POWER GENERATING DEVICE

A power generating device comprises a turbine (1) and a generator (2) with a stator (3), which is connected to a support arrangement (4), and a rotor (6). The rotor is rotatably mounted by means of at least one bearing (7). A hub (12) of the turbine is connected to the rotor (6) by means of a connecting device (14) arranged to transmit turning moment from the hub to the rotor. The hub (12) of the turbine is rotatably mounted relative to an axle part (16), which is connected to the support arrangement (4) via at least one second bearing (17) which is separate from the at least one first mentioned bearing (7). The connecting device (14) is arranged to transmit turning moment from the turbine hub (12) to the rotor (6) without or with only insignificant simultaneous transmission of bending moment.
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.
POWER GENERATING DEVICE

FIELD OF THE INVENTION AND PRIOR ART

The present invention relates to a power generating device according to the preamble of the subsequent claim 1. It is preferred that the turbine is a windpower turbine, i.e. that the device is suitable for a windpower plant. In particular, relatively high efficient devices with output powers up to several megawatts are intended in that connection.

DE C2 44 02 184 discloses a device according to the preamble of the subsequent claim 1. In connection with this known device, it is suggested that the turbine hub is fastened to the rotor in such a way that the turbine hub will be carried by the rotor. The turbine hub protrudes in a cantilever manner from the rotor, which is mounted in bearings relative to the stator. The turbine hub carries wings which have a considerable size, and will consequently be subjected to large forces. In particular, these forces result in that the rotor will be subjected to a considerable bending moment, which is accentuated by the cantilever design of the turbine hub from the rotor. There is a risk of this bending moment influencing the constancy of the air gap between the stator and the rotor of the generator. In order to counteract this at the known device, it is required a very heavily dimensioned rotor and the corresponding also applies to the bearing/the bearings between the rotor and the stator. This implies in its turn an increased weight of the rotor and a more costly design of the bearing/the bearings.
PURPOSE OF THE INVENTION

The object of the present invention is to develop the device according to the preamble of claim 1 further so that the bending moment from the turbine hub, in a manner which is advantageous as concerns the load, can be carried by the device without the rotor of the generator to an unacceptable negative extent being subjected to the bending moments.

SUMMARY OF THE INVENTION

According to the invention, this object is achieved in that the hub of the turbine is rotatably mounted relative to an axle part, which is connected or connectable to the support arrangement, via at least one second bearing which is separate from the at least one first mentioned bearing, and that the connecting device is arranged to transmit the turning moment from the turbine hub to the rotor without or with only insignificant simultaneous transmission of bending moment.

This solution implies, as the rotor is being released from bending moment, that the risk of undesired variations of the air gap between the rotor and the stator is substantially reduced and that the rotor can be dimensioned as less heavy than what would have been the case if bending moments from the turbine had been transmitted directly to the rotor. Owing to the inventive solution, the first bearing for the rotor will also be subjected to smaller stressing, which in combination with the smaller stressings on the rotor itself fully compensates for the fact that a further bearing has to be arranged for the turbine hub. The solution to the problem will also in broad result in a more rugged and reliable design in the sense that the risk of loads negatively influencing the generator in its entirety via the turbine hub is considerably reduced.
According to an advantageous embodiment of the invention, the axle part constitutes a constituent part of an axle, which is connected/connectable to the support arrangement and on which the stator of the generator is fastened. Stressings on the axle as a consequence of bending moments generated by the turbine will thereby be carried by the axle itself, without influencing the rotor, and be transmitted to the support arrangement. As a consequence of the rotor of the generator in the main not being subjected to bending moments, there will in the main not occur any variations as regards the working relation between stator and rotor.

An embodiment advantageous from a constructional and assembling point of view implies that the axle at a first end has the axle part which carries the turbine hub via the at least one second bearing, and at a second end is provided with means for connection of the axle to the support arrangement. Consequently, this axle with attached turbine hub and generator can form a premade unit, which is completely prepared in factory conditions, whereafter the axle is connected to the support arrangement at the occasion for the installation, which axle can have the character of a tower. Expressed in other words, the connection of the axle to the support arrangement consequently implies that the unit generator/turbine hub, which is fastened to the axle, is connected simultaneously.

According to the invention, the connecting device can comprise one or several connecting members which are designed to be torsion stiff but yielding to bending moments, the yieldingness can be realized through elasticity of the connecting members or freedom of movement between two connecting members included in the connecting device, one of which being fixed connected to the turbine hub whereas the other being fixed connected to the rotor.
In a particularly advantageous embodiment of the device, the rotor is provided with permanent magnets. The generator is in particular a synchronous generator, and then in particular a multipolar synchronous generator.

Further features and advantages of the invention appear from independent claims and the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the enclosed drawings, a more specific description of embodiment examples of the invention will follow hereinbelow.

In the drawings:

Fig 1 is a schematic, partly cut sectional view of the invention as seen horizontally from one side, a support arrangement in the form of the upper part of a tower or a mast being indicated, and

Fig 2 is an enlarged view of a detail of Fig 1, however in modified design.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Fig 1 illustrates the power generating device as comprising a turbine, generally denoted as 1, and a generator 2 with a stator 3, which is connected to a support arrangement 4, which here is proposed to have the character of a tower or a mast and the upper part of which being denoted as 5 in Fig 1, and a rotor 6, which is rotatably mounted by means of at least one bearing 7.

The stator 3 has stator windings 8 with a suitable core arrangement 9, suitably realized by means of packets of plates of ferromagnetic material.
The rotor 6 is provided with permanent magnets 10, which in the example are distributed along the circumference of the rotor and which have an air gap 11 between themselves and the core packet that in the example is located outwardly of the permanent magnets, which air gap is to be maintained constant as far as possible. It is emphasized that it is also possible to design the rotor in such a way that its permanent magnets will be located radially outside the stator windings 8. According to an alternative embodiment, the gap 11 is formed between flux concentrating members (soft magnetic poles) and the stator, whereas the permanent magnets in a conventional manner are co-ordinated with the flux-concentrating members.

The turbine 1 has a hub 12 and turbine wings 13 fixed on the hub in a suitable manner. The hub 12 is connected to the rotor 6 by means of a connecting device generally denoted 14 and arranged to transmit turning moment from the hub 12 to the rotor 6. Turning moment here refers to such influence that sets the rotor in pure rotation around its rotational axis.

The hub 12 of the turbine is rotationally mounted relative to an axle part 16, which is connected to the support arrangement 4, via at least one second bearing schematically indicated at 17. This second bearing is separate from the at least one first mentioned bearing 7. The connecting device 14 is arranged to transmit the turning moment from the turbine hub 12 to the rotor 6 without or with only insignificant simultaneous transmission of bending moment. Consequently, this implies that when the axle part 16 is subjected to bending, as a consequence of the load from the turbine 1, the arising bending moment will not be transmitted to the rotor 6, at least not to any appreciable extent, so that the rotor 6 consequently will not be subjected to any detrimentally deforming or otherwise position altering influence as a consequence of the deflection of the axle part 16. Such deformations or position alterations of the rotor 6 that
causes alterations of the air gap 11 between the rotor and the stator are particularly to be avoided in this respect.

The axle part 16 constitutes a constituent part of an axle, generally denoted as 15, which is connected to the support arrangement 4 and on which the stator 3 of the generator is fastened. In the example it is indicated how the generator 3 has a ring-shaped element 18, which is slipped onto the axle 15. The rotor 6 and the bearings 7 between the rotor and the stator element 18 are located radially outside the latter. It is emphasized that the rotor 6 can be mounted directly to the axle 15, i.e. without any stator element, as the one denoted 18, being provided between the rotor and the bearings 7. The stator and the rotor can be fastened to the axle 15 by means of shrinking, flange joint or the like. The axle 15 has means 19 for connection of the axle to the support arrangement 4. In the example, these means 19 are included in a connection, generally denoted as 20, which comprises corresponding means 21 on the support arrangement 4. In the example, these means 19, 21 are illustrated as consisting of flanges, which are fixed in relation to each other by means of fixing elements 22, such as screws or bolts.

At a first end the axle 15 has the axle part 16 which carries the turbine hub 12 via the at least one second bearing 17, and at a second opposite end the connecting means 19 are arranged. The stator 3 is fastened to the axle 15 in the area between the axle part 16 carrying the turbine hub and the other end of the axle provided with the means 19.

The connecting device 14 comprises one or several connecting members 23, which are torsion stiff in the sense that they are capable of transmitting turning moment between the turbine hub 12 and the rotor 6, but yielding to bending moment. Within the scope of these general directions the average man skilled in the art realizes that many possibilities of realization are offered.
Here a couple of alternatives may be discussed only for the purpose of exemplification.

According to a variant, the yieldingness of the connecting members 23 could be realized in that these are elastic. The elasticity is in this case to be such that it does not negatively affect the turning moment transmission, but this elasticity shall however allow the connecting members 23 to deform with a relatively small resistance when influenced by bending moments so that these are not, or only to an insignificant extent, transmitted to the rotor 6.

The connecting members 23 could be realized in the form of an annularly continuous structure, possibly provided with longitudinal slits facilitating elastic deformation under the influence of bending moments, but they could also be realized in the form of several separate connecting members distributed around the axle 15. Besides, these can be connected to the turbine hub 12 and the rotor 6, respectively, via suitable releasable fixing elements, such as screws or bolts or the like.

According to a second variant schematically illustrated in Fig 2, the connecting members of the connecting device 14′ could be at least two in number, and two such connecting members are illustrated in Fig 2 as 23a and 23b. A first one 23a of these is intended to be connected to the turbine hub 12, whereas a second one 23b is intended to be connected to the rotor 6. These first and second connecting members 23a, 23b are movably connected to each other via engagement elements 24, which operate force transmitting in tangential direction but allow freedom of movement between the connecting members in such an essentially axial direction that deflections of the axle part 16 are allowed without these being transmitted the rotor 6. For instance, these engagement elements could be realized by means of axially directed splines, as schematically indicated at 24.
The inventional device can be assembled in a factory, the generator 2 being applied on the axle 15 and the turbine hub 2 thereafter being applied on the axle part 16 and the connection of the turbine hub 2 and the rotor 6 being performed by means of the connecting device 14. This unit can thereafter in an assembled state be transported to the intended place of application, where the unit by means of the connection 20 is attached to the support arrangement 4 in question. Such a procedure eliminates the need of troublesome assembly of parts at the intended place of application.

It is evident that the described device can be modified in several ways within the scope of the inventional idea here referred to. What is here presented should thus only be considered as examples of a realization of the invention. Within the scope of the inventional idea all the variants falling within the scope of the subsequent claims are embraced and also equivalent embodiments. It is pointed out that the inventional power generating device realized as a windpower plant with advantage can be included in a larger windpower park comprising one or several windpower plants preferably of the same but also of other design. In a practical realization it is preferred that the generator is directly connected with a voltage above 10 kV, preferably above 20 kV. In an embodiment with directly connected generator, it is preferred that the generator is rectified. According to a further preferred embodiment, it is preferred that the generator is directly connected with a frequency lower than the traditional power frequency (50-60 Hz).
Claims

1. Power generating device comprising a turbine (1) and a generator (2) with a stator (3), which is connected or connectable to a support arrangement (4), and a rotor (6), which is rotatably mounted by means of at least one bearing (7), a hub (12) of the turbine being connected to the rotor (6) by means of a connecting device (14) arranged to transmit a turning moment from the hub to the rotor, characterized in that the hub (12) of the turbine is rotatably mounted relative to an axle part (16), which is connected or connectable to the support arrangement (4), via at least one second bearing (17), which is separate from the at least one first mentioned bearing (7), and that the connecting device (14) is arranged to transmit the turning moment from the turbine hub (12) to the rotor (6) without or with only insignificant simultaneous transmission of bending moment.

2. A device according to claim 1, characterized in that the axle part (16) constitutes a constituent part of an axle (15), which is connected/connectable to the support arrangement (4) and on which the stator (3) of the generator is fastened.

3. A device according to claim 2, characterized in that the axle (15) at a first end has the axle part (16) which carries the turbine hub (12) via the at least one second bearing (17), and at a second end is provided with means (19) for connection of the axle to the support arrangement.

4. A device according to claim 3, characterized in that the stator (3) is fastened at the axle (15) in the area between the axle part (16) carrying the turbine hub and the other end of the axle.

5. A device according to any of the preceding claims, characterized in that the connecting device (14) comprises one or
several connecting members (23), which are torsion stiff but yielding to bending moments.

6. A device according to claim 5, characterized in that the yieldingness of the connecting members (23) is elastic.

7. A device according to claim 5, characterized in that the connecting members (23) of the connecting device (14) are two in number, of which at least a first one (23a) is fixed connected to the turbine hub (12), whereas at least a second one (23b) is fixed connected to the rotor (6), and that these first and second connecting members engage with each other via engagement elements (24), which transmit turning moment but allow relative freedom of movement between the connecting members as regards bending moment.

8. A device according to any of the preceding claims, characterized in that the turbine (1) is a wind power turbine.

9. A device according to any of the preceding claims, characterized in that the rotor (6) is provided with flux generating permanent magnets (10).

10. A device according to any of the preceding claims, characterized in that the generator (2) is a synchronous generator.
## INTERNATIONAL SEARCH REPORT

### A. CLASSIFICATION OF SUBJECT MATTER

**IPC7:** F03D 9/00, F03D 11/00 // H02K 7/18

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)

**IPC7:** F03D, F16H, H02K

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

SE, DK, FI, NO classes as above

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

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C. See patent family annex.

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

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