



(11)

EP 4 825 782 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
21.10.2026 Bulletin 2026/43

(51) International Patent Classification (IPC):
B66C 3/00 (2006.01) **E02F 3/36** (2006.01)
E02F 9/00 (2006.01)

(21) Application number: **25170677.6**

(52) Cooperative Patent Classification (CPC):
B66C 3/005; E02F 3/302; E02F 3/3677;
E02F 3/3681; E02F 3/4135; E02F 3/4136;
E02F 9/264

(22) Date of filing: **15.04.2025**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR

Designated Extension States:
BA

Designated Validation States:
GE KH LA MA MD TN

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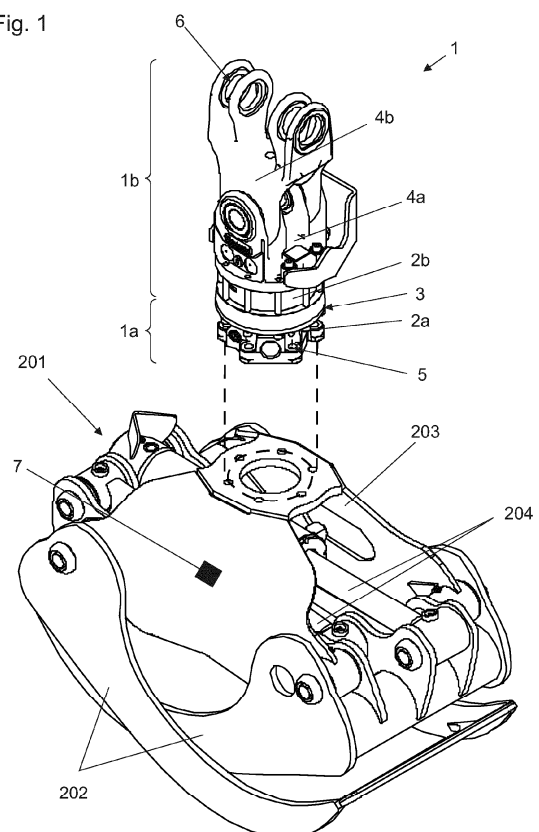
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(54) **BEARING DEVICE**

(57) Bearing device (1) for mounting a load-handling equipment (201) to a crane arm (101), the bearing device comprising:
a pendulum joint (4) comprising a first rotational axis (q_1) and a second rotational axis (q_2);
a rotator (2) connected to the pendulum joint (4), wherein the rotator comprises a third rotational axis (q_3) for rotating the load-handling equipment (201) relative to the crane arm (101) about the third rotational axis (q_3), the rotator (2) comprising a first rotational sensor (3) for determining a rotational angle of the load-handling equipment (201) about the third rotational axis (q_3);
a first section (1a) comprising a first securing means (5) for connecting the load-handling equipment (201) to the rotator (2) or the pendulum joint (4);
a second section (1b) with a second securing means (6) for connecting the crane arm (101) to the rotator (2) or the pendulum joint (4);
at least one second rotational sensor (7) for the determining tilt angles of the load-handling equipment (201) about the first (q_1) and the second (q_2) rotational axis, wherein the second rotational sensor (7) comprises an inclinometer, wherein the second rotational sensor (7) is arranged in the first section (1a) of the bearing device (1) and/or on the load-handling equipment (201).

Fig. 1



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Description

Field

[0001] The present invention concerns a bearing device for mounting a load-handling equipment to a crane arm. The bearing device includes a pendulum joint, the pendulum joint including a first rotational axis and a second rotational axis. The bearing device includes a rotator connected to the pendulum joint with a third rotational axis for rotating the load-handling equipment relative to a crane arm about the first rotational axis, the rotator including a first rotational sensor for determining a rotational angle of the load-handling equipment about the third rotational axis. The bearing device includes a first section with a first securing means for connecting the load-handling equipment to the rotational device or the pendulum joint. The bearing device includes a second section with a second securing means for connecting the crane arm to the rotational device or the pendulum joint, and at least one second rotational sensor for determining tilt angles of the load-handling equipment about the first and the second rotational axis, wherein the second rotational sensor includes an inclinometer.

[0002] The invention further concerns a method for determining a tilt angle of a load-handling equipment about a first and a second rotational axis with such a bearing device.

Background

[0003] US 2025/0031634 A1 describes a bearing device. Rotary encoders may be used in relation to a first, second and third rotational axis to determine a rotational position about said axes. Integrating such rotary encoders, especially in the pendulum joint, is quite difficult due to limited space, high maintenance requirements and cost. Additionally, measuring all joints up to the tip of a crane arm can lead to static deviations due to measurement errors and mechanical deflections, resulting in inaccurate position determination of the load-handling equipment in a resting state.

[0004] US 2025/0031634 A1 relates to the use of a camera-based sensor or an inclinometer or an inertial measurement unit (IMU) as an equivalent alternative for rotary encoders.

Summary of the invention

[0005] An objective technical problem of the invention is to provide an improved bearing device for mounting a load-handling equipment, which avoids the problems of the prior art devices at least partially, as well as a method for determining a tilt angle of a load-handling equipment about a second and a third rotational axis with such a bearing device.

[0006] This problem is solved by the features of claims 1 and 13.

[0007] With a bearing device as mentioned above it is thus provided that the second rotational sensor is arranged in the first section of the bearing device and/or on the load-handling equipment. The second rotational sensor is directly arranged on the load-handling equipment and/or on a part of the bearing device which is motion-coupled to the load handling device.

[0008] By using such an arrangement for the second rotational sensor, the tilt of the load-handling equipment relative to a vertical can directly be measured. The tilt angles of the load-handling equipment relative to the first and second rotational axes can then be determined by a method according to the invention, in particular by coordinate transformation.

[0009] Thus, static deviations due to measurement errors and mechanical deflections, resulting in inaccurate position determination of the load-handling equipment in a resting state, may be avoided.

[0010] Additionally, such an embodiment of a bearing device avoids the mechanical complexity and maintenance issues associated with using rotary encoders directly at the pendulum joint.

[0011] The bearing device can either include at least one second rotational sensor arranged in the first section of the bearing device or at least one second rotational sensor arranged on the load-handling equipment or at least one second rotational sensor arranged in the first section of the bearing device and at least one second rotational sensor arranged on the load-handling equipment.

[0012] The load-handling equipment may be any kind of device which is in some way able to handle a load, like different kinds of grapples or a harvester head.

[0013] With respect to a method according to the invention it is provided that the method includes: measuring tilt angles of the load-handling equipment relative to the vertical by means of the second rotational sensor. The method further includes measuring a rotational angle of the load-handling equipment about the third rotational axis means of the first rotational sensor. The method further includes determining the tilt angles of a load-handling equipment about the first and the second rotational on basis of the rotational angle of the load-handling equipment and the tilt angles of the load-handling equipment relative to the vertical.

[0014] The above-mentioned series of items does not define a chronological sequence. Rather, the actions mentioned may be carried out in any order or at least partly parallel to each other.

[0015] Protection is also sought for a crane including a crane arm and a bearing device for mounting a load-handling equipment to the crane arm as previously described, wherein the crane arm is connected to the second securing means of the bearing device

[0016] Protection is also sought for an arrangement including a crane as previously described and a load-handling equipment, wherein the load-handling equipment is connected to the first securing means of the

bearing device.

[0017] Furthermore, protection is sought for a vehicle including a crane or an arrangement as previously described. Further advantageous embodiments of the invention are defined in the dependent claims. It may be provided that the load-handling equipment is connected to the rotational device via the first securing means and the crane arm is connected to the pendulum joint via the second securing means.

[0018] It may be provided that the rotator includes a first part and a second part, the first part and second part being rotatable relative to each other about the third rotational axis. In particular, the first part may be rotatably mounted to the second part. This allows for a simple realization of a rotator. The rotator may further include a motor, preferably a hydraulic and/or an electric motor, to drive the first part or the second part of the rotator. In other words, the rotator is an actuated joint.

[0019] In a further embodiment, the second rotational sensor may be arranged on the first part of the rotator. The first part of the rotator may be motion-coupled to the load-handling equipment. Thus, any tilting motion of the load-handling equipment occurs at the first part of the rotator in the same manner. A second rotational sensor arranged on the first part of the rotator can thus be used to determine a tilt of the load-handling equipment relative to a vertical. Thus, no means for connecting a second rotational sensor arranged on the load-handling equipment to the bearing device are necessary. The complexity of a bearing device may be reduced.

[0020] According to another embodiment it may be provided that the rotator includes a slip ring for electrically connecting the first part of the rotator to the second part of the rotator. By means of the slip ring, electrical current and signals may be transferred between the first and the second part of the rotator and thus, between the crane arm and the load-handling equipment. Such electrical signals may be signals from the second rotational sensor to a control unit or vice versa, for example. Further, the second rotational sensor may be supplied with electrical energy by means of the slip ring. The slip ring may include a conductive ring and a conductive contact element. The contact element is in contact with the ring so that electric current or signals may be transferred between the ring and the contact element, even when the ring is rotating.

[0021] According to a further embodiment, the first rotational sensor may include a rotary encoder. As there is enough space in a rotator, a rotary encoder can easily be implemented into the rotator. It is also possible that the first rotational sensor is an inclinometer or an IMU. Further, the first rotational sensor and the second rotational sensor may be one integrated device.

[0022] In another embodiment it may be provided that the bearing device includes an interface for electrically connecting the load-handling equipment to the

bearing device. Such an interface allows for a simple electrical connection between the load-handling equipment and the bearing device. Preferably, the interface may be arranged in a first section of the bearing device and/or on a first part of the rotator. The interface may include at least a part of a plug connection.

[0023] According to a further embodiment it may be provided that the second rotational sensor is arranged in the first section in the bearing device and/or in the load-handling equipment to protect the second rotational sensor from environmental influences. As the second rotational sensor is an inclinometer, it does not have to be positioned at a specific location on the load-handling equipment and/or in the first section of the bearing device (in contrast to a rotary encoder which would have to be placed at the respective rotational axis). Thus, it is possible to arrange the second rotational sensor in the first section within the bearing device and/or within the load-handling equipment to protect the second rotational sensor from environmental influences, such as weather, dirt or mechanical impact.

[0024] With respect to an arrangement, it may be provided that the second rotational sensor is arranged on the load-handling equipment and wherein the load-handling equipment is electrically connected to the bearing device by means of the interface. Thereto, the load-handling equipment may include a corresponding interface to connect the load-handling equipment to the interface of the bearing device. With respect to the vehicle, it may be provided that the vehicle is a truck or a harvester.

[0025] Regarding a method according to the invention, the method may include calibrating the second rotational sensor in a resting position to account for static tilt due to the load-handling equipment used. The static tilt determined by calibrating the second rotational sensor may then be used as an offset when determining the tilt angle of the load-handling equipment about the first and the second rotational axis.

Brief Description of the Drawings

[0026] Further details and advantages of preferred embodiments of the invention are explained in more detail below with reference to the drawings. Therein are shown:

- Fig. 1 a schematic representation of bearing device and a load-handling equipment,
- Fig. 2A a schematic representation of bearing device and a load-handling equipment with rotational axes,
- Fig. 2B a schematic representation of the rotational axes and their location relative to each other,
- Fig. 3A a schematic representation of bearing device and a load-handling equipment with coordinate systems,

- Fig. 3B a schematic representation of a transformation of the coordinate systems,
 Fig. 4A-B schematic representations of different load-handling equipment,
 Fig. 5A a schematic representation of a crane with a bearing device,
 Fig. 5B a schematic representation of an arrangement with a crane and a load-handling equipment, and
 Fig. 6A-B schematic representations of different vehicles.

Detailed Description

[0027] Fig. 1 shows a schematic representation of bearing device 1 and a load-handling equipment 201. The bearing device 1 includes a rotator 2 and a pendulum joint 3, which are connected to each other. The bearing device 1 may include in a first section 1a and a second section 1b. The first section 1a and the second section 1b may adjoin each other at a pivot point of the rotator 2.

[0028] In the first section 1, first securing means 5 are provided for connecting the load-handling equipment 201 to the rotator 2. In some examples, the first securing means 5 is provided in the form of a flange.

[0029] In the second section 1b, second securing means 6 for connecting a crane arm 101 to the pendulum joint 4 is provided. In some examples, the second securing means 6 are of a lug-type and are part of the pendulum joint 4.

[0030] The rotator 2 includes a first part 2a and a second part 2b. The first part 2a and second part 2b may be rotatable relative to each other about a third rotational axis q_3 . The first part 2a may be rotatably mounted to the second part 2b. The rotator 2 may include a motor arranged in the second part 2b to drive the first part 2a of the rotator 2. The motor may be a hydraulic motor. For example, the rotator 2 may be an actuated joint whereas the pendulum joint 4 may be a passive or non-actuated joint.

[0031] The rotator 2 also includes a first rotational sensor 3. The first rotational sensor 3 is arranged within the rotator 2, in particular within the second part 2b, and is thus not visible. The first rotational sensor 3 may be a rotary encoder. The rotator 2 may include a slip ring for electrically connecting the first part 2a of the rotator 2 to the second part 2 of the rotator 2. The slip ring is arranged within the rotator 2 and can thus not be seen.

[0032] The pendulum joint 4 may include a first link 4a and a second link 4b. The first link 4a may be rigidly connected to the second part 2b of the rotator 2 and the second link 4b may be rotatably connected to the first link 4a. The second link 4b may further be rotatably connected to a crane arm 101. Furthermore, the bearing device 1 may include an interface 8 for electrically connecting the load-handling equipment 201 to the

bearing device 1, and thus to a crane 100 and/or a vehicle 300.

[0033] The interface 8 may be formed in any suitable manner, for example as a part of a plug connection. In particular, the interface 8 may be configured to automatically connect the load-handling equipment 201 to the bearing device 1 when the load-handling equipment 201 is attached to the bearing device 1 via the first securing means 5. The interface 8 may be electrically connected to the slip ring, so that electrical current and signals may be exchanged between the interface and a crane 100 and/or a vehicle 300.

[0034] In some examples, the load-handling equipment 201 may be provided in the form of a wood grapple. The load-handling equipment 201 may include a base body 203, on which two grapple tongs 202 are pivotally mounted. The grapple tongs 202 may be actuated by means of two grapple actuators 204. The grapple actuators 204 may be hydraulic and/or electric actuators.

[0035] The load-handling equipment 201 includes a second rotational sensor 7. The second rotational sensor 7 may be arranged on or within the base body 203, for example. The load handling equipment 201 further includes a corresponding interface 205, which may be connected to the interface 8. Depending on the form of the interface 8, the corresponding interface 205 may be of any form which is able to be connected to the particular form of the interface 8. For example the corresponding interface 205 may be part of a plug connection.

[0036] The second rotational sensor 7 may be connected to the corresponding interface 205. Electrical current and signals may be exchanged between the second rotational sensor 7 and the crane 100 and/or the vehicle 300 by means of the corresponding interface 205, the interface 8 and the slip ring.

[0037] With a bearing device 1 as mentioned above it is thus provided that the second rotational sensor 7 is arranged in the first section 1a of the bearing device 1 and/or on the load-handling equipment 201. The second rotational sensor 7 is directly arranged on the load-handling equipment 201 and/or on a part of the bearing device 1 which is motion-coupled to the load handling device 201. By using such an arrangement for the second rotational sensor 7, the tilt of the load-handling equipment 201 relative to a vertical can directly be measured. The tilt angles of the load-handling equipment 201 relative to the first and second rotational axes q_1 , q_2 can then be determined by a method according to the invention, in particular by coordinate transformation. Thus, static deviations due to measurement errors and mechanical deflections, resulting in inaccurate position determination of the load-handling equipment 201 in a resting state, may be avoided.

[0038] Additionally, such an embodiment of a bearing device 1 avoids the mechanical complexity and maintenance issues associated with using rotary encoders

directly art the pendulum joint 4. The bearing device 1 can either include at least one second rotational sensor 7 arranged in the first section 1a of the bearing device 1 or at least one second rotational sensor 7 arranged on the load-handling equipment 201 or at least one second rotational sensor 7 arranged in the first section 1a of the bearing device 1 and at least one second rotational sensor 7 arranged on the load-handling equipment 201. The load-handling equipment 201 may be any kind of device which is in some way able to handle a load, like different kinds of grapples or a harvester head.

[0039] With respect to a method according to the invention it is provided that the method includes: measuring tilt angles of the load-handling equipment 201 relative to the vertical by means of the second rotational sensor 7. The method further includes measuring a rotational angle of the load-handling equipment about the third rotational axis q_3 by means of the first rotational sensor 3. The method further includes determining the tilt angles of a load-handling equipment 201 about the first and the second rotational axes q_1 , q_2 on basis of the rotational angle of the load-handling equipment 201 and the tilt angles of the load-handling equipment 201 relative to the vertical.

[0040] The above-mentioned series of items does not define a chronological sequence. Rather, the actions mentioned may be carried out in any order or at least partly parallel to each other.

[0041] Fig. 2A shows a schematic representation of bearing device 1 and a load-handling equipment 201 with rotational axes q_1 , q_2 , q_3 , q_{4x} , q_{4y} .

[0042] With respect to Fig. 2A it can be seen that a third rotational axis q_3 may be essentially parallel to a longitudinal extension of the rotator. The first rotational axis q_1 and the second rotational axis q_2 may be assigned to the joints of the pendulum joint 4. Rotational axes q_{4x} and q_{4y} may be assigned to the load-handling equipment 201.

[0043] Fig. 2B a schematic representation of the rotational axes q_1 , q_2 , q_3 , q_4 and their location relative to each other.

[0044] As seen from Fig. 2B, the first rotational axis q_1 may have a distance of t_{12} to the second rotational axis q_2 . If the distance t_{12} is zero, the pendulum joint 4 would be a cardan joint. The third rotational axis q_3 may have a distance of t_{23} to the second rotational axis q_2 . Rotational axes q_{4x} and q_{4y} may have a distance of t_{34x} and t_{34y} to the third rotational axis q_3 .

[0045] Fig. 3A shows a schematic representation of bearing device 1 and a load-handling equipment 201 with coordinate systems CS_1 , CS_2 , CS_3 , CS_4 . Fig. 3B a schematic representation of a transformation of the coordinate systems CS_1 , CS_2 , CS_3 , CS_4 .

[0046] Regarding Fig. 3A, four coordinate systems CS_1 , CS_2 , CS_3 , CS_4 can be seen. The first coordinate system CS_1 may lie within the lug-type second securing means 6 for connecting the crane arm 101 the pen-

dulum joint 4. The second coordinate system CS_2 may lie within the connection between the first link 4a and the second link 4b of the pendulum joint 4. The third coordinate system CS_3 may lie within the pivot point of the rotator 2. The fourth coordinate system CS_4 may lie within the first securing means 5 for connecting the load-handling equipment 201 to the rotator 2 or on the corresponding means on the load-handling equipment 201 which are to be connected to the first securing means 5, respectively.

[0047] It can be seen that the rotational axis q_{4x} falls together with axis x_4 of coordinate system CS_4 and rotational axis q_{4y} falls together with axis y_4 of coordinate system CS_4 . The first rotational axis q_1 falls together with axis x_1 of coordinate system CS_1 , the second rotational axis q_2 falls together with axis x_2 of coordinate system CS_4 and the third rotational axis q_3 falls together with axis x_3 of coordinate system CS_3 .

[0048] On the basis of the Figs. 2A to 3B, one embodiment of the method according to the invention for determining tilt angles α_{pend} , β_{pend} about the first q_1 and the second q_2 rotational axis shall be described in the following:

[0049] In a first step, tilt angles α_{imu} , β_{imu} of the load-handling equipment 201 about the rotational axes q_{4x} , q_{4y} relative to the vertical are measured by means of the second rotational sensor 7. This gives inclination in euler angles around the rotational axes q_{4x} , q_{4y} , which can be written as vector φ_{imu} :

$$\varphi_{imu} = \begin{bmatrix} \alpha_{imu} \\ \beta_{imu} \\ 0 \end{bmatrix}$$

[0050] In a further step, or parallel to the first step, the rotational angle γ_{rot} of the load-handling equipment 201 about the third rotational axis q_3 is measured by means of the first rotational sensor 3.

[0051] With the rotational angle γ_{rot} a rotation matrix R_{rot} for transforming vector φ_{imu} into the coordinate system CS_3 of the rotator can be determined as follows:

$$R_{rot} = \begin{bmatrix} \cos \gamma_{rot} & -\sin \gamma_{rot} & 0 \\ \sin \gamma_{rot} & \cos \gamma_{rot} & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

[0052] By means of the rotation matrix R_{rot} the tilt angles according to vector φ_{imu} may be transformed into the coordinate system CS_3 , thus accounting for the rotation of the load-handling equipment 201 about the third rotational axis q_3 :

$$\varphi_{pend} = \begin{bmatrix} \alpha_{pend} \\ \beta_{pend} \\ 0 \end{bmatrix} = R_{rot} \varphi_{imu}$$

[0053] Since coordinate systems CS_1 , CS_2 and CS_3 do not rotate to each other about the third rotational axis q_3 , the two euler angles according to φ_{pend} represent the sequential rotations around the x_1 and x_2 axes, which corresponds to the pendulum tilt angles about the first q_1 and second rotational axes q_2 :

$$\varphi_{pend} = \begin{bmatrix} \alpha_{pend} \\ \beta_{pend} \\ 0 \end{bmatrix} = \begin{bmatrix} q_1 \\ q_2 \\ 0 \end{bmatrix}$$

[0054] If the second rotational sensor 7 is calibrated in a resting position to account for static tilt due to the load-handling equipment 201 used, the static tilt represents an offset to the measured tilt angles about rotational axes q_{4x} , q_{4y} . Thus, vector φ_{imu} would read as follows:

$$\varphi_{imu} = \begin{bmatrix} \alpha_{imu} + \alpha_{offset} \\ \beta_{imu} + \beta_{offset} \\ 0 \end{bmatrix}$$

[0055] Fig. 4A to 4B show schematic representations of different load-handling equipment 201. In Fig. 4A, the load-handling equipment 201 is provided in the form of a wood grapple. In Fig. 4B, the load-handling equipment 201 is provided in the form of a polyp grapple.

[0056] Fig. 5A shows a schematic representation of a crane 100 with a bearing device 1. Fig. 5B shows a schematic representation of an arrangement 200 with a crane 100 and a load-handling equipment 201.

[0057] The crane 100 includes a crane arm 101. On one end of the crane arm 101 a bearing device 1 for mounting the load-handling equipment 201 to a crane arm 101 can be seen.

[0058] Fig. 6A shows a schematic representation of a vehicle 300 with an arrangement 200. The vehicle 300 is provided in the form of a truck. Load-handling equipment 201 formed as a wood grapple is arranged, via the bearing device 1, on the crane arm 101, formed as an articulated attachment arm, of the crane 100 arranged on the vehicle 300.

[0059] Figure 6B shows a schematic representation of another embodiment of a vehicle 300 with an arrangement 200. The vehicle 300 is in the form of a harvester, also called timber harvester, forest harvester or crane harvester. The vehicle 300 has a crane 100 with an external crane arm 101. At one end of the crane arm 101, the bearing device 1 is arranged, to which load-handling equipment 201 is secured. The load-handling equipment 201 is provided in the form of a harvester head.

[0060] Various embodiments relate to a crane 100 including a crane arm 101 and a bearing device 1 for mounting a load-handling equipment 201 to the crane

arm 101 as previously described, wherein the crane arm 101 is connected to the second securing means of the bearing device 1. The arrangement 200 may include a crane 100 as previously described and a load-handling equipment 201, wherein the load-handling equipment 201 is connected to the first securing means of the bearing device 1.

[0061] Various embodiments relate to a vehicle 300 including a crane 100 or an arrangement 200 as previously described. Further advantageous embodiments of the invention are defined in the dependent claims. It may be provided that the load-handling equipment 201 is connected to the rotator 2 via the first securing means 5 and the crane arm 101 is connected to the pendulum joint 4 via the second securing means 6. It may be provided that the rotator 2 includes a first part 2a and a second part 2b, the first part 2a and second part 2b being rotatable relative to each other about the third rotational axis q_3 . In particular, the first part 2a may be rotatably mounted to the second part 2b. This allows for a simple realization of a rotator 2. The rotator 2 may further include a motor, preferably a hydraulic and/or an electric motor, to drive the first part 2a or the second part 2b of the rotator 2. In other words, the rotator 2 is an actuated joint.

[0062] In a further embodiment, the second rotational sensor 7 may be arranged on the first part of the rotator 2. The first part of the rotator 2 may be motion-coupled to the load-handling equipment 201. Thus, any tilting motion of the load-handling equipment 201 occurs at the first part 2a of the rotator 2 in the same manner. A second rotational sensor 7 arranged on the first part 2a of the rotator 2 can thus be used to determine a tilt of the load-handling equipment 201 relative to a vertical. Thus, no means for connecting a second rotational sensor 7 arranged on the load-handling equipment 201 to the bearing device 1 are necessary. The complexity of a bearing device 1 may be reduced.

[0063] According to another embodiment it may be provided that the rotator 2 includes a slip ring for electrically connecting the first part 2a of the rotator 2 to the second part 2b of the rotator 2. By means of the slip ring, electrical current and signals may be transferred between the first 2a and the second part 2b of the rotator 2 and thus, between the crane arm 101 and the load-handling equipment 201. Such electrical signals may be signals from the second rotational sensor 7 to a control unit or vice versa, for example. Further, the second rotational sensor 7 may be supplied with electrical energy by means of the slip ring. The slip ring may include a conductive ring and a conductive contact element. The contact element is in contact with the ring so that electric current or signals may be transferred between the ring and the contact element, even when the ring is rotating.

[0064] According to a further embodiment, the first rotational sensor 3 may include a rotary encoder. As there is enough space in a rotator 2, a rotary encoder

can easily be implemented into the rotator 2. It is also possible that the first rotational sensor 3 is an inclinometer or an IMU. Further, the first rotational sensor 3 and the second rotational sensor 7 may be one integrated device.

[0065] In another embodiment it may be provided that the bearing device 1 includes an interface 8 for electrically connecting the load-handling equipment 201 to the bearing device 1. Such an interface 8 allows for a simple electrical connection between the load-handling equipment 201 and the bearing device 1. Preferably, the interface 8 may be arranged in a first section 1a of the bearing device 1 and/or on a first part 2a of the rotator 2. The interface 8 may include at least a part of a plug connection.

[0066] According to a further embodiment it may be provided that the second rotational sensor 7 is arranged in the first section 1a in the bearing device 1 and/or in the load-handling equipment 201 to protect the second rotational sensor 7 from environmental influences. As the second rotational sensor 7 is an inclinometer, it does not have to be positioned at a specific location on the load-handling equipment 201 and/or in the first section 1a of the bearing device 1 (in contrast to a rotary encoder which would have to be placed at the respective rotational axis). Thus, it is possible to arrange the second rotational sensor 7 in the first section 1a within the bearing device 1 and/or within the load-handling equipment 201 to protect the second rotational sensor 7 from environmental influences, such as weather, dirt or mechanical impact.

[0067] With respect to an arrangement 200, it may be provided that the second rotational sensor 7 is arranged on the load-handling equipment 201 and wherein the load-handling equipment 201 is electrically connected to the bearing device 1 by means of the interface 8. Thereto, the load-handling equipment 201 may include a corresponding interface 8 to connect the load-handling equipment 201 to the interface 8 of the bearing device 1. With respect to the vehicle 300, it may be provided that the vehicle 300 is a truck or a harvester.

[0068] Regarding a method according to the invention, the method may include calibrating the second rotational sensor 7 in a resting position to account for static tilt due to the load-handling equipment 201 used. The static tilt determined by calibrating the second rotational sensor 7 may then be used as an offset when determining the tilt angle of the load-handling equipment 201 about the first q_1 and the second rotational axis q_2 .

[0069] The examples described herein may be summarized as follows:

[0070] An example (e.g. example 1) relates to a bearing device 1 for mounting a load-handling equipment 201 to a crane arm 101, the bearing device 1 comprising: a pendulum joint 4 comprising a first rotational axis q_1 and a second rotational axis q_2 ; a rotator 2 con-

nected to the pendulum joint 4, wherein the rotator 2 comprises a third rotational axis q_3 for rotating the load-handling equipment 201 relative to the crane arm 101 about the third rotational axis q_3 , the rotator 2 comprising a first rotational sensor 3 for determining a rotational angle of the load-handling equipment 201 about the third rotational axis q_3 ; a first section 1a comprising a first securing means 5 for connecting the load-handling equipment 201 to the rotator 2 or the pendulum joint 4; a second section 1a with a second securing means 6 for connecting the crane arm 101 to the rotator 2 or the pendulum joint 4; at least one second rotational sensor 7 for the determining tilt angles of the load-handling equipment 201 about the first q_1 and the second rotational axis q_2 , wherein the second rotational sensor 7 comprises an inclinometer, wherein the second rotational sensor 7 is arranged in the first section 1a of the bearing device 1.

[0071] Another example (e.g. example 2) relates to a bearing device 1 for mounting a load-handling equipment 201 to a crane arm 101, the bearing device 1 comprising: a pendulum joint 4 comprising a first rotational axis q_1 and a second rotational axis q_2 ; a rotator 2 connected to the pendulum joint 4, wherein the rotator 2 comprises a third rotational axis q_3 for rotating the load-handling equipment 201 relative to the crane arm 101 about the third rotational axis q_3 , the rotator 2 comprising a first rotational sensor 3 for determining a rotational angle of the load-handling equipment 201 about the third rotational axis q_3 ; a first section 1a comprising a first securing means 5 for connecting the load-handling equipment 201 to the rotator 2 or the pendulum joint 4; a second section 1a with a second securing means 6 for connecting the crane arm 101 to the rotator 2 or the pendulum joint 4; at least one second rotational sensor 7 for the determining tilt angles of the load-handling equipment 201 about the first q_1 and the second rotational axis q_2 , wherein the second rotational sensor 7 comprises an inclinometer, wherein the second rotational sensor 7 is arranged on the load-handling equipment 201.

[0072] Another example (e.g. example 3) relates to a bearing device 1 for mounting a load-handling equipment 201 to a crane arm 101, the bearing device 1 comprising: a pendulum joint 4 comprising a first rotational axis q_1 and a second rotational axis q_2 ; a rotator 2 connected to the pendulum joint 4, wherein the rotator 2 comprises a third rotational axis q_3 for rotating the load-handling equipment 201 relative to the crane arm 101 about the third rotational axis q_3 , the rotator 2 comprising a first rotational sensor 3 for determining a rotational angle of the load-handling equipment 201 about the third rotational axis q_3 ; a first section 1a comprising a first securing means 5 for connecting the load-handling equipment 201 to the rotator 2 or the pendulum joint 4; a second section 1a with a second securing means 6 for connecting the crane arm 101 to the rotator 2 or the pendulum joint 4; at least one second rota-

tional sensor 7 for the determining tilt angles of the load-handling equipment 201 about the first q_1 and the second rotational axis q_2 , wherein the second rotational sensor 7 comprises an inclinometer, wherein the second rotational sensor 7 is arranged in the first section 1a of the bearing device 1 and on the load-handling equipment 201.

[0073] Another example (e.g. example 4) relates to any one of examples 1 to 3, wherein the rotator 2 comprises a first part 2a and a second part 2b, the first part 2a and second part 2b being rotatable relative to each other about the third rotational axis q_3 .

[0074] Another example (e.g. example 5) relates to example 4, wherein the first part 2a is rotatably mounted to the second part 2b.

[0075] Another example (e.g. example 6) relates to any one of examples 4 or 5, wherein the rotator 2 comprises a motor to drive the first part 2a or the second part 2b of the rotator.

[0076] Another example (e.g. example 7) relates to example 6, wherein the motor is a hydraulic and/or an electric motor.

[0077] Another example (e.g. example 8) relates to any one of the examples 4 to 7, wherein the first part 2a of the rotator 2 is motion-coupled to the load-handling equipment 201.

[0078] Another example (e.g. example 9) relates to any one of the examples 1 to 8, wherein the second rotational sensor 7 is arranged on the first part 2a of the rotator 2.

[0079] Another example (e.g. example 10) relates to any one of the examples 1 to 9, wherein the rotator 2 comprises a slip ring for electrically connecting the first part 2a of the rotator 2 to the second part 2b of the rotator 2.

[0080] Another example (e.g. example 11) relates to example 10, wherein the slip ring comprises a conductive ring and a conductive contact element.

[0081] Another example (e.g. example 12) relates to example 11, wherein the contact element is in electrical contact with the conductive ring.

[0082] Another example (e.g. example 13) relates to any one of examples 1 to 12, wherein the first rotational sensor 3 comprises a rotary encoder.

[0083] Another example (e.g. example 14) relates to any one of examples 1 to 13, wherein the first rotational sensor 3 is an inclinometer or an inertial measurement unit.

[0084] Another example (e.g. example 15) relates to example 14, wherein the first rotational sensor 3 and the second rotational sensor 7 are one integrated device.

[0085] Another example (e.g. example 16) relates to any one of the examples 1 to 15, wherein the bearing device 1 comprises an interface 8 for electrically connecting the load-handling equipment 201 to the bearing device 8.

[0086] Another example (e.g. example 17) relates to

example 16, wherein the interface 8 is arranged in the first section 1a of the bearing device 1 and/or on the first part of the rotator 1.

[0087] Another example (e.g. example 18) relates to any one of the examples 16 or 17, wherein the interface 8 comprises at least a part of a plug connection.

[0088] Another example (e.g. example 19) relates to any one of the examples 1 to 18, wherein the second rotational sensor 7 is arranged in the first section 1a in the bearing device 1 and/or in the load-handling equipment 201.

[0089] An example (e.g. example 20) relates to a crane 100 comprising a crane arm 101 and a bearing device 1 for mounting a load-handling equipment 201 to the crane arm 101 according to one of examples 1 to 19, wherein the crane arm 101 is connected to the second securing means 6 of the bearing device 1.

[0090] An example (e.g. example 21) relates to an arrangement 200 comprising a crane 100 according to example 20 and a load-handling equipment 201, wherein the load-handling equipment 201 is connected to the first securing means 5 of the bearing device 1.

[0091] Another example (e.g. example 22) relates to example 21, wherein the second rotational sensor 7 is arranged on the load-handling equipment 201 and wherein the load-handling equipment 201 is electrically connected to the bearing device 1 by means of the interface 8.

[0092] Another example (e.g. example 23) relates to example 22, wherein the load-handling equipment 201 comprises a corresponding interface to connect the load-handling equipment 201 to the interface 8 of the bearing device.

[0093] An example (e.g. example 24) relates to a vehicle 300 comprising a crane 100 according to example 20 or an arrangement 200 according to any one of examples 21 to 23.

[0094] Another example (e.g. example 25) relates to a vehicle 300 according to example 24, wherein the vehicle 300 is a truck or a harvester.

[0095] An example (e.g. example 26) relates to a method for determining a tilt angle of a load-handling equipment 201 about a first q_1 and a second rotational axis q_2 with a bearing device 1 according to one of examples 1 to 19, the method comprising: measuring tilt angles of the load-handling equipment 201 relative to the vertical by means of the second rotational sensor 7; measuring a rotational angle of the load-handling equipment 201 about the third rotational axis q_3 by means of the first rotational sensor 3; and determining the tilt angles of the load-handling equipment 201 about the first q_1 and the second rotational axis q_2 based on the rotational angle of the load-handling equipment 201 and the tilt angles of the load-handling equipment 201 relative to the vertical.

[0096] Another example (e.g. example 27) relates to example 26, wherein the method comprises calibrating the second rotational sensor 7 in a resting position to

account for static tilt due to the load-handling equipment 201 used.

[0097] Another example (e.g. example 28) relates to example 27, wherein the static tilt determined by calibrating the second rotational sensor 7 is used as an offset when determining the tilt angle of the load-handling equipment 201 about the first q_1 and the second rotational axis q_2 .

[0098] List of reference signs:

1	bearing device	
1a	first section	
1b	second section	
2	rotator	
2a	first part	5
2b	second part	
3	first rotational sensor	
4	pendulum joint	
5	first securing means	
6	second securing means	10
7	second rotational sensor	
8	interface	
100	Crane	
101	Crane arm	
200	Arrangement	15
201	Load-handling equipment	
202	Grapple tongs	
203	Base Body	
204	Grapple actuator	
300	Vehicle	20
CS ₁	coordinate system	
x ₁	X-axis	
y ₁	Y-axis	
z ₁	Z-axis	
CS ₂	coordinate system	25
x ₂	X-axis	
y ₂	Y-axis	
z ₂	Z-axis	
CS ₃	coordinate system	
x ₃	X-axis	
y ₃	Y-axis	
z ₃	Z-axis	
CS ₄	coordinate system	30
x ₄	X-axis	
y ₄	Y-axis	
z ₄	Z-axis	
q ₁	first rotational axis	
q ₂	second rotational axis	
q ₃	third rotational axis	
q _{4x} , q _{4y}	rotational axes of the load-handling equipment	35

Claims

1. Bearing device (1) for mounting a load-handling equipment (201) to a crane arm (101), the bearing device comprising:

a pendulum joint (4) comprising a first rotational axis (q_1) and a second rotational axis (q_2);

a rotator (2) connected to the pendulum joint (4), wherein the rotator comprises a third rotational axis (q_3) for rotating the load-handling equipment (201) relative to the crane arm (101) about the third rotational axis (q_3), the rotator (2) comprising a first rotational sensor (3) for determining a rotational angle of the load-handling equipment (201) about the third rotational axis (q_3);

a first section (1a) comprising a first securing means (5) for connecting the load-handling equipment (201) to the rotator (2) or the pendulum joint (4);

a second section (1b) with a second securing means (6) for connecting the crane arm (101) to the rotator (2) or the pendulum joint (4);

at least one second rotational sensor (7) for the determining tilt angles of the load-handling equipment (201) about the first (q_1) and the second (q_2) rotational axis, wherein the second rotational sensor (7) comprises an inclinometer, wherein the second rotational sensor (7) is arranged in the first section (1a) of the bearing device (1) and/or on the load-handling equipment (201).

2. Bearing device (1) according to claim 1, wherein the rotator (2) comprises a first part (2a) and a second part (2b), the first part (2a) and second part (2b) being rotatable relative to each other about the third rotational axis (q_3).

3. Bearing device (1) according to claim 2, wherein the second rotational sensor (7) is arranged on the first part (2a) of the rotator (2).

4. Bearing device (1) according to one of claims 2 or 3, wherein the rotator (2) comprises a slip ring for electrically connecting the first part (2a) of the rotator (2) to the second part (2b) of the rotator (2).

5. Bearing device (1) according to one of claims 1 to 4, wherein the first rotational sensor (2) comprises a rotary encoder.

6. Bearing device (1) according to one of claims 1 to 5, wherein the bearing device (1) comprises an interface (8) for electrically connecting the load-handling equipment (201) to the bearing device (1).

7. Bearing device (1) according to one of claims 1 to 6, wherein the second rotational sensor (7) is arranged in the first section (1a) within the bearing device (1) and/or within the load-handling equipment (201) to protect the second rotational sensor

from (7) environmental influences.

8. Crane (100) comprising a crane arm (101) and a bearing device (1) for mounting a load-handling equipment (201) to the crane arm (101) according to one of claims 1 to 7, wherein the crane arm (10) is connected to the second securing means (6) of the bearing device (1). 5
9. Arrangement (200) comprising a crane (100) according to claim 8 and a load-handling equipment (201), wherein the load-handling equipment (201) is connected to the first securing means (5) of the bearing device. 10
10. Arrangement (200) according to claim 9, wherein the second rotational sensor (7) is arranged on the load-handling equipment (201) and wherein the load-handling device (201) is electrically connected to the bearing device (1) by means of the interface (8). 15 20
11. Vehicle (300) comprising a crane (100) according to any one of claims 1 to 8 or an arrangement (200) according to claim 9 or 10. 25
12. Vehicle (300) according to claim 11, wherein the vehicle (300) is a truck or a harvester.
13. Method for determining a tilt angle of a load-handling equipment (201) about a first (q_1) and a second rotational axis (q_2) with a bearing device according to one of claims 1 to 7, the method comprising: 30

measuring tilt angles of the load-handling equipment (201) relative to the vertical by means of the second rotational sensor (7);

measuring a rotational angle of the load-handling equipment (201) about the third rotational axis (q_3) by means of the first rotational sensor (3); and 40

determining the tilt angles of the load-handling equipment (201) about the first (q_1) and the second rotational axis (q_2) based on the rotational angle of the load-handling equipment (201) and the tilt angles of the load-handling equipment (201) relative to the vertical. 45
14. Method according to claim 13, wherein the method comprises calibrating the second rotational sensor (7) in a resting position to account for static tilt due to the load-handling equipment (201) used. 50

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Fig. 1

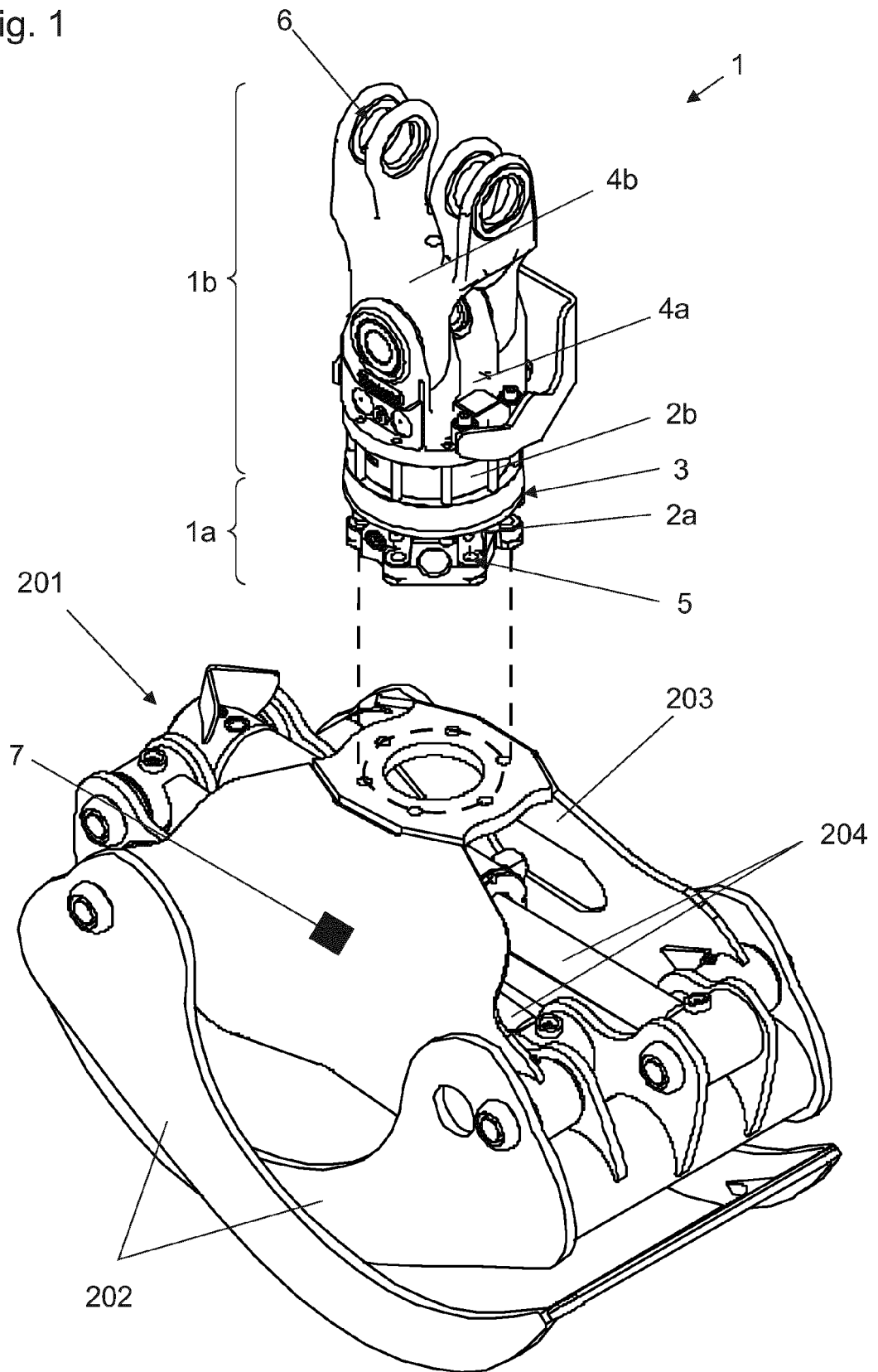


Fig. 2A

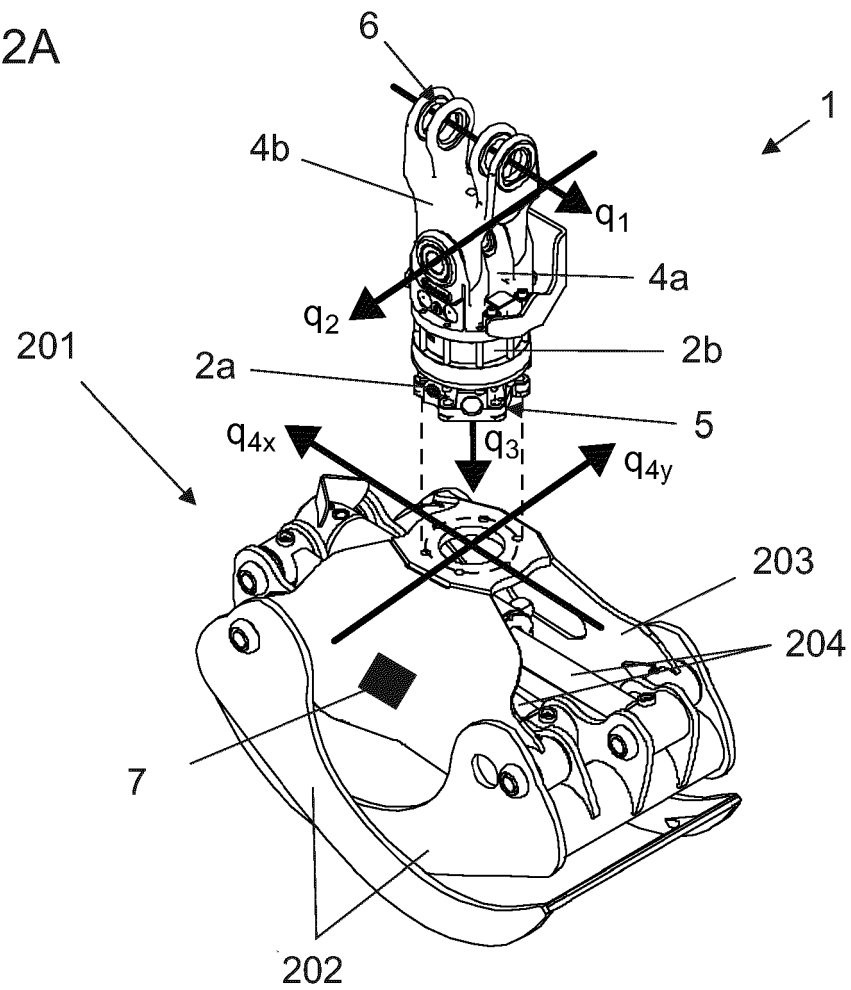


Fig. 2B

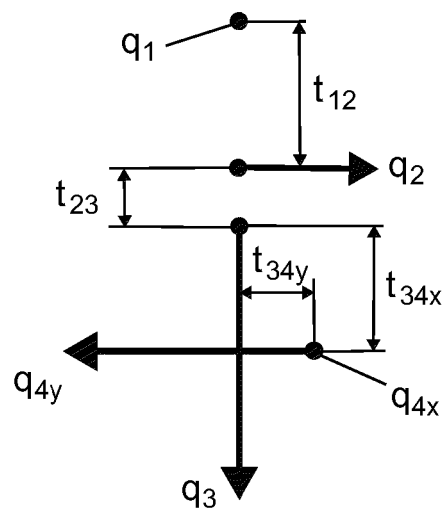


Fig. 3A

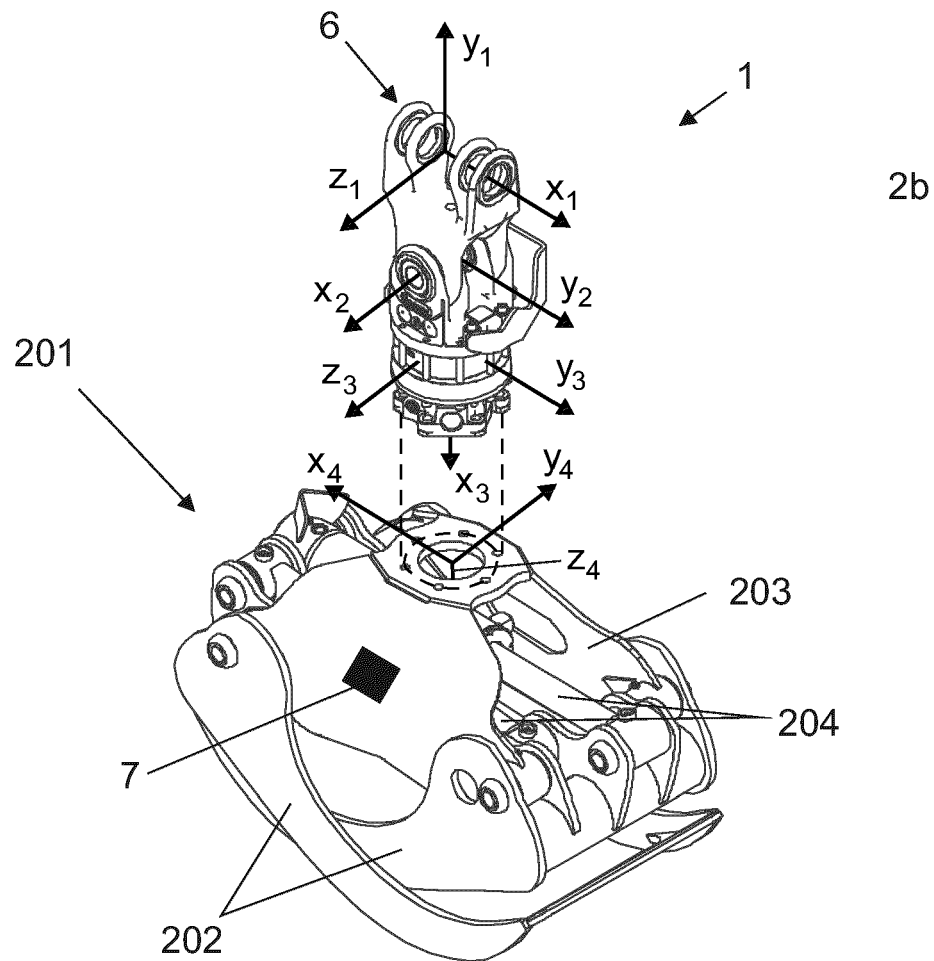


Fig. 3B

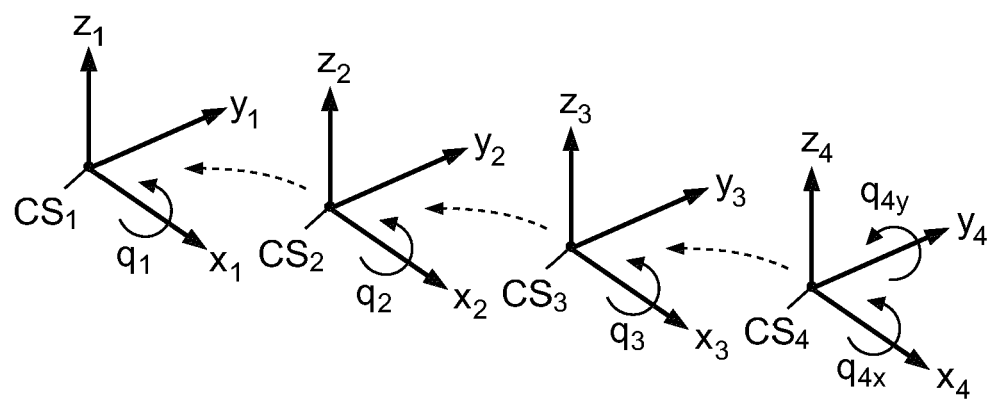


Fig. 4A

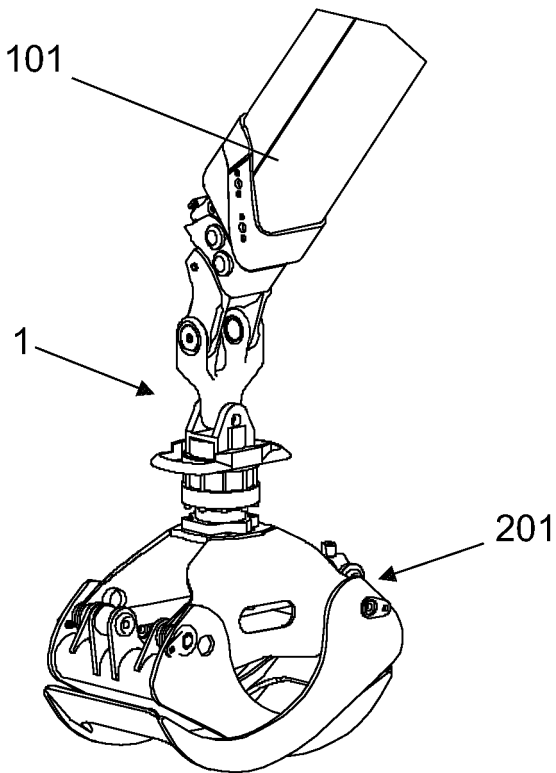


Fig. 4B

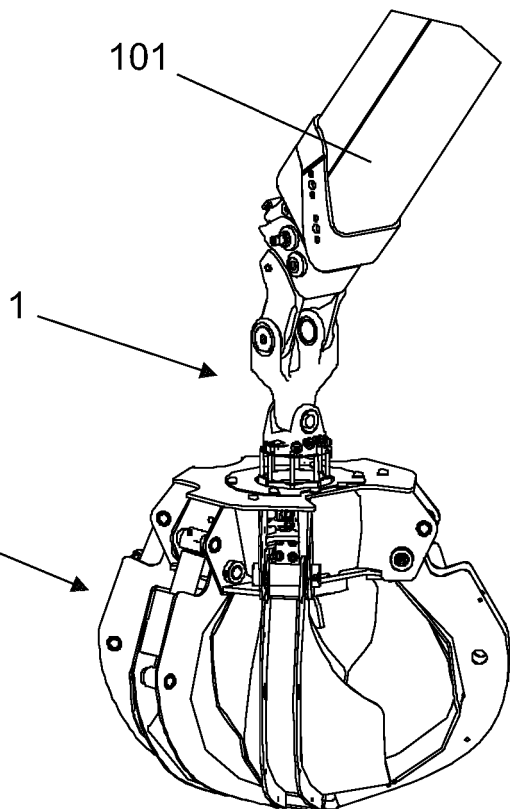


Fig. 5A

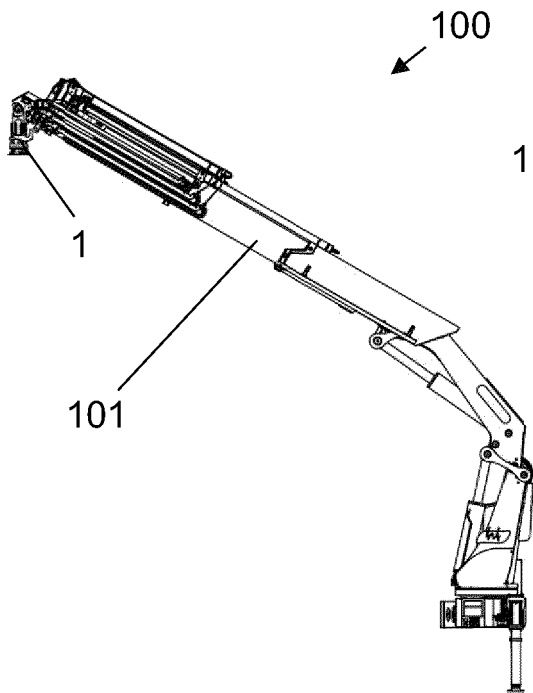


Fig. 5B

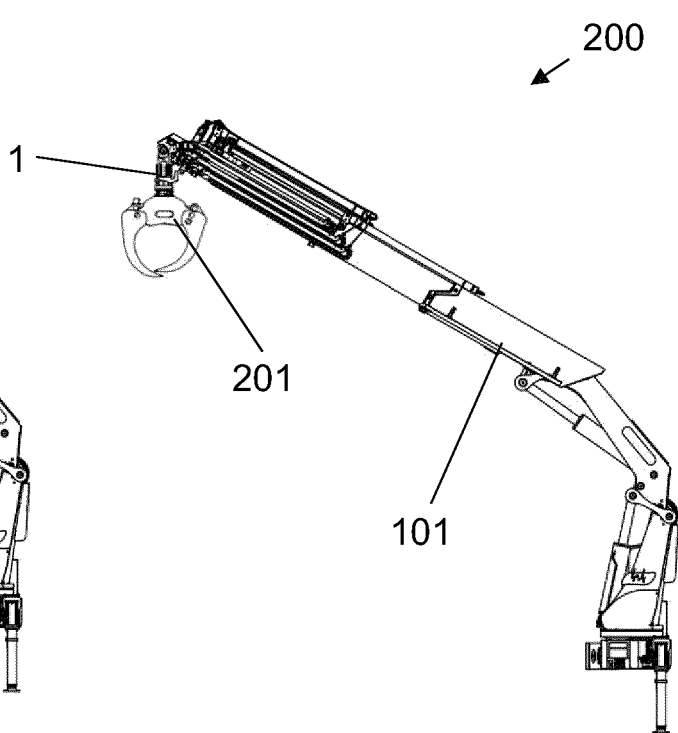


Fig. 6A

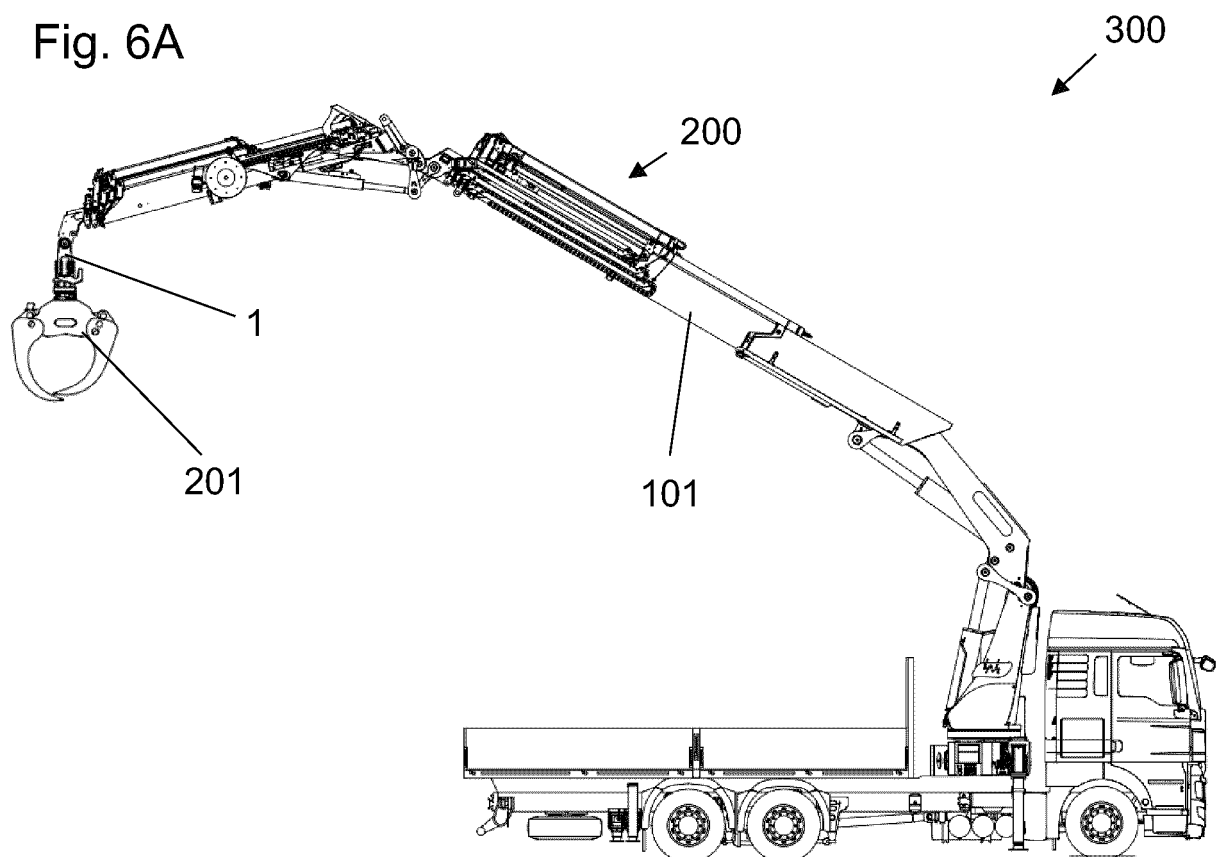
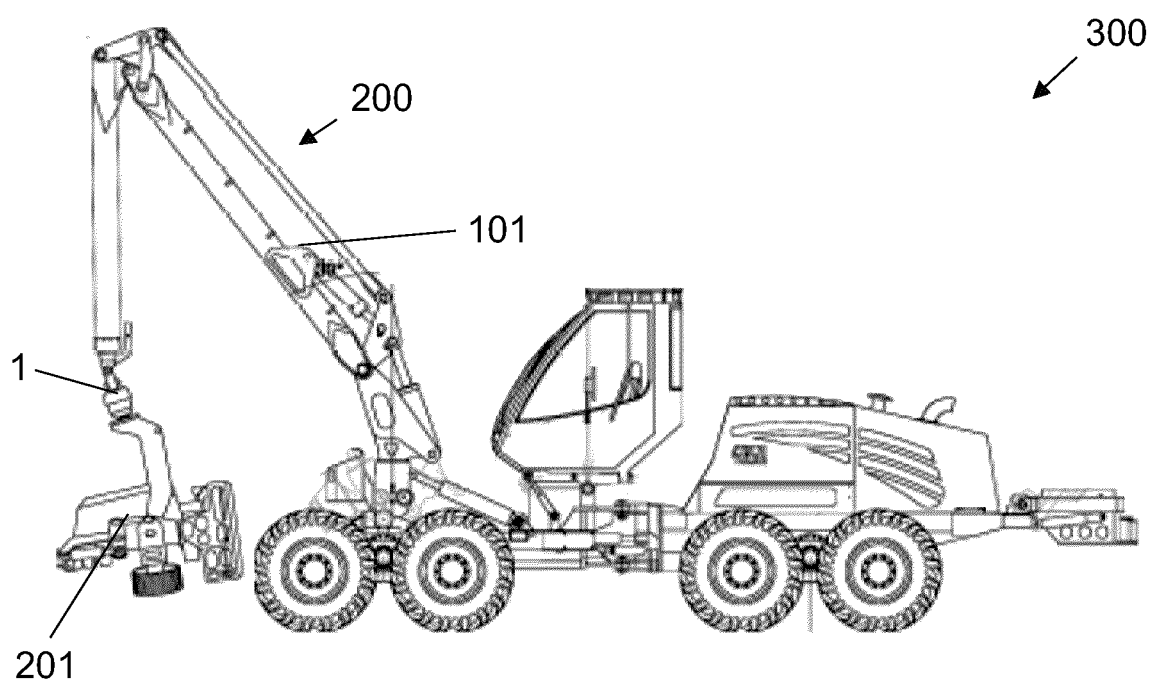


Fig. 6B





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Application Number

EP 25 17 0677

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Place of search		Date of completion of the search	Examiner
The Hague		2 October 2025	Verheul, Omiros
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