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(54) Title: A CONNECTOR FOR RELEASABLY ATTACHING A WIND TURBINE TO A CRANE

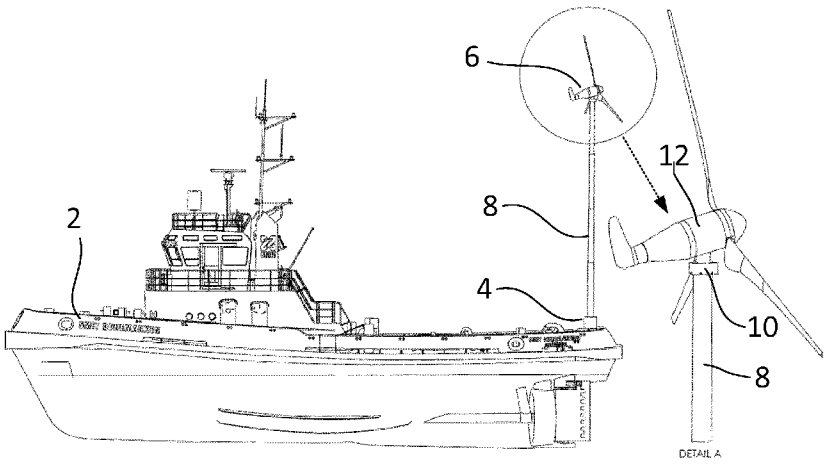

Fig. 1

(57) Abstract: The present application provides a system for use on a vessel having a crane. The system employs the crane as a support tower for a wind turbine. Thus a wind turbine may be used to generate power on the vessel without a dedicated support tower or structure. A connector is provided to connect the wind turbine to the arm of a crane. The connector comprises a first section for engaging with the end of the crane arm and a second section connected to the first section and being configured for connecting to and providing a support for the wind turbine. Using this connector the crane arm may act as a support tower for the wind turbine when in use.

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A Connector For Releasably Attaching A Wind Turbine To A Crane

Related Applications

The present application claims the priority of UK Patent Application No. 1513327.5 filed 29th July 2015 and UK Patent Application No. GB1520001.7 filed 12th November 2015, the entire contents of both of which are incorporated herein by reference.

Field

The present application relates to wind turbines and provides a connector to allow a wind turbine to be employed on a crane.

Background

Commercial marine working vessels, such as tugs, have periods of use where they are tied up in port or at anchor. These periods may arise during times of poor weather when the vessel cannot operate for safety reasons and are commonly referred to as 'downtime'.

During downtime or any other time the vessel is tied up, the vessels generators are generally still operational to provide power to the vessels electrical systems. This incurs a significant cost in fuel and also generates noise and pollution.

Whilst it is known to employ small wind turbines on smaller boats such as sailing or motor yachts, their size and scale make them entirely unsuitable for use on larger vessels, where the power requirements are significantly higher.

As a result, the small versions of wind turbines which are intended for mounting to a rail or other structure would not be sufficient to meet power requirements of a working vessel. Several smaller wind turbines could be mounted but this would be impractical and inefficient.

Conceivably larger turbines could be mounted on a more substantial structure on the vessel, for example a tower provided on the roof of a pilot house, e.g. as might currently be employed for mounting radio antennas, radar or other electronics equipment.

However, mounting a wind turbine with sufficient capacity to meet the power requirements of a working vessel would present structural difficulties in providing a sufficiently strong support and stability issues for the vessel when at sea because of their weight and position high up on a vessel.

The present application is directed generally at providing a solution to these problems.

Summary

The present application provides a system for use on a vessel having a crane. The system employs the crane as a support tower for a wind turbine. Thus a wind turbine may be used to generate power on the vessel without a dedicated support tower or structure.

Accordingly a first aspect provides a connector for releasably attaching a wind turbine to the arm of a crane. The connector comprises a first section for engaging with the end of the crane arm and a second section connected to the first section and being configured for connecting to and providing a support for the wind turbine. Using this connector the crane arm may act as a support tower for the wind turbine when in use.

The first section suitably comprises a plurality of walls defining an opening, where the opening is dimensioned to permit the first section to be slid over or into the end of the crane arm.

In one arrangement, one of the walls has a slot defined therein for accommodating a loading hook of the crane, removing the necessity to remove the hook of the crane before sliding on the connector. To match with the shape of the crane arm, the opening may be generally rectangular in shape. It will be appreciated that the opening will be dimensioned according to the particular crane arm it is to be employed with. Thus, the width of the rectangular opening may be in the range of 75 mm to 500mm with the length in the range of range of 100mm to 600mm.

At least one locking feature may be provided to allow the connector to be locked onto the crane arm. The locking feature may be movable from a first position where the locking feature is aiding in the retention of the crane arm within the first section and a second position where crane arm is free to move with respect to the first section. To ensure a tight connection, a plurality of locking features may be provided.
Where there are a plurality of locking features, a first set of the locking features are arranged in opposing walls of the end section so that the crane arm is restrained between the opposing locking features when the locking features are in their respective first positions.

The second section suitably comprises a post for engaging with a corresponding socket on a main body of the wind turbine. The post is suitably generally cylindrical in nature to allow

rotation relative to the socket. A yaw limiter may be provided to limit the yaw of the turbine relative to the crane arm/connector

In one implementation, the yaw limiter comprises at least one spline arranged on the cylindrical post for engaging with a corresponding feature on the socket of the wind turbine.

Suitably, the connector is integrally formed with a wind turbine.

The wind turbine comprising the connector described suitably further comprises a rotor having a plurality of blades, a main body with a generator housed within the main body and driven by the rotor.

It will be appreciated that different types of wind turbine may be employed including both horizontally and vertically aligned wind turbines.

Where the wind turbine is a horizontally aligned wind turbine, the turbine may have a tailfin attached to the main body for maintaining the rotor direction into the wind.

To allow rotation with the wind, the main housing is suitably free to rotate with respect to the second section of the connector.

To avoid the requirement for a gear box, the generator may be driven directly by the rotor. To facilitate this the generator is a permanent magnet alternator.

To facilitate storage on the vessel, each of the plurality of blades may be removably attachable to the rotor. To perform this quickly, the rotor may comprise a rotor body having a first section and a second section, wherein the first and second sections are rotatable with respect to one another between a first configuration and a second configuration, wherein in the first configuration an opening is defined by said first and second sections allowing the end of a rotor blade to be inserted into or removed from the opening and in the second configuration the end of the rotor blade is held within the rotor body.

In a second aspect, a wind turbine is provided which is portable and may be stored relatively conveniently. In this second aspect, a wind turbine comprising a main body, a rotor and a plurality of blades is provided. The rotor comprises a main body having a first section and a second section, wherein the first and second sections are rotatable with respect to one another between a first configuration and a second configuration, wherein in the first

configuration an opening is defined by said first and second sections allowing the end of a rotor blade to be inserted into or removed from the opening and in the second configuration the end of the rotor blade is held within the rotor body.

Suitably, the first section comprises a wall having a first opening defined therein and the second section comprises a wall having a second opening defined therein, wherein in the first configuration the first and second openings are aligned to define a larger opening and in the second configuration the first and second openings are not aligned. Each blade suitably comprises a blade end for engaging with and connecting to the rotor.

Each blade end has a locking section and a connecting section, with the connecting section provided between the locking section and an aerofoil section of the blade, wherein the locking section is larger in profile than the connecting section along the longitudinal axis of the blade. The blade end may be generally L shaped.

In a third aspect, a method of operating a wind turbine having a plurality of blades using an articulating knuckle boom crane is provided. An articulating knuckle boom crane comprises a boom supported from a base on a supporting structure. The method comprises the steps of:

connecting the wind turbine to the end of the boom;

providing an electrical connection from the wind turbine to the supporting structure;

raising the boom of the crane up relative to the base to a position where the plurality of blades are free to rotate;

allowing the blades to rotate to produce electricity which is provided through the electrical connection. Allowing the blades to rotate may comprise the step of releasing a brake on the wind turbine.

In a fourth aspect, the application provides the use of an articulating knuckle boom crane as a support tower for a wind turbine generating electricity.

Drawings

The present application will now be described in the context of the exemplary accompanying drawings in which:

Figure 1 is representation of a working vessel with a wind turbine mounted on the crane of the working vessel;

Figure 2 is a side view of a connector provided on the end of a crane arm;

Figure 3 is a profile view of the connector provided on the end of the crane arm of Figure 2;

Figure 4 is a perspective view of the connector provided on the end of the crane arm of Figure 2;

Figures 5-5B are views of the connector of Figure 2;

Figure 6 is a section of a main body of a wind turbine with a socket for engaging with the connector of Figure 5;

Figure 7 is a further view of the section of main body Figure 6;

Figure 8 is a base part of a rotor;

Figure 9 is a nose cone for a rotor;

Figure 10 illustrates different views and configurations of the base and nose cone of Figures 8 and 9;

Figure 11 is an exploded view of a turbine, connector and crane arm;

Figure 12 is a perspective view of a turbine, connector and crane arm;

Figure 13 is a view of a blade for use with a turbine having a rotor of the type shown in Figure 10;

Figure 14 is a side view of a rotor engaging section of the blade of Figure 13;

Figure 15 is a perspective view of the end of a crane arm;

Figure 16 is a side view of a Figure 15;

Figure 17 is a plug insert suitable for engaging with the crane arm of Figure 15;

Figure 18 is a bracket suitable for engaging with the crane arm of Figure 15;

Figure 19 is a perspective view of a socket section of an articulating joint suitable for use with the plug insert of Figure 17 or the bracket of Figure 18;

Figure 20 is a top view of Figure 19;

Figure 21 is a perspective view of a co-operating post section for the socket section of Figure 19 with a curved mounting plate on which a turbine body may be mounted;

Figure 22 is a side view of Figure 19;

Figure 23 is a side view of an exemplary turbine blade in a deployed state;

Figure 24 is a side view of the turbine blade of Figure 23 in a retracted state;

Figure 25 is a profile view corresponding to Figure 24;

Figure 26 is an end view corresponding to Figure 24;

Figure 27 is a side view of another exemplary turbine blade in a deployed state;

Figure 28 is a side view of the turbine blade of Figure 27 in a retracted state;

Figure 29 is a profile view corresponding to Figure 27;

Figure 30 is a side view of a further exemplary turbine blade in a deployed state;

Figure 31 is a side view of the turbine blade of Figure 30 in a retracted state;

Figure 32 is a profile view corresponding to Figure 30;

Figure 33 illustrates an exemplary cradle for moving and storing a wind turbine with a tilted base supporting the wind turbine; and

Figure 34 illustrates the cradle of Figure 33 with a flat base.

Detailed Description

The present application solves the problems of the prior art by providing a portable wind turbine which has a connector configured to be mounted on the end of an arm of a vessel's crane. During downtime, the wind turbine may be connected to the crane arm using the connector and the crane arm lifted so as to raise the wind turbine up above the surrounding deck structures. Once raised into position, the crane acts as a support for the wind turbine allowing electrical power to be produced from the wind turbine.

As the wind turbine is lifted into and maintained in the wind stream using the existing lift mechanism of the crane and harnesses the power of the available wind, there is a resulting saving in operating costs, emissions and noise. At the same time, the turbine may be readily brought back down to the deck of the vessel, removed from the crane and stored when a vessel is going to sea thus ensuring the stability of the vessel is not adversely affected.

The arrangement will now be described in greater detail with reference to an exemplary implementation, various aspects of which are shown in the accompanying drawings.

Accordingly, as shown in Figure 1, a wind turbine 6 is shown in a deployed configuration where it has been lifted into place in the air flow (wind) by a crane 4 on a working vessel 2. Having been lifted into place, the arm 8 of the crane acts as the support tower for the wind turbine allowing it to produce electrical power. A connector 10 removably connects the body (nacelle) 12 of the wind turbine to the crane arm 8. An electrical cable (not shown) provides a connection between the generator of the wind turbine and the vessel's electrical systems.

Whilst, any suitable crane may be employed, the advantage of the present approach is that working vessels generally always have a loader crane on board. By using the loader crane already present, there is no need to alter the vessel in any way, which for example, might require re-certification or other cost. Additionally, the cost of any support structure is eliminated.

The most common type of crane employed on working vessels is that of the articulating knuckle boom crane, because of its versatility and compact size. These types of crane are commonly referred to as HIAB cranes (referring to the abbreviation of the Swedish company Hydrauliska Industri AB) synonymous with their development. Other manufacturers making cranes of this type include Palfinger, Effer and MKG. In the context of the present

application, the crane acts normally as a crane and when not in use as a crane may be employed as a support tower for the wind turbine.

The idea of using an existing lifting mechanism (crane) on the vessel to hold the turbine in means that a wind turbine may conveniently be raised sufficiently high to produce electricity when required. At the same time, it may be taken down and stored when not in use ensuring that the vessels stability or general working is not affected.

A detailed implementation of an exemplary arrangement will now be described commencing with a description of a connector for releasably attaching the wind turbine to the end of the boom of a crane, as shown in Figures 2 to 5B.

The connector 10 comprises two sections 22, 24. A first section 24 engages with the end of the crane arm 8. The first section is shaped to generally co-operate in shape with the end profile of the crane arm 8. The first section comprises a plurality of walls 25a-d. The walls combine to define an opening at one end for receiving the end of the crane arm 8. The opening provides a space between the walls for retaining the end of the crane arm. The space may be closed at the opposite end to the opening by a base plate which is connected to the walls. It will be appreciated that the arms of conventional articulating boom cranes have a generally rectangular profile although the corners may be rounded or cut-off. In the cut-off form, the profile whilst having two long parallel sides and two shorter sides at right angles thereto providing a generally rectangular profile, the cut-off corners provide additional sides and so the shape also may be viewed as being of an octagonal shape. Alternatively, it may be hexagonal.

Accordingly, the opening defined by the walls of the first section provide a corresponding generally rectangular profile. The dimensions of the opening in the first section are selected with respect to the dimensions of the crane arm. More particularly, the dimensions are selected to be greater than those of the crane arm to allow the opening of the first section to be placed around the end of the crane arm and then slid along it. To ensure the first section remains attached to the crane arm, one or more fixing features may be provided which engage with the crane arm and lock the first section in place. For the purposes of most loader cranes employed on working vessels, the dimensions may be taken to be generally in the range of 75 mm to 500mm for the width of the opening (between walls 25a and 25b) and generally in the range of 100mm to 600mm length of the opening (between walls 25c and 25d).

Most loader cranes are provided with a loading hook 20 at the end of the crane arm. It will be appreciated that the hook is generally provided on a swivel at the bottom side of the crane arm. To facilitate the placement of the connector onto the end of the crane arm, without the necessity of removing the loading hook, a slit may be defined in the corresponding bottom wall 25d of the first section. The slit is dimensioned to allow the first section to be slid along the crane arm past the crane hook.

Fixing features may be provided to ensure a firm connection between the first section and the end of the crane arm. As the connector is intended to be mounted on and removed from the crane arm regularly, the fixing features are selected to provide for speed of assembly and disassembly.

The fixing features 30 are configured to ensure a rigid connection between the crane arm and the first section. At the same time, they are adjustable to allow the first section to be slid onto the end of the crane. In the exemplary arrangement shown, each fixing feature is movable from a first position where the fixing feature is aiding in the retention of the crane arm within the first section and a second position where crane arm is free to move with respect to the first section.

The fixing features may be any suitable features which co-operate to fix or lock the first section in place on the end of the crane arm. In the exemplary arrangement, each fixing feature comprises an end surface for engaging with a corresponding surface of the crane arm. The end surface is suitably configured to grip the crane arm surface. Accordingly, the end surface may comprise a material which presents a high degree of friction with the typically metal surface of the crane arm. Thus the material may be a resilient material such as rubber. The resilient material may be supported by a rigid base, which may for example be metal. Alternative methods for gripping may include for example using suction.

The end surface is attached to a longitudinal support member which extends to and connects the end surface to a wall of the first section. The longitudinal support member may be moved to allow the end surface to engage with or retract from the crane arm. In one arrangement, the longitudinal members are threaded and engage with a corresponding threaded hole in a wall of the first section. In this arrangement, the longitudinal support members may be retracted or extended by turning the longitudinal support member relative to the support wall. To facilitate this, a handle or tool engaging feature 32 may be provided on the opposite end of the longitudinal members to the engaging end surface. Suitably, for

example the tool engaging feature may be in the shape of a nut allowing a spanners or similar device to be employed to fix the first section in place on the crane arm.

A second section 22 of the connector extends from the base plate of the first section in a direction in line with and away from the opening of the first section. The second section provides a feature which engages with and acts as a support for the main body of the wind turbine. A corresponding feature is provided on the main body of the wind turbine which co-operates with and is mounted with the second section. The second section of the connector is shaped to engage with a corresponding feature on the body of the wind turbine. Thus for example, the second section could comprise a plate or similar structure having openings defined therein allowing bolts or other fastening features to engage with corresponding nuts on the body of the wind turbine.

In the exemplary arrangement shown the second section is selected to allow for ease of assembly. The exemplary second section comprises a post which is intended to slideably engage with a co-operating socket 50 on the wind turbine body 12 as shown in Figures 6 and 7. The post and socket act as an articulating joint between the body of the wind turbine and the crane arm. It will be appreciated that the use of cylindrical post is employed frequently on wind turbines of the power generation capacity that would be required for a working vessel. In the exemplary arrangement shown, the generally cylindrical post extends from the first section in a direction generally in line with the longitudinal axis of the crane arm when fixed to the first section.

In one embodiment, the connector is integrally formed with the wind turbine body. In this configuration, the second section engages with the socket allowing the turbine body to rotate about the second section. In this configuration, a flange or plate may be provided on the top of the second section so as to retain the second section within the socket 50.

A yaw limiter may be provided to prevent the electrical cable or cables for the turbine inadvertently wrapping around the crane arm or to prevent the turbine blades hitting the crane arm whilst rotating. The yaw limiter acts to limit the yaw of the turbine body relative to the crane arm or mount 10.

In one implementation, the yaw limiter comprises a spline 28 provided on the cylindrical wall of the post. A corresponding feature, for example a spline 52, on the socket 50 co-operate with the spline 28 allows rotation of the wind turbine body with respect to the post within a certain range. The law limiter suitably limits the rotation of the turbine with respect to crane arm to 270°.

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During deployment, the crane arm may be lowered to the deck of the vessel or other working surface (e.g. a jetty or pier). The first section of the connector may then be slid over the end of the crane arm until the crane arm makes contact with the base plate. Alternatively, the connector may be placed in a suitable position and the crane arm articulated to extend into the opening of the first section. Once the connector has been placed in situ, the connector may be fixed to the crane arm. To fix the connector to the crane arm, the fixing features previously described are moved from their respective first positions where they are retracted from a surface of the crane arm to a second position where they engage with and grip the surface of the crane arm. In the exemplary arrangement, a fixing feature is provided in the top wall which is opposite the bottom wall having the slit. Each of the two side walls have two fixing features each, which are arranged in opposition.

It will be appreciated, as shown in Figures 11 and 12, that the components of the wind turbine will generally be as found in a conventional wind turbine. Accordingly, the turbine may comprise a series of rotor blades 70 (aerofoils) connected to a rotor body 72 having a rotor nose 74. An associated drive shaft is driven by the rotor body.

In some arrangements, a gear box is provided for converting the relatively low speed of the drive shaft rotation to a higher speed.

A generator may then be driven by the gear box for generating electricity. Equally, as described previously the turbine may comprise a brake for locking the drive shaft (and thus the blades) either directly or through the gear box. It will be appreciated that in the present application, where the wind turbine may be taken down and put up on a daily basis, it is important that weight is minimised. Accordingly, the preferred implementation does away with a gear box and instead the generator 78 is driven directly from the rotor drive shaft, in a configuration referred to as direct drive. In this direct drive configuration, a permanent magnet alternator may be used as the generator. An exemplary generator suitable for this purpose is the frameless STK range from Alxion, of Colombes France. A suitable model is the 400STK 2M which has a 5KW capacity. Different models may be employed based on the capabilities of the crane/vessel or power requirements, for example a 15KW capability would be provided by the 500STK 6M. This is driven directly by the drive shaft of the rotor. This arrangement is described in greater detail below. An end plate 80 suitably provides bearings to allow the mounting of the drive shaft within the generator 78.

A tailfin section 82 is provided extending from the main body of the wind turbine in a direction away from the rotor at the end of which is provided the tailfin 84. The tailfin acts as

a wind vane forcing the turbine to face into the wind. Alternatively, the direction may actively be controlled by means of a yaw drive incorporating a stepper motor or similar device and a wind vane to detect wind direction with a controller causing the stepper motor to respond to the detected direction of the wind vane. In this arrangement, the yaw drive may limit the yaw to prevent the turbine blades hitting the crane. The yaw controller may be integrated/communicate with the crane controls so that the yaw may be manipulated as the crane arm is moved. Alternatively, the connector may be fixed and the crane itself may be employed as the yaw device, i.e. the crane is rotated with the wind rather than the turbine.

Suitably the wind turbine has a controller for controlling the various elements of the turbine and ensuring that the turbine produces power and acts within limits. In particular, it is advantageous that the brake of the wind turbine be remotely controlled. In this way, the brake may be applied whilst the turbine and blades are being assembled and fixed to the connector and the crane arm. Once the wind turbine has been connected to the crane arm and the crane arm lifted into free air, the brake may be released and the blades of the wind turbine allowed to turn.

In a preferred arrangement, the brake's default state is on, i.e. the brake is set to prevent rotation. The brake is required to be released before the turbine blades can rotate. In this arrangement, the brake may be released when the turbine has been raised into position by the crane. Additional safety features may be provided which might not normally be found in a wind turbine. For example, one or more inclinometers may be provided to measure the angle of the wind turbine with respect to the earth's surface. The control system may activate the break if for some reason the wind turbine is no longer generally level, for example if the crane arm is advertently moved. Similarly an accelerometer may be provided within the wind turbine for detecting excessive motion, for example, due to waves causing the vessel to rock. Again the control system may be responsive to accelerometer and cause the brake to be applied. Similarly, if the turbine is detected to be rotating too fast, e.g. in high winds, the control system may cause the brake to be applied.

The control system may also be configured to sound an alarm in the pilot house of the vessel whenever a fault or other condition arises as described above in the context of over speed, and the inclinometers and accelerometers.

An advantage of using wind turbines in a marine environment is that there is already generally an energy storage system in place in the form of a battery bank meaning that there is no general need for additional storage capacity. As a result, the power from the wind turbine may simply be used to charge the battery bank through a suitable charging circuit.

Whilst AC mains voltages are commonly available on board, they are typically provided using an electronic inverter which in turn powered by the batteries. It will be appreciated that this approach means that it fits neatly with the conventional approach of using a diesel generator to charge the batteries. Indeed, in the event of the batteries running low and there being insufficient wind for the wind turbine, the conventional diesel generator may be employed to produce power. In the case of a AC generator, the charging circuitry may be a switched mode type power supply for converting the generated AC voltage to a DC charging voltage. Monitoring circuitry may be provided to ensure that the wind turbine is providing sufficient power to the batteries or to prevent over charging. In the case of over-charging, the monitoring circuit may cause excess power to be dumped in a resistor dump. The resistor dump may for example comprise a heating element in a water storage unit of the vessel.

An electrical cable is suitably provided from the wind turbine to the vessel deck. The electrical cable may have a connector at the end for mating with a corresponding connector on the vessel deck. The electrical cable provides power from the wind turbine and allows for control signals (e.g. for activating/deactivating the brake). The connectors are suitably of the type used in marine environments.

Clips may be mounted on the crane arm to allow the electrical cable to be clipped on to the crane arm to prevent movement in the wind.

It will be appreciated that whilst the use of a crane to act as a support for a wind turbine to generate power overcomes a significant amount of the problems of the prior art, storage space on board a working vessel can be limited. At the same time, the nature of the marine environment is such that even where space is available that parts of the wind turbine may be prone to damage from movement when stored.

The present application also addresses this problem by providing a wind turbine which may be dis-assembled in a convenient manner for storage when going to sea. This also has the added advantage of improving the handling ability since the weight of any one piece of the dis-assembled turbine is considerably less than that of the overall weight.

Thus in a first aspect of this wind turbine allows for the individual blades to be detachable allowing them to be easily removed from or attached to the wind turbine. Whilst, it is known generally to provide for detachable blades, the methods employed are cumbersome and intended for applications where the blades are to be replaced for example after a number of years of use. These methods include the use of a flanged root bolted to

the rotor nose by means of multiple bolts that required specific levels of torque. Whilst, this is acceptable in a situation where the turbine blades are infrequently attached or removed, it will be appreciated that in the context of a working vessel, the blades may need to be attached or removed on a daily basis.

Accordingly, the present application provides an exemplary arrangement which facilitates rapid assembly and disassembly as will now be explained. It will be appreciated that other methods of attachment and assembly may also be employed. Each blade 70, as shown in Figure 13, comprises an aerofoil shaped section 94 which is shaped to react to the wind. At one end of each blade is the aerofoil tip 92 and at the other is the rotor engaging section 80 which is fixable to the rotor body 72. More specifically, the rotor engaging section 80 is shaped to be positionable within a corresponding opening 100 formed within the rotor body. The rotor body is arranged such that the corresponding openings provided are adjustable between a first configuration and a second configuration. In the first configuration, the openings are dimensioned to allow the insertion of the rotor section. Once the rotor section is positioned in the rotor body, the rotor body is manipulated to the second configuration in which the rotor section is prevented from being removed. More particularly, the size of the opening in the second configuration is smaller than that of the first configuration. As shown, in figures 8 to 10, each of the three openings 100 for each of the three blades is provided in part by a opening 100a in the base of the rotor body with a second part 100b of the opening provided by corresponding openings 100b provided in the rotor nose. By rotating, the nose 74 with respect to the rotor base 72, the openings may be caused to be aligned (i.e. first (open) configuration/position) or not aligned (i.e. second (closed) configuration/position)

In the exemplary arrangement shown, the rotor section 80 comprises a longitudinal member 110 generally having a section 112 extending transverse thereto at the end, thus defining a generally L shaped rotor section. In turn, the rotor body comprises a head 74 (or nose cone) shown in Figure 9 and a base 72 shown in figure 8 which as described above are rotatable with respect to one and other as illustrated in Figure 10. Each of the head and base has a respective opening 100a, 100b defined in their outer walls for receiving the end of each rotor section. In the first configuration, the openings of the head and base are aligned allowing for the L shaped end of the rotor section to pass there through. In the second configuration, the openings of the head and base are not aligned and the rotor end is held within the rotor body. A locking feature, such as a pin or bolt, may be provided for locking the rotor head in the second configuration with respect to the rotor base. In one arrangement, the rotor head is rotatable with respect to the rotor base. In one specific

implementation, the head is rotatable by an angle of 60° between the first and second configurations. It will be appreciated that different angles may be employed for the openings associated with each blade. Thus at a first angle (head relative to body), a first opening in the head may align with a first opening in the base permitting the insertion of the end of a first blade. At a second angle, a second opening in the head may align with a second opening in the base permitting the insertion of the end of a second blade. Similarly, at a third angle a third opening in the head may align with a third opening in the base permitting the insertion of the end of a third blade. Using this approach, it allows for the insertion and retention of successive blades. It will be appreciated that there will be a final angle, where none of the respective openings align and the blade ends are retained in the rotor body.

The blades are suitably selected to be light and stiff. Thus for example, the aerofoils of each blades may be manufactured from a composite material such as glass or carbon fibre reinforced plastic. The rotor engaging section of each blade may also be made from these materials or may be formed using an alternative material such as aluminium, which extends into the composite material.

Further methods of engagement with the crane arm will now be described with reference to Figures 15 to 22 in which 15 illustrates an exemplary end of the telescopic boom of a crane arm 120, the telescoping action of which is driven by a piston 122. The piston is joined to the boom by an end section 124. The crane arm has a longitudinal axis along which the telescoping is performed.

The boom of the crane arm is defined by a plurality of side walls which extend along and about the longitudinal axis. The side walls define a hollow interior space extending along the longitudinal axis to an opening 130 at the end of the boom. The end section which may surround the walls of the boom may enclose the opening or as shown in Figure 15 leave the opening exposed. Aligned apertures 132, 134 may be defined in opposing walls of the boom and end section.

The piston may extend slightly further than the boom in a direction parallel to the boom. In which case, the end section may comprise a first section 126 which is generally rectangular in shape which surrounds the end of the boom. The first section has a distal end which is positioned along the boom away from the opening and a proximal end which is at or close to the opening 130. The distal end defines a plane generally transverse to the longitudinal axis of the boom. The second section also comprises a proximal end which is joined to the proximal end of the first section and a distal end which is joined with the distal end of the first section. As with the first section, the proximal end defines a plane. The

proximal end of the second section may however be angled with respect to the first plane i.e. the first and second planes may not be co-planar.

It will be appreciated that different shapes of boom and end section are possible. However the further exemplary methods of engagement between the crane and the first section will be explained with reference to Figures 15 and 16.

Referring to Figure 17, an insert connector is provided in place of the feature 24 of the first section. The insert connector provides a plug portion 140 shaped to be insertable into an opening at the end of the crane arm.

The plug portion has a first end 142 which is shaped to be insertable into the crane arm opening to form a close fit. A second end 144 opposing the first end is fixed to a mounting section 146. The profile of the plug though a section of the axis between the first and second end may have a generally rectangular, octagonal or hexagonal shape to match the shape of the opening in the boom. The mounting section suitably provides mounting features to allow connection to a further section of the connector. This further section is suitably a part of the articulating joint allowing the turbine to rotate with respect to the crane arm. The mounting feature may, as shown, be a plurality of apertures, facilitating the use of individual fixing devices, for example nuts and bolts.

The length of the plug portion along the axis between the first and second ends may be in a range of between 5 cm and 75 cm. The length of the generally rectangular shape may be in the range of 10cm to 80cm and the width of the generally rectangular shape may be in the range of 5 cm to 70 cm.

The connector may further comprise one or more pads 150 for pressing against the interior surface of the crane arm. Suitably the pads are received within openings defined in the walls of the plug portion.The pads may be biased by a biasing feature, in a direction away from the surface of the plug portion. The biasing feature may be a spring. Optionally, the outer surface of the pad may comprise a resilient material. The resilient material may be a elastomeric material. The purpose of the pads is to improve upon the close fit between the plug and crane arm so as to reduce vibration and noise.

The connector of this arrangement may also be provided with a resilient sleeve or coating about at least one section between the first and second ends. Again the purpose of such a resilient is to act as a vibration damping material to reduce noise and vibration between the boom and the connector.

At least one pair of apertures 152 in opposing walls of the plug may be provided. which are aligned with respect to one another. The pair of apertures are positioned in a manner that allows the apertures to align with corresponding apertures 132 in the crane arm. This configuration allows the insertion of a retaining feature from one side of the crane arm to another through the pair of apertures. The retaining feature is used to retain the plug portion in the crane arm. The retaining feature may for example be a nut and bolt arrangement or a pin and clip arrangement.

The mounting section although shown as a planar section may be shaped to match the surfaces of the ends section of the crane.

An alternative to the plug is shown in Figure 18. In this arrangement, the connector comprises a C shaped bracket which is slid over the end of the end section of the crane boom. It is then fixed in place by means of a fixing arrangement, such as a nut and bolt through apertures 152 similar to those in the plug. which is is provided, which comprises a first section for engaging with the end of a crane arm and a second section which is connected to the first section and is configured to connect and to provide support for a wind turbine, so that the crane arm may act as a support tower for the wind turbine when in use.

The C-shaped bracket element comprises a mounting section and two arms extending therefrom in a substantially perpendicular manner. The mounting section 156 may correspond generally to the mounting section 146 of the plug insert.

The height of each arm 160, 162 extending from the mounting section may be in a range of between 8cm and 60cm. The length of each arm in a direction transverse to the height is in the range 10 cm to 90 cm. The distance between the arms is in the range 7 to 80cm.

A resilient material may be provided on the opposing surfaces of the arms to reduce vibration when the connector is attached to a crane arm. The resilient material may be an elastomeric material.

As discussed above, the connector of the present application provides a first section which connects to the end of a crane arm, a second section which connects to a wind turbine. An articulating joint is provided between the first and second sections to facilitate relative rotation between the crane arm and the turbine.

An arrangement for such an articulating joint which corresponds generally to that of Figures 5 to 7 will now be described with reference to figures 19 to 22. is As before, the articulating joint provides a single axis of rotation between the first section, i.e. the mounting plate 146, 156, and the post 182 of the second section 180 to permit rotation of the first section with respect to the second section. In the arrangement shown, a socket 170 is shown having a base plate 172 which is shaped to be fixed to the mounting plate of Fig 17 or

Fig 18 as required. The base plate suitably has corresponding fixing features provided. The fixing features may, for example, be the four bolt holes 174 corresponding to bolt holes 148. on the arrangements in Figure 17 and 18.

The axis of rotation may be at an angle α of between 60 and 90 degrees to the planar section of the mounting plate. A preferred angle is about 75 degrees. The rotation of the articulating joint may be limited to a certain range. The range of limited rotation may allow for a relative rotation of the first section with respect to the second section of the order between 240 and 300 degrees. The relative rotation may be further limited to about 270 degrees. The limited rotation may be provided by the co-operating action of a flange or similar feature on the post of the top section with one or more stops 176 provided on the corresponding socket.

To account for use with different cranes and different ship's structures, the stops 176 may be adjustable or repositionable to adjust the range of rotation or the relative positioning of the range of rotation with respect to the crane arm or ships structures.

The articulation joint may comprise inter-engaging male and female sections, which allow for the male section to be slidably received within the female section.

The second section may comprise a turbine mounting plate 188, wherein the turbine mounting plate is curved to accommodate a curved outer surface of a turbine. Apertures 186 may be defined in the turbine mounting plate to allow the insertion of fixtures to co-operating features on the turbine.

One of the largest parts on a wind turbine is that of a turbine blade. On a working vessel or similar situation where the aforementioned turbines may be deployed, space may be at an optimum both for delivery and storage on board. In the exemplary arrangements presented herein, the length of the individual turbine blades may be of the order of 1-10 meters in length. Whilst a blade length of 1-2m may accommodate being stored in a variety of places, lengths any longer than this present difficulties. Such difficulties include possible lack of available deck space or in navigating a blade through a hatch for storage below decks.

Accordingly, the present application provides a turbine blade which may be assembled from a storage state to a deployed state, where the length of the turbine blade in the storage state is less than that in the deployed state. In one arrangement, the turbine blade is formed from a number of separate segments having an inter-connection arrangement, e.g. pin and socket type connection allowing adjacent segments to join together. Once joined together, a suitable fixing, for example a locking pin, may be used to hold the segments together. Whilst the number of segments may be selected depending on

the application, (e.g. overall length of turbine blade), a practical value of segments is likely to be between 2 and 4 and suitably 3.

Whilst, the use of separate segments which may be assembled together is useful, it presents a difficulty in situations such as a working vessel in that the number of overall parts required to be retrieved from storage and assembled for use is increased and the possibility of losing parts such as locking pins arises. It will also be appreciated that whilst assembly may be relatively straightforward on a stable platform, a working vessel will follow the motion of the sea and wind and so be far less stable than land. Accordingly, the present application provides for the use of a turbine blade which may be assembled from a storage state to a deployed state using a plurality of blade segments that are interconnected and movable relative to one another. In the deployed state, the segments co-operate to provide the shape of the turbine blade. In the stored state, the segment providing the tip of the turbine blade along with one or more intermediate segments is positioned within or beside the segment providing the connection to the turbine body. The length of the individual segments is suitably in the range of 1m to 3m and preferably about 2m in length.

A first exemplary arrangement for such a turbine blade 200, as shown in Figures 23, 24 and 25 and 26, comprises a plurality of turbine segments 204, 206, 208. At one end of the turbine, a base segment 204 of the turbine blade 200 provides a rotor engaging section 202 for engaging with the rotor body as previously described. A tip segment 208 is provided at the opposite end and defines the aerofoil tip. One or more intermediate segments may be provided between the base segment and the tip segment. In the exemplary arrangement shown, there is a single intermediate tip 206. One or more of the tip and intermediate segment(s) may be retractable relative to the base segment allowing the segment to move (retract) toward the rotor engaging section. To facilitate this, one or more slide rails 210, 212 are provided between adjacent segments allowing for the sliding of one segment with respect to and along another. Suitably, the slide rail is rebated into the back of one of the segments. A co-operating hinge mechanism is provided with the slide rail to allow one blade section to be rotated away from the face of adjoining segment. This allows for clearance to allow the blade segment to slide back along the rail into the retracted position as shown in Figures 24-26. Cover flaps may be provided to hide hinge and slide rail mechanisms to reduce interference with air flow when the blade is rotating in the deployed state. Suitably, the hinges may be configured to be locked in position in either the deployed or retracted state so as to provide a stable turbine blade in use and to minimise movement in storage.

An alternative exemplary arrangement provides a hinged turbine blade 300, as shown in Figures 27, 28 and 29, comprises a plurality of turbine segments 304, 306, 308. At one end of the turbine, a base segment 304 of the turbine blade 300 provides a rotor engaging section 302 for engaging with the rotor body as previously described. A tip

segment 308 is provided at the opposite end and defines the aerofoil tip. One or more intermediate segments may be provided between the base segment and the tip segment. In the exemplary arrangement shown, there is a single intermediate tip 306. One or more of the tip and intermediate segment(s) are hinged relative to an adjoining segment allowing the segment to be folded back (effectively retracted) toward the rotor engaging section. To facilitate this, one or more hinges 310, 312 are provided between adjacent segments allowing for the folding of one segment back on another. The hinges are configured to provide a hard stop in the deployed position so as to prevent bending of the blade as a result of thrust force on the rotor face. The hinges may be sprung so that there is a bias towards the folded or deployed state so as to minimise movement.

In a further alternative exemplary arrangement for a turbine blade 400, as shown in Figures 30, 31 and 32, a plurality of turbine segments 404, 406, 408. As before, there is a base segment 404 of the turbine blade 400 providing a rotor engaging section 402 for engaging with the rotor body as previously described. A tip segment 408 is provided at the opposite end and defines the aerofoil tip. One or more intermediate segments 406 may be provided between the base segment and the tip segment. In the arrangement shown, the base segment is shaped to allow the intermediate segment to be withdrawn into a space provided internally in the base segment, i.e. base segment 404 is hollow. Similarly, the intermediate segment may be shaped to receive the tip segment, thus effectively allowing both the tip and intermediate segments to be retracted into the base segment. It will be appreciated that, as shown in Figure 41, parts of the intermediate and tip may protrude from the base segment when in the retracted state. One or more rams 412 or similar mechanical mechanisms may be provided internally within the blade for moving the segments between a retracted (storage) state and a deployed state (or vice versa).

The rams may be operated in a variety of different methods including manually, electrically or by the centrifugal force exerted on the telescopic rams by the rotation of the turbine. Hard stops may be built in to limit their extension to the deployed blade length.

The rams and mechanical systems required for their operation are contained within the blade profile. In this arrangement, it will be appreciated that the blade profile is intentionally simple as it is required to allow for the outer sections to be housed within the inner sections.

To allow for ease of storage and deployment, a cradle may be provided for the turbine. The cradle provides a stable base for the wind turbine body. Such a stable base makes it easier for a crane to be connected to the connector of the wind turbine as the crane may be positioned into place with the wind turbine held steady by the cradle.

The exemplary cradle 500 shown, in figures 33 and 34 comprises a frame 504 which is configured to hold a wind turbine body 506 on a support structure or surface 510. The

support surface or structure may be tiltable relative to the frames as to alter the angle that the wind turbine is held within the cradle. Thus, for example in figure 33, the support is raised to an angle of 25° with respect to the base of the frame, whereas in figure 33, the angle is much less. This variable allows for the turbine to be presented in the most convenient way to facilitate connection to the crane when being deployed.

Suitably, the support structure or surface is hinged to the frame with bolts or other fixing mechanism provided to lock the angle of the support surface or structure with respect to the frame.

The cradle may be provided with wheels to allow for it to be wheeled about. In the exemplary arrangement shown, wheels are provided at corners at one of the cradle with legs 512 and handles 508 provided at the opposite ends allowing the cradle to be wheeled about in a manner similar to a wheel barrow. Lifting points 502 may be provided on the cradle, for example on the top adjacent to the corners allowing the cradle to be hoisted by a crane.

It will be appreciated that other variations are possible beyond those previously described above, for example whilst a brake was previously described in the context of preventing movement of the turbine blades when being lifted by the crane arm into position for use, equally it may be desirable to provide for a user operating the crane to have a control input for causing the rotor of the wind turbine to rotate as required to make it easier for the turbine to be lowered to deck. Similarly, the crane operator may have a facility to allow the rotor to be yawed electrically using a dial or similar input on a control panel to allow the turbine to yaw into a position that makes it easier for the turbine to be lowered to deck.

Whilst the present application is explained with respect to and illustrated in the context of a horizontal aligned wind turbine, it will be appreciated that it may also be employed with a vertical aligned wind turbine.

Similarly, whilst the application has been described in the context of working vessels, it will be appreciated that the technique is not so restricted and may be employed generally with any articulating knuckle boom crane or extending boom crane.

In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word ‘comprising’ does not exclude the presence of other elements or steps than those listed in a claim. Furthermore, Furthermore, the terms “a” or “an,” as used herein, are defined as one or more than one. Also, the use of introductory phrases such as “at least one” and “one or more” in the claims should not be construed to imply that the introduction of another claim element by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim element to inventions containing only one such element, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an." The same holds true for

the use of definite articles. Unless stated otherwise, terms such as “first” and “second” are used to arbitrarily distinguish between the elements such terms describe. Thus, these terms are not necessarily intended to indicate temporal or other prioritization of such elements. The mere fact that certain measures are recited in mutually different claims does not indicate that a combination of these measures cannot be used to advantage.

Claims:

1. A vessel with a wind turbine system, the wind turbine system comprising:
a) an articulating knuckle boom crane of the vessel, the crane having a crane arm;
b) a wind turbine; and
c) a connector comprising:
a first section for engaging with the end of the crane arm and a second section connected to the first section and being configured for connecting to and providing a support for the wind turbine so that the crane arm may act as a support tower for the wind turbine when in use .

2. A connector according to claim 1, wherein the first section for engaging with the end of the crane arm comprises a plug portion shaped to be insertable into an opening at the end of the crane arm.

3. A connector according to claim 2, wherein the pair of apertures are positioned to align with corresponding apertures in the crane arm so as to allow the insertion of a retaining feature from one side of the crane arm to another through the pair of apertures to retain the plug portion in the crane arm.

4. A connector for releasably attaching a wind turbine to the arm of a crane, the connector comprising:
a first section for engaging with the end of the crane arm;
a second section connected to the first section and being configured for connecting to and providing a support for the wind turbine so that the crane arm may act as a support tower for the wind turbine when in use .

5. A connector according to claim 4, wherein the first section comprises a plurality of walls defining an opening, where the opening is dimensioned to permit the first section to be slid over the end of the crane arm.

6. A connector according to claim 5, wherein one of the walls has a slot defined therein for accommodating a loading hook of the crane.

7. A connector according to claim 4 or claim 5, wherein the opening is generally rectangular in shape.

8. A connector according to claim 7, wherein the width of the rectangular opening is in the range of 75 mm to 500mm.

9. A connector according to claim 7 or claim 8, wherein the length of the rectangular opening is in the range of range of 100mm to 600mm.

10. A connector according to any one of claims 4 to 9, further comprising at least one locking feature, the locking feature being movable from a first position where the locking feature is aiding in the retention of the crane arm within the first section and a second position where crane arm is free to move with respect to the first section.

11. A connector according to claim 10, wherein a plurality of locking features are provided.

12. A connector according to claim 11, wherein a first set of the locking features are arranged in opposing walls of the end section so that the crane arm is restrained between the opposing locking features when the locking features are in their respective first positions.

13. A connector according to claim 4, wherein the first section for engaging with the end of the crane arm comprises a plug portion shaped to be insertable into an opening at the end of the crane arm.

14. A connector according to claim 13, wherein the plug portion has a first end for insertion into the crane arm opening and an opposing second end fixed to a mounting section.

15. A connector according to claim 14, wherein the profile through a section of the axis between the first end and second end is generally rectangular in shape.

16. A connector according to claim 15, wherein the corners of the generally rectangular shape are rounded.

17. A connector according to claim 16, wherein the profile through a section of the axis between the first end and second end is generally octagonal in shape.

18. A connector according to claim 15 or 16, wherein the length of the plug portion along the axis between the first and second ends is a range between 5 cm and 75 cm.

19. A connector according to any one of claims 15 to 18, wherein the length of the generally rectangular shape is in the range 10 cm to 60 cm.

20. A connector according to any one of claims 15 to 19, wherein the width of the generally rectangular shape is in the range 5 cm to 50 cm.

21. A connector according to any one of claims 15 to 20, further comprising one or more pads for pressing against the interior surface of the crane arm.

22. A connector according to claim 21, wherein one or more of the pads are biased by a biasing feature in a direction away from the surface of the plug portion.

23. A connector according to claim 22, wherein the biasing feature is a spring.

24. A connector according to any one of claims 21 to 23, wherein the outer surface of the pad comprises a resilient material.

25. A connector according to claim 24, wherein the resilient material is an elastomeric material.

26. A connector according to any one of claims 14 to 25, further comprising a resilient sleeve provided about at least one section between the first and second ends.

27. A connector according to any one of claims 14 to 27, further comprising a pair of apertures provided in opposing walls and aligned with respect to one another.

28. A connector according to claim 27, wherein the pair of apertures are positioned to align with corresponding apertures in the crane arm so as to allow the insertion of a retaining feature from one side of the crane arm to another through the pair of apertures to retain the plug portion in the crane arm.

29. A connector according to claim 4, wherein the first section for engaging with the end of the crane arm comprises a substantially C-shaped bracket element having a mounting section and two arms extending therefrom in a substantially perpendicular manner.

30. A connector according to claim 29, wherein the height of each arm extending from the mounting section is in a range between 8cm and 40cm.

31. A connector according to any one of claims 29 to 30, wherein the length of each arm in a direction transverse to the height is in the range 5 cm to 75 cm.

32. A connector according to any one of claims 29 to 31, wherein the distance between the arms is in the range 5 cm to 50 cm.

33. A connector according to any one of claims 29 to 32, wherein a resilient material is provided on the opposing surfaces of the arms to reduce vibration when attached to a crane arm.

34. A connector according to claim 33, wherein the resilient material is a elastomeric material.

35. A connector according to any one of claims 29 to 34, further comprising a pair of apertures defined in the arms and aligned with respect to one another.

36. A connector according to claim 35, wherein the pair of apertures are positioned to align with corresponding apertures in the crane arm so as to allow the insertion of a retaining feature from one side of the crane arm to another through the pair of apertures to retain the plug portion in the crane arm.

37. A connector according to any one of claims 14 to 36, wherein the mounting section comprises a mounting plate.

38. A connector according to claim 37, wherein the mounting plate is substantially octagonal in shape.

39. A connector according any one of claims 14 to 36, wherein an articulating joint having a single axis of rotation is provided between the mounting plate and the second section to permit rotation of the first section with respect to the second section.

40. A connector according to claim 39, wherein the mounting plate comprises a substantially planar section and where the axis of rotation is at an angle of between 60 and 90 degrees to the planar section.

41. A connector according to claim 40 wherein the axis of rotation is at an angle of about 75 degrees to the planar section.

42. A connector according to any one of claims 39 to 41, wherein the rotation of the articulating joint is limited.

43. A connector according to claim 42, wherein the limited rotation allows for a relative rotation of the first section with respect to the second section of the order between 240 and 300 degrees.

44. A connector according to claim 43, wherein the relative rotation is limited to about 270 degrees.

45. A connector according to any one of claims 39 to 44, wherein the articulation joint comprises inter-engaging male and female sections allowing for the male section to be slidably received within the female section.

46. A connector according to any one of claims 25 to 45, wherein the second section comprises a turbine mounting plate.

47. A connector according to claim 46, wherein the turbine mounting plate is curved to accommodate a curved outer surface of a turbine.

48. A connector according to claim 47, further comprising apertures defined in the turbine mounting plate to allow the insertion of fixtures to co-operating features on the turbine.

49. A connector according to any one of claims 4 to 28, wherein the second section comprises a post for engaging with a corresponding socket on a main body of the wind turbine.

50. A connector according to claim 13, wherein the post is a generally cylindrical post.

51. A connector according to claim 50, further comprising at least one spline arranged on the cylindrical post for engaging with a corresponding feature on the socket of the wind turbine to limit yaw.

52. A wind turbine comprising the connector of one of claims 4 to 51 and further comprising a rotor having a plurality of blades, a main body, a generator housed within the main body and driven by the rotor.

53. A wind turbine according to claim 52, wherein the wind turbine is a horizontally aligned wind turbine.

54. A wind turbine according to claim 53, further comprising a fin attached to the main body for maintaining the rotor direction into the wind.

55. A wind turbine according to any one of claims 53 to 54, wherein the main housing is free to rotate with respect to the second section of the connector.

56. A wind turbine according to any one of claims 52 to 55, wherein the generator is driven directly by the rotor.

57. A wind turbine according to any one of claim 52 to 56, wherein the generator is a permanent magnet alternator.

58. A wind turbine according to any one of claims 52 to 57, wherein each of the plurality of blades are removably attached to the rotor.

59. A wind turbine according to claim 58, wherein the rotor comprises a rotor body having a first section and a second section, wherein the first and second sections are rotatable with respect to one another between a first configuration and a second configuration, wherein in the first configuration an opening is defined by said first and second sections allowing the end of a rotor blade to be inserted into or removed from the opening and in the second configuration the end of the rotor blade is held within the rotor body.

60. A wind turbine comprising a main body, a rotor and a plurality of blades, wherein the rotor comprises a main body having a first section and a second section, wherein the first and second sections are rotatable with respect to one another between a first configuration and a second configuration, wherein in the first configuration an opening is defined by said first and second sections allowing the end of a rotor blade to be inserted into or removed from the opening and in the second configuration the end of the rotor blade is held within the rotor body.

61. A wind turbine according to claim 60, wherein the first section comprises a wall having a first opening defined therein and the second section comprises a wall having a second opening defined therein, wherein in the first configuration the first and second openings are aligned to define a larger opening and in the second configuration the first and second openings are not aligned.

62. A wind turbine according to any one of claims 60 to 61, wherein at least one of plurality of blades comprises a blade end for engaging with and connecting to the rotor.

63. A wind turbine according to claim 62, wherein the blade end has a locking section and a connecting section, with the connecting section provided between the locking section and an aerofoil section of the blade, wherein the locking section is larger in profile than the connecting section along the longitudinal axis of the blade.

64. A wind turbine according to claim 62 or claim 63, wherein the blade end is generally L shaped.

65. A wind turbine according to any one of claims 52 to 64, wherein one or more the turbine blades is provided as a plurality of segments wherein the segments may be moved between a storage state and a deployed state, wherein in the storage state the presented length of the segments is reduced relative to the presented length of the segments in deployed state.

66. A wind turbine according to claim 65, wherein adjacent turbine segments provide co-operating features allowing the segments to be assembled together or disassembled to move between the deployed and storage states.

67. A wind turbine according to claim 65, a co-operating slide rail feature is provided between adjacent turbine segments to allow one segment to slide along another when moving between the storage and deployed states.

68. A wind turbine according to claim 65, wherein adjoining turbine segments are hingedly attached to one and other to allow for the segments to be folder together in the storage state and unfolded for the deployed state.

69. A wind turbine according to claim 65, wherein adjoining turbine segments co-operate to allow one turbine segment to be withdrawn into another turbine segment when moving from the deployed state to the storage state.

70. A method of operating a wind turbine having a plurality of blades using an articulating knuckle boom crane, the crane comprising a boom supported from a base on a supporting structure, the method comprising the steps of:
connecting the wind turbine to the end of the boom;

providing an electrical connection from the wind turbine to the supporting structure;
raising the boom of the crane up relative to the base to a position where the plurality of blades are free to rotate;
allowing the blades to rotate to produce electricity which is provided through the electrical connection.

71. A method of operating a wind turbine according to claim 70, wherein the step of allowing the blades to rotate comprises releasing a brake on the wind turbine.

72. The secondary use of an articulating knuckle boom crane as a support tower for a wind turbine generating electricity when not in use as a crane.

73. A connector substantially as described herein with reference to and/or as illustrated in the accompanying drawings.

74. A wind turbine substantially as described herein with reference to and/or as illustrated in the accompanying drawings.

75. A method of use of a wind turbine substantially as described herein with reference to and/or as illustrated in the accompanying drawings.

76. A method of use of an articulating knuckle boom crane substantially as described herein with reference to and/or as illustrated in the accompanying drawings.

77. A segmented blade for a wind turbine substantially as described herein with reference to and/or as illustrated in the accompanying drawings.

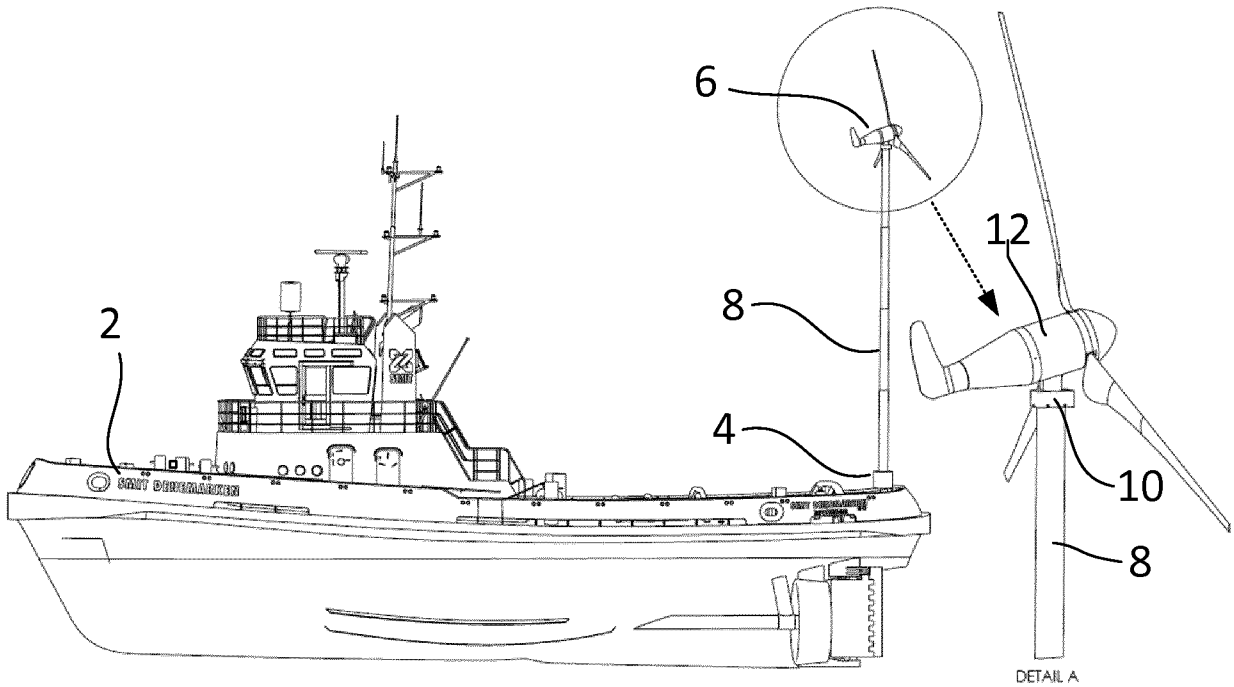

Fig. 1

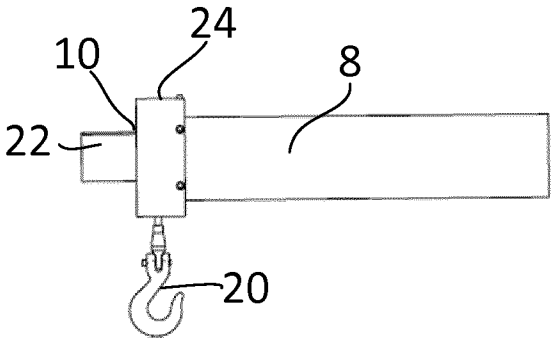

Fig. 2

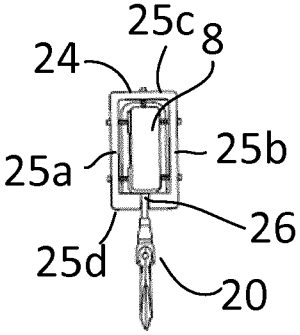

Fig. 3

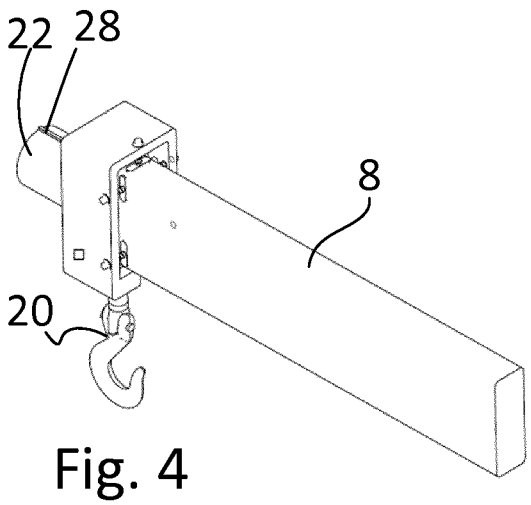

Fig. 4

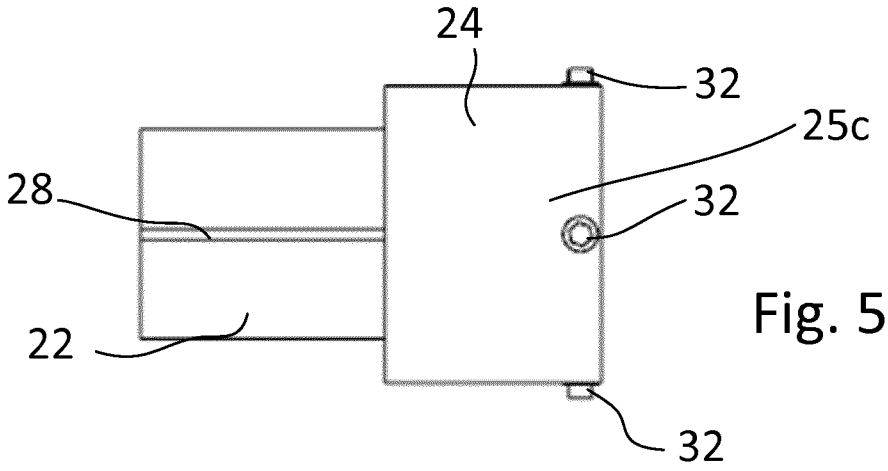

Fig. 5

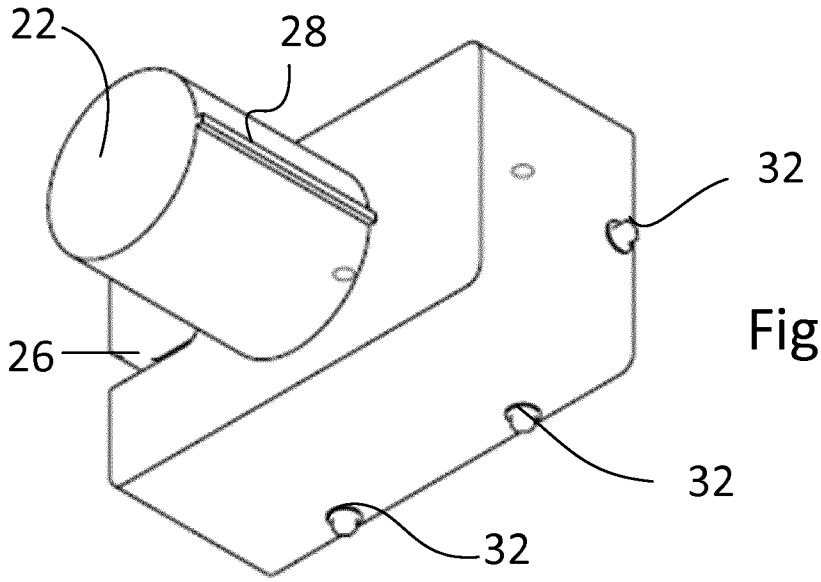

Fig. 5A

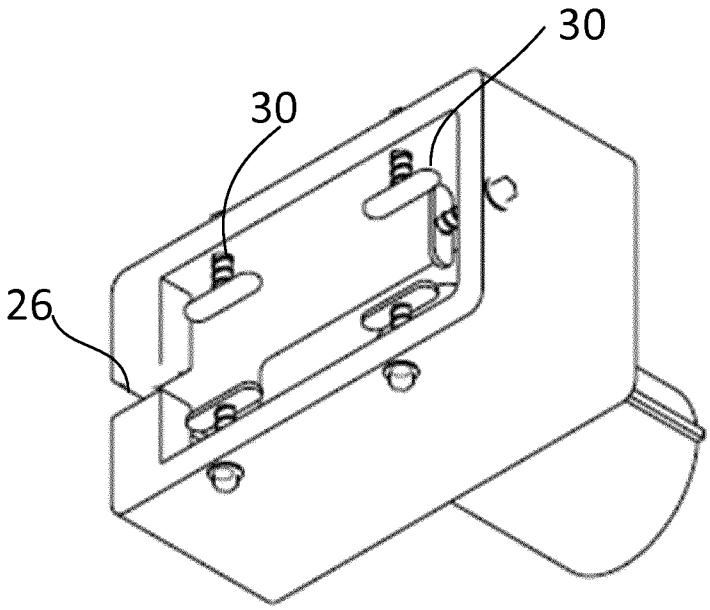

Fig. 5B

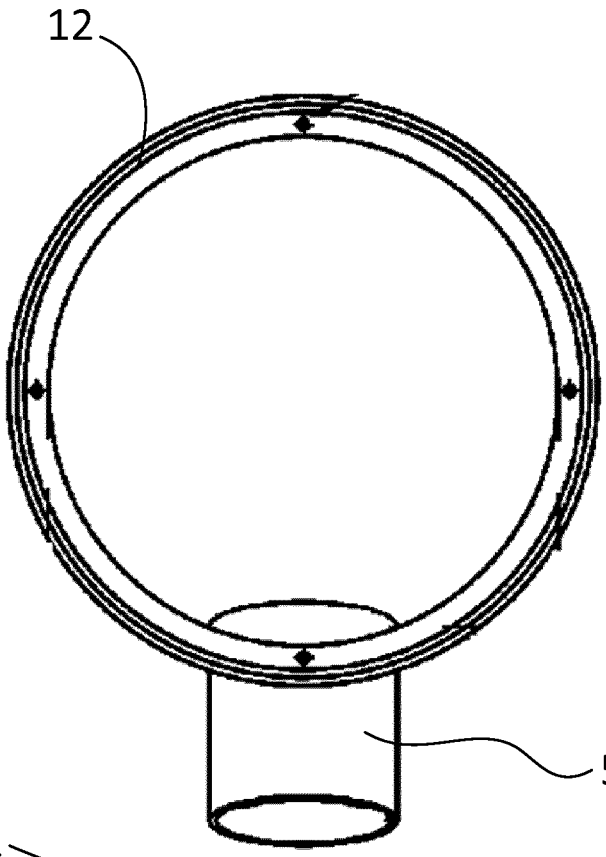

Fig. 6

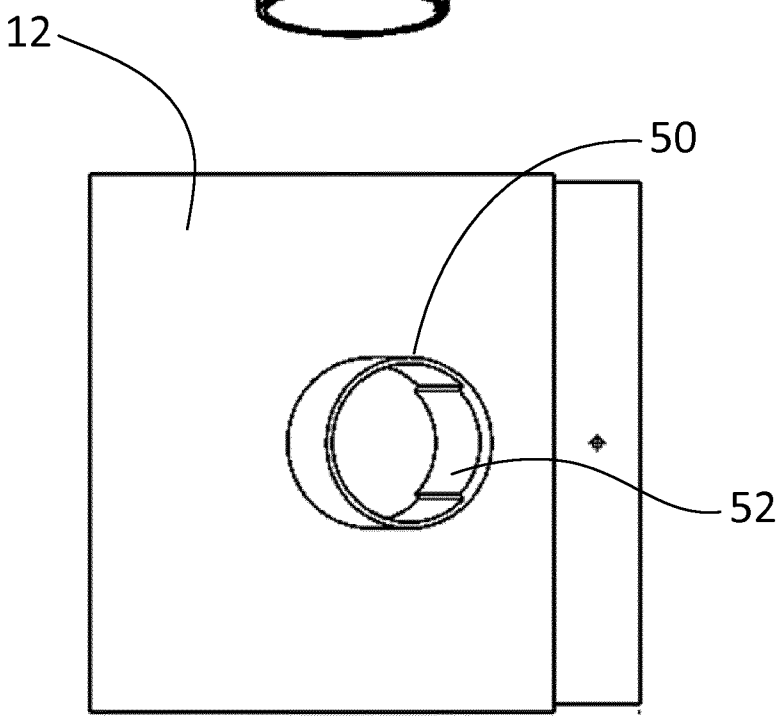

Fig. 7

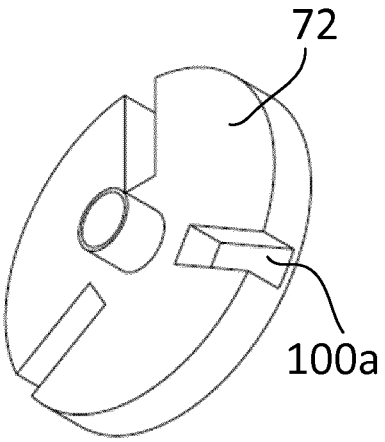

Fig. 8

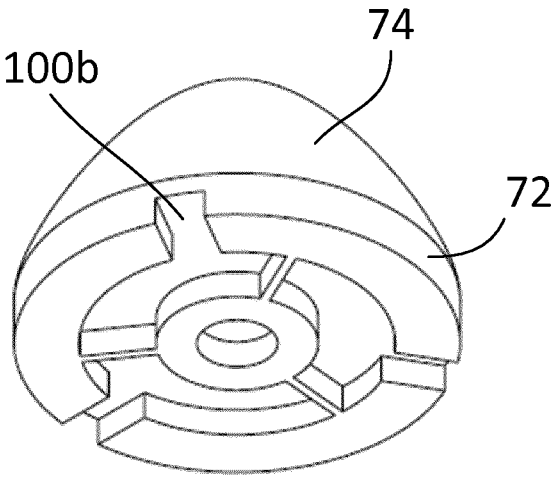

Fig. 9

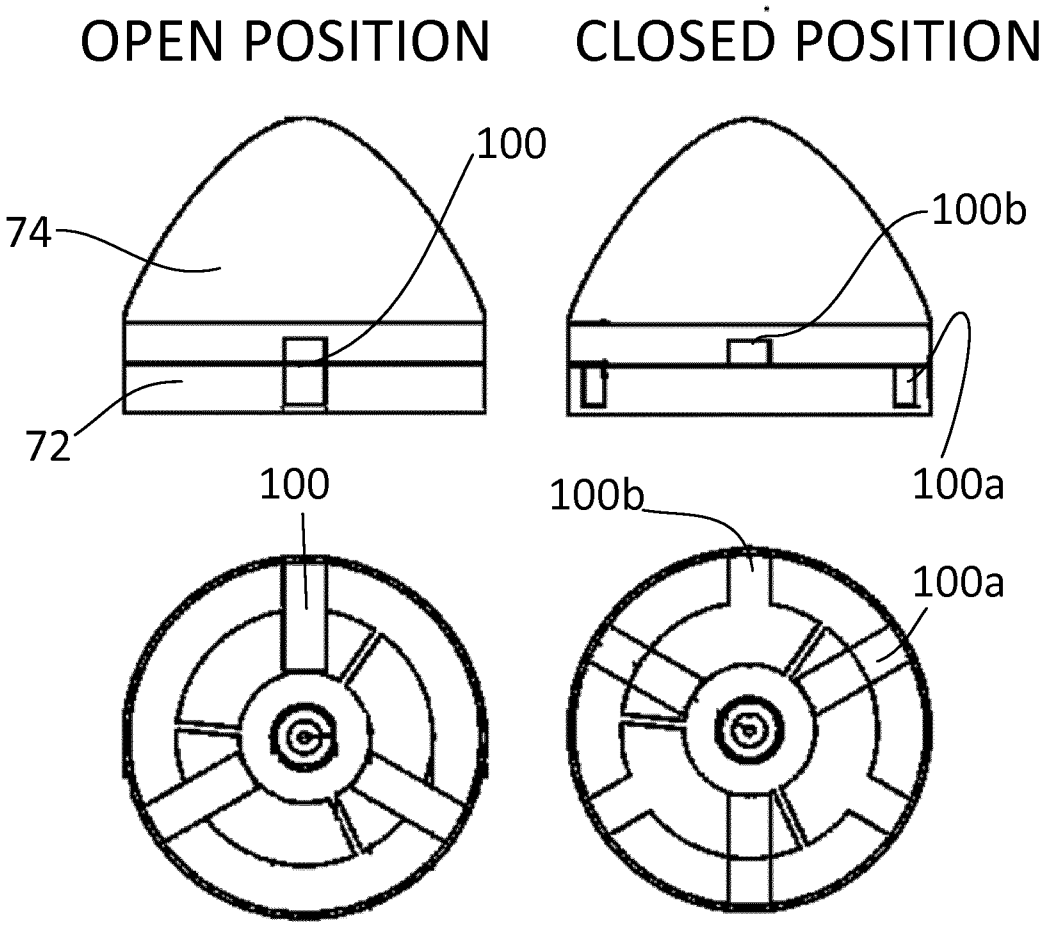

Fig. 10

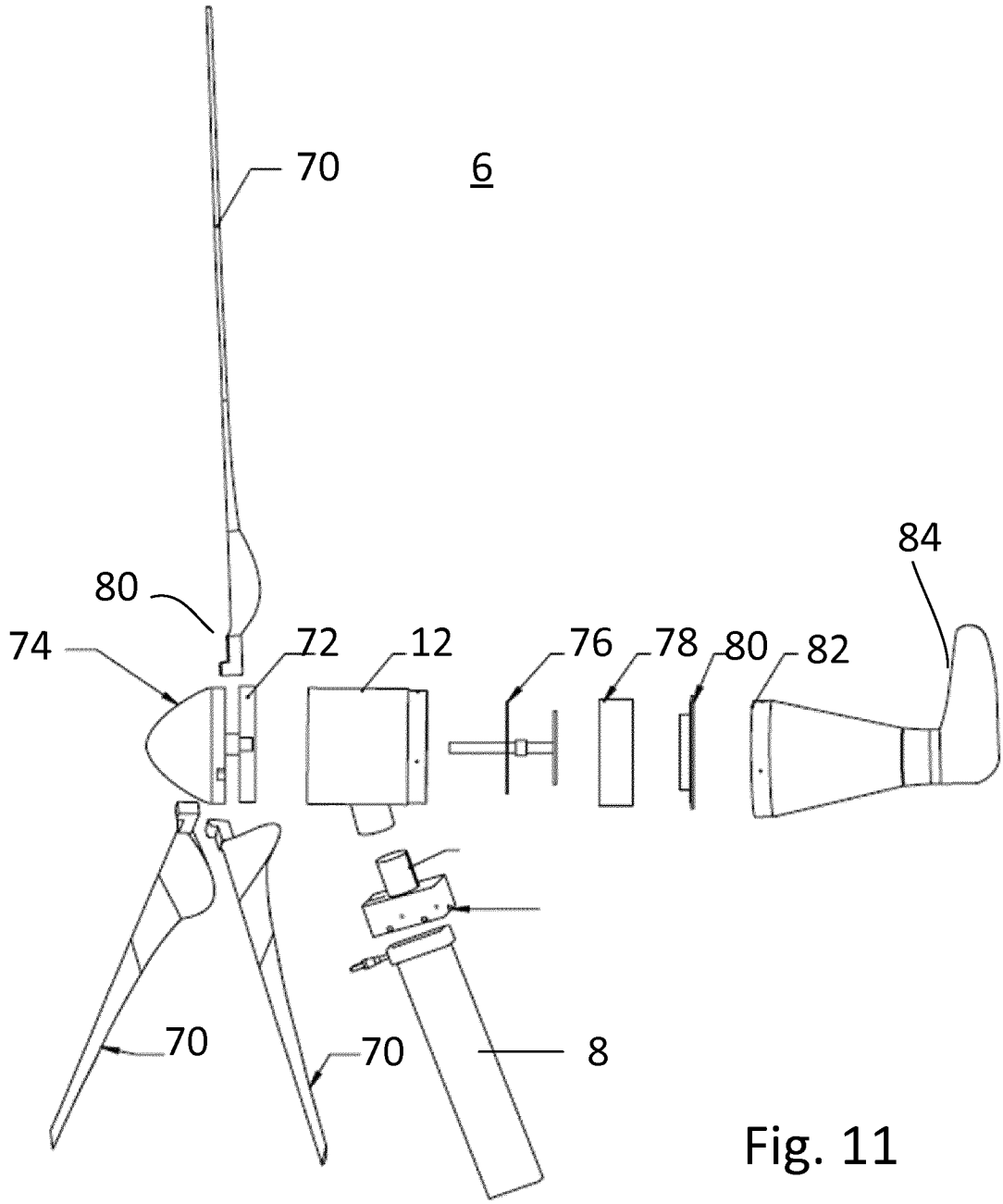

Fig. 11

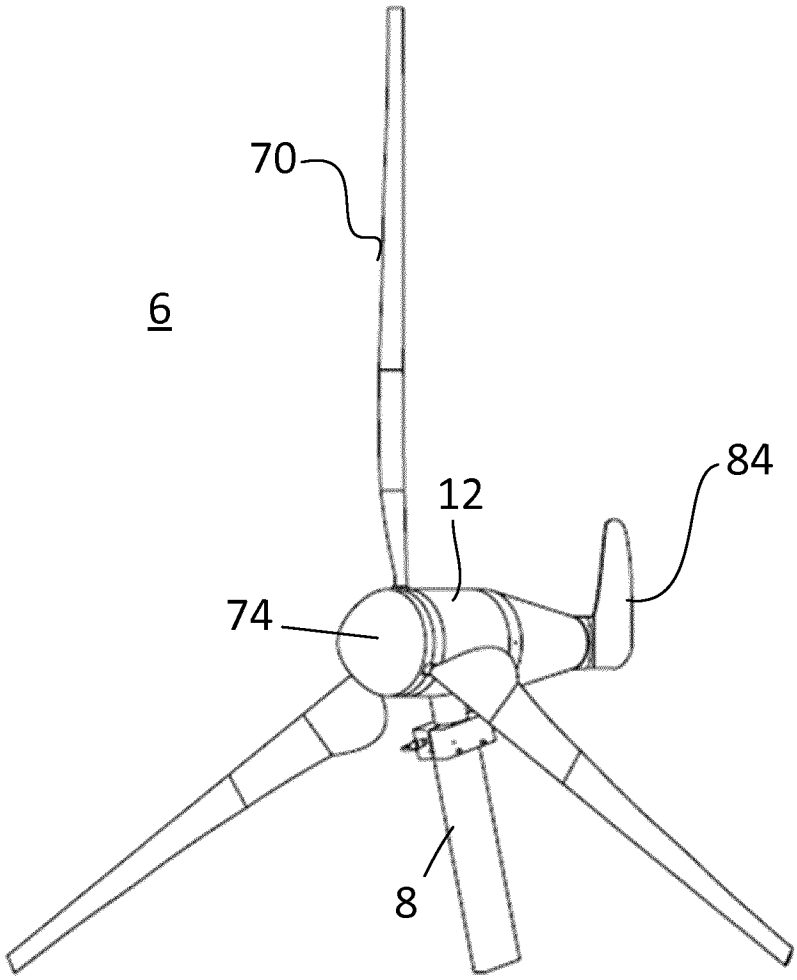

Fig. 12

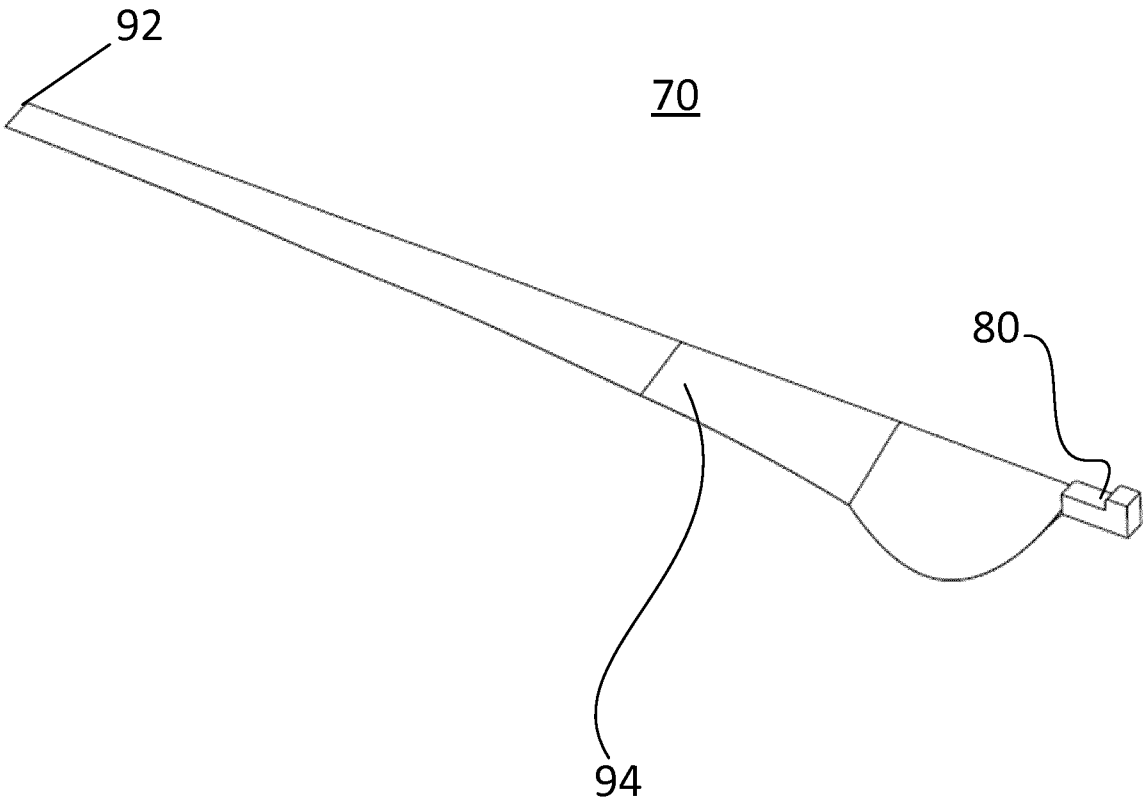

Fig. 13

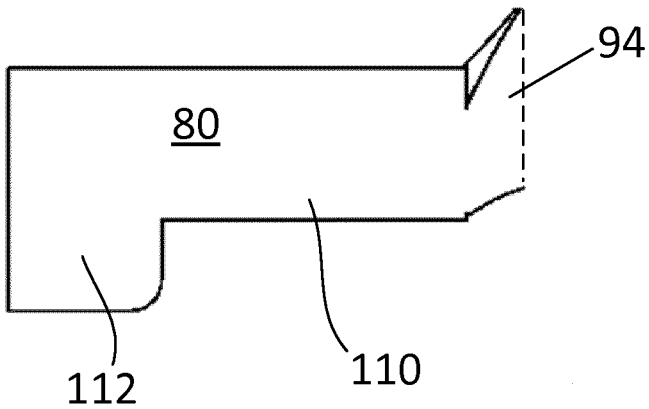

Fig. 14

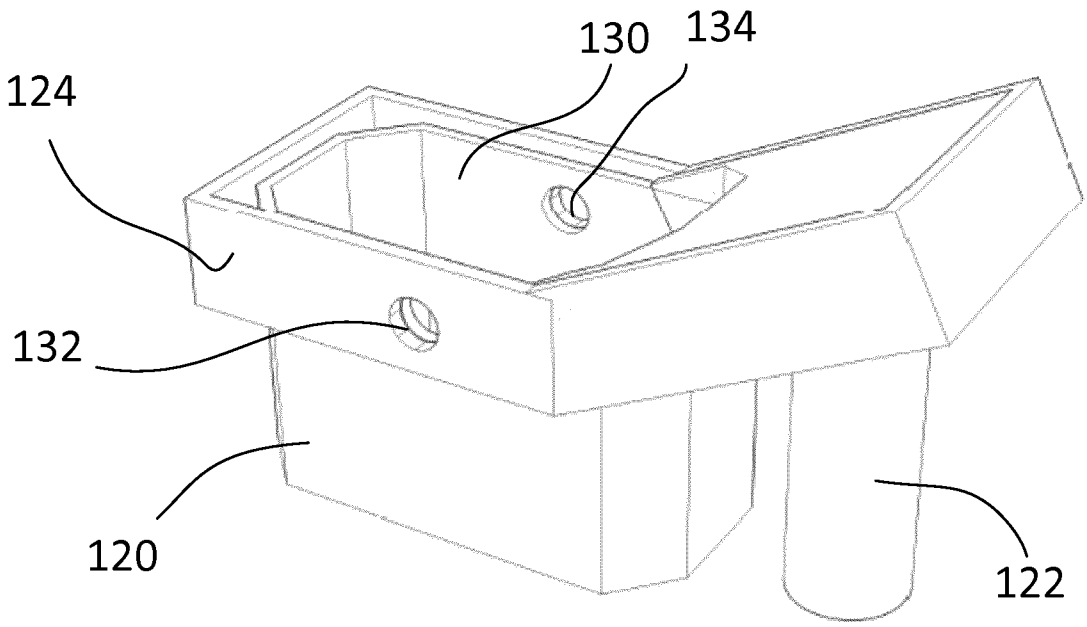

Fig. 15

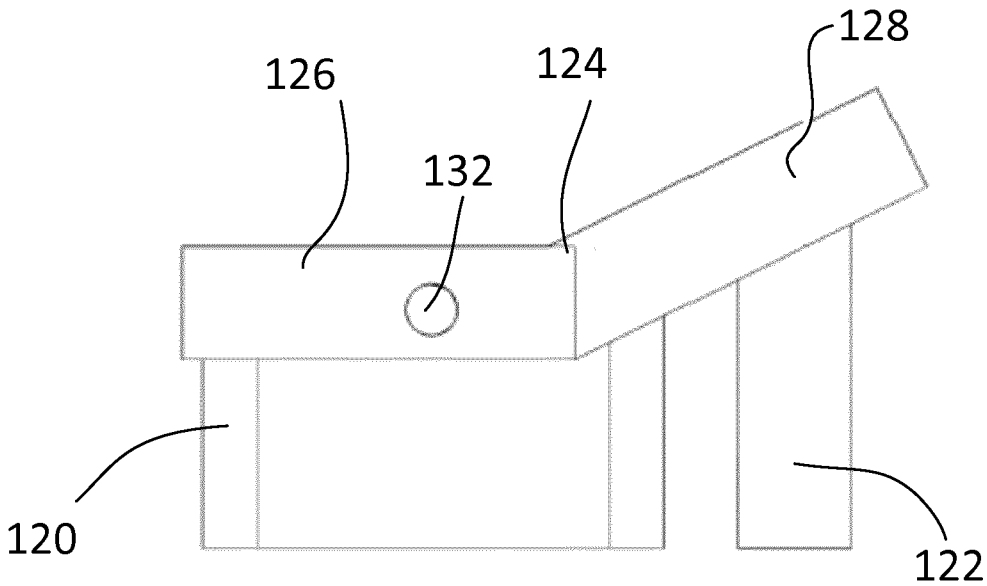

Fig. 16

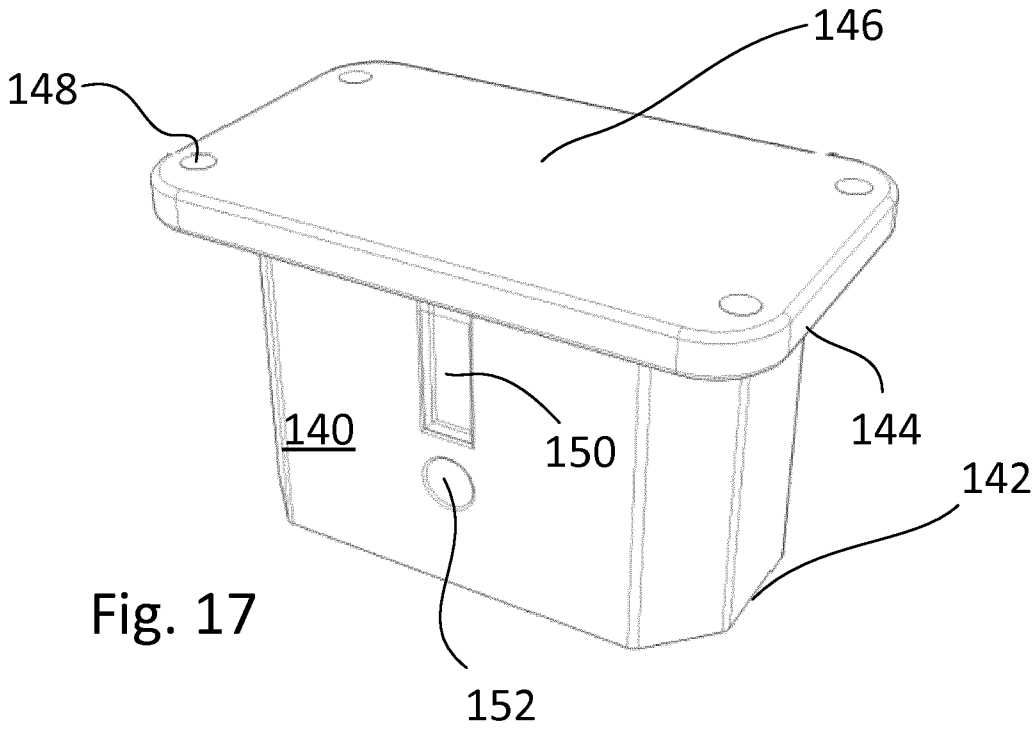

Fig. 17

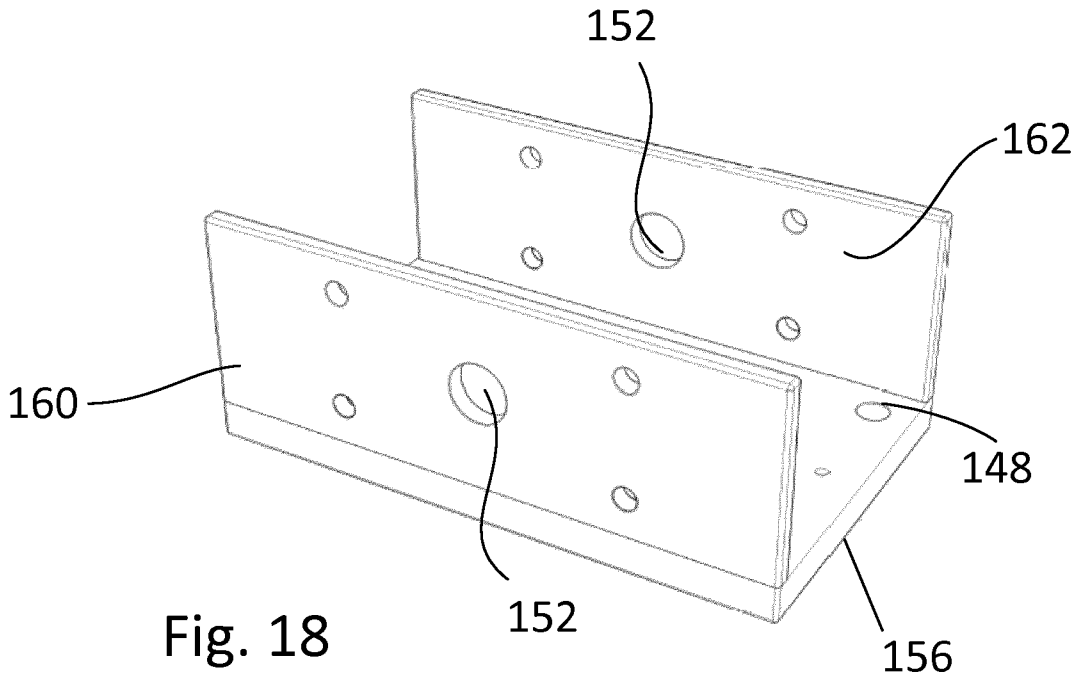

Fig. 18

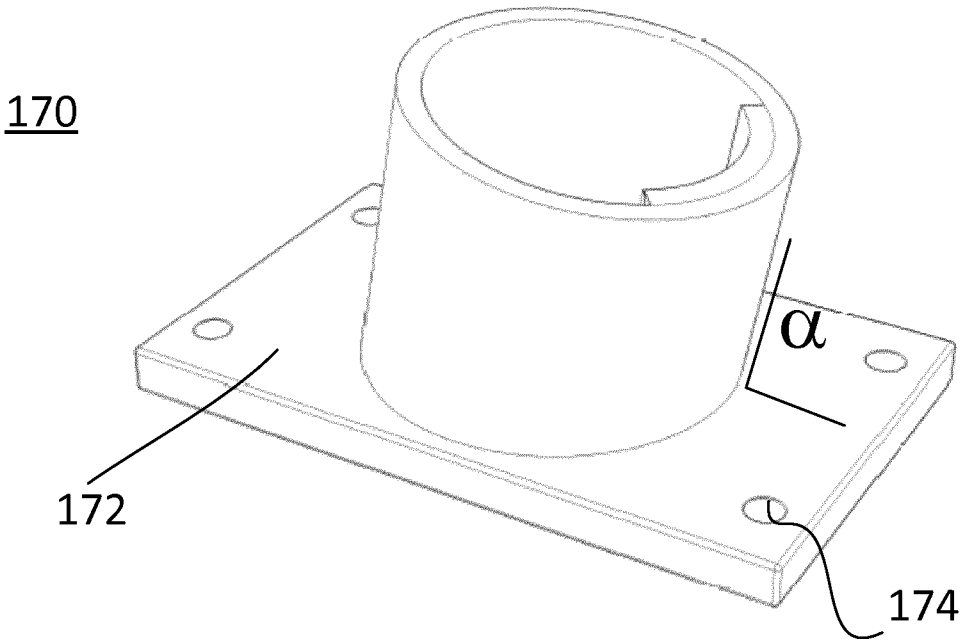

Fig. 19

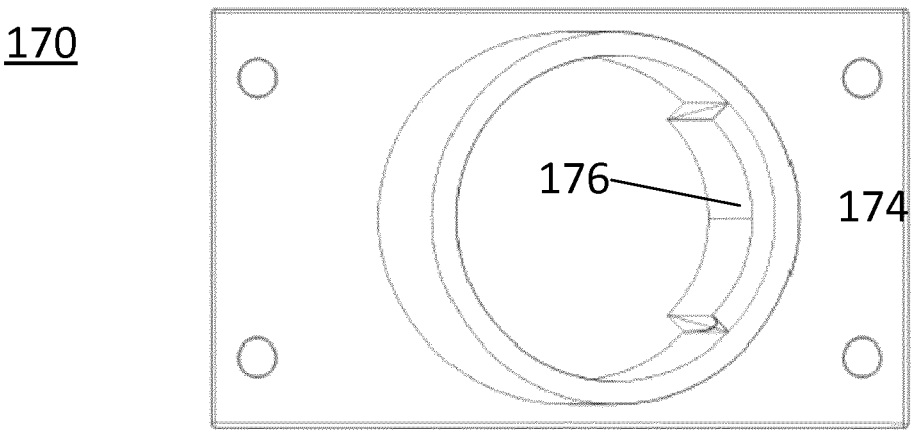

Fig. 20

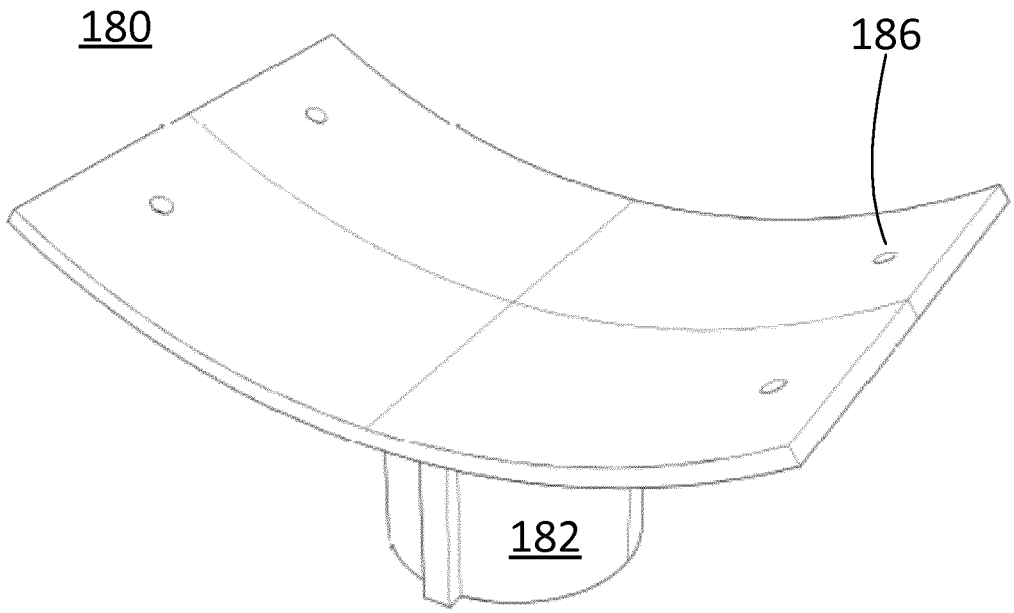

Fig. 21

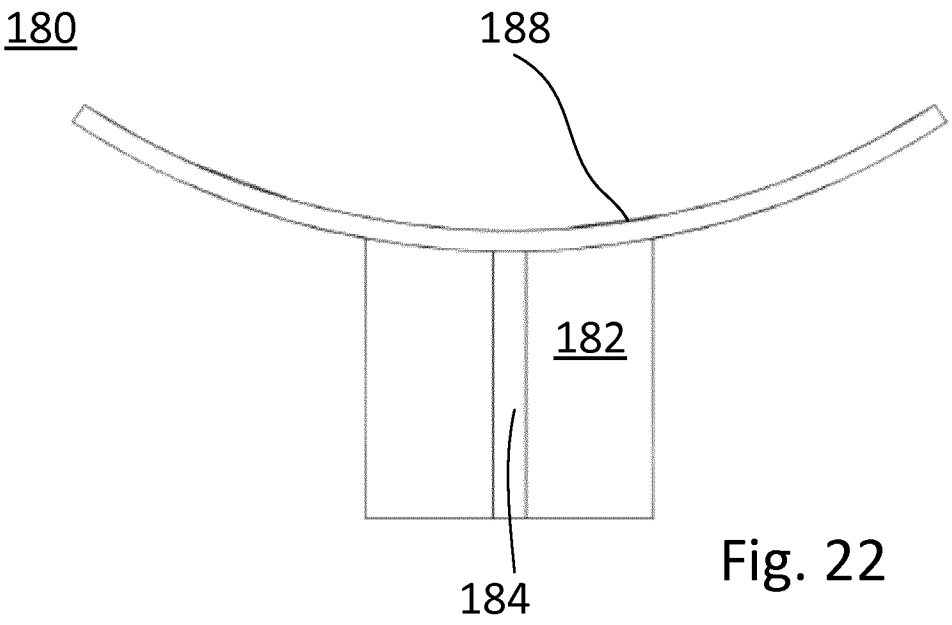

Fig. 22

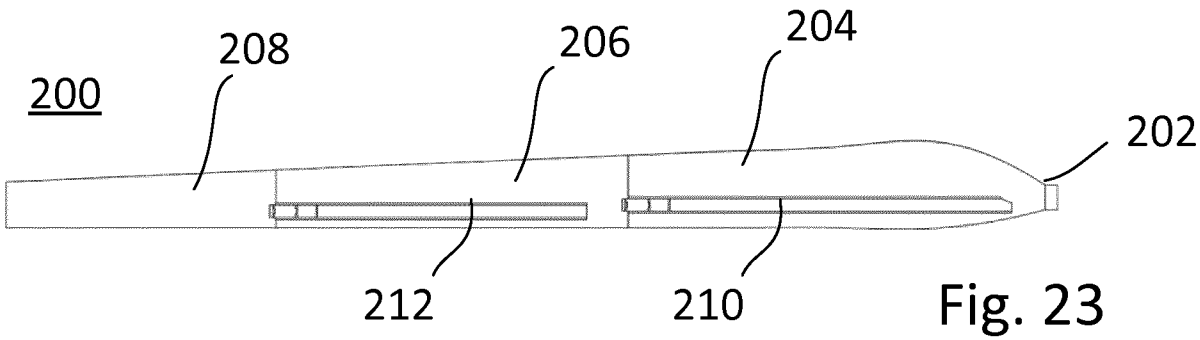

Fig. 23

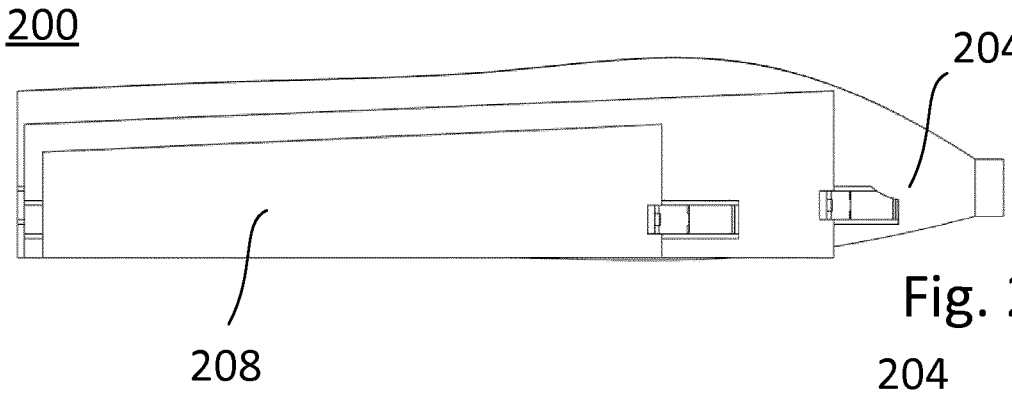

Fig. 24

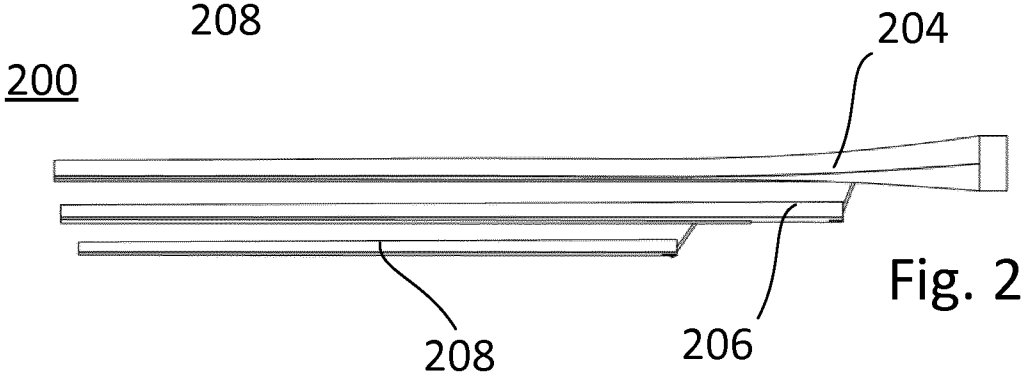

Fig. 25

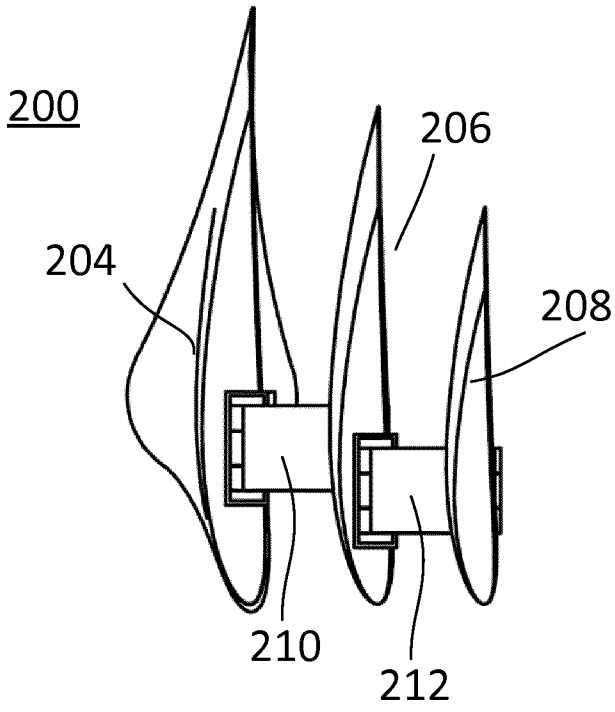

Fig. 26

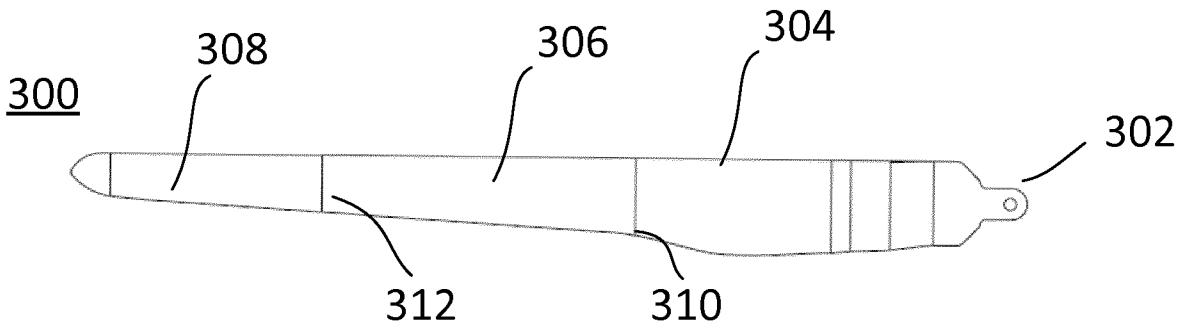

Fig. 27

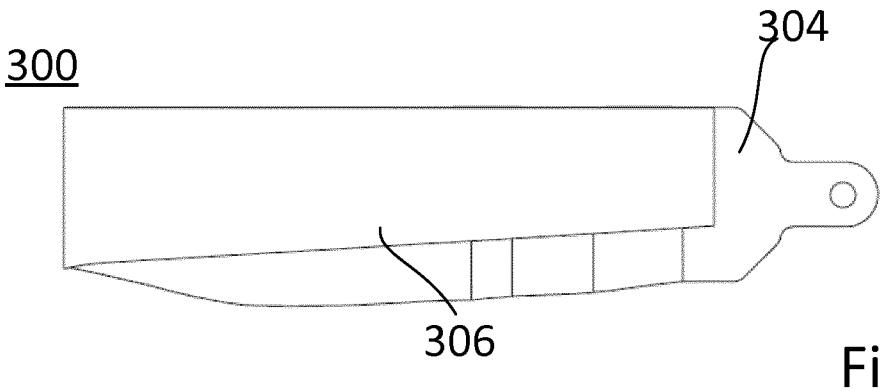

Fig. 28

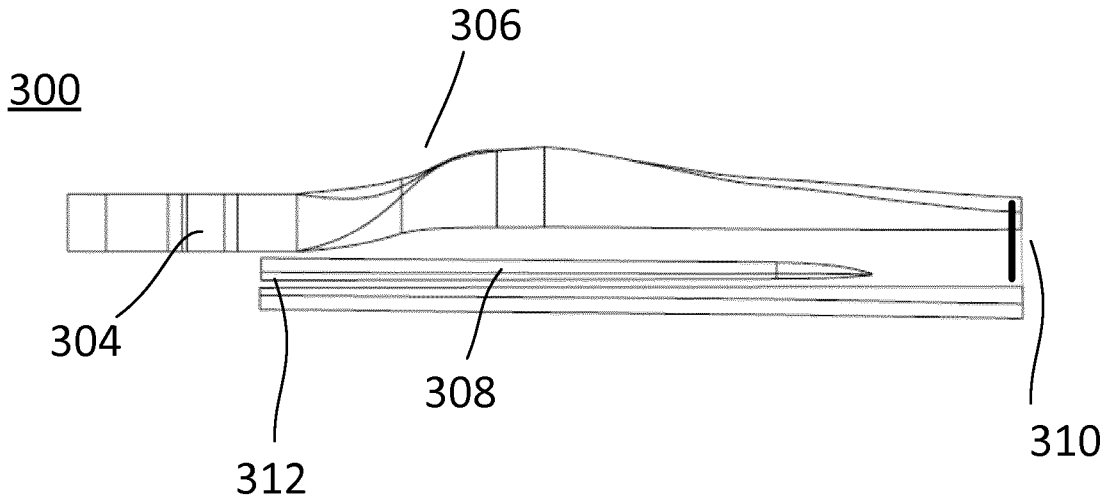

Fig. 29

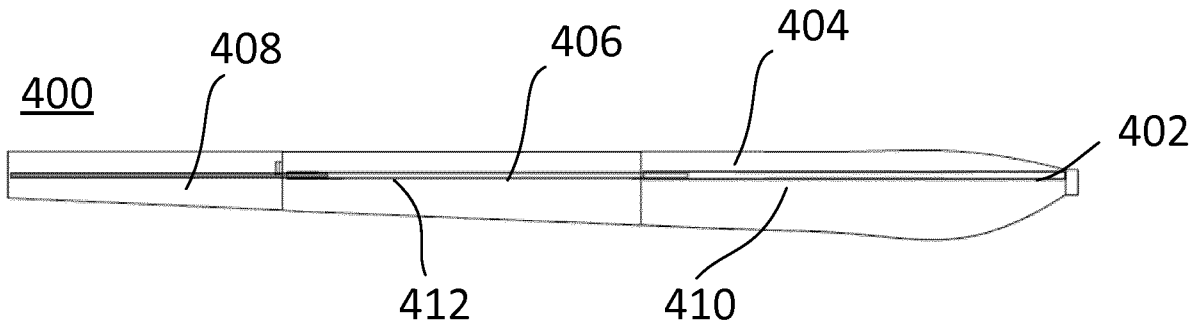

Fig. 30

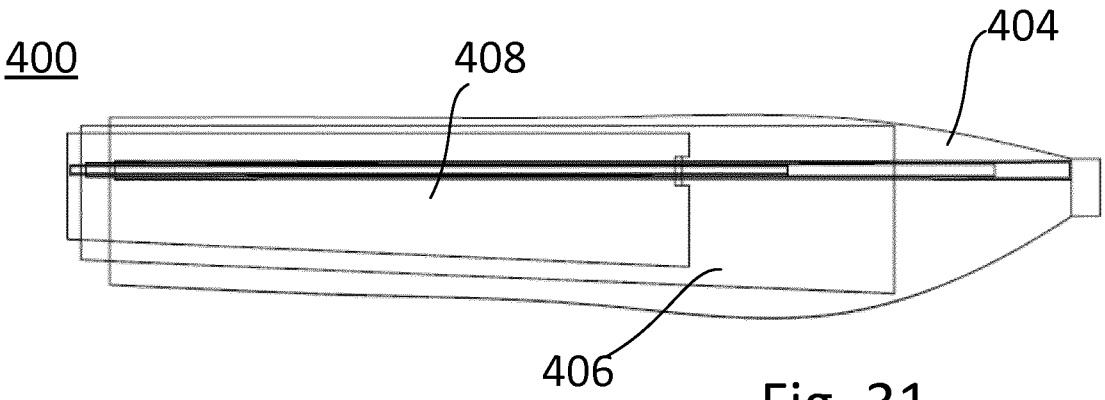

Fig. 31

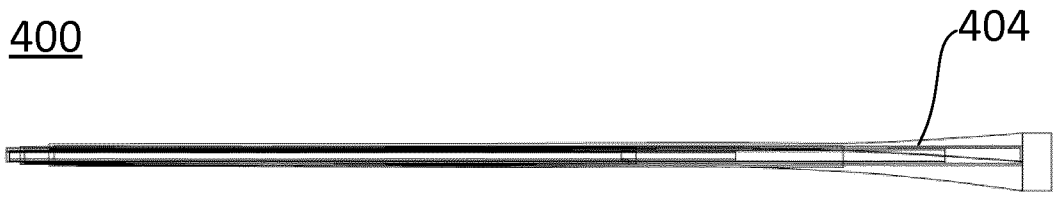

Fig. 32

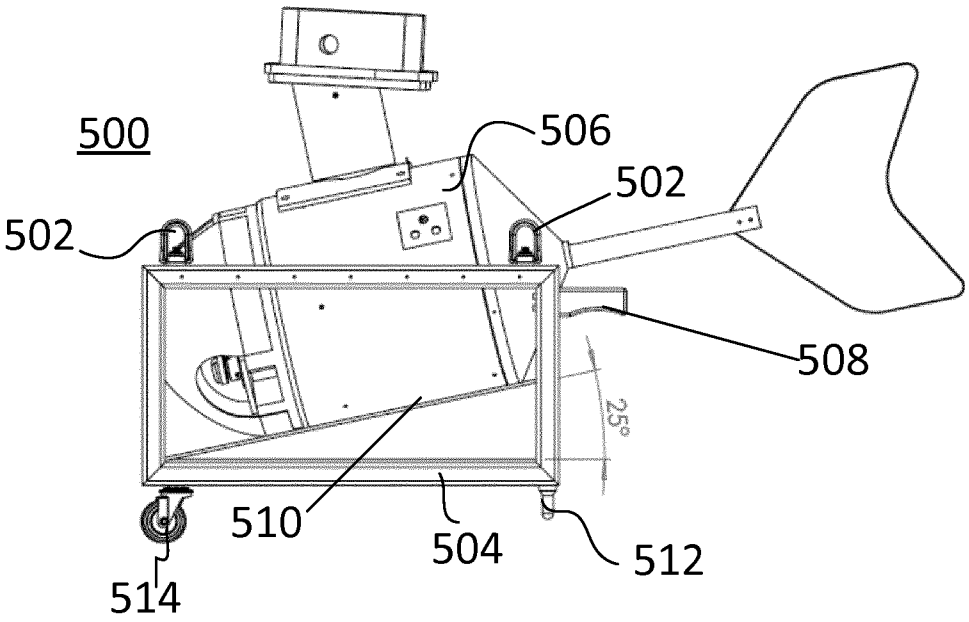

Fig. 33

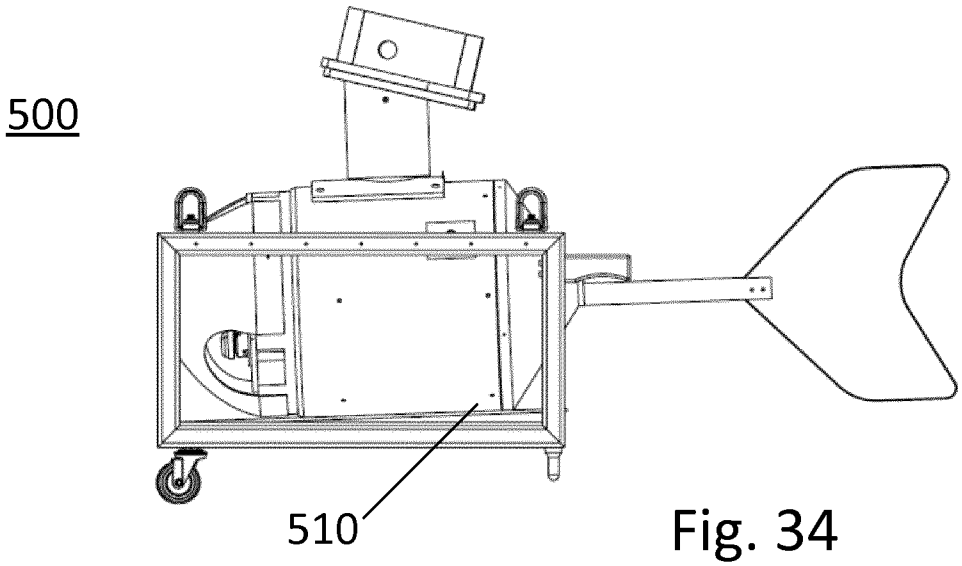

Fig. 34

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/068060

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03D13/20 F03D9/32 F03D9/43
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F03D B66C

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2003 246586 A (HITACHI PLANT KENSETSU SOFT KK; FUJISAKI JUKI KOGYO KK) 2 September 2003 (2003-09-02) abstract paragraph [0014] - paragraph [0015] paragraph [0025] - paragraph [0029]; figures 1,2	1-4, 10-20, 27,28, 37-46, 49-57, 70-73, 75,76

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 November 2016	11/01/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Westermayer, Philipp

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 2 330 069 A1 (GRU DALBE SRL [IT]) 8 June 2011 (2011-06-08) abstract paragraph [0011] paragraph [0037] - paragraph [0040]; figures 1,3	4,13,14, 49-57, 70-73, 75,76
A	EP 2 065 331 A2 (AIRMAX GROUP PLC [GB]) 3 June 2009 (2009-06-03) abstract paragraph [0050] - paragraph [0051]	1-57,72, 73,76
A	WO 2014/088166 A1 (MARINE SYSTEM CO LTD S [KR]; SEO HAN DONG [KR]) 12 June 2014 (2014-06-12) abstract paragraph [0008] - paragraph [0010]; figure 1	1-57,72, 73,76

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2016/068060

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-57, 70-73, 75, 76

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-57, 70-73, 75, 76

   Connector for releaseably attaching a wind turbine to the arm of a crane.

   ---

2. claims: 58-69, 74, 77

   Wind turbine with a rotor comprising a first and second section, which are rotatable with respect to one another between a first and second position, wherein in the first position blades can be inserted or removed in the rotor and in the second position the blades are held within the rotor body.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/068060

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2003246586 A	02-09-2003	NONE	
EP 2330069 A1	08-06-2011	EP 2330069 A1	08-06-2011
		IT 1396794 B1	14-12-2012
EP 2065331 A2	03-06-2009	EP 2065331 A2	03-06-2009
		GB 2455499 A	17-06-2009
WO 2014088166 A1	12-06-2014	KR 20140073639 A	17-06-2014
		WO 2014088166 A1	12-06-2014