



- (51) **International Patent Classification:**
E04G 3/24 (2006.01) *F03D 1/00* (2006.01)
- (21) **International Application Number:**
PCT/DK2012/000053
- (22) **International Filing Date:**
24 April 2012 (24.04.2012)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
PA 2011 00339 4 May 2011 (04.05.2011) DK
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(81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

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(54) **Title:** PLATFORM ASSEMBLY FOR ENABLING ACCESS TO A WIND TURBINE

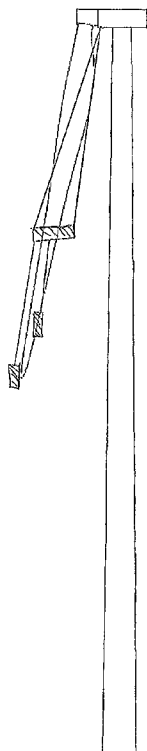


Fig. 7

(57) **Abstract:** A platform assembly for enabling access to a rotor blade of a wind turbine is disclosed, the platform assembly comprising: • a frame device having means for supporting and guiding the frame device in relation to the rotor blade, wherein said means are configured for contacting the rotor blade at regions at or near the front edge of the rotor blade and/or at or near the rear edge of the rotor blade, and means for lowering and/or lifting the frame device in relation to the rotor blade, a platform device having means for supporting and guiding the platform device in relation to the rotor blade, wherein said means are configured for contacting the rotor blade at regions at or near the front edge of the rotor blade and/or at or near the rear edge of the rotor blade. The platform device is detachably attached to the frame structure and movable in relation to the frame structure and carried by said frame structure.

WO 2012/149935 A1



Published:

— *with international search report (Art. 21(3))*

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PLATFORM ASSEMBLY FOR ENABLING ACCESS TO A WIND TURBINE

Field of the invention

The present invention relates to a platform assembly for enabling access to a rotor blade of a wind turbine, said platform assembly being adapted for moving
5 in the longitudinal direction of the rotor blade, and comprising a frame device having a frame structure, means for supporting and guiding the frame device in relation to the rotor blade, said means for supporting and guiding the frame device in relation to the rotor blade being configured for contacting the rotor blade at regions at or near the front edge of the rotor blade, and/or at or near
10 the rear edge of the rotor blade and furthermore having means for lowering and/or lifting the frame device in relation to the rotor blade.

The invention further relates to a method for enabling access to a rotor blade of a wind turbine.

Background of the invention

15 Within the field of wind turbines it is necessary to perform work on parts that are situated at a considerable height above ground level (or sea level, when sea wind turbines are concerned) such as e.g. repair of rotor blades, and their surfaces, surface treatment of rotor blades and the tower etc. Further, it has been recognized that it is advantageous or even necessary to clean such parts
20 and in particular the rotor blades in order to maintain good results as regards the power efficiency. Further, it may be advantageous to perform other kinds of maintenance in order to achieve good power production results and optimal economic results, such as e. g. surface treatments, inspection, etc.

In order to perform such work, a number of hoisting arrangements have been
25 proposed in the prior art.

A prior art hoisting arrangement is described in German utility model DE 296 03 278 U. According to this prior art arrangement, the wind turbine is brought to a stop with one rotor blade pointing straight downwards, whereafter suspension means are fastened to each of the two other rotor blades near the hub of the
30 rotor. A special work platform with a through-going slit at the bottom is fixed to these suspension means so that the rotor blade pointing downwards can be

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inserted into this slit. The work platform is subsequently being hoisted upwards in a stepwise manner, while the crew manually cleans the surface of the rotor blade, e. g. with one person located on each side of the rotor blade.

Even with such an arrangement, it is a time-consuming process to carry out
5 cleaning of the rotor blades of a windmill. This known arrangement would probably also require the use of machinery, such as a crane, for fixation of the special suspension means. Further, the platform itself will have a considerable weight and size, thereby leading to further costs and use of heavy machinery for lifting and lowering the platform.

10 Further, the platform is hanging freely from the suspension means, which means that the platform is influenced by the wind and may be moved back and forth in windy conditions. Thus, the platform may be a problematic and dangerous workplace, and it may be impossible to use the platform even at relatively modest wind speeds. Also, even though the platform has rollers at the
15 edge of the slit to reduce damage to the rotor blade, such damage may nevertheless occur under certain circumstances.

Devices of a corresponding kind are known from DE 199 09 698 A1 and DE 43 39 638 A1, which are encumbered with the same disadvantages as those mentioned above, including the requirement for extensive use of special
20 material such as cranes, for example mobile cranes, or relatively comprehensive materials which are, for example, mounted on the turbine tower beforehand. In particular, these prior art arrangements may also be influenced by the wind and may be moved back and forth in relation to the rotor blade in windy conditions and when being moved up and down. Thus, these prior art
25 platforms may be problematic work places, as it may be impossible to use the platforms even with relatively modest wind speeds, e.g. at relatively high wind turbines, and collisions with the surface of the rotor blade may occur, for example when the platforms are being moved up and down.

The above-mentioned prior art systems are generally not configured in a
30 manner facilitating user-friendliness and do not provide the staff with an optimal environment safety.

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WO 03/048569 A2 describes a method and an apparatus for treatment of a surface of a rotor blade of a windmill, where the apparatus is being placed in such a manner that it is movable in relation to the surface of a rotor blade, and said apparatus is being caused to move depending on a form of treatment
5 determined by means for treatment mounted on, in or next to the apparatus. In this manner, various forms of treatment of a rotor blade may be carried out, such as for instance washing, finishing, sealing etc.

Furthermore, WO 2005/064152 A2 describes a device for enabling access to a structure above ground level by lowering and/or lifting the device in relation to
10 the structure, the device comprising a first endless frame structure defining an opening, wherein at least part of the first endless frame structure forms a track portion, the track portion being adapted to guide an object that is movable in relation to the track portion, such as a gondola, along the track portion.

Both of these prior art documents, i.e. WO 03/048569 A2 and WO 2005/064152
15 A2 relate to devices, that are transferred to the rotor blade from below the rotor blade tip.

Still further, WO 2004/092577 A1 describes a method of servicing the outer components of a wind turbine such as the wind turbine blades and the tower by means of a work platform, said method comprising the steps of: positioning the
20 work platform at the wind turbine tower and connecting the work platform to an upper part of the wind turbine with at least one cable. Further the method comprises the steps of hoisting the work platform with the cable and cable winding means to a position of use, and holding the work platform to the side of the wind turbine tower with holding means.

25 Even further, WO 2007/085265 A1 discloses a device for enabling access to a structure above ground or sea level, in particular a rotor blade of a wind turbine, by lowering and/or lifting the device in relation to the structure. The device comprises

- a frame structure,
- 30 - means for supporting the device in relation to said structure, and
- means for lowering and/or lifting the device in relation to the structure.

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At least part of the frame structure of this prior art device comprises a track portion that is adapted to guide an object that is movable in relation to the track portion, along the track portion. The means for supporting the device in relation to the structure are configured for positioning and guiding said device in relation
5 to the structure, and the means for supporting the device in relation to said structure are configured for facilitating a movement of said device essentially in the longitudinal direction of said structure

It is an objective of the invention to provide an improved device for performing work on a rotor blade of a wind turbine, where the device can be moved up and
10 down a rotor blade, which is positioned in an essentially vertical position pointing downwards.

With the increasing height and size of wind turbines and particularly the sea-based wind turbines and their rotor blades, the material and design of the rotor blades are chosen to have a relative light structure and comprise relative light
15 materials. This gives major challenges for the design of the rotor service devices.

It is therefore an objective to provide such a device that is designed as a relatively light structure and made of relatively light materials, whilst maintaining safety standards and even providing improvements in safety aspects. With the
20 increasing heights and sizes of wind turbines, the above-mentioned objectives have become increasingly more important, since the increase in wind turbine size requires corresponding service devices with increased sizes. Therefore, the need for a relatively uncomplicated and relatively light service device requiring only a minimum of resources has been further accentuated.

25 It is a further objective to provide a service device that improves user-friendliness and safety and gives access to virtually all parts of e.g. a rotor blade.

Furthermore an objective of the present invention is to provide a device that exerts the smallest possible pressure and mass effect on the rotor blade.

30 Sea-based wind turbines are often arranged on a platform and service devices and service items are hoisted from or lowered to e.g. a service vessel that is

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subjected to waves and therefore may be moving up and down. The hoisting device on the service vessel and or service platform does often have a maximum load. It is therefore a further objective to provide a service device that does not exceed this maximum load.

- 5 Even further, it is an objective of the present invention to provide such an improved device that may be moved up and down along the rotor blade in a safe and secure manner, guided by the rotor blade, whereby the device is moving in a smooth manner along the rotor blade.

These and other objectives are achieved by the invention as explained in detail
10 in the following.

Summary of the invention

In a first aspect, the invention relates to a platform assembly for enabling access to a rotor blade of a wind turbine, said platform assembly being adapted for moving in the longitudinal direction of the rotor blade, the platform assembly
15 comprising:

- a frame device comprising:
 - a frame structure,
 - means for supporting and guiding the frame device in relation to the rotor blade, wherein said means for supporting and guiding the
20 frame device in relation to the rotor blade are configured for contacting the rotor blade at regions
 - at or near the front edge of the rotor blade and/or
 - at or near the rear edge of the rotor blade, and
 - means for lowering and/or lifting the frame device in relation to the
25 rotor blade,
- a platform device comprising:
 - a platform structure,
 - means for supporting and guiding the platform device in relation to the rotor blade, wherein said means for supporting and guiding the

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platform device in relation to the rotor blade are configured for contacting the rotor blade at regions

- at or near the front edge of the rotor blade and/or
- at or near the rear edge of the rotor blade, and

5 wherein the platform device is detachably attached to the frame structure and movable in relation to the frame structure and carried by said frame structure.

Hereby, it is achieved that, by means of the platform assembly, the user may be able to reach or access all parts of the surface of a rotor blade of a wind turbine, since the platform assembly can be moved up and down the rotor blade in a
10 secure manner, guided by the rotor blade. The means for supporting and guiding the platform in relation to the rotor blade are configured for preferably automatically adapting to the size and shape of the rotor blade, which vary considerably along the length, thereby facilitating that the rotor blade can be accessed along virtually its whole length. Furthermore, it is achieved that the
15 platform assembly is supported against parts of the rotor blade, which are suited therefore, i.e. regions at or near the front edge of the rotor blade and/or at or near the rear edge of the rotor blade, and the support is maintained at these regions, even though these regions moves in dependence on the variations of the size and shape of the rotor blade along its length. This is
20 achieved due to e.g. the nature of the contact means that allows the contact means to move along e.g. the path of the rotor blade that is suitable as support for the platform assembly, without undue friction and with ease.

The platform assembly according to the invention that may e.g. carry a tool device and/or one or more persons, may be located in any vertical position
25 along a wind turbine rotor blade, preferably controlled by a person on the platform assembly or at ground level, e. g. by controlling the means for lowering and/or lifting the frame device in relation to the rotor blade. Further, the platform device may be controlled in such a manner that all parts of the rotor blade can be accessed.

30 Thus, a large and heavy platform is avoided, since a person using the platform assembly according to the invention may access virtually any desired position in

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relation to the wind turbine rotor blade. Hereby any necessary work may be performed using a relatively light construction. Further, the safety standard is enhanced, since a person using the platform assembly according to the invention may be secured in a reliable and dependable manner, e.g. secured to
5 a work platform, e.g. a chair, gondola or the like by e.g. a safety line, and since such a person need not move around on a relatively large platform that may e.g. be swerving under the influence of the wind or bouncing against the rotor blade and/or against the wind turbine tower.

The platform assembly according to the invention may be transferred to the
10 rotor blade separated in two or more parts.

The frame device may be transferred to the rotor blade, and subsequently one or more platform devices may be transferred, e.g. hoisted up and attached to the frame structure.

Hereby, it is achieved that the platform assembly can be transferred to the rotor
15 blade in a relatively uncomplicated manner, without using extensive machinery, while still keeping the platform assembly relatively small in relation to the size of the state of the art wind turbines.

As specified, said means for supporting the platform assembly in relation to the rotor blade are adapted for supporting the platform assembly at or near the front
20 edge of the rotor blade and at or near the rear edge of the rotor blade.

Hereby, it is achieved that the platform assembly can travel along the rotor blade in a manner, in which the surface of the rotor blade is not subjected to any harmful contact, since the platform assembly is designed for contacting the said parts of the rotor blade, which have the necessary rigidity and sturdiness.

25 According to an embodiment, the platform assembly comprises two or more platform devices, each platform device being, independently of the other, detachably attached to the frame structure and movable in relation to the frame structure and carried by said frame structure.

Hereby, it is achieved that more than one platform device may be attached to
30 the frame structure. By having the platform device independently attached to

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the frame structure it will be possible to service the rotor blade at two or more places independently of each other.

According to a further embodiment the platform device and/ or the frame structure comprise means for lowering and/or lifting the platform device in
5 relation to the frame structure.

Hereby, it is achieved that the frame structure may be lowered and lifted to a given position on the rotor blade and the one or more platform devices may be lowered and/ or lifted independently of each other further down the rotor blade. Hereby the rotor blade may be accessed without transferring the frame
10 structure down to the rotor blade tip.

In accordance with a further embodiment, said means for lifting and/or lowering the platform device in relation to the frame structure comprise hoisting means having power means, said hoisting means being adapted for climbing up and down a cable or said for accumulating the cable, e.g. drum hoisting means.

15 Hereby, the platform assembly will be able to lift and/or lower itself without power assistance from e. g. a hoist located at the wind turbine tower, at a vehicle or at a vessel. Thus, the platform assembly will be able to operate independently, i.e. without concern for power assistance from other devices. This further enhances safe operation since accidents caused by a power failure
20 at a ground vehicle or at a vessel are prevented. Particularly when operation at sea is concerned, e. g. at sea wind turbines, such an independent configuration is preferable since a support vessel may be unstable, e. g. subjected to waves, current, wind etc. Thus, an arrangement at sea, where a vessel provides the elevation by e.g. hoist (s) located on the vessel is prone to accidents and
25 malfunction, and therefore a device comprising power means as mentioned above is advantageous, not only in general, but especially at sea.

Further, it is noted that even when power supply to such a platform assembly is subjected to failure, e. g. when electric power is cut off, a platform assembly according to the invention will be able to be manually operated, e. g. to be
30 hoisted to the ground and will in general present a safe work tool for all parties involved, in particular persons occupying the platform assembly.

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According to still a further embodiment, the frame device comprises means providing a place to stand or sit for individuals performing inspection, work, repair, surface treatment etc. on the rotor blade above the frame structure.

Hereby it is achieved that access to the rotor blade above the frame device may
5 be achieved, whereby parts of the rotor blade above the frame structure can be treated, inspected, repaired, etc. Such an embodiment has, for example, the advantage that upper parts of the rotor blade, e.g. even parts close to the hub, can be treated.

In an embodiment according to the invention the means providing a place to
10 stand or sit comprise a floor. By having a surrounding or partly surrounding floor all sides of the rotor blade above the frame structure may be accessed.

According to a further embodiment, at least a part of the frame structure comprises a track portion, the track portion being adapted to guide the platform device along the track portion.

15 Still further, the platform device carried by the track, comprises a work platform or a gondola adapted to carry one or more individuals and/or a tool, a robot, an apparatus etc. for performing an operation on the rotor blade in a more or less automated manner.

Hereby, the desired flexibility of the platform assembly is achieved in an
20 expedient manner since the platform device may be moved along the circumference of the rotor blade, whereby the complete surface of the rotor blade can be accessed, e.g. via the track that may be designed in various manners.

In this connection it is noted that such a platform device, e.g. a work platform or
25 a gondola, may be carried by the track in such a manner that e.g. the gondola is hanging down from the track, whereby a person in the gondola can effectively treat, inspect, repair etc., the surface of the rotor blade essentially below the frame structure of the platform assembly. Thus, it will be understood that even the outer part of the rotor blade, e.g. the tip of the rotor blade can be treated,
30 inspected, repaired, etc. in this manner, while the platform assembly is supported by the rotor blade.

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In accordance with a further embodiment, the frame structure further comprises a hoisting device.

Hereby, it is achieved that tools, apparatus, etc. may be hoisted up to the frame device.

- 5 In an embodiment the hoisting device comprises a reel, a drive motor, control means and a hoisting line.

According to a further aspect, the platform structure comprises a work platform adapted to carry one or more individuals and/or a tool, a robot, an apparatus etc., for performing an operation on the rotor blade in a more or less automated
10 manner.

According to an embodiment said means for supporting and guiding the platform device in relation to the rotor blade are configured for being adjusted to the rotor blade during movement of the platform assembly in order to maintain controllable contact at said regions. The supporting and guiding means may
15 comprise a plurality of contact means. According to one embodiment, at least one of said plurality of contact means may be adapted for contacting the rotor blade at a plurality of points and/or at adjoining points.

Hereby, it is achieved that the contact means can move along the surface of the rotor blade while providing the necessary support against the surface of the
20 rotor blade, since the at least one contact means is adapted for contacting the rotor blade at a plurality of positions and/or at adjoining positions. Thus, the rotor blade will be able to withstand the load transferred to it by the contact means, while it will still be possible for the contact means to be displaced along the surface with a minimum of friction.

- 25 According to an embodiment, at least one of said contact means may comprise brush support means for contacting the rotor blade.

Hereby, it is achieved that the platform device may be supported against the rotor blade in a manner that can spread the load over a relatively wide area, e.g. due to the plurality of bristles used and/or due to a plurality of brushes
30 being connected together or carried together by a common carrier, the contact means being readily movable in any direction. The brushes may have different

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lengths of bristles, the lengths of the bristles preferably corresponding to the shape of the rotor blade. Hereby, it is achieved that the platform assembly may be supported against the rotor blade in a manner that can spread the load over a relatively wide area. Preferably, brush support means as used in e.g. the
5 conveying field may be used, for example, industrial brushes as supplied by the company August Mink KG, Germany.

According to a further embodiment, at least one of said contact means may comprise belt, drum, roller or similar support means for contacting the rotor blade.

10 Hereby, it is achieved that the platform device may be supported against the rotor blade in a manner that can spread the load over a relatively wide area.

According to a still further embodiment, said belt, drum, roller or similar support means for contacting the rotor blade may comprise a plurality of parallel belts, chains, drums, rollers or similar means.

15 Hereby, it is achieved that the device may be supported against the rotor blade in a manner that can spread the load over a relatively wide area.

Preferably, at least one of said contact means may comprise a plurality of balls, rollers or the like.

Hereby, it is achieved that the platform device may be supported against the
20 rotor blade in a manner that can spread the load over a relatively wide area, the contact means being readily movable in any direction.

Alternatively, at least one of said contact means may comprise fluid means, e.g. gas, air, for example in the form of pneumatic or air cushioning means, liquids, etc. for facilitating contact to the surface of the rotor blade.

25 Hereby, it is achieved that the device may be supported against the rotor blade in a manner that can spread the load over a relatively wide area, the contact means being readily movable in any direction, i.e. omnidirectionally.

According to a particular embodiment, said means for supporting and guiding the platform assembly in relation to the rotor blade may comprise means such
30 as strain gauges, weighing cells, etc. for determining the contact load at said

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regions of the rotor blade, thereby facilitating detection and/or measurement of unbalance and/or variations in rotor blade dimensions, e.g. width, wind pressure, etc.

Hereby it is achieved that the load acting upon the surface of the rotor blade by the individual contact means can be determined and that the platform assembly
5 can be adjusted, e.g. the means for supporting the contact means, in such a manner that the load is kept below predetermined limits, that all contact means take part in the support, i.e. no un-loaded contact means, and that the load is distributed evenly or essentially evenly. Thus, a smooth movement of the
10 device, when it is moved along the rotor blade, is achieved when the load or pressure of each of the plurality of contact means is controlled, since the friction is controlled accordingly. Thus, abrupt movements, abrupt stops etc. can be avoided, which furthermore enhances the safety when using the platform assembly.

15 According to a further embodiment, said means for supporting and guiding the platform assembly in relation to the rotor blade may comprise means for detecting an edge of the rotor blade.

Hereby, it is facilitated in an expedient manner that the contact made by the contact means is established and maintained within the above-mentioned
20 regions, since these can be determined in relation to the edge or edges of the rotor blade.

Advantageously, said means for detecting an edge of the rotor blade may comprise measuring or detecting means, such as for example optical sensing means, e.g. laser means, photo cells, optical scanning means, etc., radiation
25 means such as X-ray means, sonic detecting means, e.g. ultrasonic means, etc., radar means, etc.

Hereby, the edge or edges of the rotor blade can be detected with a large degree of accuracy and by means of proven components and systems.

Advantageously, the platform assembly may comprise control means for
30 controlling said means for supporting and guiding the platform assembly in relation to the rotor blade on the basis of input signals provided by said means

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for determining contact load at said regions of the rotor blade and/or input signals provided by said means for detecting an edge of the rotor blade.

Hereby it is achieved that the platform assembly can be controlled to move along the rotor blade in an automated manner, whereby the contact means are kept within the desired regions and whereby the means for supporting and guiding the platform assembly in relation to the rotor blade are controlled in such a manner that the load acting upon the rotor blade by the contact means is within predetermined limits, whereby also a preferable balance is achieved and whereby a reliable, safe and user-friendly operation of the platform assembly is achieved, e.g. a movement of the platform assembly along the rotor blade, which does not involve jerks, abrupt movements, abrupt stops, etc.

Preferably, said frame structure may have an open configuration or is adapted for being opened, e.g. by having a releasable frame part and/or one or more frame parts that are pivotal.

Hereby, it is achieved that the platform assembly can readily be transferred to a convenient place along the length of the rotor blade in a relatively simple manner, instead of being placed at the rotor blade at the tip of the blade, where the distance to the tower is relatively large, thereby making such an operation relatively complex, when the size of currently used wind turbines is taken into consideration. Furthermore, as regards a frame structure that is configured for being opened, it is noted that, when such a frame structure is closed again, it may essentially and functionally be defined as being an endless frame structure and that the track may essentially extend along such an endless frame structure, whereby access can be gained in a 360° configuration.

Preferably, said means for supporting and guiding the platform assembly in relation to the rotor blade may comprise a rear guide and support arrangement comprising at least one arm for establishing contact at said regions at or near the rear edge of the rotor blade.

Preferably, said rear guide and support arrangement may be movable in the longitudinal direction of the platform assembly.

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Advantageously, said rear guide and support arrangement may comprise at least two arms for establishing contact at said regions at or near the rear edge of the rotor blade, wherein said arms may be pivotable in relation to the frame structure, whereby variations in the width of the rear edge of the rotor blade can
5 be accommodated and the position of the frame structure in relation to the rotor blade is adjustable.

Preferably, said means for supporting the platform assembly in relation to said rotor blade may comprise a front guide and support arrangement comprising one or more of said plurality of contact means, said front guide and support
10 arrangement being movable, e.g. comprising one or two pivotable arms or the like for facilitating opening and closing of said frame structure.

According to a further embodiment, the contact means, e.g. belts or the like, of said front guide and support arrangement may comprise contact detection means, for example sensors, switching means, etc., for detecting the contact
15 established between the contact means and the rotor blade.

Hereby, it is achieved that it is detected if e.g. the contact means, which are normally supported against the rotor blade on the front side, are not in contact with the surface of the rotor blade, which means that the contact means, which are supported against the other side, are taking the full load of the front part of
20 the frame. This has the undesired effect that the contact pressure may be undesirably high, and furthermore that the frame may abruptly move to a position where both contact means are supported, which is undesirable for several reasons, one of which being the work comfort of the person(s) located in the e.g. work platform(s), since such an abrupt movement will be at least
25 uncomfortable. Since such an undesirable situation can be detected in accordance with this embodiment, measures can be taken to correct the situation and achieve that e.g. both front contact means are in a correct contact with the rotor blade.

Preferably, said front guide and support arrangement may be adapted for being
30 tilted up or down in order to allow said contact means to adapt to the direction of movement along the front part of the rotor blade.

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Hereby, it can be achieved that the front contact means can be guided to maintain a desired contact with the rotor blade in spite of the changing width of the rotor blade front, when the device is moving up or down, which may require that the suspension arrangement, e.g. the arms of the front guide and support
5 arrangement are adjusted, for example a small angle up or down.

Advantageously, the platform assembly may further comprise one or more fenders on the inside of the frame structure. Preferably, the fenders are placed to face each other. Hereby, it can be achieved that any direct contact between frame and rotor blade is as gentle as possible.

10 Preferably, the frame or the fenders may comprise means for determining and or measuring the contact load. Hereby, measures can be taken to avoid a situation, where the rotor blade becomes squeezed or wedged in the frame.

Preferably, the fenders may have the shape of cylinders or rollers.

Preferably, the platform assembly may further comprise means for supporting
15 the platform assembly in relation to a wind turbine tower, where said means for supporting the platform assembly in relation to the wind turbine tower are configured for displacing the platform assembly in relation to said wind turbine tower, e.g. when the platform assembly is transferred to or removed from the rotor blade of a wind turbine.

20 Hereby, the lifting and lowering of the platform assembly along the tower is facilitated and furthermore, the operations performed when the platform assembly is transferred to the rotor blade or returned to the tower again are facilitated.

Preferably, said means for supporting the platform assembly in relation to the
25 wind turbine tower may be configured for adjusting the position, e.g. the angle of the platform assembly in relation to the wind turbine tower.

Hereby, it is achieved in a relatively simple manner that the platform assembly can be controlled with high accuracy, when, for example, it has reached a height where it is desired to contact the rotor blade. This may be of particular
30 importance when operating in windy conditions.

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Advantageously, said means for supporting the platform assembly in relation to the wind turbine tower may comprise means for measuring the support load, for example for each of the tower support arms, e.g. in order to determine load distribution between two or more tower support arms or the like.

- 5 Hereby, it can be determined whether, for example, two tower support arms carry essentially the same load or if for some reason, e.g. wind pressure, the influence of the hoisting means, etc., the load is (undesirably) uneven, whereby corrective control steps can be taken.

- According to an embodiment the platform device may comprise control means
10 for controlling the position of the platform device in relation to the track portion and in relation to the rotor blade.

- Hereby, the person or the persons using the platform assembly may control the platform assembly and in particular their own position, e. g. work position in relation to e.g. the surface of a rotor blade, in an optimal manner. Further, the
15 platform device may comprise control means for controlling the lifting/lowering and the positioning in relation to the rotor blade, said control means having the form of a joystick or the like and by means of which any controllable part may be controlled individually and/or simultaneously with other parts. Further, it is noted that a gyroscopic arrangement may be included in the control system.

- 20 According to an embodiment, the control means for controlling the position of the platform device in relation to the track portion and in relation to the rotor blade may comprise a rotation, e.g. 360°, around the axis of the platform device and a rotation, e.g. of 180°, by means of an eccentric suspension in relation to the track portion.

- 25 Further, the platform device, e.g. one or more work platforms, gondolas, tools, robots, apparatuses, etc., may comprise load detection means, e.g. for each work platform, gondola, tool, robot, apparatus, etc., said load detection means providing input for control and/or safety means.

- In accordance with a further embodiment, said means for lifting and/or lowering
30 the platform device in relation to the rotor blade may comprise hoisting means having power means such as electric motors, electric, electronic, hydraulic

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and/or pneumatic means and said hoisting means may be adapted for climbing up and down a cable or said hoisting means may be adapted for accumulating the cable, e.g. drum hoisting means.

Hereby, the platform assembly will be able to lift and/or lower itself without power assistance from e. g. a hoist located at the wind turbine tower, at a vehicle or at a vessel. Thus, the platform assembly will be able to operate independently, i.e. without concern for power assistance from other devices. This further enhances safe operation, since accidents caused by a power failure at a ground vehicle or at a vessel are prevented. Particularly when operation at sea is concerned, e. g. at sea wind turbines, such an independent configuration is preferable since a support vessel may be unstable, e. g. subjected to waves, current, wind etc. Thus, an arrangement at sea where a vessel provides the elevation by e.g. hoist (s) located on the vessel is prone to accidents and malfunction, and therefore a device comprising power means as mentioned above is advantageous, not only in general, but especially at sea.

Further, it is noted that, even when power supply to such a platform assembly is subjected to failure, e. g. when electric power is cut off, a device according to the invention will be able to be manually operated, e. g. to be hoisted to the ground and will in general present a safe work tool for all involved, in particular persons occupying the device.

In a further embodiment the platform assembly may further comprise control means for controlling the lifting and/or lowering means.

Such control means may be controlled from a platform as explained above or from e.g. ground level, for example when an automated operation is taking place.

According to an embodiment, said means for lifting and/or lowering the platform assembly in relation to the rotor blade may comprise a plurality of hoisting means, wherein one of said plurality of hoisting means is a master hoisting means and wherein the other/others of said plurality of hoisting means is/are controlled in dependence of the master hoisting means.

Hereby it is achieved that the platform assembly can be lifted and lowered in such a manner that the platform assembly is maintained in a desired position, e.g. horizontally or at a desired angle while being moved up and down and/or that furthermore the load taken by the individual hoisting means is within
5 predetermined limits.

It will be understood, though, that the hoisting means may also be synchronized in relation to each other.

According to a further embodiment, the platform assembly may comprise measuring means, e.g. weighing cells, strain gauges, etc., for measuring the
10 load on the hoisting means or on each of a plurality of hoisting means.

Even further, the platform assembly may comprise measuring means, e.g. encoders, laser measuring means, etc., for measuring or estimating e.g. the position of the platform assembly, the lifting and lowering distances and/or velocity for each of a plurality of hoisting means.

15 Thus, it will be understood that the hoisting means may be adapted for measuring or calculating the length of the wire, line or cable in order to determine the actual altitude of the device. A calibration of these means may take place, when the platform assembly is placed e.g. at ground level.

According to a still further embodiment, the platform assembly may further
20 comprise means for automatically adjusting said hoisting means, e.g. automatic levelling means, in order to provide a desired position, e.g. a horizontal position of the frame structure.

Advantageously, the platform assembly may be adapted to assist individuals and/or facilitate the use of automated equipment such as robots in performing
25 inspection, work, repair, surface treatment etc. on a rotor blade of a wind turbine.

Preferably, said platform assembly may comprise a control system for automatically controlling actuators, hoisting means etc. of the platform assembly on the basis of control input from e.g. gyroscopic sensor(s), pressure sensor(s),
30 optical sensor(s) such as laser sensor(s), strain gauge sensor(s), contact sensor(s) and/or other sensors, detectors and/or measuring means.

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Hereby, a highly automated operation of the platform assembly is achieved, and furthermore enhanced user friendliness and enhanced efficiency are achieved since, for example, the user need not to attend to various compensative control operations in order to counteract changing wind, changing balance as the
5 device is moved up and down etc., but can concentrate on the work that has to be performed.

According to an embodiment, the control system may be configured for limiting the speed, with which the platform assembly is lowered and/or lifted, when the platform assembly is within a predetermined distance from the ground or
10 another base level or within a predetermined distance from e.g. the nacelle.

When moving up and down along the wind turbine tower, it is desirable to move as fast as possible in view of the considerable distances, e.g. in order to minimise the non-productive time used for moving up and down. However, in order to enhance the safety of the persons involved, the speed of the platform
15 assembly may preferably be reduced when the platform assembly is approaching the ground, e.g. when the platform assembly is within a few metres to the ground, in order to avoid a hazardous collision with the ground, which will in most cases be a collision between the ground and the gondola(s) and the person(s) situated in the gondola(s). The distance to the ground may be
20 determined or calculated by means of the hoisting means, which as mentioned above may comprise means for measuring or calculating the length of the wire, line or cable in order to determine the actual altitude of the platform assembly. However, also special measuring means such as laser distance means located at the platform assembly may be used for this safety related arrangement,
25 whereby the ground level can be determined or detected with high accuracy.

According to an embodiment, said means adapted for supporting the platform assembly in relation to a rotor blade of a wind turbine may be displaceable, e.g. in the lateral direction and/or the longitudinal direction of the platform assembly.

Hereby, the platform assembly can readily travel along the length of the rotor
30 blade, while the support means are automatically adapted to the actual size and/or shape of the rotor blade. Furthermore, the transfer of the platform assembly from the tower to the blade is facilitated in this manner.

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Preferably, said front guide and support arrangement may be movable in the longitudinal direction of the platform assembly.

Hereby, the control of the position of the contact means in relation to width and/or position of the rotor blade is facilitated.

- 5 According to a further aspect of the invention, the frame device may be configured for supporting against the surface of a wind turbine tower at least at two points in the vertical direction, the means for supporting the platform assembly at least at one of these points being adjustable in relation to the surface of a wind turbine tower.
- 10 Hereby, it is achieved that the frame device can be transported along the surface of the tower, even when the surface comprises obstacles or the like, for example in the form of flanges or the like or in the form of various equipment, such as antennas, that is located at the tower.

Preferably, the frame structure may form an essentially elongated structure.

- 15 Hereby, the platform assembly can efficiently be used for servicing a wind turbine rotor blade, since the elongated configuration provides the possibility of reaching all parts of the surfaces of the rotor blade, when the platform assembly is moved along the rotor blade. It is noted that, even though the frame structure has been described as having an essentially U-shaped form, various other
- 20 forms are possible. It should be mentioned that for example rectangular, triangular, circular, oval forms etc. may be used as well. Further, forms having an L-shape, V-shape, etc. may also be used, and it is noted that forms allowing access to a restricted part only of the rotor blade, for example only one side of the rotor blade, are possible.
- 25 According to an embodiment, said one or more platform devices that are guided by said track portion, e.g. a work platform, a gondola, a tool, a robot, an apparatus, etc. may comprise means for adjusting the position in relation to said track portion, e.g. transversely to the direction of the track portion.

- Hereby, it is achieved that in instances, where a platform device that is guided
- 30 by the track portion is not positioned optimally in relation to the rotor blade, e.g. at a suitable work distance, the platform device can be displaced until it reaches

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the desired distance. This may be particularly important, when the track portion has a gap, for example at an open end of the frame structure of the platform assembly, e.g. at the front edge of the rotor blade. The adjustment or displacement of the platform device may be achieved in various manners, for example by having the platform device suspended in an S-shaped suspension, which can be rotated, whereby the adjustment is performed in a circular motion. Further the adjustment can be performed via a linear movement, for example using a linear actuator, a beam structure or the like

Expediently, said means for lifting and/or lowering the platform assembly in relation to the rotor blade may be connected to a plurality of lines, wires or the like.

Such wires or lines etc. may be connected to any suitable spot on the wind turbine, e.g. the nacelle, the hub, the tower etc., and they may be permanently fixed. Furthermore, it is noted that, in accordance with the invention, the platform assembly can be operated using three such lines or wires, two connected at or near the rear of the platform assembly and one connected to a spot along the length of the frame structure, preferably at the end of the frame facing away from the tower, whereby a triangular suspension is achieved. As it is explained herein, the platform assembly may be balanced, e.g. by adjusting the position of one or both of these connection spots, for example on the basis of measured parameters and/or gyroscopic input. Further, it is noted that with such an arrangement it is achieved that during the operation of the platform assembly, the lines or wires will not get in contact with the rotor blade.

According to a further embodiment, the platform assembly may further comprise means for changing the direction of one or more of the lines or wires, by means of which the device is hoisted, lifted and/or lowered, thereby altering the balance of the platform assembly.

Hereby, a balancing of the platform assembly as described above is facilitated.

According to a still further aspect of the invention, the platform assembly may further comprise dampening means for performing a dampening action of the platform assembly in relation to the rotor blade.

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Since the platform assembly may be used and operated at considerable heights, it is apparent that it will be affected by the environment, e.g. influenced by wind, turbulences, etc. In order to counteract such influences, the device according to any of the embodiments described herein may be equipped with means for effecting a dampening of the undesired influences. Such dampening means may be passive, but preferably or in addition to passive dampening means, active dampening means may be used. Such active dampening means may be controlled by control means, for example integrated with the central control means for the platform assembly, and the control of the active dampening means may take place on the basis of input signals from e.g. sensor means, by means of which for example wind speed, turbulence, vibrations etc., may be measured. Hereby it is achieved that the mass of the platform assembly including work platform, gondola, personnel, tools etc., may be used to dampen the movements of the structure itself.

According to a further embodiment, said platform assembly may be adapted for being permanently fixed at the wind turbine, e.g. at a nacelle of said wind turbine, and for being operated by lowering and transferring the device to a rotor blade.

According to a second aspect the invention furthermore relates to method for enabling access to a rotor blade of a wind turbine, whereby a frame device that comprises a frame structure, means for supporting and guiding the frame device in relation to said rotor blade, and means for lowering and/or lifting the frame device in relation to the rotor blade, is placed near said wind turbine essentially at ground or sea level,

- the frame device is lifted in relation to said wind turbine by means of at least one line, wire or the like connected to said wind turbine,

- when the frame device has reached a suitable level, the rotor blade is contacted by support means at or near the edge of the rotor blade, said support means being movable in relation to said frame device,

- the frame device is lifted and/or lowered in relation to the rotor blade while supported and guided by said support means at regions at or near the front edge of the rotor blade and/or at or near the rear edge of the rotor blade,

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-one or more platform devices comprising a platform structure and means for supporting and guiding the platform device in relation to the rotor blade is/are hoisted and attached to the frame structure, the frame structure and the attached platform device together being called a platform assembly.

- 5 It should be noted that a skilled person would readily recognise that any features described in combination with the first aspect of the invention could also be combined with the second aspect of the invention, and vice versa.

Expediently, the platform assembly is lowered in relation to the rotor blade to a given diameter of the rotor blade.

- 10 Hereby, it is achieved that access to a rotor blade of a wind turbine can be affected in an expedient manner.

Preferably, access to the rotor blade below the given diameter of the rotor blade is performed by lowering and/or lifting the one or more platform devices in relation to the frame device.

- 15 Hereby, it is achieved that the frame structure may be lowered and lifted to a given position on the rotor blade and the one or more platform devices may be lowered and or lifted independently of each other further down the rotor blade. Hereby the rotor blade may be accessed without transferring the frame structure down to the rotor blade tip.

- 20 Expediently the frame device is supported in relation to the tower of the wind turbine while being lifted.

Hereby, it is achieved that the device is lifted and or lowered in a stable and controlled manner.

- 25 Advantageously, the step of establishing contact to the rotor blade is performed at a level at or near "chord max"-level, and/or at a level where a minimum distance, e.g. a safe and suitable distance, between the front edge of the rotor blade and the tower exists.

Hereby, the transfer of the device can be effected in a particularly simple manner and in a manner that minimises the size of the wind turbine.

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Expediently, the wind turbine is initially arranged with an essentially vertical rotor blade and with the rear edge of the rotor blade near the tower. E.g. placed in the mode, which may be referred to as the natural emergency mode of the wind turbine.

- 5 Hereby, optimal working conditions are achieved, e.g. with the edge of the rotor blade facing any possible wind, the device expediently contacting the edge as soon as possible when being lifted upwards, whereby increased stability is achieved.

The Figures

- 10 The invention will be described in detail in the following with reference to the drawings, in which

Figs. 1 -7 show a platform assembly according to an embodiment of the present invention and a method for enabling access to a rotor blade of a wind turbine.

15 Detailed description

The platform assembly and a method for enabling access to a rotor blade of a wind turbine will be explained in general with reference to Figs. 1-7.

Figs 1-7 illustrate the platform assembly in a schematic matter.

- 20 The Figs. 1-7 disclose a wind turbine tower (1) upon which a nacelle (2) is mounted. From the nacelle (2) extends a not visible main shaft on which a hub (3) carrying a rotor blade (4) is mounted.

In the shown situation only one rotor blade (4) is disclosed. In the shown situation the wind turbine is stopped and the disclosed rotor blade (4) is essentially vertical and has its rear edge near the tower (1).

- 25 Fig. 1 shows schematically, how the frame device (5) is hoisted by the hoisting lines (6). At the ground two platform devices (7) are waiting to be hoisted.

- Fig. 2 is a schematic view of a sea-based wind turbine. The wind turbine tower is positioned on a sea-based platform (8). A hoisting device (9) is placed on the platform; the platform has a maximum load of 1000 kg. Two platform devices (7) have been hoisted onto the sea-based platform (8) from a vessel (10). The
- 30

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frame structure (5) has reached a suitable level and the rotor blade (4) is being transferred to the rotor blade; not to the tip of the rotor blade, but to a level, where the distance from the tower to the rotor blade is convenient.

Fig 3 schematically shows a situation where the frame device is positioned on the rotor blade and where not disclosed means for supporting and guiding the frame in relation to the rotor blade are configured for contacting the rotor blade at regions near the front and rear edges of the rotor blade. The frame structure is now ready for being connected to the two platform devices placed on the ground.

Fig 4. schematically shows a situation where an individual (11) is placed on the frame device for performing inspection, work, repair, surface treatment etc. on the rotor blade above the frame structure. A platform device (7) with an individual (12) is lifted up to the frame device (5), a hoisting line connecting the frame device (5) to a platform device (7).

Fig 5. is a schematic view of a platform assembly for enabling access to a rotor blade of a wind turbine, where the frame device and two platform devices are connected and where the platform devices are attached to the frame structure and the means for supporting and guiding the frame device in relation to the rotor blade are contacting the rotor blade near the front and rear edge of the rotor blade. One of the platform devices is contacting the rotor blade near the front edge and the other platform device is contacting the rear edge of the rotor blade.

Fig 6. discloses the situation from Fig. 5, where the two platforms are lowered to two different positions of the rotor blade.

Fig. 7 discloses the situation from Figs. 5 and 6, where both the frame device and the two platform devices are lowered the rotor blade.

Patent Claims

1. A platform assembly for enabling access to a rotor blade of a wind turbine, said platform assembly being adapted for moving in the longitudinal direction of the rotor blade, the platform assembly comprising:

- 5 • a frame device comprising:
- a frame structure,
 - means for supporting and guiding the frame device in relation to the rotor blade, wherein said means for supporting and guiding the frame device in relation to the rotor blade are configured for
10 contacting the rotor blade at regions
 - at or near the front edge of the rotor blade and/or
 - at or near the rear edge of the rotor blade, and
 - means for lowering and/or lifting the frame device in relation to the rotor blade,
- 15 • a platform device comprising:
- a platform structure,
 - means for supporting and guiding the platform device in relation to the rotor blade, wherein said means for supporting and guiding the platform device in relation to the rotor blade are configured for
20 contacting the rotor blade at regions
 - at or near the front edge of the rotor blade and/or
 - at or near the rear edge of the rotor blade, and

wherein the platform device is detachably attached to the frame structure and movable in relation to the frame structure and carried by said frame structure.

- 25 2. A platform assembly according to claim 1, the platform assembly comprising two or more platform devices, the platform devices being independently of each other detachably attached to the frame structure and movable in relation to the frame structure and carried by said frame structure.

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3. A platform assembly according to claim 1 or 2, wherein the platform device and/ or the frame structure comprise means for lowering and/or lifting the platform device in relation to the frame structure.
4. A platform assembly according to claim 3, wherein said means for lifting and/or lowering the platform device in relation to the frame structure comprise hoisting means having power means, said hoisting means being adapted for climbing up and down a cable or for accumulating the cable, e.g. drum hoisting means.
5. A platform assembly according to any one of the preceding claims, wherein the frame device comprises means for providing a place to stand or sit for individuals performing inspection, work, repair, surface treatment etc. on the rotor blade above the frame structure.
6. A platform assembly according to claim 5, wherein the means for providing a place to stand or sit comprise a floor.
7. A platform assembly according to any one of the preceding claims, wherein at least a part of the frame structure comprises a track portion, the track portion being adapted to guide the platform device along the track portion.
8. A platform assembly according to any one of the preceding claims, wherein the frame structure further comprises a hoisting device.
9. A platform assembly according to claim 8, wherein the hoisting device comprises a reel, a drive motor, control means and a hoisting line.
10. A platform assembly according to any one of the preceding claims, wherein the platform structure comprises a work platform adapted to carry one or more individuals and/or a tool, a robot, an apparatus etc., for performing an operation on the rotor blade in a more or less automated manner.
11. A platform assembly according to any one of the preceding claims, wherein said means for supporting and guiding the platform device in relation to the rotor blade are configured for being adjusted to the rotor blade during movement of the platform device in order to maintain controllable contact at said regions.

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12. A platform assembly according to any one of the preceding claims, wherein said means for supporting and guiding the platform device in relation to the rotor blade comprise a plurality of contact means.

13. A platform assembly according to claim 12, wherein at least one of said plurality of contact means is adapted for contacting the rotor blade at a plurality of points and/or at adjoining points.

14. A platform assembly according to claims 12 or 13, wherein said contact means for contacting the rotor blade comprise brush support means or belt support means.

15. A platform assembly according to claim 12 or 13, wherein said contact means comprise a plurality of balls, rollers or like.

16. A platform assembly according to any of the preceding claims, wherein said means for supporting and guiding the platform device in relation to the rotor blade comprise means for determining contact load at said regions of the rotor blade, such as such as strain gauges, weighing cells, etc., thereby facilitating detection and/or measurement of unbalance and variations, like wind pressure or variations in rotor blade dimensions, e.g. width, size and shape, etc.

17. A platform assembly according to any of the preceding claims wherein said frame structure has an open configuration or is adapted for being opened, e.g. by having a releasable frame part and/or one or more frame parts that are pivotal.

18. A platform assembly according to any of the preceding claims wherein the frame structure further comprises means for supporting the frame device in relation to a wind turbine tower, said means for supporting the frame device in relation to the wind turbine tower being configured for displacing the device in relation to said wind turbine tower, e.g. when the frame device is transferred to or removed from the rotor blade of a wind turbine.

19. A method for enabling access to a rotor blade of a wind turbine, whereby a frame device comprising a frame structure, means for supporting and guiding the frame device in relation to said rotor blade, and means for lowering and/or

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lifting the frame device in relation to the rotor blade, is placed near said wind turbine, essentially at ground or sea level,

- the frame device is lifted in relation to said wind turbine by means of at least one line, wire or the like connected to said wind turbine,

5 - when the frame device has reached a suitable level, the rotor blade is contacted by support means at or near the edge of the rotor blade, which support means are movable in relation to said frame device,

10 - the frame device is lifted and/or lowered in relation to the rotor blade while supported and guided by said support means at regions at or near the front edge of the rotor blade and/or at or near the rear edge of the rotor blade,

-one or more platform devices comprising a platform structure and means for supporting and guiding the platform device in relation to the rotor blade is/are hoisted and is/are attached to the frame structure, the frame structure and the attached the platform device together being called a platform assembly.

15 20. A method according to claim 19, whereby a platform assembly according to any of the claims 1-18 is lowered in relation to the rotor blade to a given diameter of the rotor blade.

20 21. A method according to claim 20, whereby access to the rotor blade below the given diameter of the rotor blade is performed by lowering and/or lifting the one or more platform devices in relation to the frame device.

22. A method according to claims 19-21, whereby the frame device is supported in relation to the tower of the wind turbine while being lifted.

25 23. A method according to claims 19-22, whereby said step of establishing contact to the rotor blade is performed at a level at or near "chord max"-level, and/or at a level, where a minimum distance, e.g. a safe and suitable distance, between the front edge of the rotor blade and the tower exists.

24. A method according to claims 19 – 23, whereby the wind turbine is initially arranged with an essentially vertical rotor blade and with the rear edge of the rotor blade near the tower.

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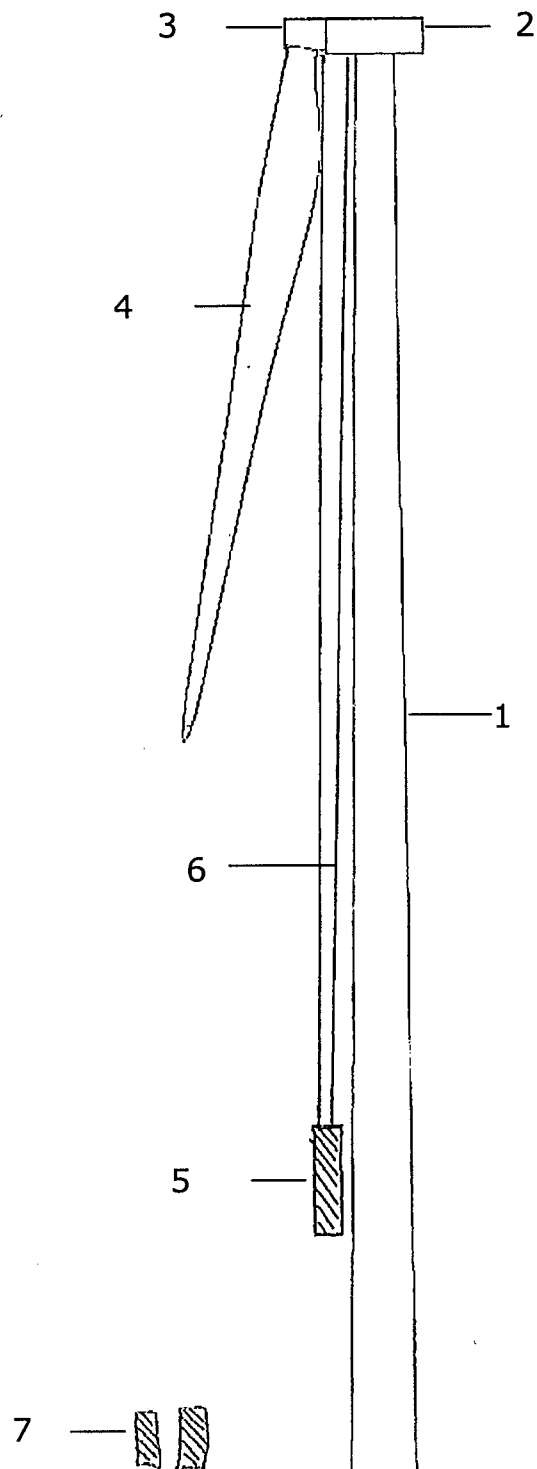


Fig. 1

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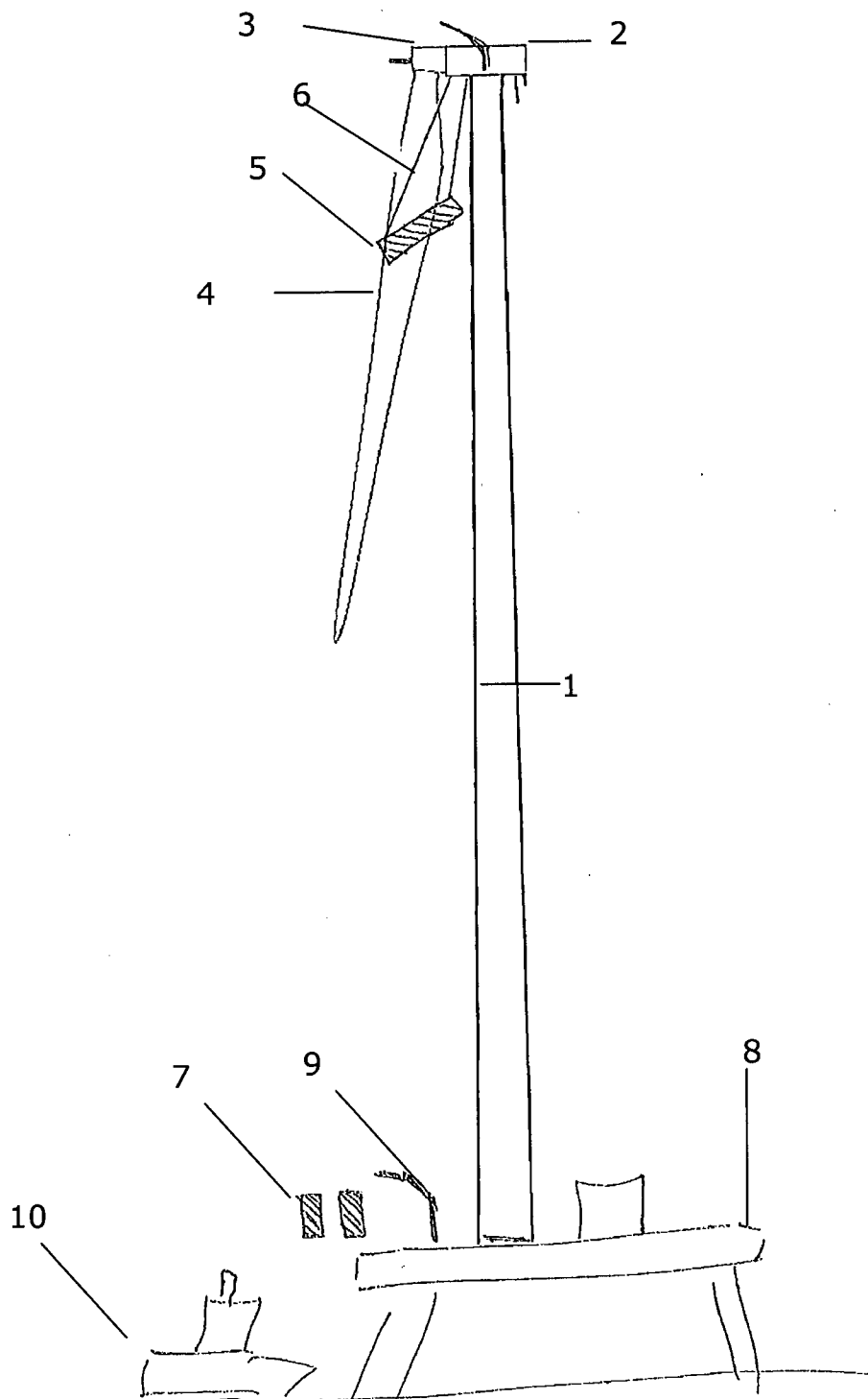


Fig. 2

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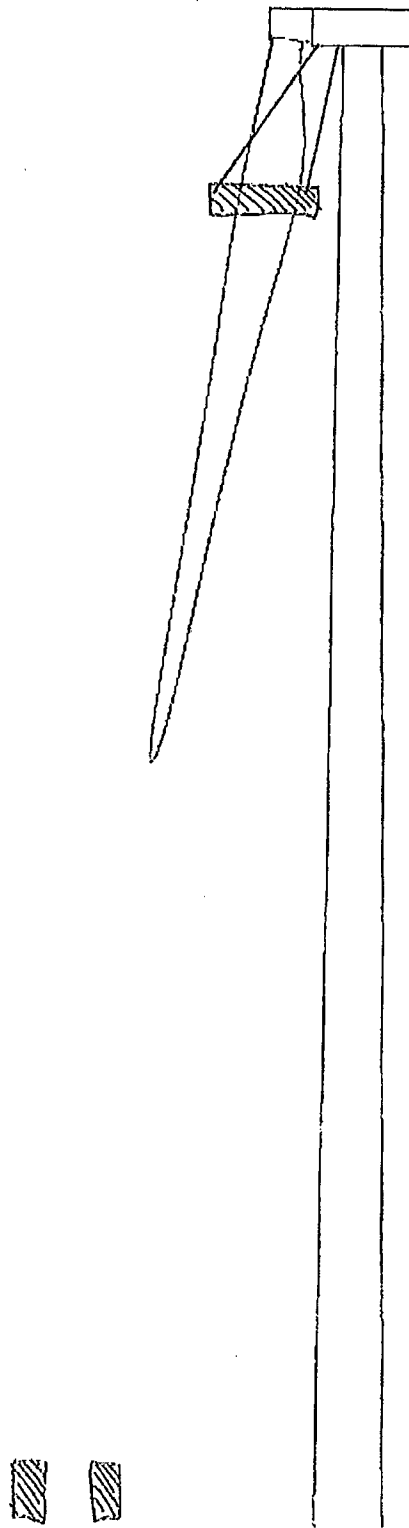


Fig. 3

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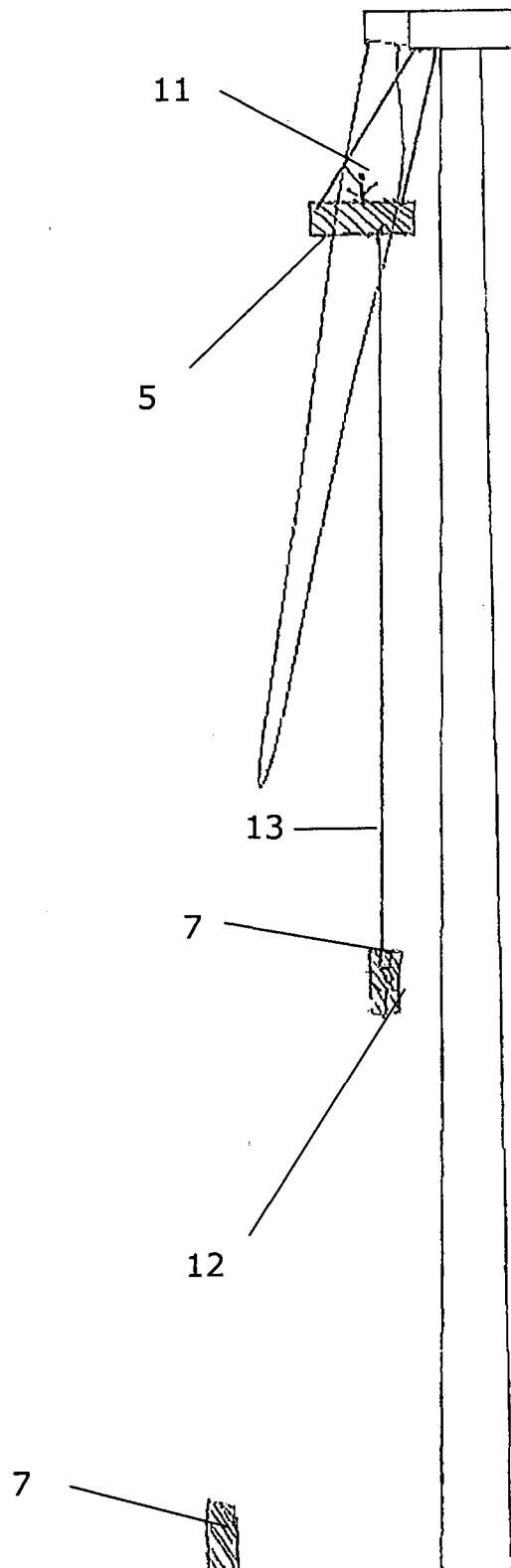


Fig. 4

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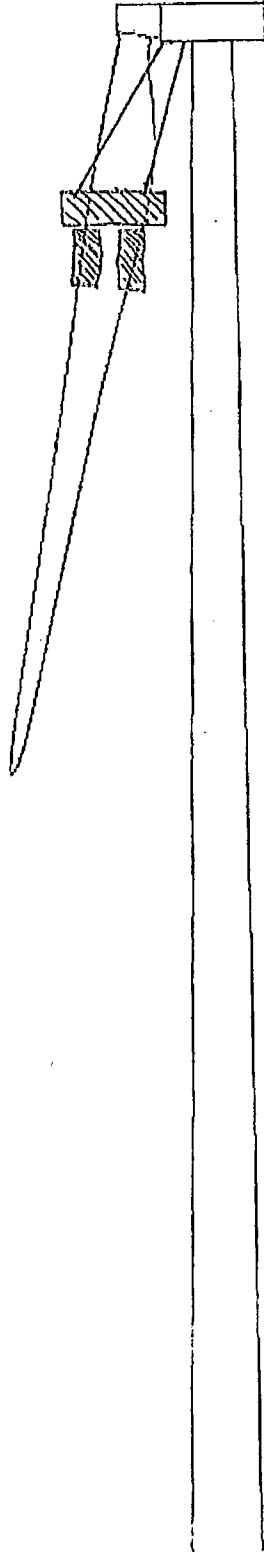


Fig. 5

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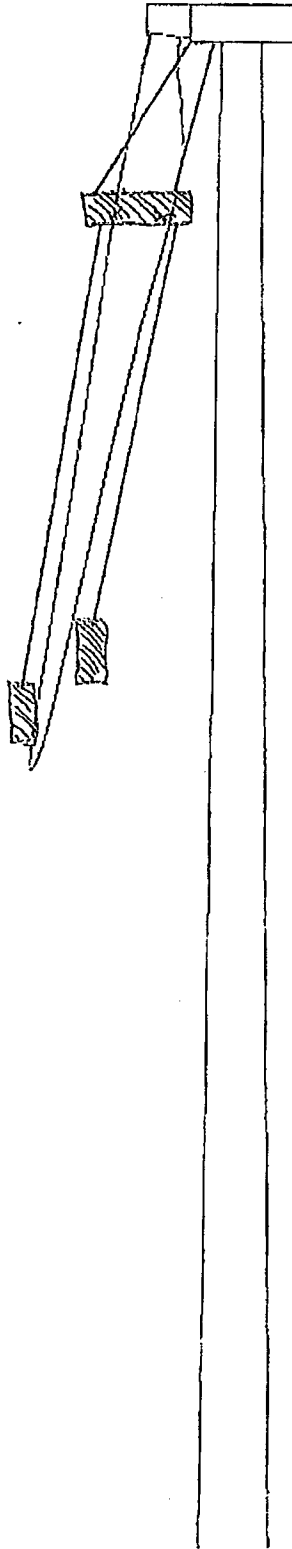


Fig. 6

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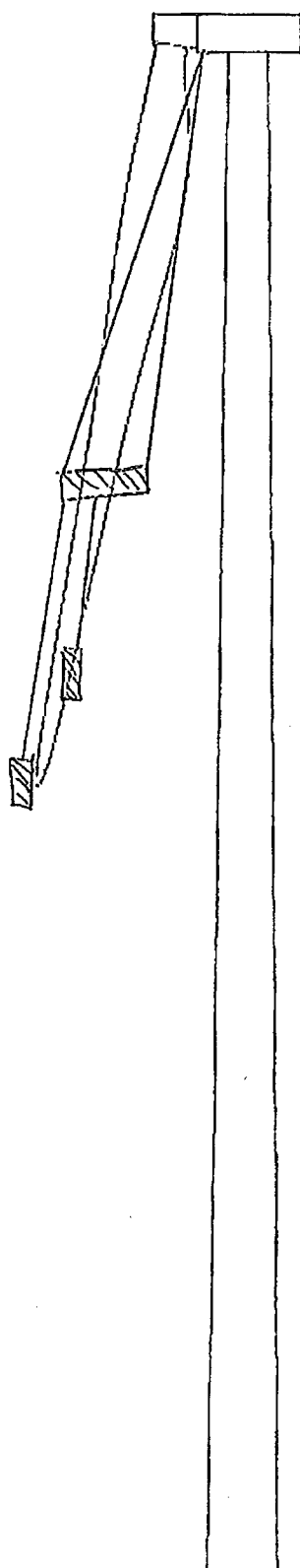


Fig. 7

INTERNATIONAL SEARCH REPORT

International application No

PCT/DK2012/000053

A. CLASSIFICATION OF SUBJECT MATTER
 INV. E04G3/24 F03D1/00
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 E04G F03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

2 August 2012

Date of mailing of the international search report

13/08/2012

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INTERNATIONAL SEARCH REPORT

International application No

PCT/DK2012/000053

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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