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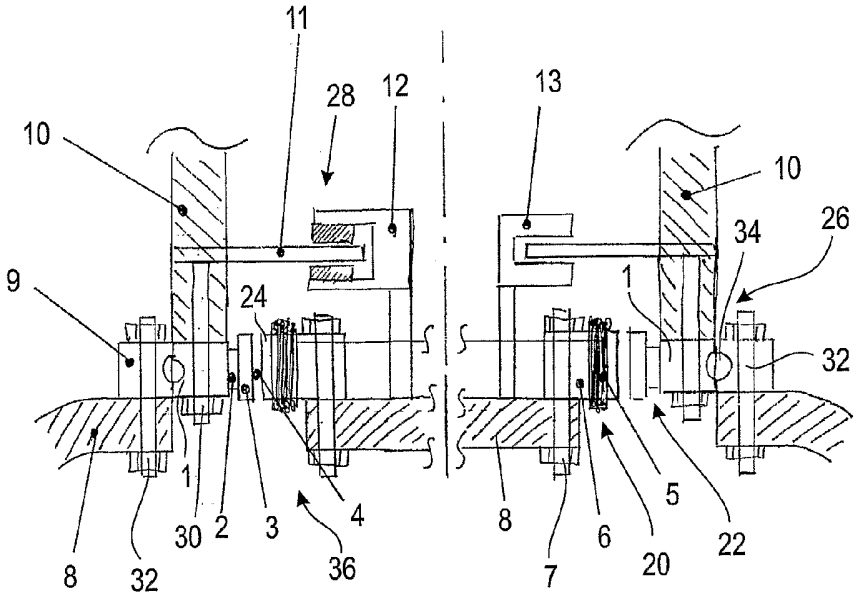
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(54) Title: WIND TURBINE BLADE PITCH CHANGE BY MEANS OF ELECTRIC STEPPING MOTOR



(57) Abstract: A rotor for a wind turbine includes a hub (8) and at least one rotor blade (10), which is rotatably mounted on the hub (8). The pitch angle of each rotor blade (10) or rotor blade part (111) is driven by a pitch drive comprising a direct drive (36). The term direct drive is used for electric machines, which are directly coupled to the system load without the use of belts or gears. This direct drive may also be used for a wind turbine's yaw drive system. In this configuration a direct drive is used to rotate the wind turbine's nacelle with respect to its tower.

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WIND TURBINE BLADE PITCH CHANGE BY MEANS OF ELECTRIC STEPPING MOTOR

The present invention relates generally to the rotor of a wind turbine, and relates more particularly to a pitch drive and a yaw drive system.

Wind turbines are used to generate electricity by converting kinetic energy of an air stream into electric energy. The set-up and the functional principle of a wind turbine are described in conjunction with Fig. 2, (see also Fig. 3.5 of E. Hau. "Wind Turbines", Springer, 2000). A typical wind turbine includes a nacelle 102 mounted on a tower 100 supported by a foundation 128. The nacelle 102 houses a drive train for transmitting the rotation of a rotor 106 to a drive-shaft 118 of a generator 114. The drive train includes a rotor shaft 104 that connects the rotor 106 to a gearbox 112 in order to increase the rotation of the drive-shaft 118 of the generator 114. The drive-shaft 118 is often called the high-speed shaft and the rotor shaft 104 is known as the low-speed shaft. The rotor shaft 104 is connected to the rotor's hub 108, which generally supports three rotor blades 110. The gearbox can be optionally omitted thereby directly linking rotor 106 to generator 114. This configuration is known as a direct drive generator. The generator 114 feeds the generated electric energy into the public grid via power cables 124 with a grid connection 126 containing electrical power devices like frequency converter and / or transformer. Also it is possible that the electrical energy will be directly consumed by consumers without being fed to a public grid.

When an incoming air stream 116 turns the rotor 106, the wind's kinetic energy is converted into rotational energy of the rotor 106 and transmitted by the drive train to the generator, which finally converts the rotational energy into electric energy. When not in motion the rotor 106 may be fixed in place by a brake 130 on the side of the high-speed shaft.

The efficiency of a wind turbine depends on many parameters including the orientation of the nacelle, or more specifically the location of the rotor plane with respect to the direction of the air stream. This is controlled by a yaw drive 122 or azimuth-drive, which orients the nacelle into the wind. In modern wind turbines electrical and mechanical components form a yaw drive (DE 198 14 629; Tacke Windenergie GmbH). More specifically, an electric high-speed drive motor is coupled by a gear reducer having a drive pinion gear engaging a bull gear. Usually the electric drive motor, the gear reducer, and the drive pinion gear are mounted on the nacelle's bedplate 120 while the bull gear is fixed to tower 100. For controlling the yaw-drive a wind-measuring sensor is used, which is capable of measuring the direction of the wind.

A similar configuration applies to a pitch drive 107 for adjusting the pitch angle of each of the rotor blades 110. This also dramatically affects the efficiency of the wind turbine. At high wind speeds, the power captured from the wind by the rotor will exceed the limits set by the wind turbine's structural strength. Additionally, it is important to maintain the rotor's speed either at a constant value or within a given range. The most effective way of influencing the pitch angle, which determines the

aerodynamic angle of attack of the rotor blades and hence the rotor's speed, is by mechanical adjustment of the rotor blades. In general, each rotor blade is turned with the aid of an actively controlled pitch drive along its longitudinal axis.

Power control by changing the rotor blade's pitch angle is possible through two principle methods. The most common method is to change the rotor blade's pitch angle to a smaller angle of attack in order to reduce power capture. Inversely, increasing the angle of attack increases the power capture. This process allows sensitive and stable control of the aerodynamic power capture and rotor speed.

The other method is to change the blade pitch angle to a greater angle of attack to the point where the flow separates at the rotor blade's surface, thus limiting the aerodynamic power capture. This effect is known as stall.

Usually, the pitch drive includes a gear reducer that couples a high-speed electric drive motor with a drive pinion gear. These components are installed in the hub of the rotor. The drive pinion gear engages with a bull gear. The drive pinion gear is mounted on the hub while the bull gear is fixed to the rotor blade.

Although the configuration for the yaw drive and the pitch drive is fairly robust and reliable, these devices require continuous maintenance. In particular, abrasion of the teeth of the drive pinion gear and constant oil delivery for the gear reducer are critical maintenance issues. Due to the wind turbine's long life span of about 20 years, this maintenance increases the cost of ownership. Further, the

mechanical elasticity of the gear reducer impairs the accuracy of the complete configuration.

As a result of the problems presented above it is an object of the invention to improve the yaw drive and/or the pitch drive of a wind turbine by reducing the amount of required maintenance and improving their accuracy.

This object is attained by using a direct drive for the pitch drive and/or for the yaw drive.

The pitch drive is part of the rotor of the wind turbine. Therefore, the rotor includes a hub and at least one rotor blade; and at least one blade pitch system for adjusting the blade pitch angle of the entire rotor blade or a part of the rotor blade, the blade pitch system includes a direct drive.

Typically, the entire rotor blade is rotatably mounted on the hub for changing the pitch angle. Alternatively, only a part of the rotor blade may be rotatably mounted. In this case the rotor blade includes at least one fixed part and at least one rotatable part, whereas the pitch angle of the rotatable part can be adjusted by the direct drive. The fixed part is rigidly attached to the hub.

The term 'direct drive' is used for electric machines, typically electric motors, which can be directly coupled to the system's load without the use of belts or gears or other transmission / transformation devices. In particular, the rotor blade or a part of it is rotated at the same rotational speed that the direct drive provides. Conventional pitch-drive systems include a high speed electric motor which lacks adequate torque or resolution.

In such systems, a gear-reducer is typically interposed between the electric motor and the drive pinion gear for increasing the torque and the resolution. In contrast thereto, a direct drive provides sufficient torque and angle resolution which allows a direct coupling to the rotor blade without any mechanical means for increasing the torque, such as gear reducers. Torque motors, variable-reluctance machines (VRMs) or stepping motors are electric motors that may be used as direct drives. One of the main advantages of direct drives is their ability to provide a uniform moment of torque regardless of the position of their rotors, and the possibility of a precise and stepwise control of the rotation. The stepwise rotation of the direct drive allows a direct control of the pitch angle without using a gear-box or other mechanical components.

The direct drive may include a driven rotor and a stator, whereby the stator is attached to the hub and the driven rotor is attached to the rotor blade. Typically, the stator is used to generate a rotating or stepwise turning magnetic field which drives the driven rotor. The term 'attached' may be understood as rigidly attached. However, it is not necessary for the driven rotor to be directly attached to the rotor blade, but it is required that a fixed linkage exists between the driven rotor and the rotor blades or parts of them. The same is true for the attachment of the stator to the hub.

This configuration allows a directly driven rotation of the rotor blade or blade portion without using a gear-reducer, a drive pinion gear, or a bull gear; hence, the maintenance cost is reduced. In particular, mechanical

components such as the tooth system of the drive pinion gear, bull gear and gear-reducer are not corroded or abraded. Further, no permanent oil-delivery for the gear-reducer is required. Additionally, high-speed drive-motors, as typically used for conventional yaw and pitch drives, are not required, including their high-speed bearings and collectors (for a DC-drive). The overall advantage of this configuration is that no additional mechanical components for increasing the torque and the angle resolution are required. Therefore, the pitch drive does not show any mechanical elasticity problems which arise when using gears. A precise and instant adjustment of the pitch angle can be obtained by this configuration. In order to provide sufficient torque, the diameter of the direct drive may reach the diameter of the root of the rotor blade. The term 'root' typically describes that part of a rotor blade which provides the linkage to the hub. Since the rotor blades can be rotated around their longitudinal axis, the cross-section of the root is usually circular. A typical diameter of a root of a modern wind turbine may reach values of 2 to 3 meters. Giant off-shore wind-turbine dimensions often exceed these values. Further, direct drives of large dimensions allow a higher angle resolution when adjusting the pitch angle. Therefore, the driven rotor may have a ring-like or a disc-like shape with a diameter which substantially equals the diameter of the root of the rotor blade. The stator of such large direct drives also have a ring-like shape and a large inside opening.

The invention may also cover configurations where only the gear reducer and the high-speed motor are replaced by a direct drive. In this case, the driven rotor of the direct drive is directly attached to the drive pinion gear. Since

the gear transmission ratio of the drive pinion gear and the bull gear may reach values up to ten or higher, smaller direct drives can be used which may relax the weight constraint of the rotor.

In a further embodiment of the invention the driven rotor has a ring-like shape surrounding the stator. The externally arranged driven rotor provides for easy integration into existing rotor designs. In particular, if the external diameter of the driven rotor roughly meets the diameter of the root of the rotor blade, the driven rotor can be directly attached to the root of the rotor blade. However, it is also possible to use a configuration with an internal driven rotor.

A further aspect of the invention involves a pitch bearing that is interposed between the hub and the rotor blade. The pitch bearing typically includes an inner and an outer ring. In some configurations, the outer ring is attached to the hub and the rotor blade is attached to the driven rotor via the inner ring. In this particular configuration, the driven rotor is not directly attached to the rotor blade because the inner ring of the pitch bearing is fixed between them.

Another aspect of the invention relates to a brake, which maintains the rotor blade in a given pitch angle position. Although the direct drive provides sufficient torque to keep the rotor blade in a desired position, an additional mechanical brake ensures a reliable fixation of the rotor blade even if the direct drive malfunctions. The brake may include a typically "ring-shaped" brake disc attached to the rotor blade and a brake caliper attached to the hub.

The rotor may further include a sensor for determining the rotor blade's pitch angle. This sensor is usually integrated into a feed-back control.

In a further possible configuration of the direct drive according to the present invention, the stator includes a plurality of poles, each pole having at least one electric coil for generating a magnetic field. The driven rotor, which surrounds the stator, includes a plurality of permanent magnets. This brushless configuration is very reliable and does not require any maintenance. Further, by raising the number of poles and/or permanent magnets the angle resolution of the direct drive increases.

A desired configuration therefore includes a plurality of permanent magnets attached in a ring-like shaped manner to each of the rotor blades. On the other hand, the poles having electric coils which are attached to the hub in a ring-like shaped manner as well. For each rotor blade a separate ring of poles is provided.

The present invention is suitable for any type of rotor, particularly for rotors comprising three rotor blades and three blade pitch systems. Each of the three blade pitch systems is assigned to one of the three rotor blades.

Concerning the yaw drive system, a configuration similar to that of the pitch-drive applies. However, instead of using a direct drive in the rotor to adjust the pitch angle of the rotor blade, the direct drive is used to adjust the yaw angle of the nacelle with respect to the tower. The same advantages outlined with respect to the pitch drive configuration discussed above, also apply to the yaw drive

system. Furthermore, all of the embodiments of the pitch drive system apply to the yaw drive system and are reiterated below.

The wind turbine includes a tower and a nacelle, the nacelle is rotatably mounted on the tower for changing the nacelle's yaw angle; and a yaw drive system for turning the nacelle with respect to the tower, where the the yaw drive system includes a direct drive. The driven rotor of the direct drive can either be attached to the nacelle or to the drive pinion gear.

In an embodiment of the invention the direct drive includes a driven rotor and a stator, the stator is attached to the tower whereas the driven rotor is attached to the nacelle. The driven rotor of the yaw drive may have a ring-like shape and surround the stator. A bearing is optionally interposed between the tower and the nacelle, whereas the bearing includes an inner and an outer ring.

In another configuration also similar to that of the pitch drive, the outer ring of the bearing may be fixed to the tower, whereas the nacelle and the driven rotor are attached via the inner ring. However, the reverse configuration is also possible.

The wind turbine may include a sensor for determining the nacelle's yaw angle.

The direct drive may include a plurality of poles, each pole having electric coils for generating a magnetic field, where the driven rotor would include a plurality of permanent magnets.

In an embodiment of the invention the yaw drive and the pitch drives of the wind turbine include a direct drive.

A full and enabling disclosure of the present invention, including the best mode thereof, to one of ordinary skill in the art, is set forth more particularly in the remainder of the specification, including reference to the accompanying figures wherein:

Fig. 1 shows a cross section of a rotor comprising a hub and a rotor blade along the longitudinal axis of the rotor blade;

Fig. 2 shows a top view of a torque motor used as direct drive;

Fig. 3 shows an example of a modern wind turbine; and

Figure 4 shows a divided rotor blade with pitch angle adjustment of only a part of the rotor blade.

Figure 3 illustrates a principle set-up of a modern turbine which was already explained above.

Reference will now be made in detail to the presently preferred embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, and is not meant as a limitation of the invention. For example, features illustrated or described as part of one embodiment can be used on or in conjunction with other embodiments to yield yet a further embodiment. It is intended that the present invention include such modifications and variations.

Figure 1 shows a part of a rotor of a wind turbine comprising a hub 8 and a rotor blade 10. The rotor blade 10 is rotatably mounted on its root end via a pitch bearing 26. In figure 1 only the attached end of rotor blade 10 is indicated. The bearing 26 includes an inner ring 1 and an outer ring 9. Inner ring 1 is fixed to the rotor blade 10 while outer ring 9 is attached to hub 8 by bolts 32. Since the rotor blade, which may have a length of several tens of meters, is only attached on its root end, the connection between the rotor blade and the inner ring should be sufficiently strong. In this embodiment bolts 30 are used to fix rotor blade 10 to inner ring 9 which may extend into rotor blade 10 to provide a reliable connection. Balls or rollers 34 interposed between the inner and outer ring allow a rotation of inner ring 1 with respect to outer ring 9 free from play.

As indicated in Figure 2, a plurality of permanent magnets 3 are attached to the inner wall of inner ring 1 in a circular or ring-shaped arrangement. An optional ring 2 of a material with a high magnetic permeability is provided between inner ring 1 and permanent magnets 3 (circular rotor bar) for constraining the magnetic field generated by permanent magnets 3. The magnetic flux thus forms closed loops passing through ring 2 and the air gap 4 as further described later. If ring 2 is omitted, inner ring 1 acts as confinement for the magnetic flux.

Disposed from permanent magnets 3, a ring 6 comprising a plurality of poles 24 with coils 5 is attached to hub 8 by bolts 7. The outer diameter of ring 6 defined by the outer surfaces of the poles 24 is slightly smaller than the free inner diameter of the circular arrangement of permanent

magnets 3 to allow a small air gap 4 between the poles 24 and the permanent magnets 3.

The permanent magnets 3 and ring 2 form, in this particular embodiment, the driven rotor 22 of the direct drive 36 while ring 6 with poles 24 and coils 5 are part of the stator 20. Such a configuration is known as torque motor. The number of poles and the number of permanent magnets may vary, but a sufficiently great number is preferred to increase the angle resolution of the direct drive 36. As a rule of thumb, by increasing the diameter of the direct drive a high number of poles and of permanent magnets can be arranged. It should be noted that the number of poles and magnets are usually not equal. Due to the high number of poles and magnets the direct drive 36 provides sufficient torque to directly turn the rotor blade 10. No additional mechanical means for increasing the torque are required, leading to a reliable pitch drive with no additional need for maintenance.

The described direct drive is a brushless torque motor or stepping motor comprising a plurality of permanent magnets on the driven rotor side and a plurality of poles with coils on the stator side. Rotor conductors are not required because torque is produced by the tendency of the driven rotor to align with the stator-produced magnetic flux in such a fashion as to maximize the stator flux linkage that results from a given applied stator current. However, other configurations can be used as long as direct drive 36 can provide sufficient torque to directly couple the driven rotor with the rotor blade.

In contrast to many standard electric motors, a direct drive needs to be actively controlled. Depending on the configuration, coils can be controlled individually or as a group. An individual control gives the highest angle resolution. A straightforward control includes switches such as transistors or thyristors assigned to each coil for independently applying a current of different phase. By sequentially exciting the coils, the driven rotor will rotate in a step-wise fashion, rotating through a specific angle per step. The angle strongly depends on the number of poles. For a proper control of rotation and torque, the current must be applied in a fashion consistent with the rotor position. To this end, direct drives typically include some sort of rotor-position sensing (encoder) as well as a controller.

Despite the rotational mode, the direct drive can be driven in a torque mode as well. In this mode, the applied currents generate a magnetic field which is aligned to the magnetic field of the permanent magnets. The magnetic flux linkage between driven rotor and stator is therefore at its maximum value. Depending on the strength of the magnetic fields, the driven rotor is kept in a given position even if an external momentum is applied. The direct drive acts as an electronic brake to keep the rotor blade in a given angular position.

Besides the configuration of the driven rotor 22 just outlined, other configurations are suitable as well. For instance, the driven rotor can be a ring of a material with a high magnetic permeability comprising a plurality of saliency on its inner wall facing the stator 20. The turning of the driven rotor is caused by the tendency of the

magnetic material to align with the magnetic field generated by the coils of stator 20 to maximize the magnetic flux linkage between driven rotor and stator. Different geometrical shapes of the inner ring wall may be used to enhance this tendency.

Although torque motors provide sufficient torque for keeping the rotor blade in a desired angular position, an optional mechanical brake 28 is attached to hub 8 for an additional mechanical fixation of the rotor blade, or in the event of a malfunction of the direct drive 36. Brake 28 includes a ring-shaped brake disc 11 fixed to the inner wall of rotor blade 10 and a caliper 12 attached to hub 8.

Further, for controlling the angular position of rotor blade 8, a sensor 13 is mounted to hub 8. Sensor 13 can be, for instance, a Ferraris-Sensor for detecting eddy currents induced in brake disc 11. Alternatively, controlling of the angular position can be done by the position sensor of direct drive 36.

Fig. 3 shows a typical three-blade wind turbine with a pitch drive 107. Instead of having a conventional pitch drive, a direct drive 36as described above is used in such wind turbines. The described rotor with a pitch drive can be used for any type of wind turbine and is not restricted to a three-blade wind turbine.

Figure 4 shows a divided rotor blade on which the pitch angle can be set by a direct drive for the outer part 110a (rotatable part) of a rotor blade 10 while the inner part 110b remains fixed. This embodiment of the invention allows to pitch only a part or a segment of a rotor blade instead

of turning the entire blade around its mainly longitudinal axis.

A yaw drive comprising a direct drive 36 may have the same general set-up as described in conjunction with the pitch drive with the exception that hub 8 would be the tower and rotor blade 10 the nacelle.

Having thus described the invention in detail, it should be apparent that various modifications can be made in the present invention without departing from the spirit and scope of the following claims. Other configurations contemplated as within the scope of the invention include external driven rotors. In particular, gearless wind turbines, which have a direct connection between rotor and the drive shaft of the generator, may also be equipped with the described pitch and yaw drive.

LIST OF REFERENCE NUMBERS

1	inner ring of bearing 26
2	ring
3	permanent magnets
4	air gap
5	coils
6	bearing ring
7	bolts of stator
8	hub
9	outer ring of bearing 26
10	rotor blade
11	brake disc
12	caliper
13	sensor
20	stator
22	driven rotor
24	poles
26	pitch bearing
28	brake
30	bolts of inner ring 1
32	bolts of outer ring 9
34	rollers
36	direct drive
100	tower
102	nacelle
104	rotor shaft
106	rotor
107	pitch drive
108	hub
110	rotor blades
110a	outer section of a rotor blade (rotatable part of a rotor blade)

110b	fixed part of a rotor blade
112	gearbox
114	generator
116	air stream
118	drive-shaft of generator
120	bedplate of nacelle 102
122	yaw drive
124	power cables
126	grid connection
128	foundation
130	high-speed shaft brake

Claims

1. Rotor for a wind turbine comprising
a hub (8) and at least one rotor blade (10); and
at least one blade pitch system for adjusting the blade pitch angle of said entire rotor blade (10) or a part of said rotor blade (10), said blade pitch system comprises a direct drive (36).

2. Rotor according to claim 1,
characterized in that
the direct drive (36) comprises a driven rotor (22) and a stator (20), said stator (20) is attached to said hub (8) whereas said driven rotor (22) is attached to said rotor blade (10).

3. Rotor according to claim 1 or 2,
characterized in that
said driven rotor (22) has a ring-like shape surrounding the stator (20).

4. Rotor according to any one of the claims 1 to 3,
characterized in that
said rotor comprises a pitch bearing (26) interposed between said hub (8) and said rotor blade (10).

5. Rotor according to claim 4,
characterized in that
said pitch bearing (26) comprises an inner and outer ring (1, 9);
said outer ring (9) is attached to said hub (8),
said rotor blade (10) and said driven rotor (22) are attached via said inner ring (1).

6. Rotor according to any one of the claims 1 to 5, characterized in that
the rotor comprises a brake (28) for keeping said rotor blade (10) in a given pitch angle position.

7. Rotor according claim 6,
characterized in that
said brake (28) comprises a ring-shaped brake disc (11) attached to said rotor blade (10) and a brake caliper (12) attached to said hub.

8. Rotor according to any one of the claims 1 to 7, characterized in that
said rotor comprises a sensor (13) to determine said rotor blade's pitch angle.

9. Rotor according to any one of the claims 1 to 8, characterized in that
said stator comprises a plurality of poles (24), each pole having at least one electric coil (5) for generating a magnetic field.

10. Rotor according to any one of the claims 1 to 9, characterized in that
said driven rotor (22) comprises a plurality of permanent magnets (3).

11. Rotor according to any one of the claims 1 to 10, characterized in that
said rotor blade (10) comprises at least one fixed part (110b) and at least one rotatable part (110a), whereas the

pitch angle of said rotatable part is adjusted by the direct drive.

12. Rotor according to any one of the claims 1 to 11, characterized in that

said rotor comprises three rotor blades and three blade pitch systems, each of said three blade pitch systems is assigned to one of said three rotor blades.

13. Wind turbine comprising

a tower (100) and a nacelle (102), said nacelle is rotatably mounted on said tower (100) for changing the nacelle's yaw angle; and

a yaw drive system for turning said nacelle (102) with respect to said tower (100), said yaw drive system comprising a direct drive (36).

14. Wind turbine according to claim 13, characterized in that

the direct drive (36) comprises a driven rotor (22) and a stator (20), said stator (20) is attached to said tower (100) whereas said driven rotor (22) is attached to said nacelle (102).

15. Wind turbine according to claims 13 or 14, characterized in that

said driven rotor (22) has a ring-like shape surrounding the stator (20).

16. Wind turbine according to any one of the claims 13 to 15, characterized in that

said wind turbine comprises a bearing (26) interposed between said tower (100) and said nacelle (102).

17. Wind turbine according to claim 16, characterized in that said bearing (26) comprises an inner and an outer ring (1, 9); said outer ring (9) is fixed to said tower (100), said nacelle (102) and said driven rotor (22) are attached via said inner ring (1).

18. Wind turbine according to any one of the claims 13 to 17, characterized in that said wind turbine comprises a sensor to determine the nacelle's yaw angle.

19. Wind turbine according to any one of the claims 13 to 18, characterized in that said stator comprises a plurality of poles (24), each pole having at least one electric coil (5) for generating a magnetic field.

20. Wind turbine according to any one of the claims 13 to 19, characterized in that said driven rotor (22) comprises a plurality of permanent magnets (3).

21. Wind turbine according to any one of the claims 13 to 20, characterized in that

said wind turbine comprises a rotor according to any one of the claims 1 to 12.

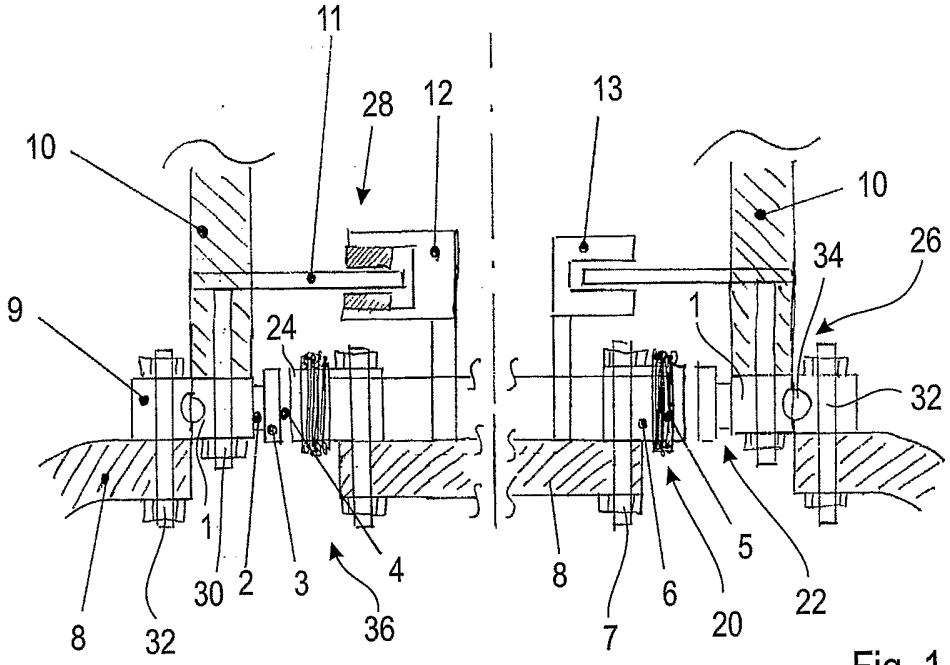

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Fig. 1

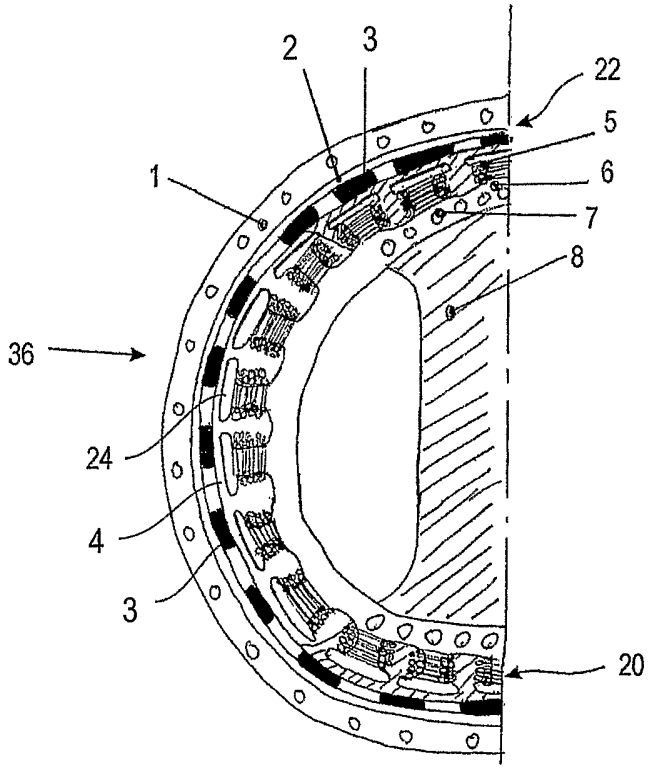

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Fig. 2

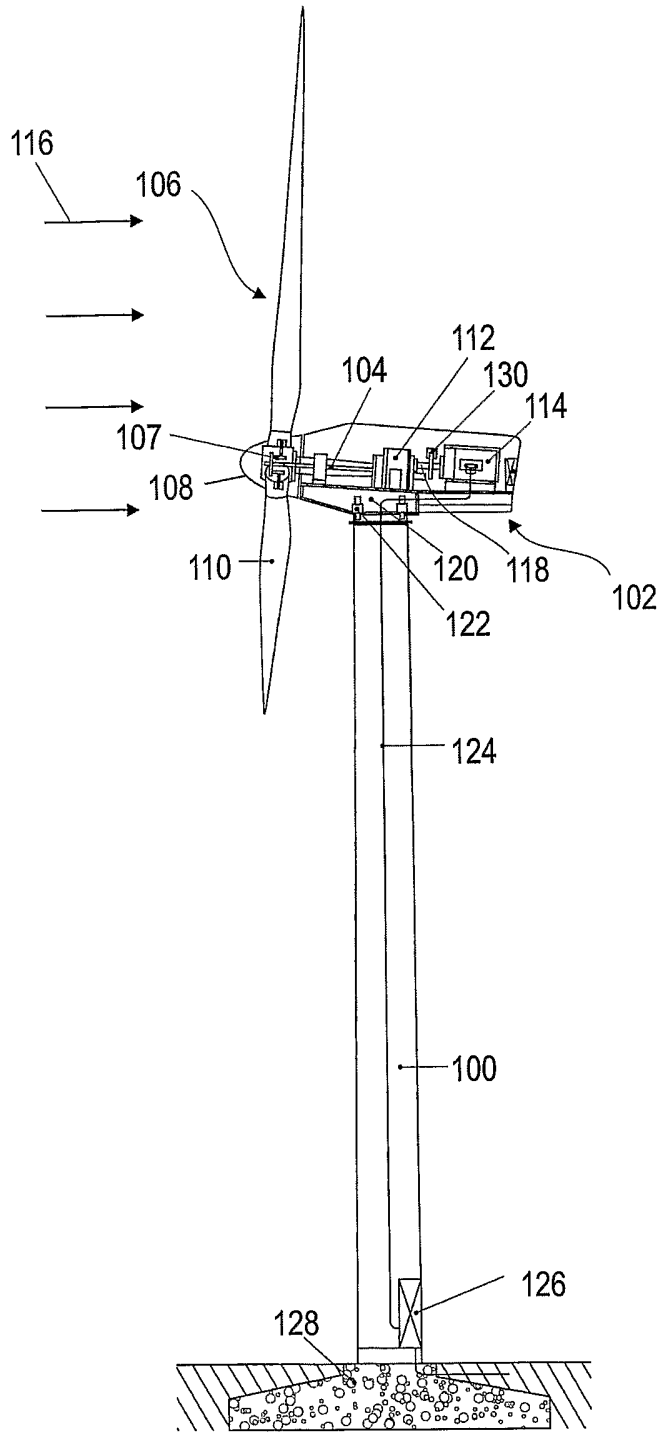

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Fig. 3

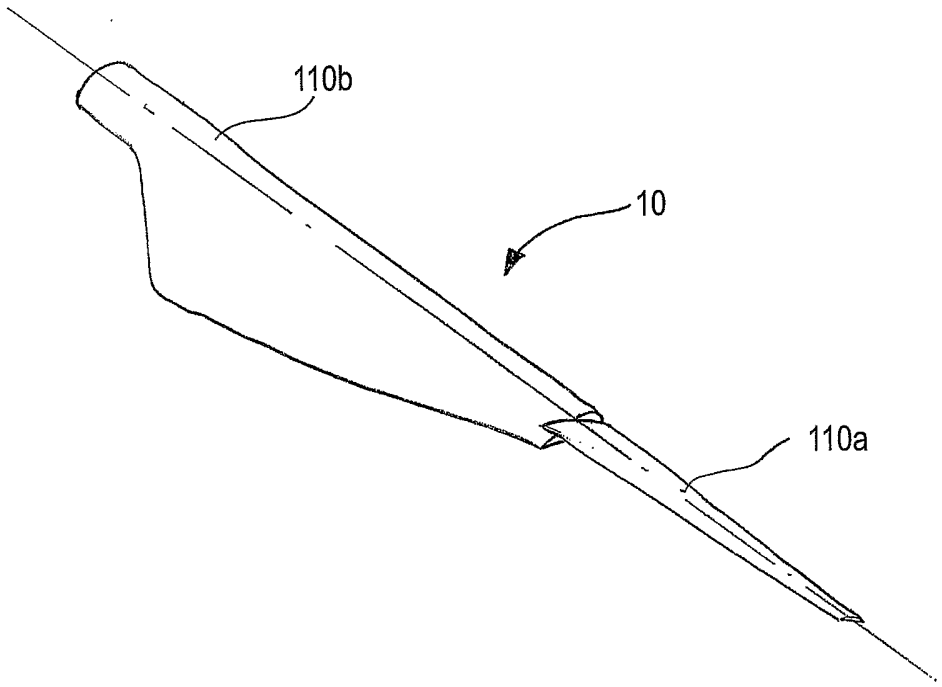


Fig. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 03/09306

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F03D7/02 F03D11/00

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)
IPC 7 F03D H02K B64C

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 practical, 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	DE 477 371 C (KURT BILAU) 8 June 1929 (1929-06-08) the whole document	1,11
Y	EP 0 809 022 A (SCHOENFELDT GUENTER ; RASCHKA JOST (DE)) 26 November 1997 (1997-11-26) abstract claim 3	1-12
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 June 2004	08. 07. 2004

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Criado Jimenez, F

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 03/09306

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP 03/09306

Box I Observations where certain claims were found unsearchable (Continuation of item 1 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 II Observations where unity of invention is lacking (Continuation of item 2 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 fee, this Authority did not invite payment of any additional fee.

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.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ 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: 1-12

Wind turbine blade pitch change mechanism using an electric stepping motor of large diameter placed at the union between blade and hub.

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2. claims: 13-21

Wind turbine nacelle yawing system utilizing a large diameter electric stepping motor

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 03/09306

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