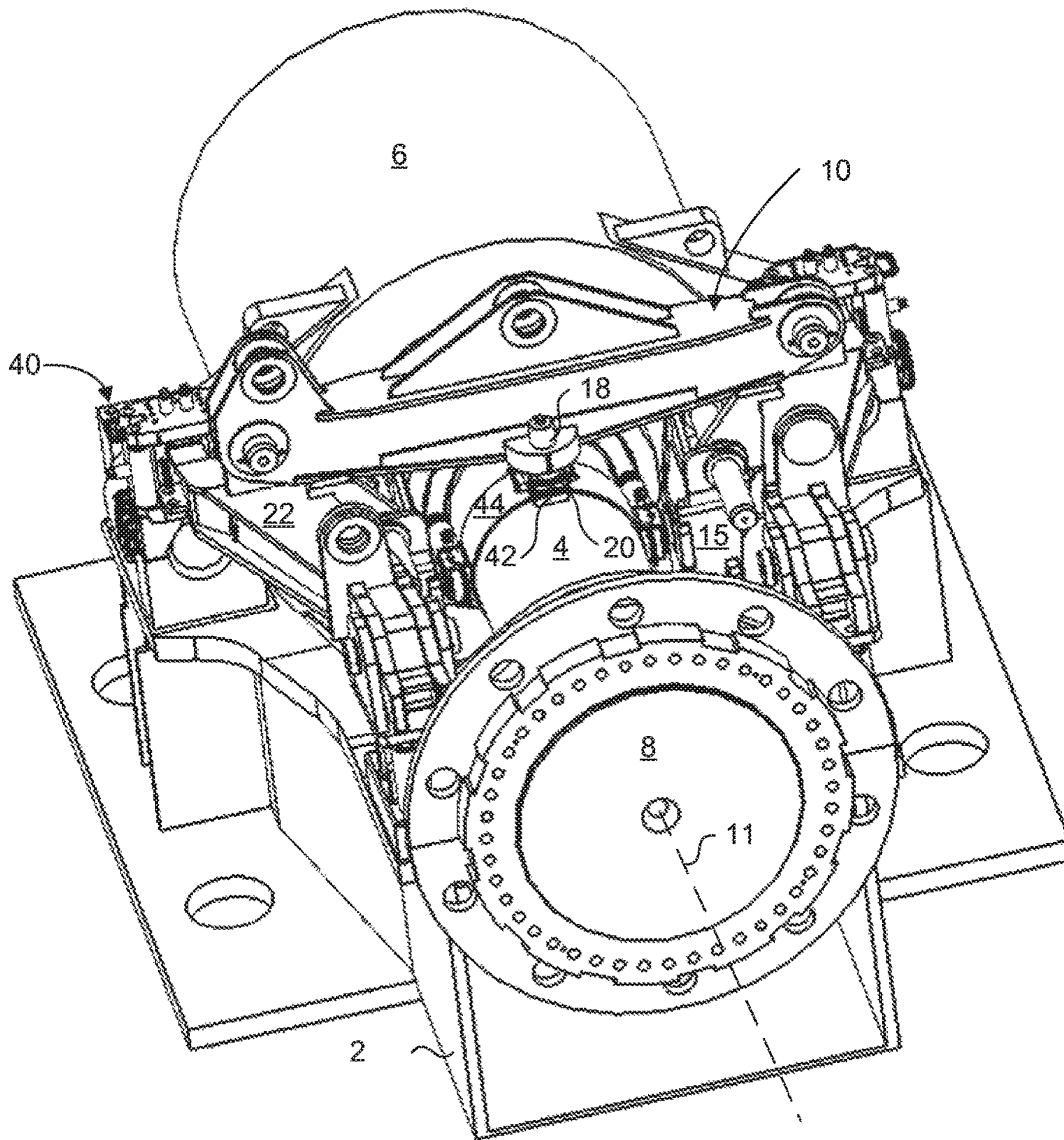


FIG. 4

U.S. Patent

Oct. 1, 2024

Sheet 5 of 5

US 12,104,578 B2

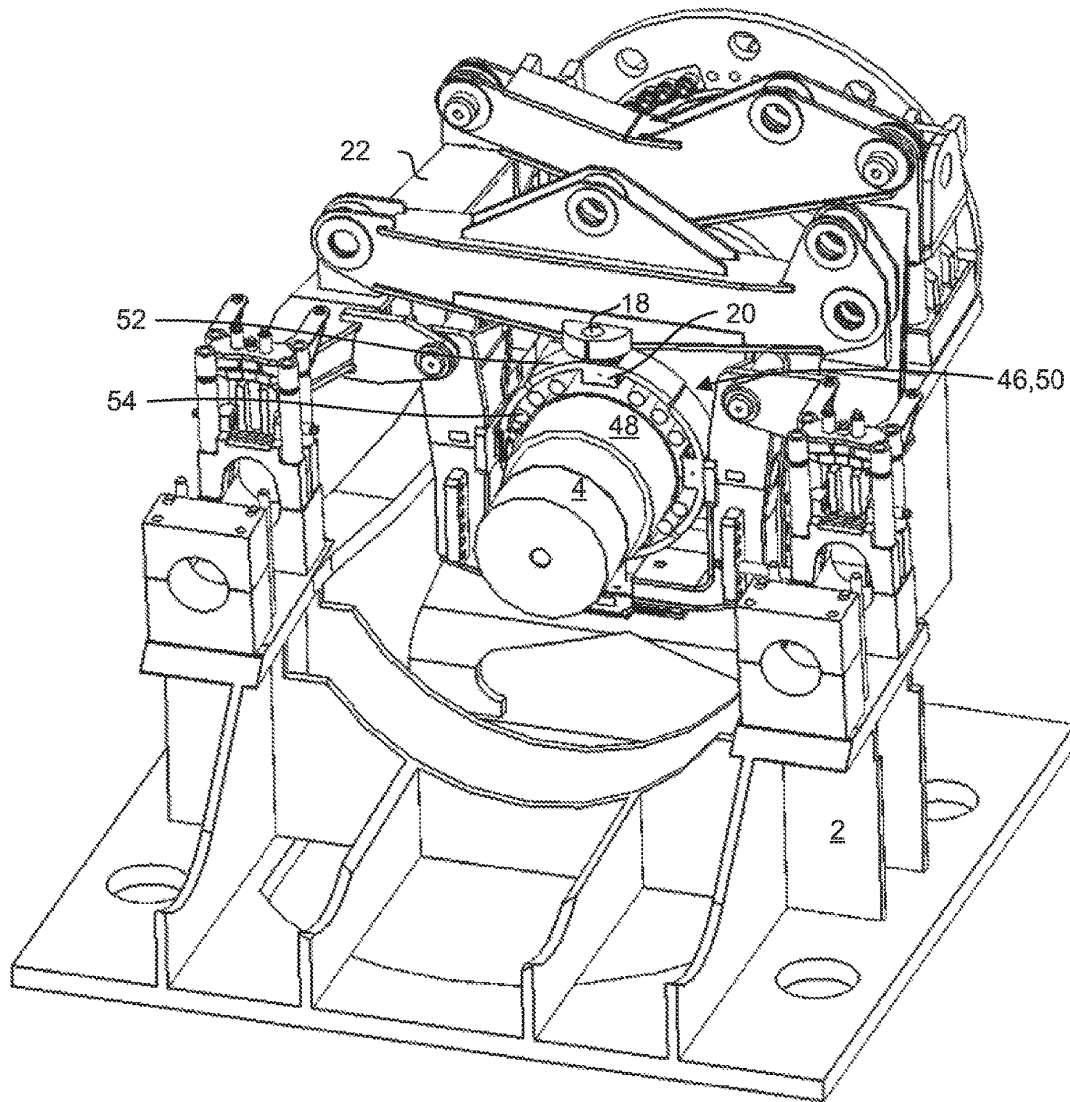


FIG. 5

US 12,104,578 B2

1

MAIN SHAFT FIXTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Continuation of U.S. application Ser. No. 16/452,617, filed Jun. 26, 2019, which is a Divisional of U.S. patent application Ser. No. 15/517,288 filed Apr. 6, 2017, which is a 371 of International Patent Application No. PCT/DK2015/000040 filed Oct. 6, 2015, which claims the benefit of priority to Denmark Patent Application No. PA 2015 00527 filed Sep. 4, 2015, and to Denmark Patent Application No. PA 2014 00573 filed Oct. 7, 2014, the contents of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a main shaft fixture for the fixing of a main shaft on a wind turbine during the execution of installation and repair work in heavy parts of a wind turbine arranged in a nacelle on wind turbines, with the fixture being divided up into a number of sections for installation on stable structural parts in a nacelle in a wind turbine, including the nacelle's bottom frame.

Description of Related Art

During installation and repair work on the nacelle of wind turbines there is often a need to perform fixing of the main shaft of the wind turbine, for example, with the replacement and servicing of a wind turbine gear box, generator or with the replacement of its main bearing, or other heavy structural parts present in the nacelle of the wind turbine. The stated components, which are mutually conjoined and anchored to the nacelle's bottom frame, are stable in an assembled state, but when separation needs to be undertaken during repairs and servicing of the turbine, static instability and imbalance arises, which can lead to the turbine's structural parts being damaged, so that there is a need to fix the wind turbine main shaft.

German Patent Application DE 102006013539 A1 (NORDEX ENERGY GMBH) discloses a main shaft fixture for fixing the main shaft on a wind turbine during the execution of installation and repair work on heavy parts that are arranged in the nacelle on wind turbines, with the fixture being divided up into a number of sections for installation on stable structural parts that are found on a wind turbine nacelle, including the bottom frame of the nacelle.

Up to now it has been necessary to halt the turbine, i.e., brake it and fix the rotor with a rotor lock, and then mount an actual fixture to firmly hold the main shaft, subsequent to which servicing of the components in the wind turbine nacelle is able to take place. However, it is inappropriate to have to halt the operation of the wind turbine while the mounting of the main shaft fixture is taking place, as the standstill of the wind turbine during the time that is spent to install the fixture involves a not insignificant operating loss in the form of a lack of energy produced (power). Furthermore, the known main shaft fixtures are relatively inflexible in relation to shaft geometry, which means that in practice nearly just as many different fixtures need to be built and stored as there are shaft geometries that exist, which is inappropriate. In addition, the use of self-hoisting cranes, whose winches are placed on the ground surface near the

2

turbine's tower, is increasing, because the use of such involves large savings in the level of expenses for servicing of wind turbines since the use of large mobile cranes for handling the above-mentioned large and heavy components is made superfluous. This causes however a need for facilities for anchoring the self-hoisting crane with the ground-based winch in the nacelle. However, the self-hoisting winch requires furthermore the presence of a lightweight crane, for the hoisting of snatch blocks, etc., that are to be anchored on/in the nacelle or on the blades of the wind turbine, which poses requirements concerning the facilities for mounting the lightweight crane.

In the event of servicing in particular large wind turbines, it may however be inappropriate to block the main shaft's rotation with an actual rotor lock, but rather be appropriate to simply retain the shaft in position and permit a certain rotation of the shaft, which is possible by turning the blades/nacelle out of the wind so that the shaft via the effects of the wind on the blades only rotates very slowly, or not at all, whereby it is acceptable in terms of safety, to perform service work in the nacelle of the wind turbine concerned.

SUMMARY OF THE INVENTION

Thus, it is the purpose of the invention to specify a main shaft fixture that provide a more universal application in relation to shaft geometry, which moreover does not require halting and fixing of the wind turbine main shaft, but which may however comprise the means for such.

It is further the purpose of the invention to provide a main shaft fixture that in addition offers facilities for the mounting of a self-hoisting crane, with a ground-based winch.

It is by the invention realized that this is possible by a main shaft fixture of the nature specified in the introduction, which is characterised by that the main shaft fixture comprises adjustable pressure mandrels with tap shoes, and said pressure mandrels being displaceable between a passive, withdrawn lockable position where the tap shoes are configured to be located at a distance from the surface of the main shaft and an advanced lockable position where the tap shoes are configured to be engaged with the main shaft and mounting facilities suitable for a lightweight crane.

Considerable flexibility is hereby attained with respect to the main shaft fixture's use for the fixing of main shafts with different geometries on wind turbines, since solely the degree of mobility of the pressure mandrels and the size of the main shaft fixture pose limiting factors for the usability of such. The main shaft fixture is thus both usable for fixing of cylinder-shaped shafts with different diameters and for the fixing of shafts with conical shapes. The main shaft fixture according to the invention is multi-part, and may be mounted on permanent structural parts, preferably the bottom frame of the nacelle, while the rotor of the wind turbine is in operation.

With the intent of being able to use a self-hoisting crane with a ground-based winch together with the main shaft fixture according to the invention, it may comprise mounting facilities for a self-hoisting crane whose winch is placed on the ground surface ground near the foot of the wind turbine.

The advance thereof is that the establishment of facilities for the fixing of the wind turbine's main shaft, as well as the establishment of mounting facilities for the self-hoisting crane with a ground-based winch, take place simultaneously, which saves work processes, and space, which are of great importance, as the space in the nacelle in a wind turbine are most often narrow, and furthermore the main shaft fixture as

US 12,104,578 B2

3

well as the mounting facilities for a self-hoisting crane in the nacelle normally utilize the same permanent structural parts in the nacelle for anchoring.

With the intent of ensuring easy and rapid establishment of the self-hoisting crane, which requires the hoisting of snatch blocks with wires originating from the ground-based winch with a lightweight crane which is mounted on stable structural parts in the nacelle, the main shaft fixture may comprise mounting facilities for a lightweight crane.

For the purpose of securing the rapid fixing of the main shaft using the main shaft fixture according to the invention, the pressure mandrels may be provided with actuators for displacing and retaining the tap shoes in the passive position and the active position, respectively, alternatively in a selectable position between the passive and the active position.

Time is thereby saved in the displacement of the tap shoes between the passive position, and the active position pressed against the main shaft's surface.

In a more simple form of embodiment of the main shaft fixture according to the invention, the pressure mandrels may be comprised of threaded bolts whose free ends facing the main shaft are furnished with tap shoes, where the threaded bolts work together with threaded holes in relevant sections of the fixture. The pressure mandrels with the tap shoes are hereby displaced by manual turning of the threaded bolts between the passive position and the active position.

With the intent of being able to permit rotation of the main shaft during performance of servicing of a relevant wind turbine and in order to protect the main shaft and the main shaft fixture, slide plates may exist between the opposing sides of the main shaft's surface and the tap shoes.

This enables the main shaft to be fixed in its position by the main shaft fixture, but with the main shaft being permitted to rotate without it being damaged due to the presence of the slide plates.

In a first embodiment of the slide plates, this could comprise the free ends of tap shoes facing against the main shaft being furnished with slide plates, which in the active extended position are engaged with the main shaft.

In a further embodiment, the main shaft fixture may according to the invention comprise a multi-part slide plate working in conjunction with the main shaft to be mounted on the main shaft, where the multi-part slide plate in its mounted state on the main shaft cooperates with the tap shoes.

This enables the tap shoes on the main shaft fixture's pressure mandrel to slide directly on the multi-part slide plate, in the event of a possible rotation of the main shaft caused by the effects of wind on the blades. The tap shoes on the main shaft fixture's pressure mandrels may cooperate with the multi-part slide plate on the main shaft, with or without slideway linings on the opposing sides of the tap shoes facing the main shaft.

In a further embodiment of the main shaft fixture as per the invention, it may comprise a multi-part needle bearing, roller bearing, ball bearing, consisting of a, multi-part inner ring, fastened on the main shaft, and a therewith cooperating multi-part outer ring consisting a number of bowed sub segments according to the number of tap shoes mounted on the opposing side of the tap shoes facing the multi-part inner ring, which in the advanced active position of the pressure mandrels form the outer ring at a distance from the external periphery of the multi-part inner ring, and where a suitable number of needle rollers, rollers or balls are placed between

4

the inner ring and outer ring, and where means are present for retaining the needles, rollers, or balls in position between the inner ring and outer ring.

An actual temporary bearing connection is hereby formed between the main shaft fixture and the main shaft, about which the main shaft is able to rotate.

With the intent of being able to fix the rotor on the wind turbine after it has been braked to a stop, the main shaft fixture according to the invention, may comprise a rotor lock, for fixing the wind turbine rotor.

In a preferred embodiment of the rotor lock, it is comprised of a flange, whose bolt circle geometry corresponds to a bolt circle geometry on the rotor, said flange element being fastened at the ends to the first end of two first beam-shaped brackets extending parallel with, and on each side of the main shaft, said beam shaped brackets belonging to the main shaft fixture, and where the other end of the brackets are pivotally mounted with horizontally oriented bolt connections, on other brackets belonging to the main shaft fixture, which are anchored on the bottom frame of the nacelle.

It is hereby achieved that the rotor can be fixed by introducing a bolt through one or more of the overlapping holes in the bolt circles on the flange fastened to the bottom frame and the bolt circle on the rotor, respectively.

With the intent of being able to perform replacement of the shaft's main bearing, without being forced to dismount the main shaft, the main shaft fixture may furthermore comprise at least a second actuator, between the nacelle's bottom frame and the opposing side of the first beam-shaped brackets facing such and the nearest rotor lock, where the other actuator is movable between a first passive outer position and an active outer position whereby the flange element is moved vertically.

This enables the main shaft to be able to be raised from its bearing hanging in the rotor lock, such that the main bearing of the shaft can be replaced or serviced without the necessity of removing the shaft from the nacelle.

The invention is explained in further detail in the following with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of parts of a wind turbine nacelle, presenting the nacelle bottom frame, the wind turbine main shaft, and a main shaft fixture according to the invention, with a lightweight crane and a self-hoisting crane mounted,

FIG. 2 is a more detailed perspective view from another angle of what is shown in FIG. 1, where the main shaft is made transparent, presenting the pressure mandrel with tap shoe belonging to the main shaft fixture according to the invention,

FIG. 3 is a more detailed perspective view from another angle of what is shown in FIG. 1, presenting the actuators for raising the main shaft, where the main shaft is made transparent,

FIG. 4 is a detailed perspective view of the main shaft fixture for a wind turbine, where the tap shoes and the main shaft are furnished with slide plates, and

FIG. 5 is a detailed perspective view of the main shaft fixture for a wind turbine, where the slide plates are replaced by a multi-part needle bearing/roller bearing/ball bearing formed of a multi-part inner ring fastened to the main shaft and a therewith cooperating multi-part outer ring consisting

US 12,104,578 B2

5

of bowed sub-segments of the number of tap shoes mounted on the opposing side of the tap shoes facing the inner ring.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 shows a bottom frame 2 in a nacelle (not shown) on a wind turbine (not shown), where the main shaft 4 of the turbine, with a gear box 6 and a rotor 8, and where the main shaft fixture 10 according to the invention is shown in the mounted state, bearing a lightweight crane 12 and a self-hoisting crane 14 with a ground-based winch (not shown), respectively. The bottom frame 2 has for reasons of clarity been made transparent.

In the illustrated embodiment, the main shaft fixture 10 is anchored to the bottom frame 2 near the gear box 6 and near the rotor 8, and comprises a multi-part frame 14, which together with a cross member 16 fastened on it encloses a part of the main shaft 4 between the rotor 8 and the gear box 6. The multi-part frame 14 is anchored on the bottom frame 2.

FIG. 2 shows what is seen in FIG. 1, but in an end view, seen from the rotor side of the shaft 4, and where the rotor 8 for reasons of clarity has been made transparent. As it appears from FIG. 2, the multi-part frame 14 and cross member 16 comprise in total four pressure mandrels 18 symmetrically placed around the main shaft 2, with tap shoes 20 that are engaged onto the main shaft 4 in order to fix it in place.

The pressure mandrels 18 may be comprised of hydraulically driven pistons whose free ends comprise the tap shoes 20, but may also be executed in other manners, where they are moved manually between the active position where the tap shoes 20 are engaged with the main shaft 4 and the passive, withdrawn position.

As it appears from FIG. 3, the main shaft fixture 10 comprises two parallel passing first beams 22, one on each side of the main shaft 4. In first ends of each first beam 22 nearest to the rotor 8, a rotor lock is fastened in the form of a flange element 24, the hole circle geometry 26 of which is similar to the hole circle geometry 28 of the rotor 8 over part of the periphery of the rotor. For locking of the rotor 8, the holes 7 in the rotor 8 and the holes 9 in the flange element 24 are brought to overlap, and subsequently, bolts are inserted through the overlapping holes, which are tightened with nuts, after which the rotor 8 is fixed/locked by the flange element 24.

The other end of the parallel passing first beams 22 (that nearest to the gear box 6) are pivotally anchored on horizontally oriented bearing bolt 30, on a bracket 32, which is fastened to the bottom frame 2. The parallel passing first beams 22 are mutually connected with second cross members 34, on which bracket facilities 23 are seen for a self-hoisting crane 14 with a ground-based winch (not shown).

As it appears in FIGS. 1 & 3, an actuator 36 is located between the bottom frame 2 and the parallel passing first beams 22. Activation of the actuator 36 will result in a change of the distance between the bottom frame 2 and the first beams 22, in which the flange element 24 is suspended, which will cause the flange element 24 and the rotor 8 and thereby the main shaft 4 to be raised, which will result in the possibility to replace the main shaft's bearing 38 without the necessity of hoisting the main shaft 4 down to the ground, which is quite time-saving when the main shaft bearing 38 has to be repaired or replaced.

6

In FIG. 1, it is moreover shown how the main shaft fixture 10 comprises mounting facilities 40 for the lightweight crane 12.

FIG. 4 shows an embodiment of the main shaft fixture according to the invention, which is specially suited for use for fixing the wind turbine main shaft 4 in position on the nacelle, but where rotation of the main shaft 4 is possible, in the active position of the pressure mandrels/tap shoes (18, 20), engaged with the main shaft.

As shown in FIG. 4, a slideway 42, 44 is located between the opposing sides of the tap shoes 20 facing the surface of the main shaft 4.

The slideway may be comprised of slide plates 42 that are fastened to the opposing free ends of the tap shoes 20 facing the main shaft 4, which in their active advanced position are engaged with the main shaft 4, but which alternatively may comprise a multi-part slide plate 44 cooperative working with the main shaft 4, for mounting on the main shaft 4, said multi-part slide plate 44 in its mounted state on the main shaft 4 cooperates with the tap shoes 20. It must be stated that the presence of the multi-part slide plate 44 on the main shaft 4 does not necessarily exclude the presence of the slide plates 42 and the tap shoes 20.

In a further embodiment, the main shaft fixture 10 is comprised of a multi-part needle bearing/roller bearing/ball bearing 46, formed of a multi-part inner ring 48 fastened on the main shaft as well as, a cooperating multi-part outer ring 50 formed of bowed sub-segments 52 equal to the number of tap shoes mounted on the opposing side of the tap shoes 20 facing the inner ring 48, which in the advanced position of the pressure mandrels form the outer ring 50 at a distance from the outer periphery of the multi-part inner ring 48, and where an appropriate number of needle rollers, rollers, or balls 54 (in the shown embodiment rollers 54) are arranged between the inner ring 48 and the outer ring 50, and where means (not shown) are present for retaining the needles/rollers or balls (54) in position between the inner ring 48 and outer ring 50.

The means mentioned for fastening of needle rollers/rollers/balls 54 may be formed of cooperating edge delimiters in opposing sides of the inner ring 48 and the outer ring 50, alternatively as a means for holding between which the needle rollers/rollers/balls 54 are fastened.

The presence of the slide plates 42, 44, alternatively the multi-part needle bearing, roller bearing, ball bearing 46, involves the main shaft 4 being permitted to rotate simultaneously with it being fixed in its position during servicing of the wind turbine, which can serve a purpose namely for larger wind turbines.

The inventor has recognized that the main shaft fixture 10 can assume other embodiments than disclosed in the preceding and shown in the figures, however such do not change the inventive aspect that is comprised of specifying a main shaft fixture 10 of the given type that comprises adjustable pressure mandrels 18 with tap shoes 20, which causes the fixture 10 to be usable regardless of the geometry of the main shaft 4 on a wind turbine, and thus that such can be mounted without fixing the rotor 8 in place, and furthermore of combining the main shaft fixture with facilities 40 for mounting of a lightweight crane 12 and a self-hoisting crane 14 with a ground-based winch, respectively, as well as a rotor lock 24 and finally of furnishing the main shaft fixture 10 with actuators 36, enabling the main shaft 4 and the main shaft bearing 38 to be raised sufficiently from its bearing in the nacelle that it can be serviced or replaced.

US 12,104,578 B2

7

What is claimed is:

1. Main shaft fixture for fixation of a main shaft on a wind turbine during execution of installation and repair work on heavy parts of a wind turbine, where the fixture is divided up into a number of sections for mounting on stable structural parts in a nacelle of a wind turbine, including a bottom frame of the nacelle, characterised in that the main shaft fixture comprises adjustable pressure mandrels with tap shoes, and the adjustable pressure mandrels being displaceable between a passive position where the tap shoes are configured to be located at a distance from a surface of the main shaft and an active position where the tap shoes are configured to be engaged with the main shaft and in that the main shaft fixture further comprises mounting facilities adapted for anchoring a crane on/in a nacelle of a wind turbine.

2. Main shaft fixture according to claim 1, characterized in that the adjustable pressure mandrels with tap shoes comprise at least three radial displaceable pressure mandrels, substantially symmetrical located around a centre axis of the main shaft, ends of the adjustable pressure mandrels facing the main shaft being furnished with the tap shoes.

3. Main shaft fixture, according to claim 1, characterised in, that the mounting facilities are adapted for anchoring a self-hoisting crane on/in a nacelle of a wind turbine and in that a winch of the self-hoisting crane is located on a ground surface near a foot of the wind turbine.

4. Main shaft fixture, according to claim 1, characterised in, that the adjustable pressure mandrels is provided with actuators for displacing and retaining the tap shoes in the passive position and the active position, respectively, alternatively in a selectable position between the passive and the active position.

5. Main shaft fixture, according to claim 1, characterised in, that the adjustable pressure mandrels consists of threaded bolts whose opposing free ends facing the main shaft are furnished with tap shoes, and the threaded bolts cooperates with threaded holes in relevant sections of the main shaft fixture.

6. Main shaft fixture, according to claim 1, characterised by a slideway lining being located between opposing sides of a surface of the main shaft and tap shoes.

7. Main shaft fixture according to claim 6, characterised in, that the slideway lining is configured so that of opposing free ends of the tap shoes facing the main shaft are provided with a slide plate which in the active position is engaged with the main shaft.

8. Main shaft fixture according to claim 7, characterised in that it comprises a multi-part slide plate cooperating with the main shaft for mounting on the main shaft, where the multi-part slide plate in its mounted position on the main shaft is cooperating with the tap shoes.

9. Main shaft fixture according to claim 1, characterised in, that it comprises one of a multi-part needle bearing, roller bearing, ball bearing consisting of a multi-part inner ring fastened to the main shaft, and a therewith cooperating multi-part outer ring consisting of bowed subsegments corresponding to a number of tap shoes, mounted on opposing side of the tap shoes facing an inner ring, which in the active position of the adjustable pressure mandrels form an outer ring at a distance from an outer periphery of the multi-part inner ring, and where an appropriate number of needle rollers, rollers, or balls are arranged between the inner ring and the outer ring, and where means are present for retaining needles, rollers, or balls in position between the inner ring and outer ring.

8

10. Main shaft fixture, according to claim 1, characterised in, that it comprises a rotor lock for fixation of a rotor of the wind turbine.

11. Main shaft fixture, according to claim 10, characterised in, that the rotor lock consists of a flange element, whose bolt circle geometry corresponds to a bolt circle geometry on the rotor, the flange element being fastened at the ends to a first end of two first beam-shaped brackets extending parallel with, and on each side of the main shaft, the beam shaped brackets belonging to the main shaft fixture, and where a second end of the beam-shaped brackets are pivotally mounted with horizontally oriented bolt connections, on other beam-shaped brackets belonging to the main shaft fixture, which are adapted to be anchored on the bottom frame of the nacelle.

12. Main shaft fixture, according to claim 11, characterised in, that at least one actuator is located nearest the rotor lock between the bottom frame of the nacelle and an adjacent side of the first beam-shaped brackets facing the bottom frame, the actuator is displaceable between a first passive outer position and an active outer position where the flange element is displaced vertically.

13. Assembly for installing and repairing heavy parts of a wind turbine arranged in a nacelle of a wind turbine, the assembly comprising a main shaft fixture according to claim 1, characterized in that a crane is mounted to the main shaft fixture via the mounting facilities of the main shaft fixture.

14. Main shaft fixture, according to claim 1, characterised in that the mounting facilities are adapted for anchoring a lightweight crane on/in a nacelle of a wind turbine.

15. Main shaft fixture for fixation of a main shaft on a wind turbine during execution of installation and repair work on heavy parts of a wind turbine, where the main shaft fixture is divided up into a number of sections for mounting on stable structural parts in a nacelle of a wind turbine, including a bottom frame of the nacelle, characterised in that,

the main shaft fixture comprises adjustable pressure mandrels with tap shoes, and the adjustable pressure mandrels being displaceable between a passive position where the tap shoes are configured to be located at a distance from a surface of the main shaft and an active position where the tap shoes are configured to be engaged with the main shaft, the adjustable pressure mandrels consisting of threaded bolts whose opposing free ends facing the main shaft are furnished with tap shoes, and the threaded bolts cooperates with threaded holes in relevant sections of the main shaft fixture, and in that the main shaft fixture further comprises mounting facilities adapted for anchoring a crane on/in a nacelle of a wind turbine.

16. Main shaft fixture for fixation of a main shaft on a wind turbine during execution of installation and repair work on heavy parts of a wind turbine, where the main shaft fixture is divided up into a number of sections for mounting on stable structural parts in a nacelle of a wind turbine, including a bottom frame of the nacelle, characterised in, that the main shaft fixture comprises adjustable pressure mandrels with tap shoes, and the adjustable pressure mandrels being displaceable between a passive position where the tap shoes are configured to be located at a distance from a surface of the main shaft and an active position where the tap shoes are configured to be engaged with the main shaft and in that the main shaft fixture further comprises mounting facilities adapted for anchoring a crane on/in a nacelle of a wind turbine, and further comprising a rotor lock for fixation of a rotor of the wind turbine, wherein the rotor lock consists

US 12,104,578 B2

9

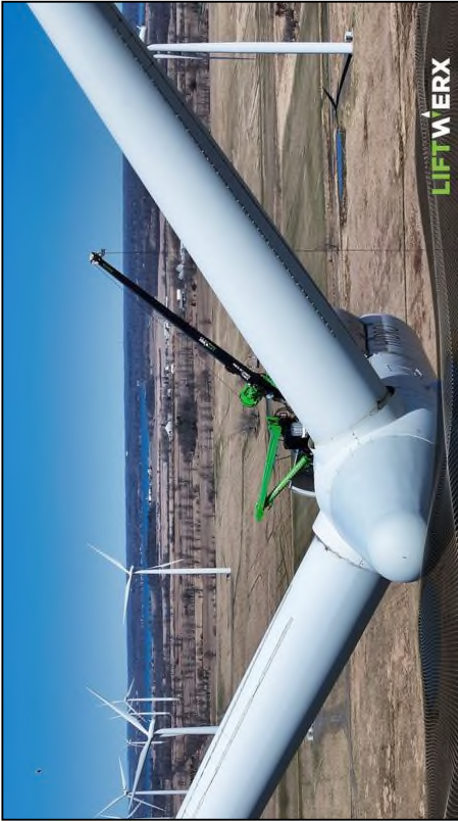
10

of a flange element, whose bolt circle geometry corresponds to a bolt circle geometry on the rotor, the flange element being fastened to a first end of two first beam-shaped brackets extending parallel with, and on each side of the main shaft, the two first beam shaped brackets belonging to the main shaft fixture, and where a second end of the two first beam shaped brackets are pivotally mounted with horizontally oriented bolt connections, on other brackets belonging to the main shaft fixture, which are adapted to be anchored on the bottom frame of the nacelle.

17. Main shaft fixture, according to claim 16, wherein at least one actuator is located nearest the rotor lock between the bottom frame of the nacelle and an adjacent side of the first beam shaped brackets facing the bottom frame, the actuator is displaceable between a first passive outer position and an active outer position where the flange element is displaced vertically.

* * * * *

Exhibit D

	U.S. Patent No. 12,104,578 Claim Language	Infringement Analysis
1(pre)	Main shaft fixture for fixation of a main shaft on a wind turbine during execution of installation and repair work on heavy parts of a wind turbine,	The Accused Products include a main shaft fixture for fixation of a main shaft on a wind turbine during execution of installation and repair work on heavy parts of a wind turbine. LiftWerx describes a five-crane system: “RotorHook, GenHook, Heli-Hook. The RotorHook crane is part of a five-crane system. It is assembled by a GenHook crane, which itself is assembled by a Heli-Hook crane, which is assembled by two small service cranes. All of these cranes comprise a complex crane system which is now in use by our sister company LiftWerx in North America. You could compare the assembly of the RotorHook with a Russian matryoshka, a doll inside a doll inside a doll.” https://eager.one/the-rotorhook-has-arrived/#:~:text=All%20of%20these%20cranes%20comprise%20a%20complex,doll%20inside%20a%20doll%20inside%20a%20doll. WO2021168549A1, titled “Multiple up-tower lifting appliances on wind turbines” describes this same multi-crane system.  <i>LiftWerx HeliHook. https://www.linkedin.com/posts/liftwerx-solutions-inc-_heres-a-glimpse-of-our-heli-hook-crane-activity-7320041987150135297-qtOw</i>

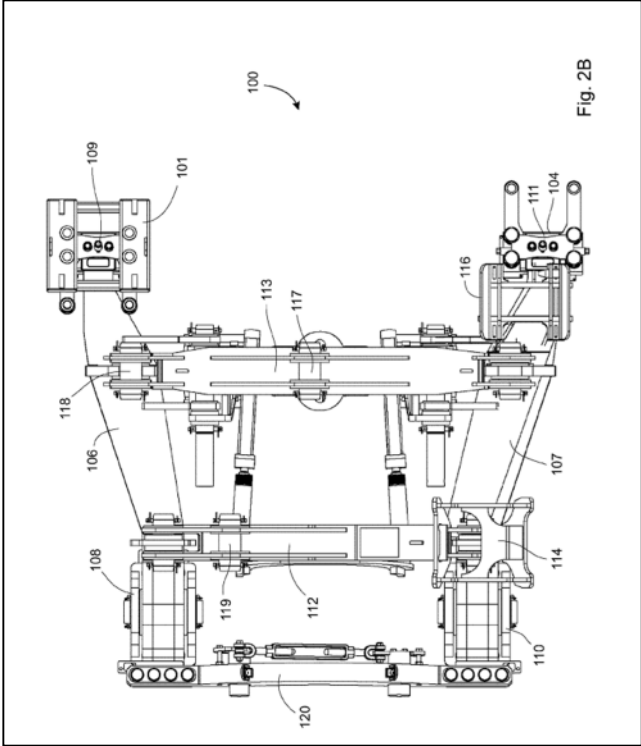


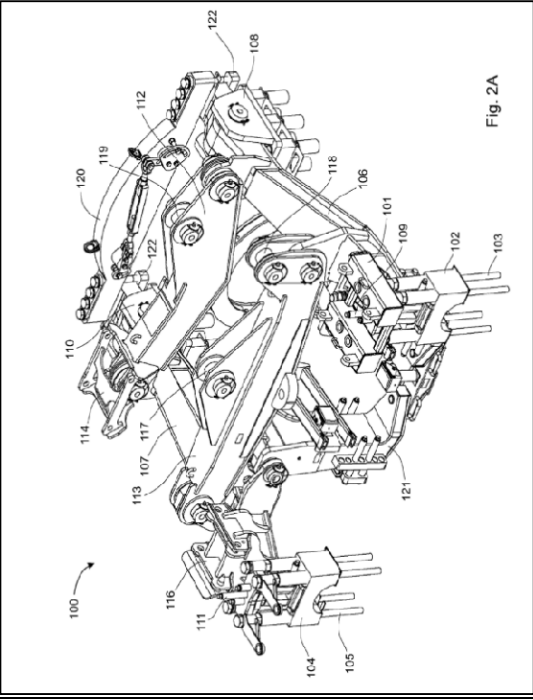
LiftWerx GenHook <https://liftwerx.com/news/the-genhook-is-launched/>

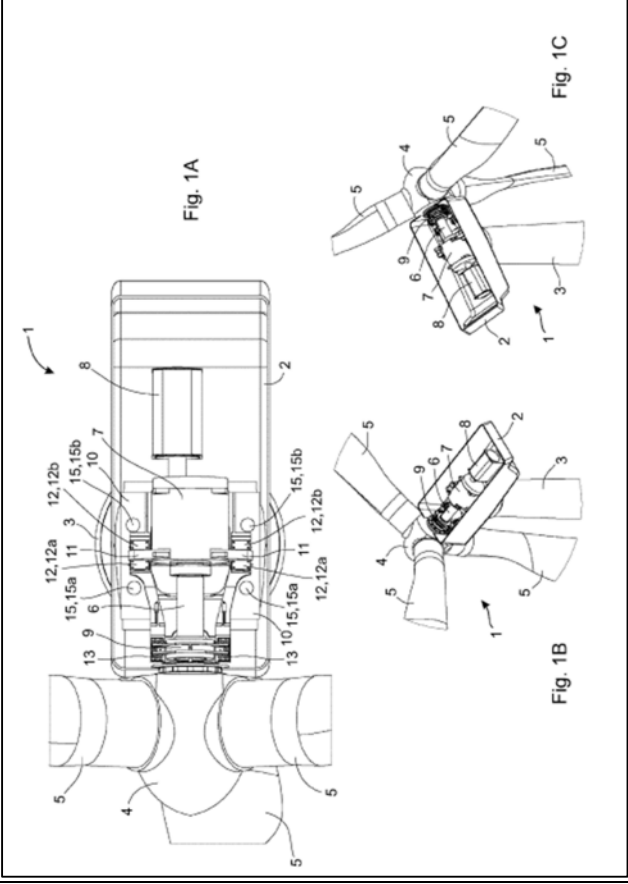


LiftWerx RotorHook <https://liftwerx.com/our-cranes/>

See also [WO2021168549A1](#), at abstract (“The first and second lifting appliances share one or both of the main bearing housing securements and the gearbox pillow blocks. The system permits having multiple lifting appliances mounted at the same in the restricted space of the nacelle.”; at 2[0015] (“The lift system is therefore capable of being used for a variety of different lifting tasks from the nacelle of the wind turbine, including but not limited to installation, removal and repair of wind turbine components such as the main bearing, the main shaft, the gearbox, the generator, the yaw drives and the rotor blades.”).

	U.S. Patent No. 12,104,578 Claim Language	Infringement Analysis
		The Accused Products include a “rotor lock 120 and a main shaft clamp 121 for preventing rotational and translational movement of the main shaft during an installation or repair procedure of a wind turbine component.” WO2021168549A1 at 9:3-5. WO2021168549A1 Fig. 2B, 8:16-23 (“The lifting appliance support base 100 further comprises a front transverse beam 112 and a rear transverse beam 113. The front transverse beam 112 rests on top of and straddles the first and second longitudinal beams 106, 107, respectively, at a location to the rear of the first and second main bearing supports 108, 110, respectively. The rear transverse beam 113 rests on top of and straddles the first and second longitudinal beams 106, 107, respectively, at a location forward of the first and second pillow block bridges 102, 104, respectively. A hydraulic power unit 114 to permit mounting of a hydraulic power unit to operate the lifting appliances is mounted on the second longitudinal beam 107 forward of the front transverse beam 112 and over the second main bearing support 110.”).  WO2021168549A1 Fig. 2B

	U.S. Patent No. 12,104,578 Claim Language	Infringement Analysis
1(a)	where the fixture is divided up into a number of sections for mounting on stable structural parts in a nacelle of a wind turbine, including a bottom frame of the nacelle,	 WO2021168549 Fig. 2A The Accused Products include a “number of sections,” for mounting on stable structural parts in a nacelle of a wind turbine, including a bottom frame of the nacelle. See, e.g., WO2021168549A1 at 6:29-7:5 (“Inside the nacelle 2, the main bearing 9 and the gearbox 7 are supported on a bedplate 10. Torque arms 11 connected to the gearbox 7 and the bedplate 10 at the right and left sides of the gearbox 7 stabilize the gearbox 7 against twisting forces. The torque arms 7 are reinforced by gearbox pillow blocks 12 attached to the bedplate 10 in front of and behind the torque arms 7. The gearbox pillow blocks 12 comprise forward gearbox pillow blocks 12a and rearward gearbox pillow blocks 12b. The main bearing 9 is housed in a main bearing housing secured to the bedplate 10 by main bearing housing securements 13 at the right and left sides of the main bearing 9. The bedplate 10

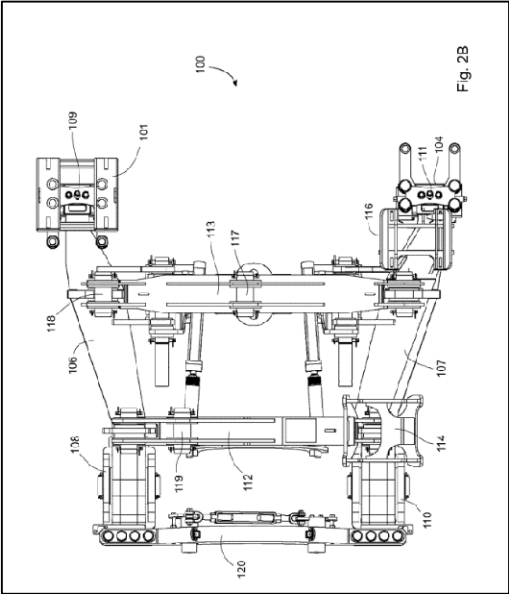
	U.S. Patent No. 12,104,578 Claim Language	Infringement Analysis
		further comprises lifting lugs 14 attached to the right and left sides of the bedplate 10. The nacelle 2 is rotatable atop the tower 3 by virtue of yaw drives (not shown) seated in yaw drive pockets 15 in the bedplate 10. The yaw drive pockets 15 comprise forward yaw drive pockets 15a and rearward yaw drive pockets 15b.”).  WO2021168549 Fig. 1C
1(b)	characterised in that the main shaft fixture comprises adjustable pressure mandrels with tap shoes,	The Accused Products include a main shaft fixture that comprises adjustable pressure mandrels with tap shoes, <i>See, e.g.,</i> WO2021168549A1 at 9:3-5, (“rotor lock 120 and a main shaft clamp 121 for preventing rotational and translational movement of the main shaft during an installation or repair procedure of a wind turbine component”); Figs. 2A and 2B. “The rotor lock 120 is mounted at the front ends of the longitudinal beams 106, 107 using clamps 122, and the main shaft clamp 121 is mounted proximate rear ends of the longitudinal beams 106, 107 using pinned connections.” <i>Id.</i> at 9:25-28.

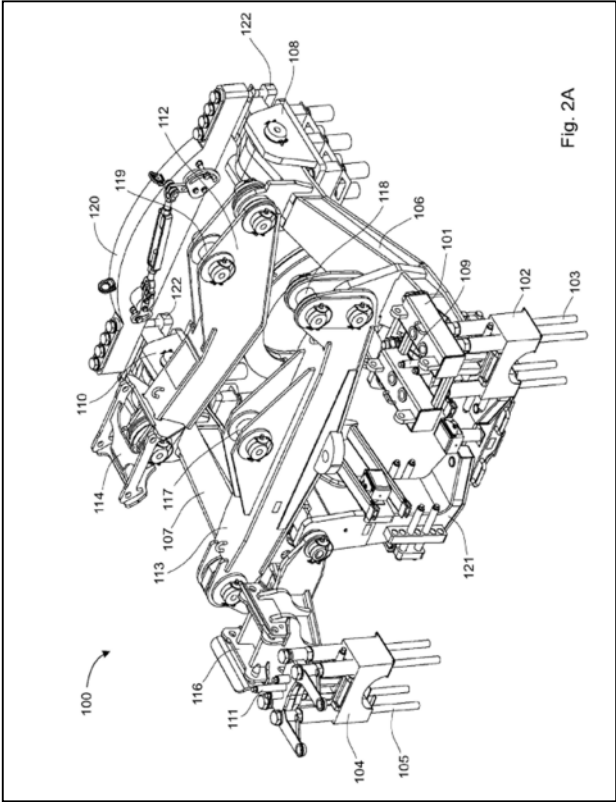


WO2021168549 Fig. 2A

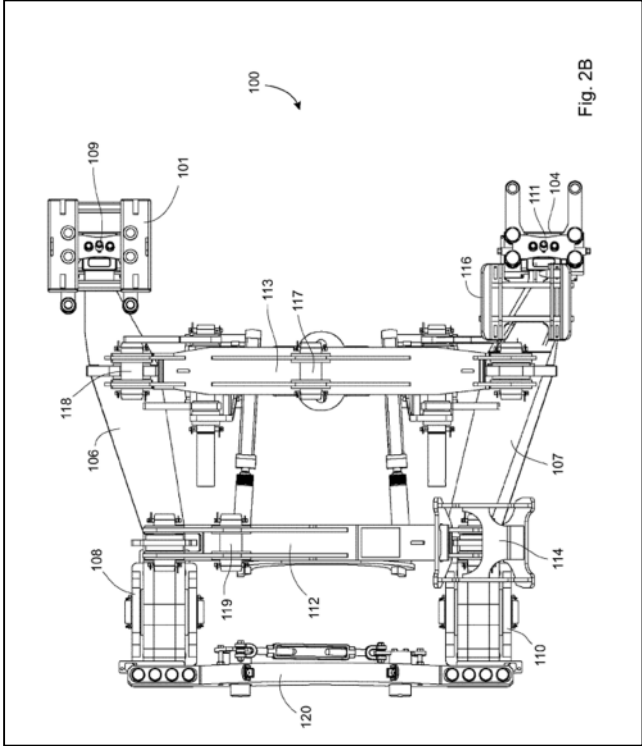


WO2021168549 Fig. 5B

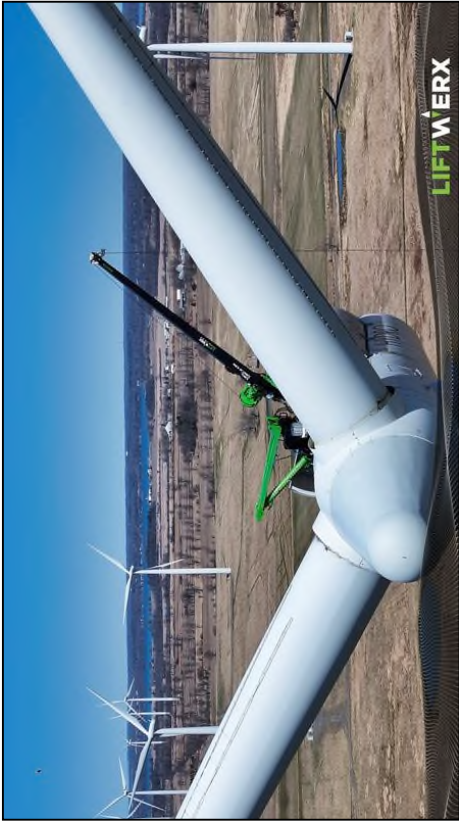
	U.S. Patent No. 12,104,578 Claim Language	Infringement Analysis
1(c)	and the adjustable pressure mandrels being displaceable between a passive position where the tap shoes are configured to be located at a distance from a surface of the main shaft and an active position where the tap shoes are configured to be engaged with the main shaft	 Fig. 2B WO2021168549A1 Fig. 2B The Accused Products include adjustable pressure mandrels being displaceable between a passive position where the tap shoes are configured to be located at a distance from a surface of the main shaft and an active position where the tap shoes are configured to be engaged with the main shaft. See, e.g., WO2021168549A1 at 9:3-5, Figs. 2A and 2B (“rotor lock 120 and a main shaft clamp 121 for preventing rotational and translational movement of the main shaft during an installation or repair procedure of a wind turbine component.”).



WO2021168549A1 Fig. 2A



WO2021168549A1 Fig. 2B

U.S. Patent No. 12,104,578	Claim Language	Infringement Analysis
1(d)	and in that the main shaft fixture further comprises mounting facilities adapted for anchoring a crane on/in a nacelle of a wind turbine.	The Accused Products include a main shaft fixture that comprises mounting facilities adapted for anchoring a crane on/in a nacelle of a wind turbine. LiftWerx describes a five-crane system: “RotorHook, GenHook, Heli-Hook. The RotorHook crane is part of a five-crane system. It is assembled by a GenHook crane, which itself is assembled by a Heli-Hook crane, which is assembled by two small service cranes. All of these cranes comprise a complex crane system which is now in use by our sister company LiftWerx in North America. You could compare the assembly of the RotorHook with a Russian matryoshka, a doll inside a doll inside a doll.” https://eager.one/the-rotorhook-has-arrived/#:~:text=All%20of%20these%20cranes%20comprise%20a%20complex,doll%20inside%20a%20doll%20inside%20a%20doll. WO2021168549A1, titled “Multiple up-tower lifting appliances on wind turbines” describes this same multi-crane system. 

LiftWerx HeliHook. https://www.linkedin.com/posts/lifwerx-solutions-inc-_heres-a-glimpse-of-our-heli-hook-crane-activity-7320041987150135297-qtOw



LiftWerx GenHook <https://liftwerx.com/news/the-genhook-is-launched/>



LiftWerx RotorHook <https://liftwerx.com/our-cranes/>

See, e.g., WO2021168549A1, at abstract (“The first and second lifting appliances share one or both of the main bearing housing securements and the gearbox pillow blocks. The system permits having multiple lifting appliances mounted at the same in the restricted space of the nacelle.”; at 2:10-15 (“The lift system is therefore capable of being used for a variety of different lifting tasks from the nacelle of the wind turbine, including but not limited to installation, removal and repair of wind turbine components such as the main bearing, the main shaft, the gearbox, the generator, the yaw drives and the rotor blades.”).

Exhibit E

(12) **United States Patent**
Fenger

(10) **Patent No.: US 12,473,179 B2**
(45) **Date of Patent: Nov. 18, 2025**

(54) **BASE FOR SUPPORTING A PORTABLE CRANE AND A METHOD FOR REMOVING A MAIN BEARING OF A WIND TURBINE**

(56) **References Cited**
U.S. PATENT DOCUMENTS
2010/0021278 A1* 1/2010 Stegemann B66C 23/207 414/629
2012/0294720 A1 11/2012 Smook
(Continued)
FOREIGN PATENT DOCUMENTS
EP 1677006 A2 7/2006
EP 2147885 B1 2/2013
(Continued)
OTHER PUBLICATIONS
International Search Report and Written Opinion issued in related App. No. PCT/EP2022/061836, mailed Sep. 14, 2022.
(Continued)
Primary Examiner — Anna M Momper
Assistant Examiner — Juan J Campos, Jr.
(74) *Attorney, Agent, or Firm* — AVEK IP, LLC

(21) Appl. No.: **18/558,242**
(22) PCT Filed: **May 3, 2022**
(86) PCT No.: **PCT/EP2022/061836**
§ 371 (c)(1),
(2) Date: **Oct. 31, 2023**
(87) PCT Pub. No.: **WO2022/233861**
PCT Pub. Date: **Nov. 10, 2022**
(65) **Prior Publication Data**
US 2024/0367950 A1 Nov. 7, 2024
(30) **Foreign Application Priority Data**
May 3, 2021 (DK) PA 2021 70204
(51) **Int. Cl.**
B66C 23/20 (2006.01)
F03D 13/10 (2016.01)
F03D 80/80 (2016.01)
(52) **U.S. Cl.**
CPC **B66C 23/207** (2013.01); **F03D 13/122** (2023.08); **F03D 80/881** (2023.08); **F05B 2240/916** (2013.01)
(58) **Field of Classification Search**
CPC ... B66C 23/207; F03D 13/122; F03D 80/881; F03D 13/00; F03D 80/80; F05B 2240/916
See application file for complete search history.

(57) **ABSTRACT**
A base for supporting a portable crane for handling components of a wind turbine is described. The base is mountable on the wind turbine, and configured to be switched between a first configuration and a second configuration. In the first configuration the base is configured for being supported by a main bearing of the wind turbine to allow the portable crane to lift a gearbox of the wind turbine. In the second configuration the base is configured for being supported by a bed plate of a nacelle of the wind turbine to allow the portable crane to lift the main bearing. The base is configured for supporting the portable crane while switching between the first configuration and the second configuration. A method for removing a main bearing of a wind turbine is also disclosed.

20 Claims, 7 Drawing Sheets

The drawing is a perspective view of a mechanical assembly, likely a portable crane base for a wind turbine. It features a main body with a large cylindrical component (300) at the rear. Various structural elements are labeled with numerals: 100, 101, 102, 103, 104, 108, 200, 301, 302, 303, 304, and 305. A dashed line labeled 'LD' indicates a longitudinal direction. The assembly appears to be designed for mounting and supporting heavy components within a confined space.

[Page 86 of 113]

Liftra 2004
LiftWerx v Liftra
IPR2026-00102

US 12,473,179 B2

Page 2

(56)

References Cited

U.S. PATENT DOCUMENTS

2015/0086367	A1	3/2015	Holloway et al.	
2017/0306930	A1 *	10/2017	Fenger	F03D 13/10
2018/0335023	A1	11/2018	Trede	
2019/0203700	A1 *	7/2019	Numajiri	B66C 1/108
2020/0362824	A1 *	11/2020	Kofman	F03D 1/125
2020/0378368	A1 *	12/2020	Aitken	F03D 80/50

FOREIGN PATENT DOCUMENTS

EP	3312415	A1	4/2018
WO	2011051272	A2	5/2011
WO	2015078475	A1	6/2015
WO	2016055065	A1	4/2016
WO	2019100146	A1	5/2019
WO	2020041867	A1	3/2020
WO	2021077207	A1	4/2021

OTHER PUBLICATIONS

Search Report dated Nov. 2, 2021, issued by Danish Patent and Trademark Office in priority App. No. PA 2021 70204.

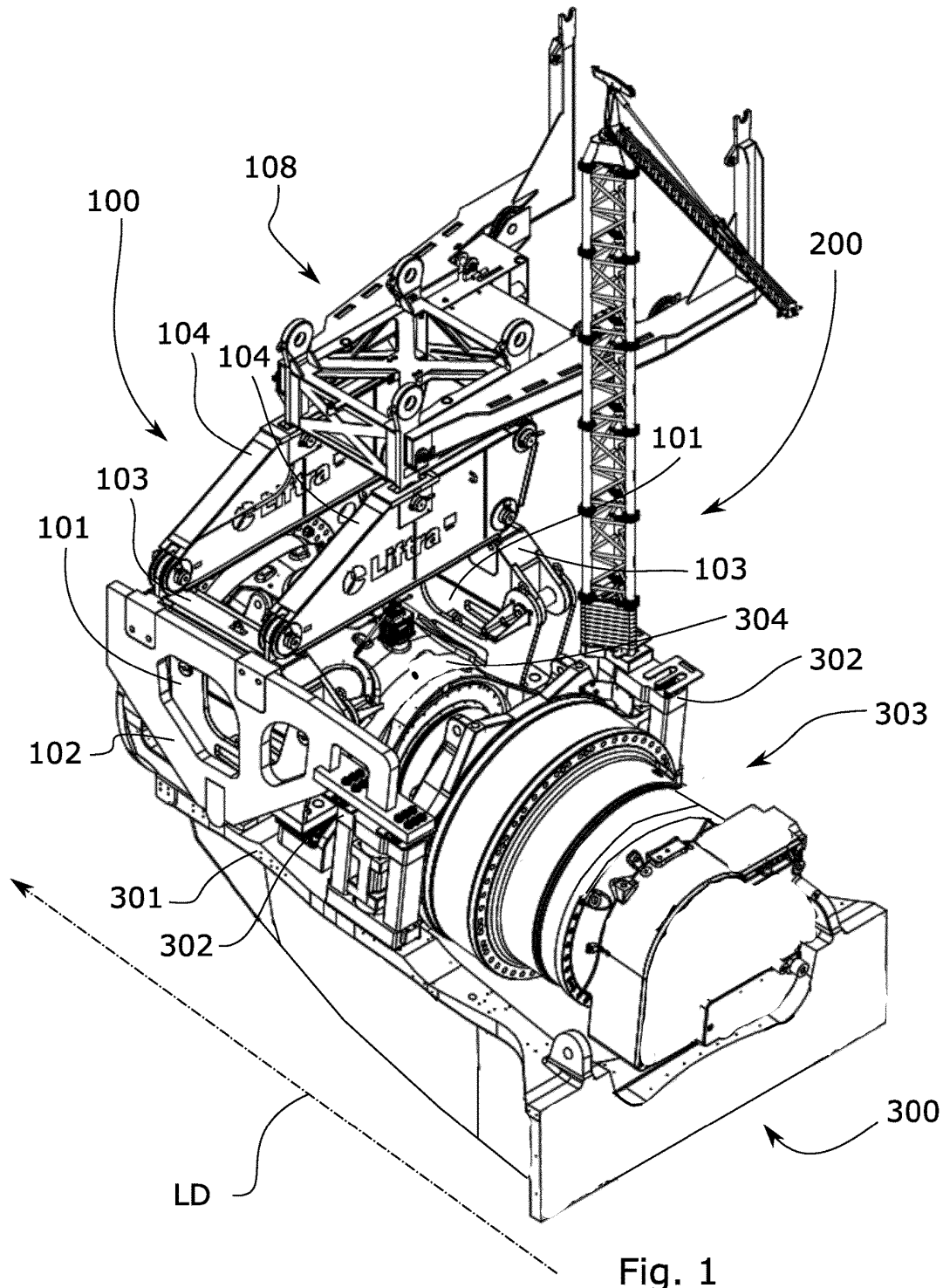
* cited by examiner

U.S. Patent

Nov. 18, 2025

Sheet 1 of 7

US 12,473,179 B2



U.S. Patent

Nov. 18, 2025

Sheet 2 of 7

US 12,473,179 B2

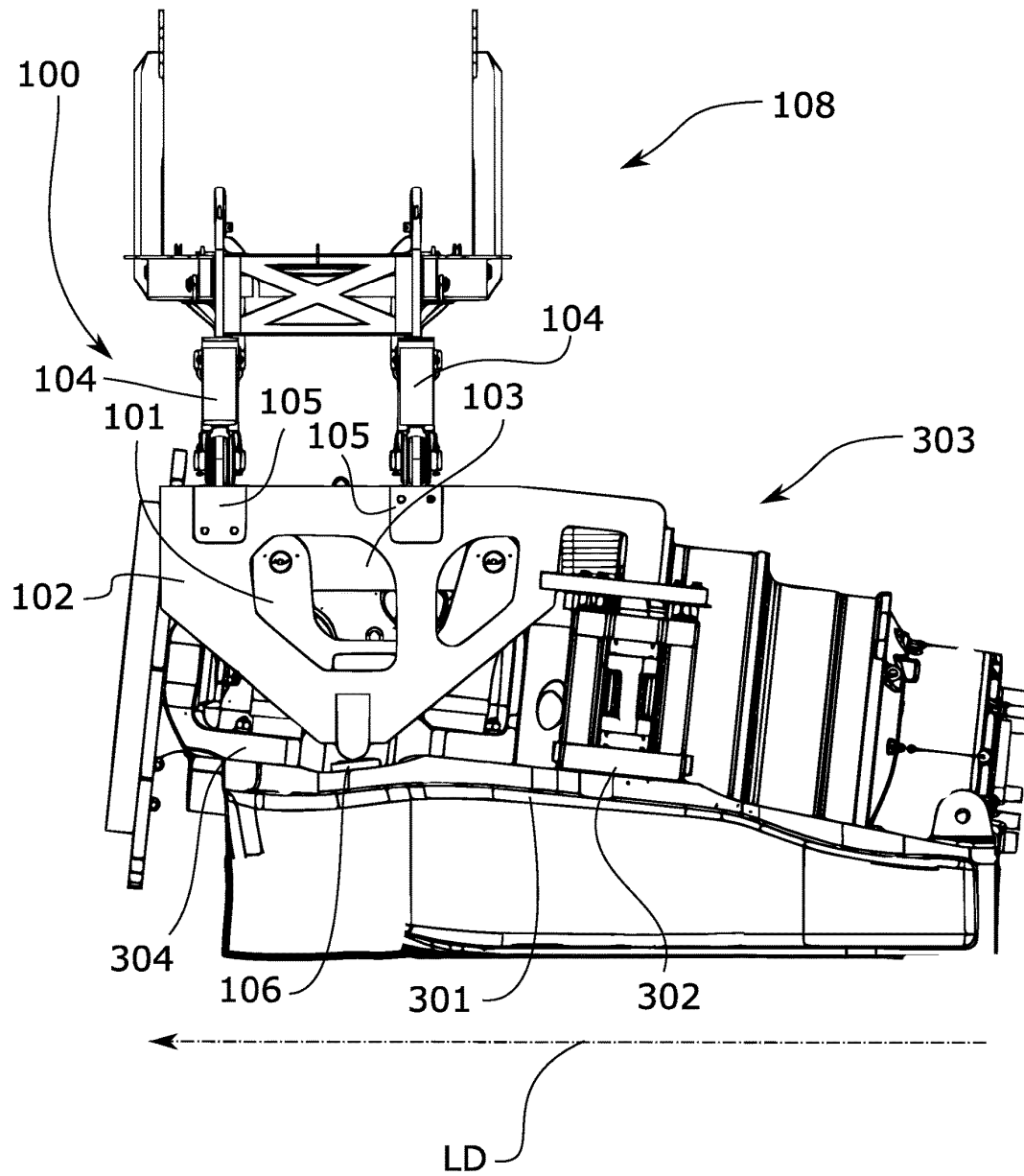


Fig. 2

U.S. Patent

Nov. 18, 2025

Sheet 3 of 7

US 12,473,179 B2

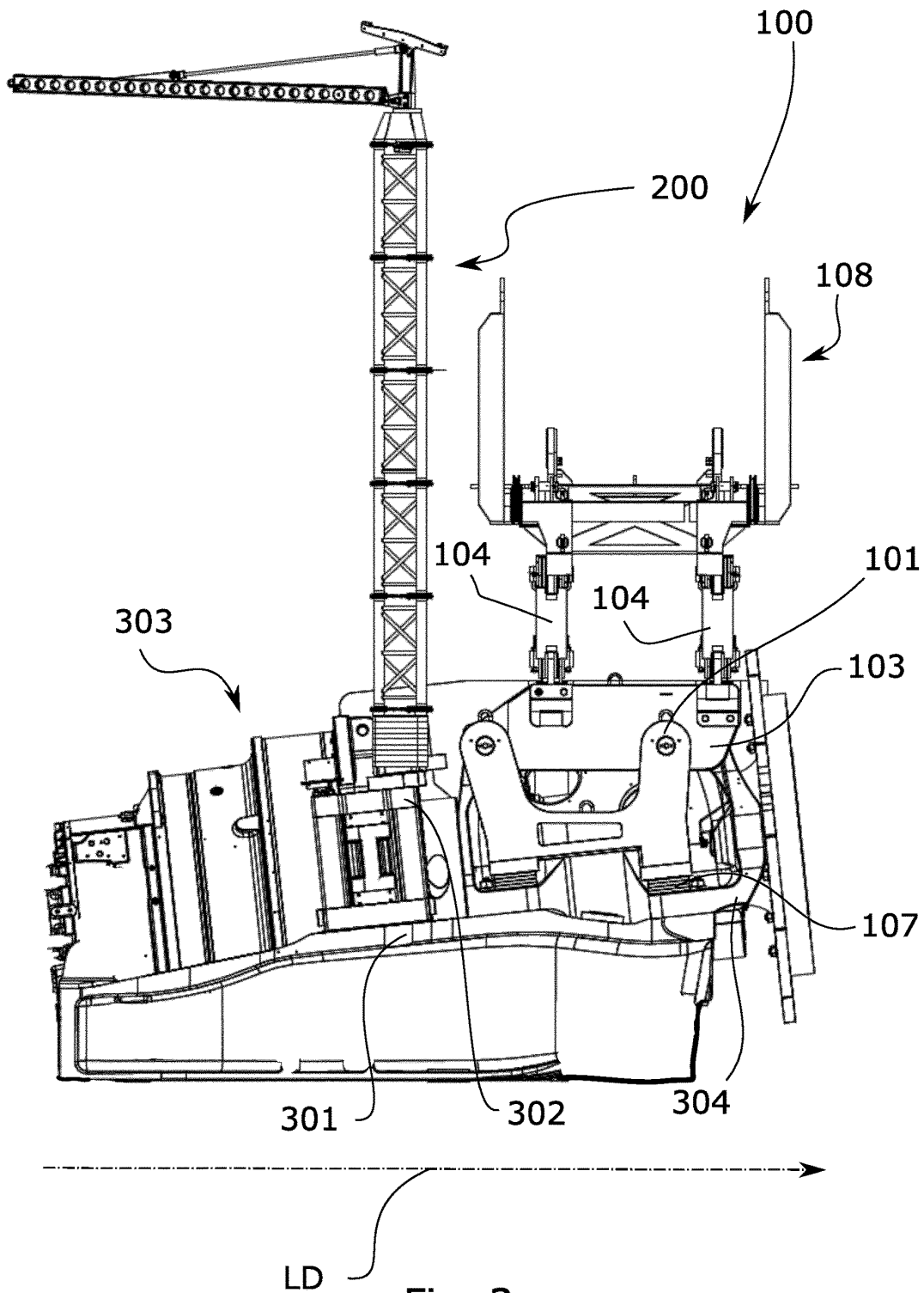


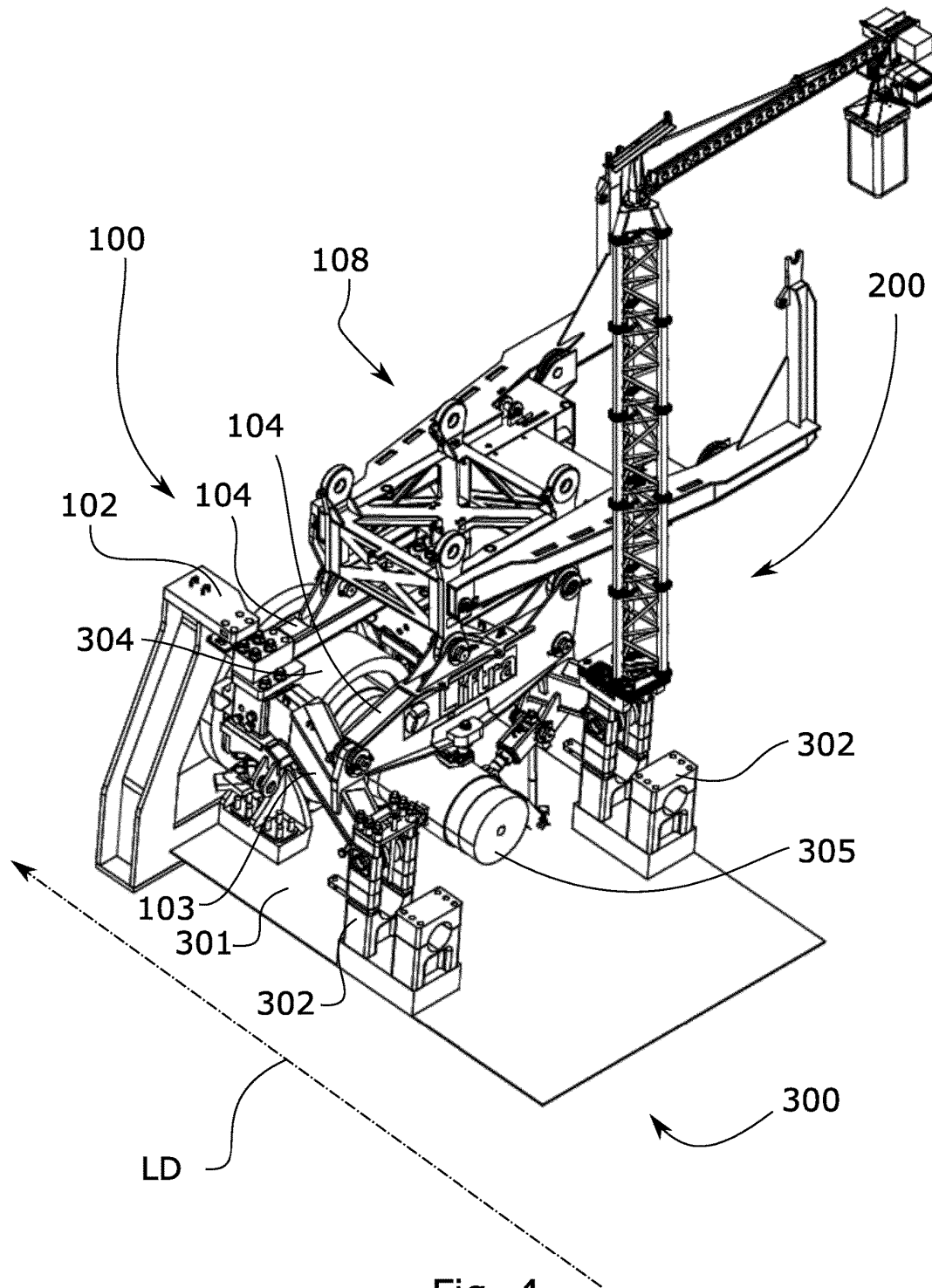
Fig. 3

U.S. Patent

Nov. 18, 2025

Sheet 4 of 7

US 12,473,179 B2



U.S. Patent

Nov. 18, 2025

Sheet 5 of 7

US 12,473,179 B2

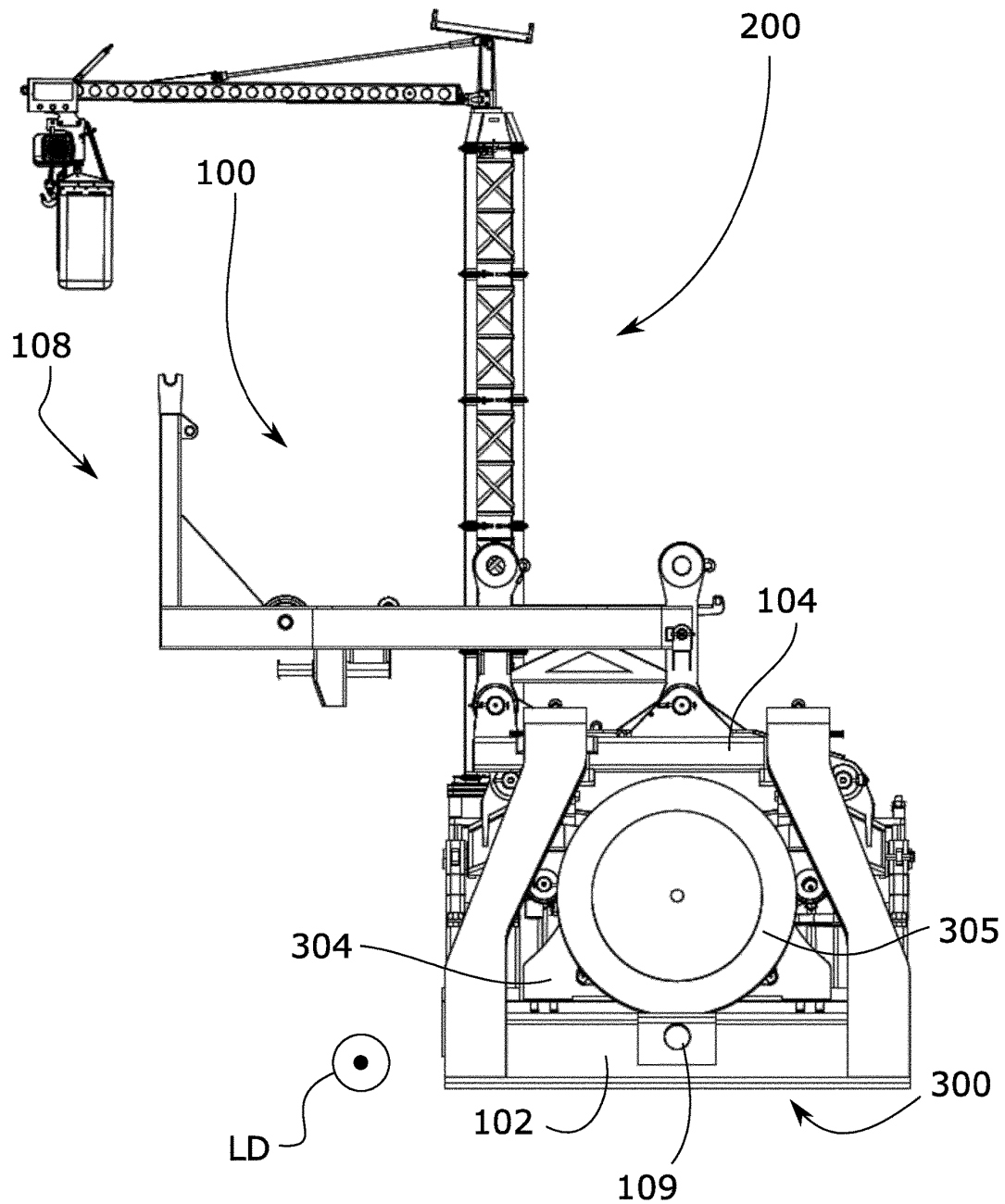


Fig. 5

U.S. Patent

Nov. 18, 2025

Sheet 6 of 7

US 12,473,179 B2

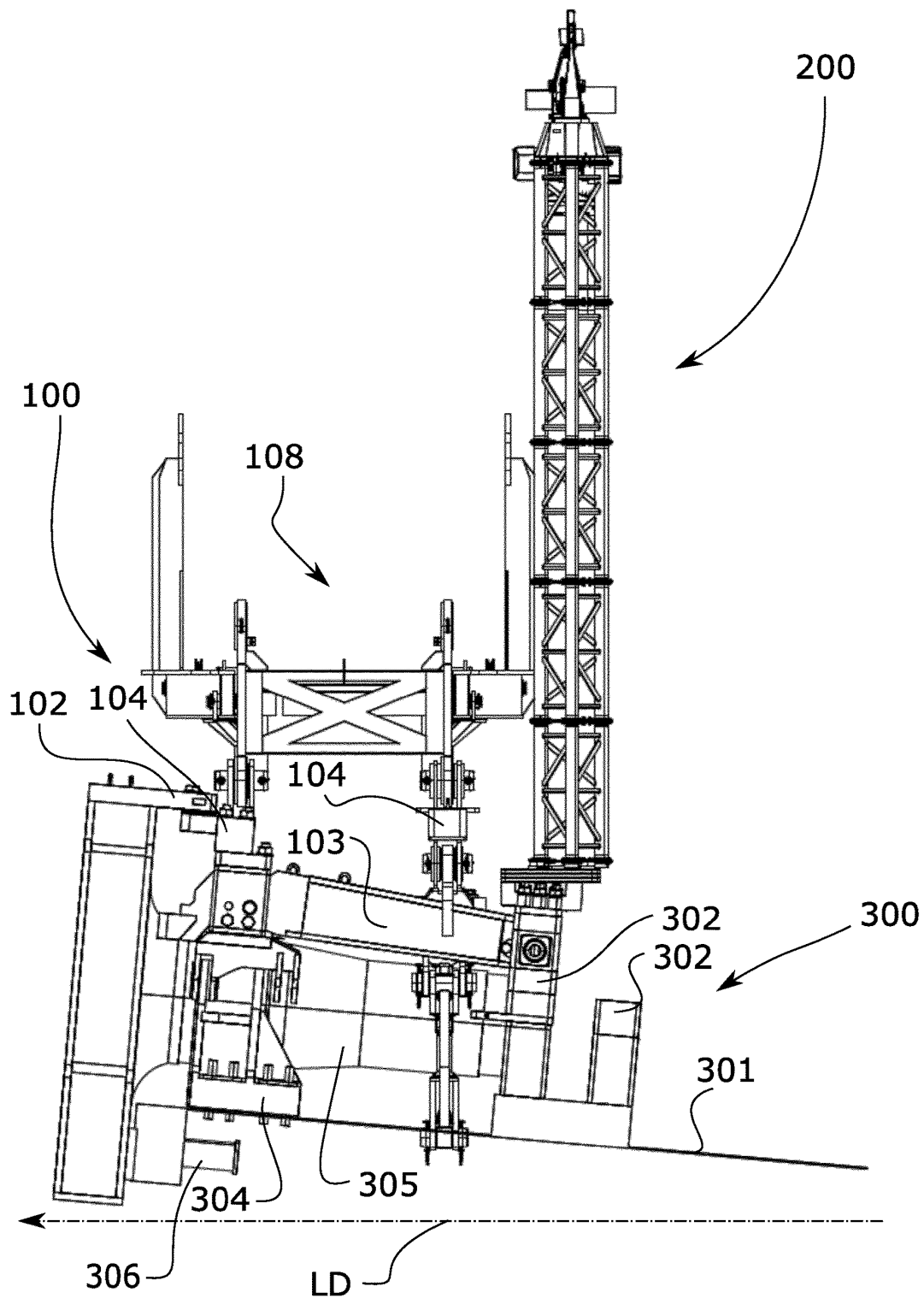


Fig. 6

U.S. Patent

Nov. 18, 2025

Sheet 7 of 7

US 12,473,179 B2

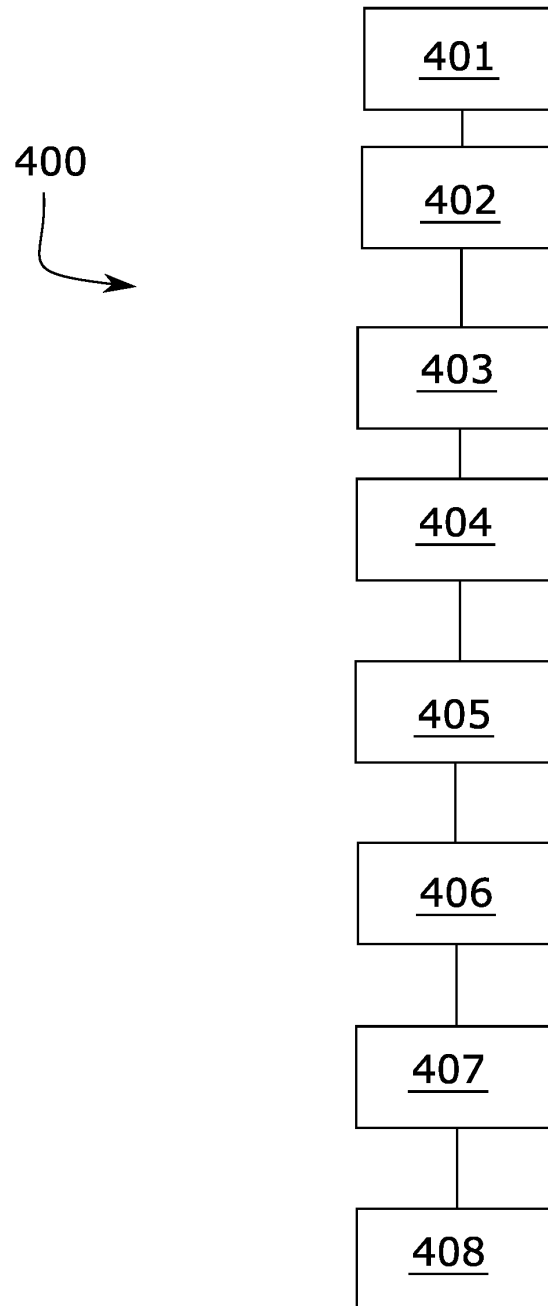


Fig. 7

US 12,473,179 B2

1

**BASE FOR SUPPORTING A PORTABLE
CRANE AND A METHOD FOR REMOVING A
MAIN BEARING OF A WIND TURBINE**

**CROSS-REFERENCE TO RELATED
APPLICATIONS**

This application is the national phase of, and claims priority to, International Application No. PCT/EP2022/061836, filed May 3, 2022, which claims priority to Danish Application No. PA 2021 70204, filed May 3, 2021.

FIELD OF THE INVENTION

The invention relates to a base for supporting a portable crane for handling components of a wind turbine and to a method for removing a main bearing of a wind turbine.

BACKGROUND OF THE INVENTION

Wind power generated by wind turbines is one energy source which has gained traction as an environmentally friendly viable energy source. A wind turbine typically includes a tower, a nacelle arranged at the top of the tower, and a rotor including one or more rotor blades. The nacelle comprises a bed plate for supporting components of the wind turbine, such as a generator, a gearbox, and a main bearing.

The handling of wind turbine components in connection with assembly, maintenance, repairs, and disassembly can be a complicated task as they are often heavy and bulky. This problem is particularly pronounced when the handling of components is to be carried out in a nacelle high above ground or sea level.

Portable cranes are typically used for handling large components, such as gearboxes and main bearings, in the nacelles of wind turbines. The portable crane is hoisted up to the nacelle, for example by means of a smaller crane mounted permanently in the nacelle, and mounted onto the nacelle to allow the portable crane to handle components within the nacelle. As the structure of the wind turbine will often not allow a safe direct mounting of the portable crane, it is typically mounted onto a base configured for supporting the portable crane during handling of components. As limited space is available in the nacelle, the base is often mounted on one or more components of the wind turbine and this may result in limitations with respect to which components can be handled by the portable crane.

SUMMARY OF THE INVENTION

It is therefore an object of the invention to provide an improved base for supporting a portable crane for handling components of a wind turbine, which base provides a greater versatility when it comes to handling of components in the nacelle.

This is achieved with a base, which is mountable on the wind turbine and is configured to be switched between a first configuration and a second configuration, wherein in the first configuration the base is configured for being supported by a main bearing of the wind turbine to allow the crane to lift a gearbox of the wind turbine, wherein in the second configuration the base is configured for being supported by a bed plate of a nacelle of the wind turbine to allow the crane to lift the main bearing, and wherein the base is configured for supporting the crane while switching between the first configuration and the second configuration.

2

Consequently, the base is not limited to use in lifting either the gear box or the main bearing but may be used for both purposes. In addition to facilitating the handling of components inside the nacelle, the logistics associated with the base is also reduced as only a single base needs to be transported to the wind turbine even when needing to lift different components.

Furthermore, as the portable crane is also supported by the base while switching between the first configuration and the second configuration, the base may be switched between the first configuration and the second configuration without having to dismount and remove the portable crane from the base.

In this context, “handling components of the wind turbine” is to be understood as comprising any actions associated with maintenance of the wind turbine, replacement of parts of the wind turbine, installation of the wind turbine, or disassembly of the wind turbine, etc.

In this context, a reference to an item being supported by another is not limited to meaning that there must be a direct contact between them. On the contrary, unless otherwise stated, intermediate elements may be arranged between them. Similarly, references to items being connected to each other are intended to include indirect connections where the two items are connected via one or more intermediate elements.

In this context the wording “the base is configured to be switched between a first configuration and a second configuration” is to be interpreted as the base being designed for being arranged either in the first configuration or in the second configuration. The switching will be dependent on the requirements needed of the base, such as if the portable crane is to be used for lifting the main bearing, the gear box, or another component of the wind turbine. In the following, reference will be made to the base and the portable crane being for lifting either the main bearing or the gear box as these, but it is to be understood that the base is not limited to these uses.

Switching of the base between the first configuration and the second configuration may involve one or more manually or automatically performed steps. Switching of the base between the first configuration or the second configuration may involve using one or more tools.

The base is preferably mountable to the wind turbine by bolting, screwing or other releasable connections, but it is within the scope of the invention that the base is simply configured for resting directly or indirectly on the main bearing and/or the gear box under the influence of gravity.

Preferably, the base is configured to be mounted up tower of a wind turbine, i.e. the base being transported up to the nacelle of the wind turbine and then connected on a component of the window turbine, such as the bed plate of the nacelle or the main bearing. The base may be lifted up to the nacelle by means of an additional crane mounted to the nacelle of the wind turbine, where the additional crane is smaller than the portable crane.

The bed plate of the nacelle is preferably formed as a substantially rectangular plate when viewed from above. The bed plate extends longitudinally along a longitudinal direction, and extends transversally along a transversal direction, where the transversal direction is perpendicular to the longitudinal direction. The bed plate supports other components arranged in the nacelle, such as a generator, a gearbox, and a main bearing. The gear box and the main bearing are normally arranged sequential after each other along the longitudinal direction.

US 12,473,179 B2

3

In the first configuration of the base, the base is configured for being supported by a main bearing of the wind turbine. The base may be directly connected to the main bearing or indirectly connected to the main bearing. For example, the base may be connected to a component of the wind turbine connected to the main bearing, thus achieving an indirect connection between the main bearing and the base. When the base is in the first configuration, the portable crane will thus be fully or partly supported by the main bearing. The connection between the base and the main bearing or one or more other components connected to the main bearing may be carried out by bolting, screwing or other releasable connections. In the first configuration, the portable crane can lift the gearbox of the wind turbine, i.e. the base does not support the portable crane via the gearbox.

In the second configuration of the base, the base is supported by a bed plate of the nacelle of the wind turbine. The base may be directly connected to the bed plate or indirectly connected to the bed plate. For example, the base may be connected to a component of the wind turbine connected to the bed plate, thus achieving an indirect connection between the bed plate and the base. When the base is in the second configuration, the portable crane is fully or partly supported via the bed plate. The connection between the base and the bed plate or other components connected to the bed plate may be carried out by bolting, screwing or other releasable connections. In the second configuration, the portable crane can lift the main bearing of the wind turbine, i.e. the base does not support the portable crane via the main bearing.

In an embodiment, the base further comprises one or more bearing adapters configured for being connected to the main bearing in the first configuration and for supporting the portable crane in the first configuration.

The bearing adapters may be directly connected to the main bearing, i.e. abutting or otherwise contacting the main bearing. Alternatively, the bearing adapters may be connected via one or more bearing shims. The one or more bearing shims allows for the height of the bearing adapters relative to the main bearing to be adjusted. Alternatively, the bearing adapters or bearing shims may be connected indirectly to the main bearing, e.g. connected to a component connected to the main bearing. The bearing adapters are preferably connected to the main bearing via bolts, screws or other releasable connections. The bearing adapters may be connected to a pillow block of the main bearing. When using two bearing adapters, they are preferably arranged on opposing sides of the main bearing, i.e. symmetric with each other about the longitudinal direction defined by the bed plate. In some embodiments the bearing adapter(s) are only configured for supporting the portable crane in the first configuration.

In an embodiment the base further comprises one or more side structures configured for being connected to the bed plate of the nacelle in the second configuration of the base, and for supporting the portable crane in the second configuration of the base.

The side structure(s) may be directly connected to the bed plate of the nacelle, i.e. abutting or otherwise contacting the bed plate. Alternatively, the side structures may be connected via one or more side shims. The one or more side shims allows for the height of the side structures relative to the bed plate to be adjusted. Alternatively, the side structures may be connected indirectly to the bed plate, e.g. connected to a component connected to the bed plate. The side structures are preferably connected to the bed plate via bolts, screws or other releasable connections. In some embodi-

4

ments, the side structures are connected to the bed plate by resting on the bed plate without being fixedly connected to the bed plate. Where the portable crane is to lift a component, e.g. the main bearing, along the longitudinal direction, it may be enough to only have the side structures supporting the crane by resting on the bed plate of the nacelle. The side structures may further or alternatively be connected to a pillow block of the gear box of the wind turbine. In some embodiments the side structures are only configured for supporting the portable crane in the second configuration. When using two side structures they are preferably arranged on opposing sides of the main bearing, i.e. symmetric with each other about the longitudinal direction defined by the longitudinal extension of the bed plate.

In an embodiment the base further comprises one or more longitudinal beams configured for supporting the portable crane, wherein each longitudinal beam is connectable to a bearing adapter and a side structure, wherein in the first configuration the bearing adapter(s) are connected to the two longitudinal beams, and wherein the base is configured to be switched from the first configuration to the second configuration by connecting the side structure(s) to the longitudinal beam(s) and the bed plate of the nacelle and disconnecting the bearing adapter(s) from the main bearing.

Consequently, a simple structure is achieved for switching the base between the first configuration and the second configuration. Furthermore, the process described is easily reversible, i.e. going from the second configuration to the first configuration, by connecting the bearing adapter(s) to the main bearing and disconnecting the side structure(s) from the bed plate and/or the longitudinal beam(s). Furthermore, the above-described structure allows for the base to support the portable crane while going from the first configuration to the second configuration and vice versa.

It is presently considered advantageous that the base comprises two longitudinal beams each connectable to a bearing adapter and a side structure and being arranged on opposite sides of the main bearing in use.

The longitudinal beams are preferably connected to the side structures and the bearing adapters via bolts, screws or other releasable connections. The longitudinal beams may be directly connectable to the side structures and the bearing adapters, i.e. that is abutting or otherwise contacting each other. Alternatively, the longitudinal beams may be connectable to the side structures and the bearing adapters via one or more beam shims.

In this context, "disconnecting" is to be understood as removing a connection. For example, when writing the side structures are disconnected from the bed plate and/or the two longitudinal beams it may be interpreted as the bolts or screws connecting these are removed, thus disconnecting the side structures from the bed plate and/or the two longitudinal beams. Furthermore, disconnecting may refer to both removing a direct connection or an in-direct connection.

In an embodiment the two bearing adapters are configured to be disconnected from the two longitudinal beams, raised vertically and then reconnected to the two longitudinal beams, when switching the base from the first configuration to the second configuration. Consequently, by raising the bearing adapters an additional clearance for lifting the main bearing is provided. The bearing adapters may be raised manually. Alternatively, the bearing adapters may be raised by the usage of a jack or similar. The bearing adapters may be reconnected by bolts, screws or other releasable connections.

In an embodiment the base further comprises a rotor lock support configured for being connected to the bed plate of

US 12,473,179 B2

5

the nacelle via at least part of a rotor lock of the nacelle in the second configuration of the base and for supporting the portable crane in the second configuration of the base.

The rotor lock support may be directly connected to a rotor lock of the wind turbine, i.e. abutting, or otherwise contacting the rotor lock. The rotor lock support is preferably arranged at a longitudinal end of the bed plate and extending transversely to the longitudinal direction of the bed plate. In some embodiments, the rotor lock support is connected to the rotor lock by resting on the rotor lock without being fixedly connected to the rotor lock. In some embodiments the rotor lock support is only configured for supporting the portable crane in the second configuration. In an embodiment the rotor lock support comprises a through-going hole configured for receiving the at least part of the rotor lock.

Consequently, a simple and easy connection is achieved. Most wind turbines are provided with a rotor lock comprising a pin, thus the addition of a through-going hole configured for receiving such a pin allows for the rotor lock support to be engaged with the rotor lock, without the need for additional tools or equipment.

In an embodiment the rotor lock support is formed with an opening configured to allow the main bearing to pass through the rotor lock support in the second configuration of the base.

Consequently, the rotor lock support may only need to support against normal stresses, without having to support against shear stresses. Preferably, the opening is configured to allow a main bearing to be moved along a longitudinal direction of the nacelle to pass through the opening. Preferably, the opening extends in a plane perpendicular to the longitudinal direction.

In an embodiment the base further comprises a transversal beam configured for supporting the portable crane, wherein the transversal beam is connectable to two bearing adapters and the rotor lock support, wherein in the first configuration of the base the two bearing adapters are connected to the transversal beam, and wherein the base is switchable from the first configuration to the second configuration by connecting the rotor lock support to the transversal beam and disconnecting the bearing adapters from the main bearing.

Consequently, a simple structure is achieved for switching the base between the first configuration and the second configuration. Furthermore, the process described is easily reversible, i.e. going from the second configuration to the first configuration, by connecting the bearing adapters to the main bearing and disconnecting the rotor lock support from the rotor lock and the transversal beam. Furthermore, the structure allows for the base to support the portable crane while going from the first configuration to the second configuration and vice versa. The transversal beam is preferably connected to the rotor lock support and the bearing adapters via bolts, screws or other releasable connections. The transversal beam may be directly connectable to the rotor lock support and the bearing adapters, i.e. that is abutting or otherwise contacting each other. Alternatively, the transversal beam may be connectable to the rotor lock support and the bearing adapters via one or more beam shims.

According to a second aspect of the invention the object is achieved with a crane system for handling components of a wind turbine comprising a base according to the first aspect of the invention and a portable crane.

According to a third aspect of the invention the object is achieved with a method for removing a main bearing of a wind turbine comprising the steps of:

6

providing a base mountable on the wind turbine, wherein the base is configured to be switched between a first configuration and a second configuration, wherein in the first configuration the base is configured for being supported by a main bearing of the wind turbine, wherein in the second configuration the base is configured for being supported by a bed plate of a nacelle of the wind turbine, and wherein the base is configured for supporting a portable crane while switching between the first configuration and the second configuration, providing the portable crane mountable on the base, mounting the base to the nacelle of the wind turbine, mounting the portable crane to the base, if the base is in the first configuration, switching the base from the first configuration to the second configuration, and lifting the main bearing using the portable crane.

Other presently preferred embodiments and further advantages will be apparent from the subsequent detailed description and drawings.

Unless otherwise stated, a feature described in relation to one of the aspects of the invention may also be incorporated in the other aspects, and the advantage of the feature is applicable to all aspects in which it is incorporated.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following description embodiments of the invention will be described with reference to the schematic drawings, in which:

FIG. 1 is a schematic perspective view of a base mounted on the bed plate of a nacelle according to a first embodiment of the invention.

FIG. 2 is a schematic side view of a base mounted on the bed plate of a nacelle according to the first embodiment of the invention.

FIG. 3 is a schematic side view of a base mounted on the main bearing of a nacelle according to the first embodiment of the invention.

FIG. 4 is a schematic perspective view of a base mounted on the bed plate of a nacelle according to a second embodiment of the invention.

FIG. 5 is a schematic front view of a base mounted on the bed plate of a nacelle according to the second embodiment of the invention.

FIG. 6 is a schematic side view of a base mounted on the bed plate of a nacelle according to a second embodiment of the invention.

FIG. 7 is a flow chart depicting a method for removing a main bearing of a wind turbine.

DETAILED DESCRIPTION

In the following detailed description, preferred embodiments of the invention will be described. However, it is to be understood that features of the different embodiments are exchangeable between the embodiments and may be combined in different ways, unless anything else is specifically indicated. It may also be noted that, for the sake of clarity, the dimensions of certain components illustrated in the drawings may differ from the corresponding dimensions in real-life implementations.

It is noted that terms such as “up”, “down”, “left-hand”, “right-hand”, “exterior”, “interior”, “outer”, “inner” are relative and refers to the viewpoint in question.

Referring initially to FIG. 1, which shows a schematic perspective view of a base 100 mounted on the bed plate 301

US 12,473,179 B2

7

of a nacelle 300 according to a first embodiment of the invention. The nacelle 300 has been simplified and parts have been left out to ease understanding of the invention. The nacelle 300 is shown with the bed plate 301, a gear box 303, gear box pillow blocks and a main bearing 304. The bed plate 301 of the nacelle extends longitudinally in a longitudinal direction LD.

The base 100 is configured for supporting a portable crane (not shown) for handling components of a wind turbine, and in the shown embodiment, the base 100 is in a second configuration and is supported by the bed plate 301 of the nacelle 300. The base 100 is further supported by a gear box pillow block 302. In the second configuration, the base 100 is not supported by the main bearing 304, thus allowing a portable crane mounted on the base 100 to lift the main bearing 304.

The base 100 comprises two bearing adapters 101 arranged symmetrically around the main bearing 304, which will be explained in greater detail with reference to FIG. 3. The base 100 further comprises two side structures 102 arranged symmetrically around the main bearing 304, which will be explained in greater detail with reference to FIG. 2. The base 100 further comprises two longitudinal beams 103, each of which are each connectable to one of the two bearing adapters 101 and one of the two side structures 102. In the first configuration of the base the two bearing adapters 101 are connected to the two longitudinal beams 103. In the second configuration of the base the two side structures 102 are connected to the two longitudinal beams 103. The two longitudinal beams 103 extend longitudinally in parallel with the longitudinal direction LD and are arranged symmetrically around the main bearing 304.

Arranged on the two longitudinal beams 103 are two transversal beams 104. The two transversal beams 104 extend perpendicularly to the two longitudinal beams 103 and are at opposing ends connected to the longitudinal beams 103. Arranged on the transversal beams 104 is a crane receiving section 108. The crane receiving section 108 is configured for receiving a portable crane, to allow the portable crane to be connected to and supported by the base 100. Alternatively, the portable crane may be directly connected to the transversal and/or the longitudinal beams 104, 103.

In this embodiment, an additional crane 200 is mounted on a gear box pillow block 302. The additional crane 200 may assist in raising parts of or the entire base 100 up to the nacelle 300. The additional crane 200 may also assist in raising the portable crane to be mounted on the base 100, and in installing the portable crane onto the base 100. In embodiments, where the base 100 is required to rest on both gear box pillow blocks 302 in the second configuration it may be necessary to disassemble and remove the additional crane 200.

Referring to FIG. 2, which shows a schematic side view of a base 100 mounted on the bed plate 301 of a nacelle 300 according to the first embodiment of the invention.

In FIG. 2 the base 100 is shown in the second configuration. In the second configuration of the base 100, the side structure 102 is configured to support a portable crane received on the crane receiving section 108. The side structure 102 is seen extending longitudinally in parallel to the longitudinal direction LD. The side structure 102 is connected to the bed plate 301 via a side shim 106 and a similar shim may be found at the side structure on the opposite side of the main bearing 304. The side shim 106 is directly contacting the bed plate 301 and the side structure 102. The side structure 102 in the shown embodiment rests

8

on the side shim 106 by gravitational force. Alternatively, the side structure 102 may be bolted to the bed plate 301 through the side shim, or directly resting on the bed plate 301. The side structure 102 is further connected to the gear box pillow block 302. Consequently, the base 100 is supported by the bed plate 301 and the gear box pillow block 302 via the side structure 102. By having the base 100 supported by the bed plate 301 and the gearbox pillow block 302 it allows a portable crane received by the crane receiving section 108 to lift the main bearing 304.

In this embodiment the side structure 102 is connected to the longitudinal beam 103 via two mounting brackets 105 and to the longitudinal beam 103 via bolts. The side structure 102 is connected to the longitudinal beam 103 so that it overlies the bearing adapter 101.

Reference is now made to FIG. 3, which shows a schematic side view of a base 100 mounted on the main bearing 304 of a nacelle 300 according to the first embodiment of the invention.

The base 100 is here in the first configuration. The bearing adapter 101 is seen extending longitudinally in parallel to the longitudinal direction LD. Although not shown, another bearing adapter 101 is arranged symmetric to the shown side adapter 102 on the opposite side of the main bearing 304. The bearing adapter 101 is connected to the main bearing 304 via a side shim 106. Specifically, the bearing adapter 101 is connected to a pillow block associated with the main bearing 304. The bearing adapter 101 is connected to the main bearing via a plurality of bearing shims 107. The bearing shims 107 are directly contacting the main bearing 304 and the bearing adapter 101. The connection between the bearing adapter 101 and the main bearing 304 allows for the bearing adapter 101 to support a portable crane received by the crane receiving section 108. Furthermore, as the base 100 is not supported by the gear box 303 it allows a portable crane received by the crane receiving section to lift the gear box 303.

In this embodiment, the bearing adapter 101 is formed with a substantially H-shape. The two feet of the H-shape is connected to the main bearing 304 at two different positions. The tops of the H-shape are connected to the longitudinal beam 103 via bolts. The bearing adapter 101 may be connectable to the longitudinal beam 103 at two different positions. A first position, as shown, associated with the base 100 being in the first configuration, and a second position, associated with the base 100 being in the second configuration. The bearing adapter 100 when connected to the longitudinal beam 103 in the second position is raised when compared to the first position. The longitudinal beam 103 may for example be provided with a first set of bolt holes for connecting the bearing adapter 101 to the longitudinal beam in the first position, and a second set of bolt holes for connecting the bearing adapter 101 to the longitudinal beam in the second position.

The bearing adapter 101 in FIG. 3 is not connected to the gear box pillow block 302, thus allowing for other structures to be connected to the gear box pillow block 302. In the shown embodiment, the additional crane 200 is connected to the gear box pillow block 302.

Referring now to both FIGS. 2 and 3. When switching the base from the first configuration shown in FIG. 3 to the second configuration shown in FIG. 2, the two side structures 102 are connected to the longitudinal beams 103 and the bed plate 301 of the nacelle 300. Then the two bearing adapters 101 are disconnected from the main bearing 304. During the process a portable crane received by the crane receiving section 108 is supported by the base 100. Further-

US 12,473,179 B2

9

more, bearing adapters **101** may be disconnected from the longitudinal beams **103** and raised, and then reconnected to the longitudinal beams **103** to provide clearance for lifting the main bearing **304**. Alternatively, if the bearing adapters **101** are resting on bearing shims **107**, it may be sufficient to remove these to provide clearance for lifting the main bearing **304**.

Referring to FIG. 4, which shows a schematic perspective view of a base **100** mounted on the bed plate **301** of a nacelle **300** according to a second embodiment of the invention.

In the shown embodiment, the base **100** is in a second configuration and is supported by the bed plate **301** of the nacelle **300**. The base **100** is further supported by a gear box pillow block **302**. In the second configuration the base is not supported by the main bearing **304**, thus allowing a portable crane mounted on the base **100** to lift the main bearing **304**.

The nacelle **300** in the shown embodiment has been simplified and parts have been left out to ease understanding of the invention. The nacelle **300** is shown with the bed plate **301**, gear box pillow block **302**, a main shaft **305**, and the main bearing **304**. The bed plate **301** of the nacelle extends longitudinally in a longitudinal direction LD.

The base **100** in the shown embodiment differs from the first embodiment in that the two longitudinal beams **103** are connected to the gear box pillow block **302** and the two transversal beams **104**, when the base **100** is in the second configuration. When the base **100** is in the first configuration, two bearing adapters **101** are introduced and connected to the two longitudinal beams **103** and the main bearing **304**.

Referring now to FIG. 5, a schematic front view of a base **100** mounted on the bed plate of a nacelle **300** according to the second embodiment of the invention is illustrated.

In this embodiment a rotor lock support **102** serves substantially the same purpose as the side structures described above and have therefor been given the same reference number.

The rotor lock support is formed with a substantial U-shape, which defines an opening. The opening is configured to allow the main bearing **304** to pass through the rotor lock support **102**, when the base **100** is in the second configuration. The opening allows a portable crane received on the crane receiving section **108** to lift the main bearing **304** through the opening along the longitudinal direction LD. A yoke (not shown) may be provided to facilitate lifting of the main bearing **304**.

The rotor lock support **102** shown further comprises a through-going hole **109**. The through going hole **109** is configured for receiving the rotor lock, shown in FIG. 6.

FIG. 6 shows a schematic side view of a base **100** mounted on the bed plate **301** of a nacelle **300** according to the second embodiment of the invention.

The base **100** is in the shown embodiment in the second configuration. The rotor lock support **102** is connected to a rotor lock **306**. The rotor lock **306** comprises a pin, which is introduced into the through-going hole **109** of the rotor lock support **102**, thus connecting the two parts.

The rotor lock support **102** is further connected to one of the transversal beams **104**. Consequently, in the second configuration of the base **100**, the base **100** is supported by the connection between the rotor lock support **102** and the rotor lock **306**, and the connection between the longitudinal beams **103** and the gear box pillow block **302**, thus allowing for a portable crane received by the crane receiving section **108** to lift the main bearing **304**.

In this embodiment, the rotor lock support **102** is formed with a flange which is bolted together with the transversal beam **104**.

10

One or more rotor lock shims may be arranged in-between the transversal beam **104** and the rotor lock support **102**. The one or more rotor locks shims may facilitate alignment of the through-going hole **109** with the rotor lock **306**.

The base **100** in the second embodiment may be changed from the second configuration to the first configuration by connecting bearing adapters to the main bearing **304**, and disconnecting rotor lock support **102** from the transversal beam **104**.

FIG. 7 shows a flow chart of a method for removing a main bearing of a wind turbine according to an embodiment of the invention.

In a first step **401**, a base is provided. The base is mountable on a nacelle of the wind turbine. As described above, the base is configured to be switched between a first configuration and a second configuration, where in the first configuration the base is connected to a main bearing of the wind turbine, and in the second configuration the base is connected to a bed plate of the nacelle, and the base is configured for supporting a portable crane while switching between the first configuration and the second configuration.

In a second step **402**, a portable crane mountable on the base is provided.

In a third step **403**, the base is mounted in the nacelle of the wind turbine.

In a fourth step **404**, the portable crane is mounted to the base.

In a fifth step **405**, the base is switched from the first configuration to the second configuration, if the base is initially in the first configuration.

In a sixth step **406**, the main bearing is lifted using the portable crane. Lifting of the main bearing may comprise exchanging the main bearing, performing maintenance work on the main bearing, or the like.

The method may further comprise a seventh step **407** and an eighth step **408**. In the seventh step **407**, the base is switched from the second configuration to the first configuration. In the eighth step **408**, the gear box is lifted using the portable crane. Lifting of the gear box may comprise exchanging the gear box, performing maintenance work on the gear box or the like.

The person skilled in the art realizes that the present invention by no means is limited to the preferred embodiments described above. On the contrary, many modifications and variations are possible within the scope of the appended claims.

The invention claimed is:

1. A base for supporting a portable crane for handling components of a wind turbine, wherein:

the base is mountable on the wind turbine, the base is configured to be switched between a first configuration and a second configuration,

in the first configuration the base is configured for being supported by a main bearing of the wind turbine to allow the portable crane to lift a gearbox of the wind turbine,

in the second configuration the base is configured for being supported by a bed plate of a nacelle of the wind turbine to allow the portable crane to lift the main bearing, and

the base is configured for supporting the portable crane while switching between the first configuration and the second configuration.

2. The base according to claim 1, wherein the base further comprises two bearing adapters configured for being supported by the main bearing in the first configuration and for supporting the portable crane in the first configuration.

US 12,473,179 B2

11

3. The base according to claim 2, wherein the base further comprises two side structures configured for being supported by the bed plate of the nacelle in the second configuration of the base and for supporting the portable crane in the second configuration of the base.

4. The base according to claim 3, wherein the two side structures are configured for being directly connected to the bed plate of the nacelle in the second configuration of the base.

5. The base according to claim 4, wherein:
the base further comprises two longitudinal beams configured for supporting the portable crane,
each of the two longitudinal beams are connectable to one of the two bearing adapters and one of the two side structures,

in the first configuration the two bearing adapters are connected to the two longitudinal beam, and
the base is configured to be switched from the first configuration to the second configuration by connecting the two side structures to the two longitudinal beams and the bed plate of the nacelle and disconnecting the two bearing adapters from the main bearing.

6. The base according to claim 5, wherein:
the base further comprises a transversal beam configured for supporting the portable crane,
the transversal beam is connectable to the two bearing adapters and the rotor lock support,
in the first configuration of the base the two bearing adapters are connected to the transversal beam, and
the base is switchable from the first configuration to the second configuration by connecting the rotor lock support to the transversal beam and disconnecting the bearing adapters from the main bearing.

7. The base according to claim 3, wherein:
the base further comprises two longitudinal beams configured for supporting the portable crane,
each of the two longitudinal beams are connectable to one of the two bearing adapters and one of the two side structures,
in the first configuration the two bearing adapters are connected to the two longitudinal beam, and
the base is configured to be switched from the first configuration to the second configuration by connecting the two side structures to the two longitudinal beams and the bed plate of the nacelle and disconnecting the two bearing adapters from the main bearing.

8. The base according to claim 7, wherein the two bearing adapters are configured to be disconnected from the two longitudinal beams and raised vertically and reconnected to the two longitudinal beams when switching the base from the first configuration to the second configuration.

9. The base according to claim 2, wherein the base further comprises a rotor lock support configured for being connected to the bed plate of the nacelle via at least part of a rotor lock of the nacelle in the second configuration of the base and for supporting the portable crane in the second configuration of the base.

10. The base according to claim 9, wherein the rotor lock support comprises an opening configured to allow the main bearing to pass through the rotor lock support in the second configuration of the base.

11. The base according to claim 10, wherein:
the base further comprises a transversal beam configured for supporting the portable crane,

12

the transversal beam is connectable to the two bearing adapters and the rotor lock support,

in the first configuration of the base the two bearing adapters are connected to the transversal beam, and
the base is switchable from the first configuration to the second configuration by connecting the rotor lock support to the transversal beam and disconnecting the bearing adapters from the main bearing.

12. The base according to claim 1, wherein the base further comprises a rotor lock support configured for being connected to the bed plate of the nacelle via at least part of a rotor lock of the nacelle in the second configuration of the base and for supporting the portable crane in the second configuration of the base.

13. The base according to claim 12, wherein the rotor lock support comprises a through-going hole configured for receiving the least part of the rotor lock.

14. The base according to claim 13, wherein the rotor lock support comprises an opening configured to allow the main bearing to pass through the rotor lock support in the second configuration of the base.

15. A crane system for handling components of a wind turbine comprising a base according to claim 1 and a portable crane.

16. The crane system according to claim 15 mounted in a nacelle of a wind turbine, wherein, when in the first configuration, the base is supported by a main bearing of the wind turbine, and wherein, when in the second configuration, the base is supported by a bed plate of a nacelle of the wind turbine.

17. The base according to claim 1, wherein the base further comprises two side structures configured for being supported by the bed plate of the nacelle in the second configuration of the base and for supporting the portable crane in the second configuration of the base.

18. The base according to claim 17, wherein the two side structures are configured for being directly connected to the bed plate of the nacelle in the second configuration of the base.

19. A method for removing a main bearing of a wind turbine comprising the steps of:

providing a base mountable on the wind turbine, wherein the base is configured to be switched between a first configuration and a second configuration, wherein in the first configuration the base is configured for being supported by a main bearing of the wind turbine, wherein in the second configuration the base is configured for being supported by a bed plate of a nacelle of the wind turbine, and wherein the base is configured for supporting a portable crane while switching between the first configuration and the second configuration,
providing a portable crane mountable on the base,
mounting the base to the nacelle of the wind turbine,
mounting the portable crane to the base,
if the base is in the first configuration, switching the base from the first configuration to the second configuration, and
lifting the main bearing using the portable crane.

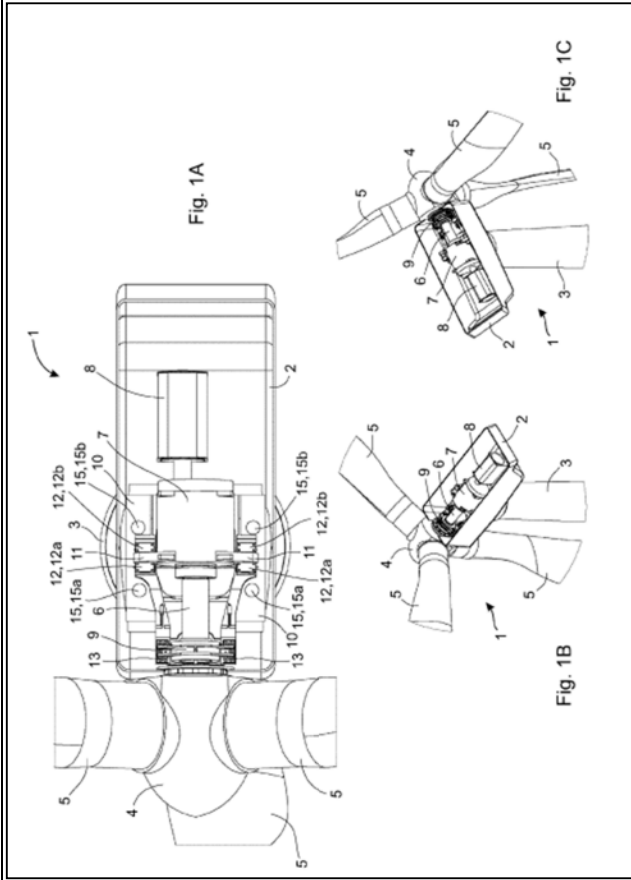
20. The method according to claim 19 further comprising the steps of:

switching the base from the second configuration to the first configuration, and
lifting the gear box using the portable crane.

* * * * *

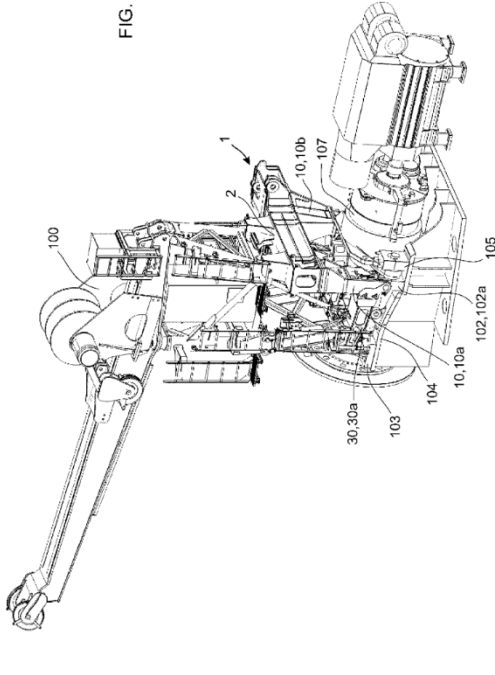
Exhibit F

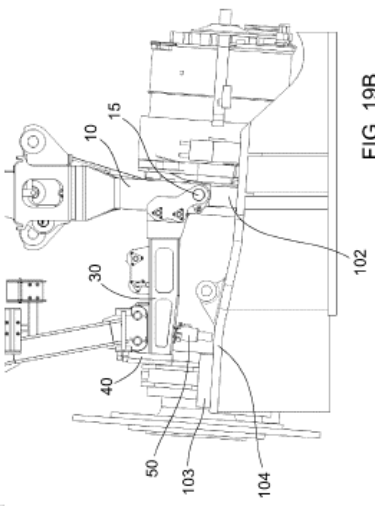
	U.S. Patent No. 12,473,179 Claim Language	Infringement Analysis
1(pre)	A base for supporting a portable crane for handling components of a wind turbine;	The Accused Products include a base for supporting a portable crane for handling components of a wind turbine. <i>See, e.g.,</i> WO2021168549A1 at 6:29-7:5 (“Inside the nacelle 2, the main bearing 9 and the gearbox 7 are supported on a bedplate 10. Torque arms 11 connected to the gearbox 7 and the bedplate 10 at the right and left sides of the gearbox 7 stabilize the gearbox 7 against twisting forces. The torque arms 7 are reinforced by gearbox pillow blocks 12 attached to the bedplate 10 in front of and behind the torque arms 7. The gearbox pillow blocks 12 comprise forward gearbox pillow blocks 12a and rearward gearbox pillow blocks 12b. The main bearing 9 is housed in a main bearing housing secured to the bedplate 10 by main bearing housing securements 13 at the right and left sides of the main bearing 9. The bedplate 10 further comprises lifting lugs 14 attached to the right and left sides of the bedplate 10. The nacelle 2 is rotatable atop the tower 3 by virtue of yaw drives (not shown) seated in yaw drive pockets 15 in the bedplate 10. The yaw drive pockets 15 comprise forward yaw drive pockets 15a and rearward yaw drive pockets 15b.”).



WO2024/164064

LifWerx PCT Publication, WO2024/164064 is titled “Base for Supporting a Lift System in a Nacelle of a Wind Turbine” and is representative of the Accused Products. “Fig. 1 to Fig. 4 provide context and depict an interior of a nacelle of a wind turbine in which a lift system 100 is supported on a base 1 mounted in the nacelle beside and over a main shaft 101 of the wind turbine.”

	U.S. Patent No. 12,473,179 Claim Language	Infringement Analysis
		 FIG. 1 WO2024/164064 Fig. 1 <i>See, e.g., WO2024/164064 at 3:1-15: “A base for supporting a lift system in a nacelle of a wind turbine comprises: a pillow block mount configured to be supported on a pillow block in the nacelle of the wind turbine, the pillow block mount mountable on the pillow block through studs connecting the pillow block mount to the pillow block; a longitudinal beam pivotally connected to the pillow block mount, the longitudinal beam having a longitudinal axis, a proximal end proximate the pillow block mount and a distal end remote from the pillow block mount, the longitudinal beam pivotable about a horizontally oriented axis transverse to the longitudinal axis of the longitudinal beam; a beam support connected to the longitudinal beam, the beam support configured to support the longitudinal beam on a main bearing of the wind turbine proximate the distal end of the longitudinal beam; and, a jack situated proximate the distal end of the longitudinal beam, the jack operable to engage the longitudinal beam and a bedplate of the nacelle to raise and lower the distal end of the longitudinal beam to pivot the longitudinal beam about the horizontally oriented axis”.</i>

U.S. Patent No. 12,473,179 Claim Language	Infringement Analysis
1(b) the base is configured to be switched between a first configuration and a second configuration,	The base is configured to be switched between a first configuration and a second configuration. See, e.g., WO2024/164064 at 9:6-11: “As seen in Fig. 18A and Fig. 18B, with the longitudinal beams 30 supported on the main bearing 103 and connected to the respective trunnion mount assemblies 10, the longitudinal beams 30 can support the weight of the lift system 100 as the lift system 100 lifts a heavy component of the wind turbine...In this configuration of the base 1, the lift system 100 is usable for mounting and dismounting the rotor or individual rotor blade, which is a very heavy wind turbine component.”  WO2024/164064 Fig. 19B WO2024/164064 at 9:33-10:4 “Continued extension of the jacks 50 raises the distal ends of the longitudinal beams 30, the longitudinal beams 30 pivoting about the trunnion pins 15 at the proximal end of the longitudinal beams 30. Raising the distal ends of the longitudinal beams 30 lifts the beam supports 40 off the main bearing 103 until the beam supports 40 are lifted to a height sufficient to permit the lift system 100 to lift and dismount the main bearing 103.”

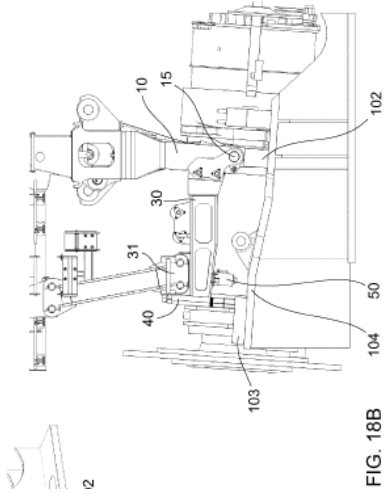


FIG. 18B

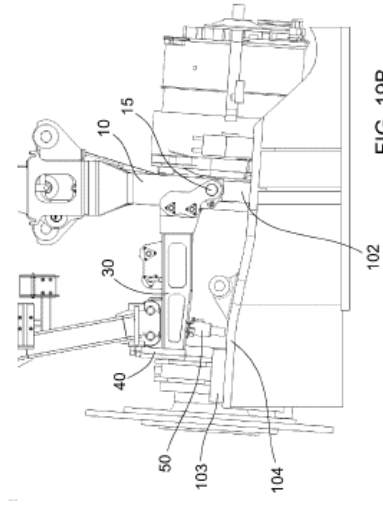


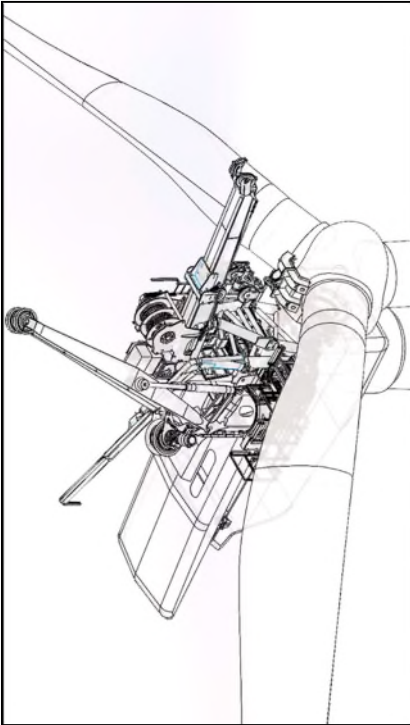
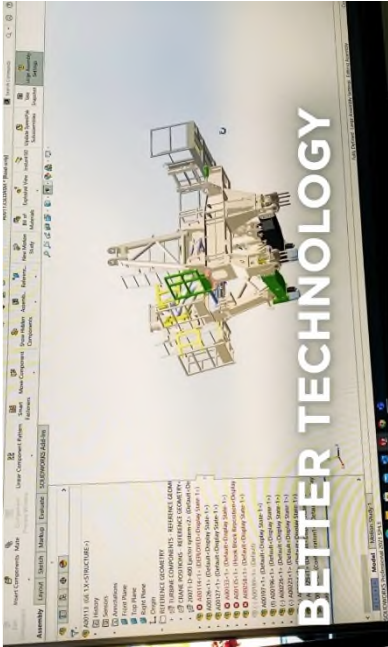
FIG. 19B

WO2024/164064 Fig. 18B and 19B

WO2024/164064 at 9:29-31 (“To accomplish the reconfiguration of the base 1, the jacks 50 are actuated to extend to engage the base plate 104, as seen in Fig. 19A and Fig. 19B.”). See also, *Id.* at 10: 4-6: “Thus, the base 1 is reconfigurable to switch between lifting the rotor and the main bearing with minimal effort and without needing to remove the base 1 or add components to the base 1.”

TYPES OF EXCHANGES			LEGEND	
WIND TURBINE	GEN-HOOK	ROTOR-HOOK		
GE 1.X 6.3 MW 100 ft				
GE 2.X 7.5 MW 100 ft				
GE 3.X Sierra 9.5 MW 100 ft				
Siemens 2050 8.0 MW 100 ft				
Siemens G2 (2.3) 6.0 MW 100 ft				
Gamesa 2.1 MW 80 ft 100 ft				
Vestas 2 MW 80 ft 100 ft				
Vestas 3 MW 100 ft 100 ft				

<https://liftwerx.com/our-cranes/>

U.S. Patent No. 12,473,179 Claim Language	Infringement Analysis
	 LifWerx promotional video at 0m17s https://youtu.be/uFjCEjWavg?si=WvI972dCNbuFkBIq  LifWerx promotional video at 0m20s https://youtu.be/uFjCEjWavg?si=WvI972dCNbuFkBIq

	U.S. Patent No. 12,473,179 Claim Language	Infringement Analysis
1(c)	in the first configuration the base is configured for being supported by a main bearing of the wind turbine to allow the portable crane to lift a gearbox of the wind turbine,	In the first configuration in the Accused Products, the base is configured for being supported by a main bearing of the wind turbine to allow the portable crane to lift a gearbox of the wind turbine. <i>See, e.g.</i>, WO2024/164064 at 9:6-11: “As seen in Fig. 18A and Fig. 18B, with the longitudinal beams 30 supported on the main bearing 103 and connected to the respective trunnion mount assemblies 10, the longitudinal beams 30 can support the weight of the lift system 100 as the lift system 100 lifts a heavy component of the wind turbine...In this configuration of the base 1, the lift system 100 is usable for mounting and dismounting the rotor or individual rotor blade, which is a very heavy wind turbine component.” <i>See, e.g.</i>, WO2024/164064 at 10: 4-6: “Thus, the base 1 is reconfigurable to switch between lifting the rotor and the main bearing with minimal effort and without needing to remove the base 1 or add components to the base 1.” WO2024/164064 at 10:9-11: “Thus, with minimal reconfiguration of the base 1, the lift system 100 can also then be used to lift the gearbox.” As shown below, the RotorHook and GenHook are both capable of lifting a gearbox.

	U.S. Patent No. 12,473,179 Claim Language	Infringement Analysis																																
1(d)	in the second configuration the base is configured for being supported by a bed plate of a nacelle of the wind turbine to allow the portable crane to lift the main bearing, and	TYPES OF EXCHANGES WIND TURBINE GEN:HOOK ROTOR:HOOK LEGEND <table><tr><td>GE 1.X 5, 5E, 9E, B35</td><td></td><td></td><td> Generator Main Bearing Pitch Bearing In Development</td></tr><tr><td>GE 2.X 716, 127</td><td></td><td></td><td></td></tr><tr><td>GE 3.X Sierra 140, 154</td><td></td><td></td><td></td></tr><tr><td>Servion 2050 HAWK 9-10M150</td><td></td><td></td><td></td></tr><tr><td>Siemens G2 (2.3) 82, 85, 101, 108</td><td></td><td></td><td></td></tr><tr><td>Gamesa 2 MW G82, G98</td><td></td><td></td><td></td></tr><tr><td>Vestas 2 MW V90, V90</td><td></td><td></td><td></td></tr><tr><td>Vestas 2 MW V100, V110, V120</td><td></td><td></td><td></td></tr></table> In the second configuration in the Accused Products, the base is configured for being supported by a bed plate of a nacelle of the wind turbine to allow the portable crane to lift the main bearing. See, e.g., WO2024/164064 at 9:33-10:4 “Continued extension of the jacks 50 raises the distal ends of the longitudinal beams 30, the longitudinal beams 30 pivoting about the trunnion pins 15 at the proximal end of the longitudinal beams 30. Raising the distal ends of the longitudinal beams 30 lifts the beam supports 40 off the main bearing 103 until the beam supports 40 are lifted to a height sufficient to permit the lift system 100 to lift and dismount the main bearing 103.”	GE 1.X 5, 5E, 9E, B35			Generator Main Bearing Pitch Bearing In Development	GE 2.X 716, 127				GE 3.X Sierra 140, 154				Servion 2050 HAWK 9-10M150				Siemens G2 (2.3) 82, 85, 101, 108				Gamesa 2 MW G82, G98				Vestas 2 MW V90, V90				Vestas 2 MW V100, V110, V120			
GE 1.X 5, 5E, 9E, B35			Generator Main Bearing Pitch Bearing In Development																															
GE 2.X 716, 127																																		
GE 3.X Sierra 140, 154																																		
Servion 2050 HAWK 9-10M150																																		
Siemens G2 (2.3) 82, 85, 101, 108																																		
Gamesa 2 MW G82, G98																																		
Vestas 2 MW V90, V90																																		
Vestas 2 MW V100, V110, V120																																		

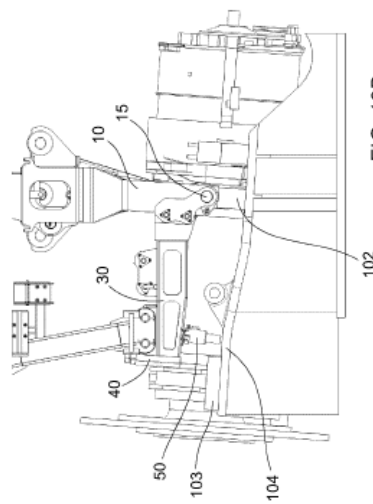
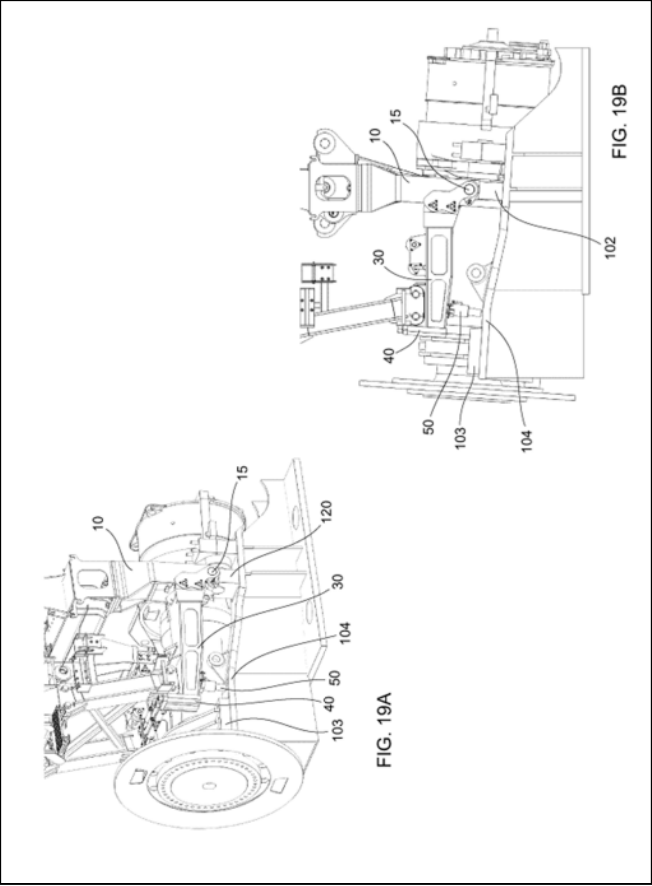


FIG. 19B

WO2024/164064 Fig. 19B

Fig. 19A depicts a magnified front left side view of the interior of the nacelle of Fig. 1 showing the base supported on a bedplate instead of on the main bearing.

Infringement Analysis		
U.S. Patent No. 12,473,179 Claim Language		The Accused Products base is configured for supporting the portable crane while switching between the first configuration and the second configuration. “The RotorHook™ crane is part of a five-crane system. It is assembled by a GenHook™ crane, which itself is assembled by a Heli-Hook™ crane, which is assembled by two small service cranes. All of these cranes comprise a complex crane system which is now in use by our sister company LiftWerx in North America. You could compare the assembly of the RotorHook™ with a Russian matryoshka, a doll inside a doll inside a doll.” https://eager.one/the-rotorhook-has-arrived/#:~:text=All%20of%20these%20cranes%20comprise%20a%20complex,doll%20inside%20a%20doll%20inside%20a%20doll WO2024/164064 describes a “base for supporting a lift system in a nacelle of a wind turbine...” . “Fig. 1 to Fig. 4 provide context and depict an interior of a nacelle of a wind
1(e)	the base is configured for supporting the portable crane while switching between the first configuration and the second configuration.	

U.S. Patent No. 12,473,179 Claim Language	Infringement Analysis
	turbine in which a lift system 100 is supported on a base 1 mounted in the nacelle beside and over a main shaft 101 of the wind turbine.” FIG. 1