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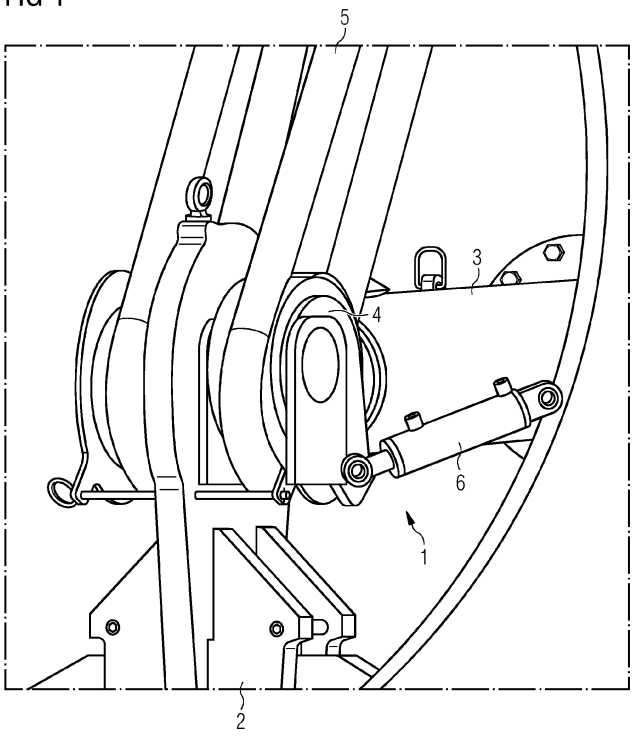
(54) RIGGING DEVICE FOR LIFTING A LOAD BY A CRANE AND METHOD OF LIFTING A WIND TURBINE COMPONENT

(57) It is described a rigging device (1) for lifting a load (2) by a crane, the rigging device comprising a beam (3) and a first pulley (4) mounted to the beam (3) at a first end in a longitudinal axis of the beam (3), the first pulley (4) is configured to receive a first sling (5), wherein the first sling (5) is configured to be connected to a carrier device (20) of a crane or to the load (2). The first pulley (4) is mounted to be eccentrically rotatable with respect to the beam (3), and the first pulley (4) is connected to a first actuator (6) which is configured to rotate the first pulley (4) .

FIG 1



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Description

Field of invention

[0001] The present invention relates to a rigging device for lifting a load by a crane, and to a method of lifting a component of a wind turbine by a crane and the rigging device.

[0002] During complex or heavy lifting of a load by use of a rigging device, which is arranged between a crane hook and the load to be lifted, it will be a benefit to be able to adjust a length of individual rigging leg during the lift procedure for enabling a faster and safer lifting operation. Different solutions have been used to solve this problem so far.

[0003] **Fig. 4** shows a rigging device according to the prior art. The rigging device comprises a beam 30 and two slings 51, 52, wherein each sling 51, 52 is connected at one side to a respective end of the beam 30 in its longitudinal axis. Another side of the respective sling 51, 52 is connected to a carrier device in the shape of a pendulum 70 of a crane. The beam 30 carries a load such as a blade 2 of a wind turbine. The pendulum 70 can be tilted by an actuator 60 so that a rigging length of the sling 51, 52 is adjusted.

[0004] In a different attempt, at least one of the slings 51, 52 can be replaced by a hydraulic cylinder for adjusting the rigging setup during the lifting operation.

[0005] However, in uses cases with heavy loads, for instance above 100 t, there is not yet any solution that can adjust the length of the rigging device during the lifting operation under load.

Summary of the Invention

[0006] There may be a need for a rigging device for lifting a load by a crane, and for a method of lifting a component of a wind turbine by a crane. This need may be met by the subject matters according to the independent claims. The present invention is further developed as set forth in the dependent claims.

[0007] According to a first aspect of the invention, a rigging device for lifting a load by a crane is provided. The rigging device comprises a beam and a first pulley mounted to the beam at a first end in a longitudinal axis of the beam, wherein the first pulley is configured to receive a first sling, and the first sling is configured to be connected to a carrier device of a crane or to the load. The first pulley is mounted to be eccentrically rotatable with respect to the beam, and the first pulley is connected to a first actuator which is configured to rotate the first pulley.

[0008] The rigging device of the present invention consists of few parts which can be assembled with the first pulley as a center piece that is born offset from its center. Together with a reaction arm in the shape of the first actuator, a rigging length can be adjusted under load. By operating the first actuator, the first pulley is rotated, which results in an adjustment of the rigging length.

[0009] By the rigging device of the present invention, the lifting operation can be faster because the length can be adjusted "under load" so that the load does not have to be unloaded before adjusting the sling length. By adjusting the length, a bottom surface of the lifted load can be aligned with a landing surface.

[0010] The lifting operation by the rigging device of the present invention can also be safer because the load does not need to be lifted again after the length adjustment. If a load, such as a nacelle, would be unloaded downwards again, the crane setting, particularly a cog wheel, could otherwise be offset from a support line.

[0011] A particular advantage of the present invention is to enable a rigging adjustment under load, especially an adjustment under a heavy load, while the prior art adjustment was restricted to low load cases only. The adjustment by use of the rigging device of the present invention can be used to achieve faster lifting and landing operations which results in less time spent during the lifting operation. For example, a size of a hydraulic cylinder can be reduced compared with the cylinder of the prior art actuator shown in Fig. 4. This can be achieved because the rigging device of the present invention exhibits much lower friction in the moving parts, so lower forces need to be applied. Compared with the prior art solutions, a precision railing used for a sliding mechanism is not necessary in the present invention.

[0012] According to an embodiment, the first pulley comprises a core made of a first material, preferably metal, and a second material at a circumference of the core, wherein the second material and the first sling have a smaller friction coefficient that the first material of the core and the first sling. According to an embodiment, the second material can comprise a resin-bonded, fabric-reinforced composite and/or Polytetrafluorethylen (PTFE).

[0013] According to an embodiment, the beam comprises a plurality of beam portions, preferably pipes, wherein the beam portions are mounted to each other along the longitudinal axis of the beam by means of flanges. This embodiment achieves a modular concept, where the final beam length can be adapted to the load, such as to wind turbine nacelles having different sizes.

[0014] According to an embodiment, the rigging device further comprises a second pulley mounted to the beam at a second end in the longitudinal axis of the beam, wherein the second pulley is configured to receive a second sling, and the second sling is configured to be connected to the carrier device of the crane or to the load. According to an embodiment, the second pulley is mounted to be eccentrically rotatable with respect to the beam, and the second pulley is connected to a second actuator which is configured to rotate the second pulley. In this embodiment, two adjustment stages are implemented by the first and second pulleys to increase the range of adjustment.

[0015] According to an embodiment, the beam, the first

sling and the second sling form a triangle, when the first sling and the second sling are either connected to the carrier device of the crane or to the load. This configuration enables a well-balanced rigging device, which is configured to tilt the load. However, the second pulley is not essential for the present invention and can be omitted.

[0016] According to an embodiment, the rigging device further comprises another pulley mounted to the beam at the first end or a second end in the longitudinal axis of the beam, the other pulley is configured to receive another sling. The other pulley is mounted to be eccentrically rotatable with respect to the beam, and the other pulley is connected to another actuator which is configured to rotate the other pulley. One of the first sling and the other sling is configured to be connected to the carrier device of a crane, and the other one of the first sling and the other sling is configured to be connected to the load. In this embodiment, another adjustment stage is implemented by the pulley and the other pulley to further increase the range of adjustment.

[0017] According to an embodiment, one of the rotation planes of the first pulley and the other pulley is arranged in parallel to the longitudinal axis of the beam, and the other one of the rotation planes of the first pulley and the other pulley is arranged perpendicularly to the longitudinal axis of the beam. Any pulley is usually vertically arranged. By appropriately arranging the first pulley and the other pulley, a three-dimensional tilting and alignment of the load is conceivable.

[0018] According to an embodiment, the first actuator comprises a hydraulic cylinder, an electrically operated spindle or a spring actuator comprising a biased spring.

[0019] According to a second aspect of the invention, a method of lifting a component of a wind turbine by a crane and the rigging device is provided.

[0020] According to an embodiment, the component of the wind turbine is a nacelle or a blade. According to an embodiment, the component is a blade, and the rigging device is used to tilt the blade. The rigging device of the present invention can work under extreme load and can be implemented in a base of a yoke, instead of having an extra yoke with hydraulics, for example, above a blade yoke.

[0021] It has to be noted that embodiments of the invention have been described with reference to different subject matters. In particular, some embodiments have been described with reference to apparatus type claims whereas other embodiments have been described with reference to method type claims. However, a person skilled in the art will gather from the above and the following description that, unless other notified, in addition to any combination of features belonging to one type of subject matter also any combination between features relating to different subject matters, in particular between features of the apparatus type claims and features of the method type claims is considered as to be disclosed with this application.

Brief Description of the Drawings

[0022] The aspects defined above and further aspects of the present invention are apparent from the examples of embodiment to be described hereinafter and are explained with reference to the examples of embodiment. The invention will be described in more detail hereinafter with reference to examples of embodiment but to which the invention is not limited.

Fig. 1 shows a rigging device according to an embodiment;

Fig. 2 shows an operation of a rigging device according to an embodiment;

Fig. 3 shows a rigging device according to an embodiment;

Fig. 4 shows a rigging device according to the prior art.

Detailed Description

[0023] The illustrations in the drawings are schematically. It is noted that in different figures, similar or identical elements are provided with the same reference signs.

[0024] **Fig. 1** shows a rigging device 1 according to an embodiment, and **Fig. 2** shows an operation of the rigging device 1. The rigging device 1 is configured to lift a load 2 by a crane. The rigging device comprises a yoke or beam 3 and a first pulley 4 mounted to the beam 3 at a first end in a longitudinal axis of the beam 3, wherein the first pulley 4 is configured to receive a first sling 5. In the context of the present invention, the term "receive" can mean that a sling is at least partly wound around a pulley. The sling can be an endless sling. In the present embodiment, the first sling 5 is configured to be connected to a carrier device 20 of a crane. The carrier device 20 can be a hook as shown in Fig. 2, or it can have the shape of a pendulum 70 as shown in Fig. 4, or it can be another pulley, for instance.

[0025] In a modified embodiment, the first sling 5 can be configured to be connected to the load 2 so that the first sling 5 would be arranged between the first pulley 5 and the load 2 there below.

[0026] The first pulley 4 is mounted to be eccentrically rotatable with respect to the beam 3, and the first pulley 4 is connected to a first actuator 6 which is configured to rotate the first pulley 4.

[0027] The first pulley 4 comprises a core 41 made of a first material, preferably metal, and a second material 42 at a circumference of the core 41, wherein the second material 42 and the first sling 5 have a smaller friction coefficient that the first material of the core 41 and the first sling 5. For example, the second material 42 can preferably comprise a resin-bonded, fabric-reinforced composite and/or Polytetrafluorethylen (PTFE).

[0028] The operation of the rigging device 1 is described. As shown at the left-hand side in Fig. 2, a first distance L1 between a lowermost point at a circumference of the first pulley 4 and the carrier device 20 is provided. The first sling 5 extends between the lowermost point at the circumference of the first pulley 4 and the carrier device 20. During the operation of the rigging device 1, the first distance L1 shall be changed. For this purpose, the first actuator 6 is operated to rotate the first pulley 4. As the first pulley 4 is born at the beam 3 to be eccentrically rotatable with respect to the beam 3, a second distance L2 between a lowermost point at a circumference of the first pulley 4 and the carrier device 20 is provided, wherein the second distance L2 is different from the first distance L1.

[0029] By the rigging device 1 of the present invention, the distance or rigging length can be adjusted under load, so that the load 2 can be tilted.

[0030] **Fig. 3** shows a rigging device 1 according to an embodiment. The beam 3 comprises a plurality of beam portions 31, 32, 33, 34, preferably pipes, wherein the beam portions 31, 32, 33, 34 are mounted to each other along the longitudinal axis of the beam 3 by means of flanges 35, 36, 37. This embodiment achieves a modular concept, where the final beam length can be adapted to the load, such as to wind turbine nacelles having different sizes.

[0031] The rigging device 1 further comprises a second pulley 7 mounted to the beam 3 at a second end in the longitudinal axis of the beam 3, the second pulley 7 is configured to receive a second sling 8, wherein the second sling 8 is configured to be connected to the carrier device 20 of the crane. Preferably, also the second pulley 7 is mounted to be eccentrically rotatable with respect to the beam 3 and the second pulley 7 is connected to a second actuator which is configured to rotate the second pulley 7. The beam 3, the first sling 5 and the second sling 8 form a triangle, when the first sling 5 and the second sling 8 are connected to the carrier device 20 of the crane. Alternatively, the beam 3, the first sling 5 and the second sling 8 can form a triangle, when the first sling 5 and the second sling 8 are both connected to the load 2.

[0032] The rigging device 1 further comprises another pulley 10 mounted to the beam 3 at the second end in the longitudinal axis of the beam 3, wherein the other pulley 10 is configured to receive another sling 11, the other pulley 10 is mounted to be eccentrically rotatable with respect to the beam 3, and the other pulley 10 is connected to another actuator which is configured to rotate the other pulley 10. In this embodiment, other adjustment stages are implemented by the second pulley and the other pulley to further increase the range of adjustment.

[0033] While the first sling 5 is configured to be connected to the carrier device 20 of a crane, the other sling 11 is configured to be connected to the load 2. Alternatively, the first sling 5 can be configured to be connected to the load 2, while the other sling 11 can be configured to be connected to the carrier device 20 of the crane.

[0034] Alternatively or in addition, the other pulley 10 or a further pulley can be mounted to the beam 3 at the first end in the longitudinal axis of the beam 3 to further increase the range of adjustment.

[0035] The rotation plane of the first pulley 4 is arranged in parallel to the longitudinal axis of the beam 3, while the rotation plane of the other pulley 10 is arranged perpendicularly to the longitudinal axis of the beam 3. Alternatively, the rotation plane of the first pulley 4 can arranged perpendicularly to the longitudinal axis of the beam 3, while the rotation plane of the other pulley 10 can be arranged in parallel to the longitudinal axis of the beam 3. Any rotation plane of the first pulley 4, the second pulley 7 or the other pulley 10 can be arranged either in parallel or perpendicularly to the longitudinal axis of the beam 3. The rotation planes of the pulleys are usually vertically arranged.

[0036] Any one of the first actuator 6, the second actuator or the other actuator can comprise a hydraulic cylinder, an electrically operated spindle or a spring actuator comprising a biased spring.

[0037] The present invention is particularly useful in a method of lifting a component 2 of a wind turbine by use of a crane and the rigging device 1. The component of the wind turbine can be a nacelle or a blade 2. If the component is a blade 2, the rigging device 1 can advantageously be used to tilt the blade 2.

[0038] It should be noted that the term "comprising" does not exclude other elements or steps and "a" or "an" does not exclude a plurality. Also elements described in association with different embodiments may be combined. It should also be noted that reference signs in the claims should not be construed as limiting the scope of the claims.

[0039] Independent of the grammatical term usage, individuals with male, female or other gender identities are included within the term.

Claims

1. A rigging device (1) for lifting a load (2) by a crane, the rigging device comprising a beam (3) and a first pulley (4) mounted to the beam (3) at a first end in a longitudinal axis of the beam (3), the first pulley (4) is configured to receive a first sling (5), wherein the first sling (5) is configured to be connected to a carrier device (20) of a crane or to the load (2), wherein

   the first pulley (4) is mounted to be eccentrically rotatable with respect to the beam (3); and
   the first pulley (4) is connected to a first actuator (6) which is configured to rotate the first pulley (4).

2. The rigging device (1) according to the preceding claim, wherein
   the first pulley (4) comprises a core (41) made of a

first material, preferably metal, and a second material (42) at a circumference of the core (41), wherein the second material (42) and the first sling (5) have a smaller friction coefficient that the first material of the core (41) and the first sling (5).

3. The rigging device (1) according to the preceding claim, wherein
the second material comprises a resin-bonded, fabric-reinforced composite and/or Polytetrafluorethylen (PTFE).

4. The rigging device (1) according to any one of the preceding claims, wherein
the beam (3) comprises a plurality of beam portions (31, 32, 33, 34), preferably pipes, wherein the beam portions (31, 32, 33, 34) are mounted to each other along the longitudinal axis of the beam (3) by means of flanges (35, 36, 37).

5. The rigging device (1) according to any one of the preceding claims, further comprising:

a second pulley (7) mounted to the beam (3) at a second end in the longitudinal axis of the beam (3), the second pulley (7) is configured to receive a second sling (8), wherein the second sling (8) is configured to be connected to the carrier device (20) of the crane or to the load (2).

6. The rigging device (1) according to the preceding claim, wherein

the second pulley (7) is mounted to be eccentrically rotatable with respect to the beam (3); and
the second pulley (7) is connected to a second actuator which is configured to rotate the second pulley (7).

7. The rigging device (1) according to claim 5 or 6, wherein
the beam (3), the first sling (5) and the second sling (8) form a triangle, when the first sling (5) and the second sling (8) are either connected to the carrier device (20) of the crane or to the load (2).

8. The rigging device (1) according to any one of the preceding claims, further comprising:

another pulley (10) mounted to the beam (3) at the first end or a second end in the longitudinal axis of the beam (3), the other pulley (10) is configured to receive another sling (11), wherein the other pulley (10) is mounted to be eccentrically rotatable with respect to the beam (3);
the other pulley (10) is connected to another actuator which is configured to rotate the other pulley (10); and one of the first sling (5) and the other sling (11) is configured to be connected to the carrier device (20) of a crane, and the other one of the first sling (5) and the other sling (11) is configured to be connected to the load (2).

9. The rigging device (1) according to the preceding claim, wherein one of the rotation planes of the first pulley (4) and the other pulley (10) is arranged in parallel to the longitudinal axis of the beam (3), and the other one of the rotation planes of the first pulley (4) and the other pulley (10) is arranged perpendicularly to the longitudinal axis of the beam (3) .

10. The rigging device (1) according to any one of the preceding claims, wherein
the first actuator (6) comprises a hydraulic cylinder, an electrically operated spindle or a spring actuator comprising a biased spring.

11. The rigging device (1) according to any one of the preceding claims, wherein
a rotation plane of the first and second pulleys (4, 7) is arranged either in parallel or perpendicularly to the longitudinal axis of the beam (3).

12. A method of lifting a component (2) of a wind turbine by a crane and the rigging device (1) according to any one of the preceding claims.

13. The method according to the preceding claim, wherein
the component of the wind turbine is a nacelle or a blade (2).

14. The method according to the preceding claim, wherein
the component is a blade (2), and the rigging device (1) is used to tilt the blade (2).

FIG 1

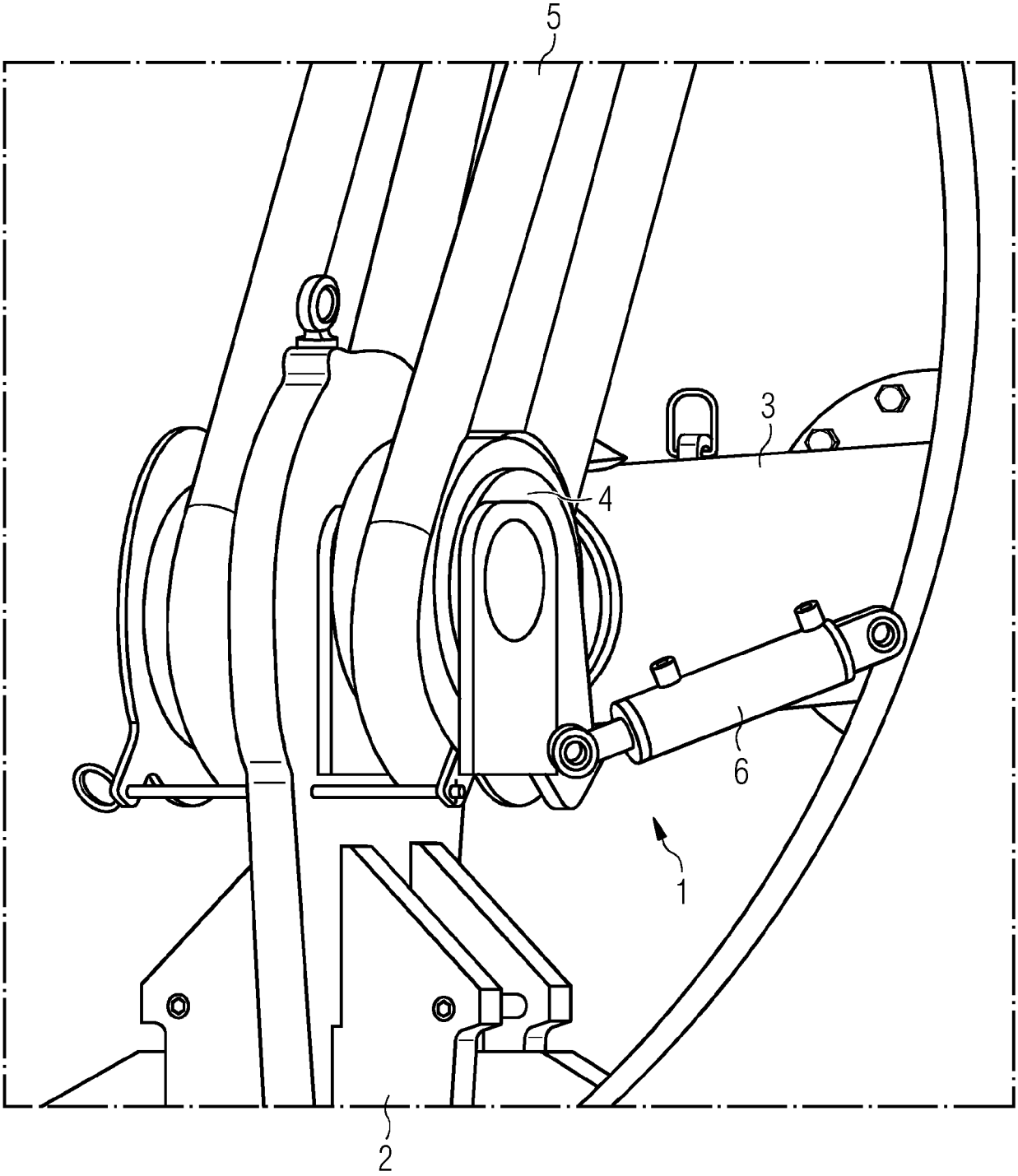


FIG 2

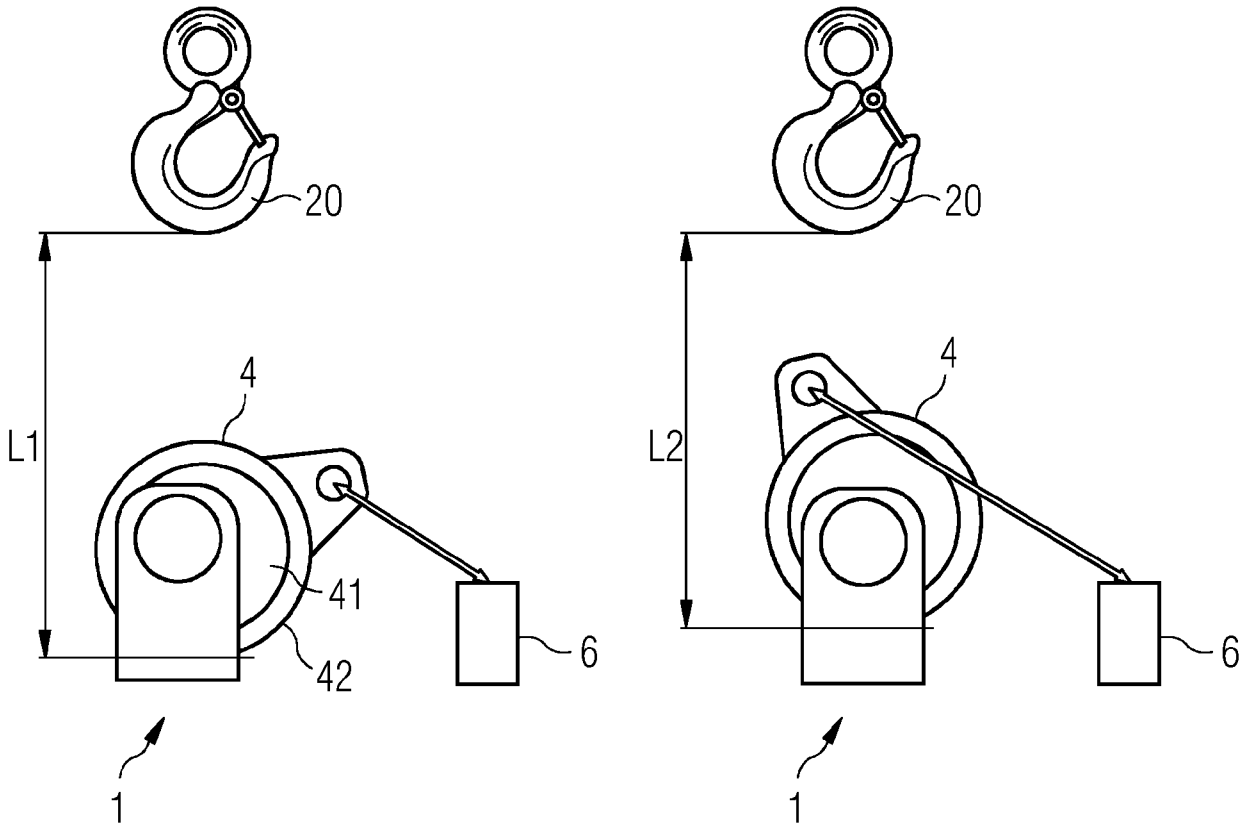


FIG 3

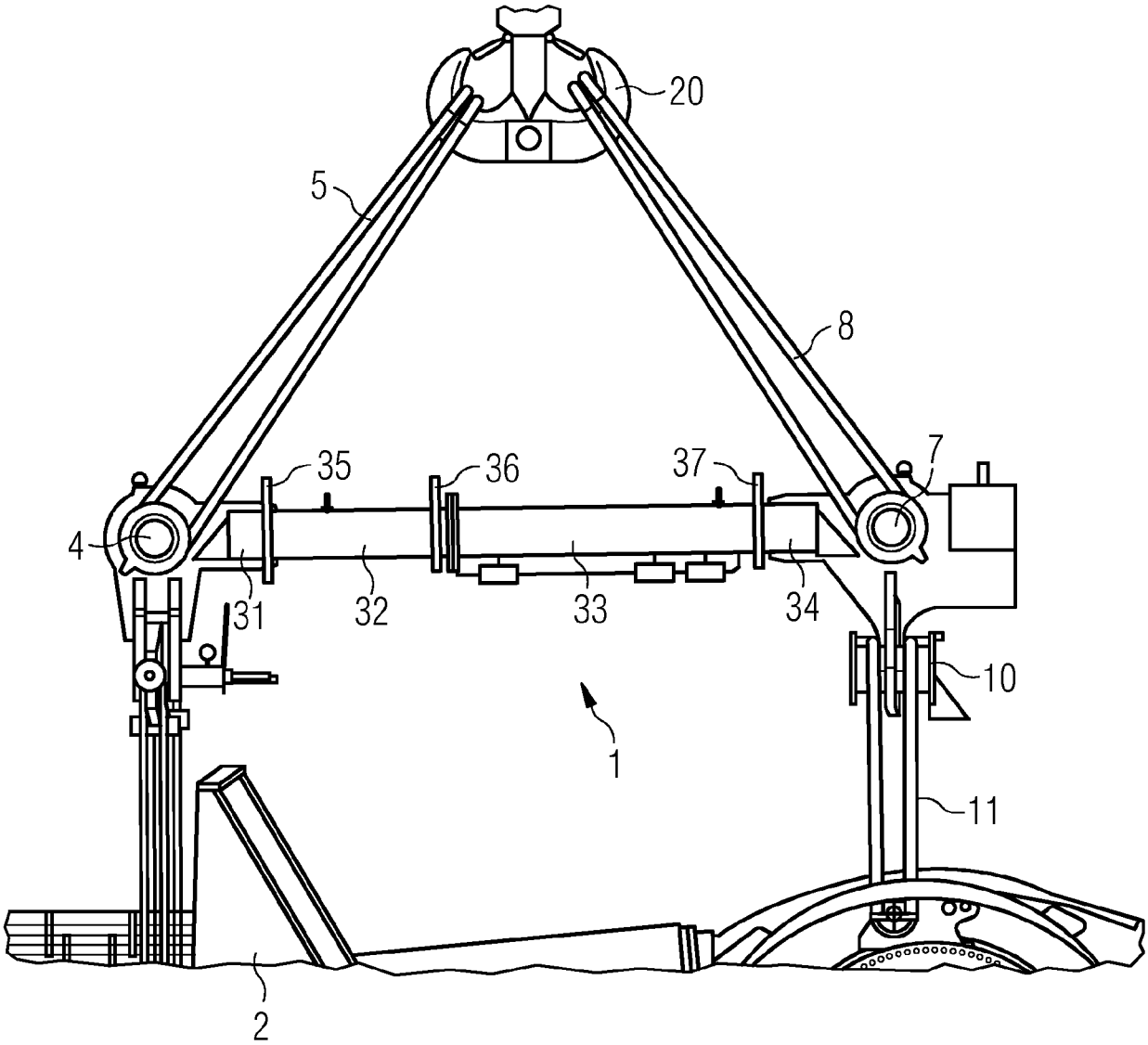
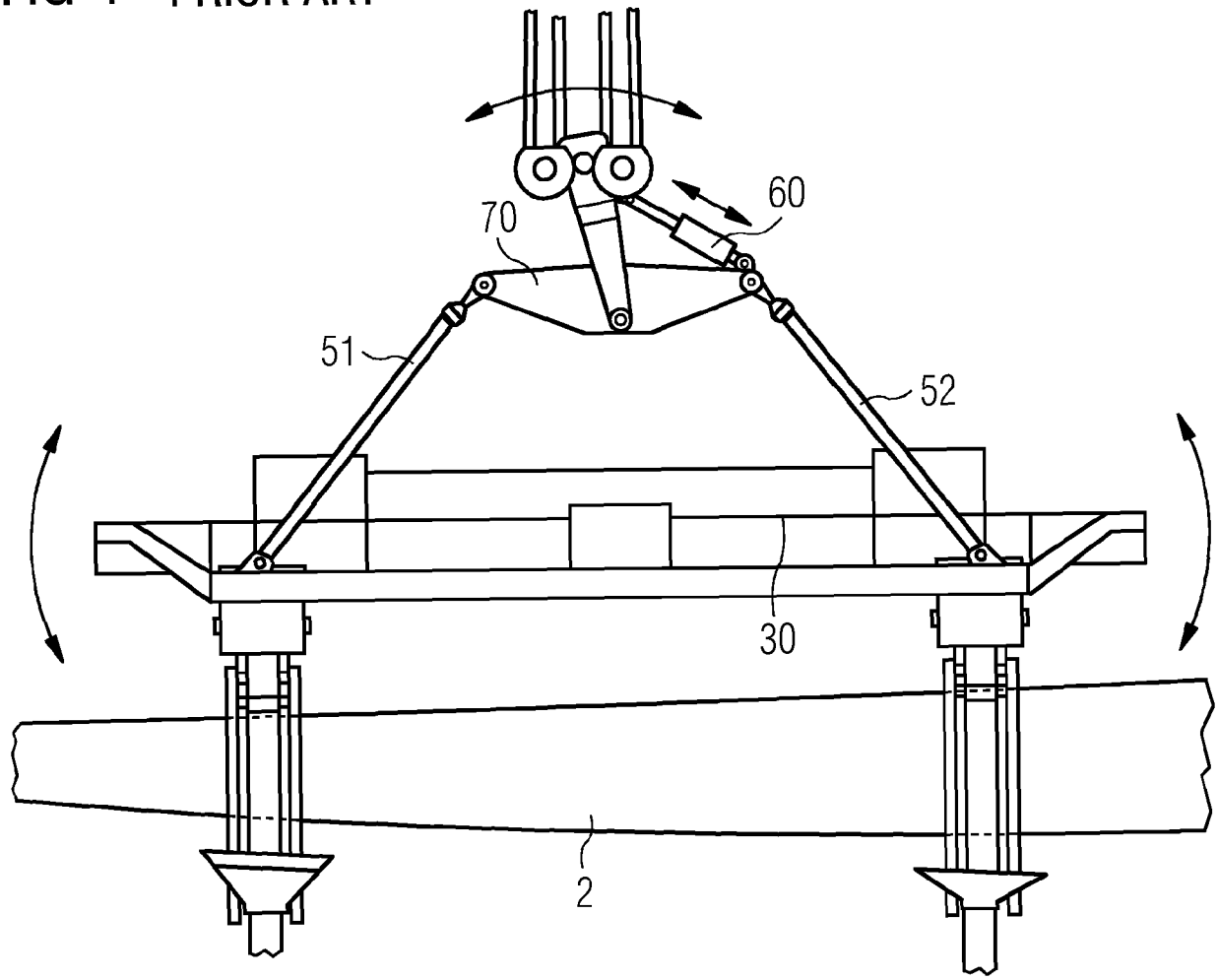


FIG 4 PRIOR ART



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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 9521

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	15 December 2023	Güzel, Ahmet

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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