

(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 200112797 B2**
(10) Patent No. **758742**

(54) Title
Wind power installation with two rotors in tandem

(51)⁶ International Patent Classification(s)
F03D 001/02

(21) Application No: 200112797 (22) Application Date: 2000 . 11 . 14

(87) WIPO No: WO01/55590

(30) Priority Data

(31) Number	(32) Date	(33) Country
10003385	2000 . 01 . 26	DE

(43) Publication Date : 2001 . 08 . 07

(43) Publication Journal Date : 2001 . 10 . 18

(44) Accepted Journal Date : 2003 . 03 . 27

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(56) Related Art
DE 746340C
US 4345161
US 4065225

AU 200112797

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES
PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

(19) Weltorganisation für geistiges Eigentum
Internationales Büro



(43) Internationales Veröffentlichungsdatum
2. August 2001 (02.08.2001)

PCT

(10) Internationale Veröffentlichungsnummer
WO 01/55590 A1

(51) Internationale Patentklassifikation: F03D 1/02

(21) Internationales Aktenzeichen: PCT/EP00/11218

(22) Internationales Anmeldedatum:
14. November 2000 (14.11.2000)

(25) Einreichungssprache: Deutsch

(26) Veröffentlichungssprache: Deutsch

(30) Angaben zur Priorität:
100 03 385.7 26. Januar 2000 (26.01.2000) DE

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(81) Bestimmungsstaaten (national): AE, AG, AL, AM, AT,
AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU,
CZ, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR,
HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR,
LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ,
NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM,
TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

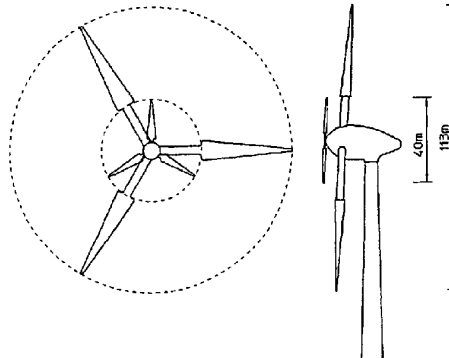
(84) Bestimmungsstaaten (regional): ARIPO-Patent (GH,
GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW),
eurasisches Patent (AM, AZ, BY, KG, KZ, MD, RU, TJ,
TM), europäisches Patent (AT, BE, CH, CY, DE, DK,
ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR),
OAPI-Patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML,
MR, NE, SN, TD, TG).

Veröffentlicht:
mit internationalem Recherchenbericht

[Fortsetzung auf der nächsten Seite]

(54) Title: WIND POWER INSTALLATION WITH TWO ROTORS IN TANDEM

(54) Bezeichnung: WINDENERGIEANLAGE MIT ZWEI HINTEREINANDER ROTOREN



(57) Abstract: The invention relates to a large-scale wind power installation. While rotor blades that are optimized to provide for maximum output can be easily produced for smaller installations and can be transported without problems, rotor blades for larger installations have two draw-backs. The very large surface of the rotor blade produces very high loads on the rotor blade base at high wind speeds so that the power installation has to be switched off. These very high loads require a specific design (dimensioning) of the entire wind power installation. The second draw-back resides in the production of a rotor blade with a very large blade depth. The aim of the invention is to overcome these problems and to simplify both the production and the operation of the wind power installation. To this end, the wind power installation is provided with at least two rotors in tandem, the first rotor that is disposed in front of the second rotor having a smaller diameter than the second rotor.

[Fortsetzung auf der nächsten Seite]

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Zur Erklärung der Zweibuchstaben-Codes, und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

(57) Zusammenfassung: Die Erfindung betrifft eine Grosswindenergieanlage. Während ein solches auf maximalen Wirkungsgrad optimiertes Rotorblatt für kleinere Anlagen gut zu fertigen ist und auch problemlos transportiert werden kann, hat ein solches Rotorblattkonzept zwei Nachteile. Erstens erzeugt die sehr grosse Fläche des Rotorblattes an der Rotorblattwurzel bei hohen Windgeschwindigkeiten sehr hohe Lasten. Regelmässig ist dann bereits die Windenergieanlage abgeschaltet. Für diese sehr hohen Lasten muss aber die gesamte Windenergieanlage ausgelegt (dimensioniert) werden. Der zweite Nachteil besteht in der Fertigung eines Rotorblatts mit sehr grosser Blatttiefe. Aufgabe der Erfindung ist es, die vorgenannten Probleme zu beseitigen und die Fertigung einer Windenergieanlage sowie deren Betrieb zu vereinfachen. Windenergieanlage mit wenigstens zwei hintereinander angeordneten Rotoren, von denen der erste Rotor, der vor dem zweiten Rotor angeordnet ist, einen kleineren Durchmesser aufweist als der zweite Rotor.

Abstract

The invention concerns a wind power installation, in particular a large-scale wind power installation with an output power of more than two MW, preferably about five MW or more

In accordance with the invention, for a large-scale wind power installation of that kind, there is proposed a rotor design and the configuration of corresponding rotor blades, so that reliable operation of such a wind power installation is possible.

While such a rotor blade which is optimised for a maximum degree of efficiency is good to produce for relatively small installations and can also be transported without any problem, such a rotor blade design suffers from two disadvantages. Firstly, the very large area of the rotor blade at the rotor blade root gives rise to very high loads when high wind speeds are involved. The wind power installation is usually then already shut down. However, the entire wind power installation has to be designed (dimensioned) for those very high loads. The second disadvantage lies in production of a rotor blade involving a very great blade depth.

The object of the invention is to eliminate the above-indicated problems and to simplify the production of a wind power installation and the operation thereof.

A wind power installation comprising at least two rotors which are arranged one behind the other and of which the first rotor which is arranged in front of the second rotor is of a smaller diameter than the second rotor.



Bremen 10th November 2000
Our Ref: W 2158 KGG/esa/dw
Applicant/proprietor: WOB BEN, Aloys
Office Ref: New application

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Wind power installation

The invention concerns a wind power installation, in particular a large-scale wind power installation with an output power of more than two MW, preferably about five MW or more

In accordance with the invention, for a large-scale wind power
5 installation of that kind, there is proposed a rotor design and the configuration of corresponding rotor blades, so that reliable operation of such a wind power installation is possible.

In that respect it should be pointed out that it is already state of the art (Erich Hau, "Windkraftanlagen" ("Wind Power Installations"), 1996,
10 2nd edition, page 113 ff) for a rotor blade which is optimised for a maximum degree of efficiency to be provided in the inner region with very great blade depths. Such rotor blades are used for example by Enercon in the wind power installation of type E-40 (power range is between 500 and 600 KW). The inner region of a rotor blade is in that respect that portion



which is close to the hub (rotor blade root) and accordingly involves a small radius.

While such a rotor blade which is optimised for a maximum degree of efficiency is good to produce for relatively small installations and can
5 also be transported without any problem, such a rotor blade design suffers from two disadvantages. Firstly, the very large area of the rotor blade at the rotor blade root gives rise to very high loads when high wind speeds are involved. The wind power installation is usually then already shut down. However, the entire wind power installation has to be designed
10 (dimensioned) for those very high loads. The second disadvantage lies in production of a rotor blade involving a very great blade depth. While that disadvantage is still scarcely significant in relation to rotor blades of a relatively small radius, manufacture and subsequent transportation of such a rotor blade which is of a very great length (for example more than
15 50 m) is highly complicated and in part impossible and the very great blade depth entails an extremely great increase in material and labour.

For those reasons the proposal has been made to circumvent the great blade depths. Figure 2 shows a design configuration which was earlier frequently built in Denmark.

20 In this embodiment of a rotor blade, the inner region was completely eliminated. As the harvest area corresponds to the rotor area which is swept, it was assumed that it was possible to forego that very small area (inner region area) which only corresponds to about 5% of the total area, or to slightly enlarge the rotor diameter in order thereby to
25 compensate for the area flow.

In that respect however the point was overlooked or not noted that this results in the formation of an aerodynamic hole in the near region of the wind power installation with rotor blades as shown in Figure 2. In the near region the wind can flow unimpededly through that hole without
30 experiencing any resistance. The result of this is that no laminar flow is built up in the inner region (first region of the rotor of the wind power



installation) of the beginning profile at the rotor blade. That also means that the first region of the rotor blade with an (active) rotor profiling cannot contribute to energy generation.

5 Enercon already developed at a very early date (about 1990) thick, cut-off profiles in order to get around the above-indicated problems.

Figure 3 shows such a profile which was used in the inner region of the rotor blade. In the case of large wind power installations (rotor diameters of over 70m) however even the cut-off profiles result in blade depths of up to 6m, which makes transportation of such rotor blades
10 extremely difficult and makes the manufacture thereof extraordinarily complicated and expensive.

The object of the invention is to eliminate the above-indicated problems and to simplify the manufacture of a wind power installation and the operation thereof.

15 The invention attains that object with the features of a wind power installation as set forth in claim 1. Advantageous developments are set forth in the appendant claims.

The concept of the wind power installation in accordance with the invention involves providing the wind power installation with two rotors of
20 which the first, the small rotor, is arranged in front of the second, the larger rotor. Accordingly it is proposed in accordance with the invention that the inner region of the rotor of a wind power installation is completely separated from the outer region.

Such a wind power installation is described by way of example with
25 reference to the Figures hereinafter. In this respect the model adopted for the description is a large-scale wind power installation involving a diameter of about 113m and an installed generator output of about 5 MW. The rotor for the inner region is in this case of about 40m in diameter.

Accordingly, for the second rotor, the larger rotor, there still
30 remains an active rotor blade length of about 36.5m. The first small rotor rotates at a nominal speed of about 38 rpm. The second large rotor



rotates at a nominal speed of 11 rpm. That means that the peripheral speeds of the rotor blade tips of the two rotors are almost the same.

The advantage of the wind power installation according to the invention is that only a very small engagement surface presents itself in relation to high wind speeds, for the inner region of the rotor. Accordingly the extreme loadings on the entire wind power installation are very much lower.

A further advantage is that the rotor blade for the outer region (the second rotor) can be produced as a unit of a length of about 36.5m. Such a rotor blade can be fitted onto a rotor blade stump which aerodynamically no longer provides any relevant contribution to driving the rotor. That means that transportation of the rotor blades is readily possible.

A further advantage is also that the rotor blade adjusting device of the second rotor no longer has to be so large in design as the rotor blade adjusting device can be fitted (mounted) on the rotor blade stump and accordingly is about 20m (radius of the small rotor) away from the hub.

In operation of the wind power installation each rotor drives its own generator. The generator of the first rotor is disposed between the first and second rotors and is preferably driven directly by it. In regard to the design structure of the wind power installation according to the invention, this means that a rotor-generator arrangement of relatively small type, for example of type E-40 from Enercon, is placed in front of the second rotor. In that case both rotors and both generators are carried by a single trunnion and are mounted rotatably thereon.

Preferably both rotors rotate in the same direction (clockwise), but it is also possible if the rotor blades are of a suitable design configuration for the rotors to be caused to rotate in opposite directions.

The pylon of the wind power installation according to the invention is more than 100m in height, for example the hub height is in the region of between 120 and 160m.



In operation of the wind power installation the smaller rotor (the first rotor) provides that no aerodynamic hole can be formed in the inner region of the second rotor.



CLAIMS

1. A wind power installation comprising at least two rotors which are arranged one behind the other and of which the first rotor which is arranged in front of the second rotor is of a smaller diameter than the second rotor characterised in that the nominal speed of rotation of the first rotor is markedly higher than the nominal speed of rotation of the second rotor and the peripheral speed of the rotor blade tips of both rotors is approximately equal in nominal operation.

2. A wind power installation as set forth in claim 1 characterised in that the first rotor rotates at a higher rotary speed than the second rotor.

3. A wind power installation as set forth in claim 1 and claim 2 characterised in that the nominal rotary speed of the first rotor is approximately in the range of between 25 and 45 rpm.

4. A wind power installation as set forth in claim 1 and claim 2 characterised in that the nominal rotary speed of the second rotor is approximately in the range of between 5 and 19 rpm.

5. A wind power installation as set forth in one of the preceding claims characterised in that the peripheral speed of the rotor blade tips of both rotors is approximately equal in nominal operation.

6. A wind power installation as set forth in one of the preceding claims characterised in that a respective generator is associated with each rotor.

7. A wind power installation as set forth in one of the preceding claims characterised in that the first rotor is of a diameter of between about 35 and 55m and the second rotor is of a diameter of between about 100 and 150m, preferably about 113m.



8. A wind power installation comprising a first and a second rotor, wherein the second rotor is of a markedly larger diameter than the first rotor and is arranged behind the first rotor and the second rotor has rotor blades whose active blade areas begin only in the region of the rotor blade tips of the first rotor.

9. A wind power installation as set forth in one of the preceding claims characterised in that the second rotor has rotor blades which comprise two portions, wherein the second outer portion of the rotor blades forms the active rotor blade and the first portion of the rotor blade is aerodynamically such that it makes no relevant contribution to driving the rotor.

10. A wind power installation as set forth in claim 9 characterised in that a rotor blade adjusting device is provided for a rotor blade of the second rotor, said rotor blade adjusting device being between the first and second rotor blade portions.

11. A wind power installation as set forth in claim 9 and claim 10 characterised in that the first rotor blade portion of the second rotor is fixed rigidly to the hub of the second rotor.

12. A wind power installation comprising a rotor arrangement which has a rotor inner region and a rotor outer region, wherein the inner region of the rotor is separated from the outer region of the rotor.

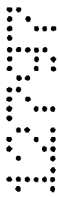
13. A wind power installation as set forth in one of the preceding claims characterised in that arranged between the first rotor and the second rotor is a first generator whose generator rotor is connected to the first rotor and is driven thereby.



14. A wind power installation as set forth in one of the preceding claims characterised in that the first rotor is arranged so closely in front of the second rotor that no aerodynamic hole can be formed in the region of the second rotor.

15. A wind power installation as set forth in one of the preceding claims characterised in that both rotors rotate in the same direction (clockwise).

16. A wind power installation substantially as herein described.



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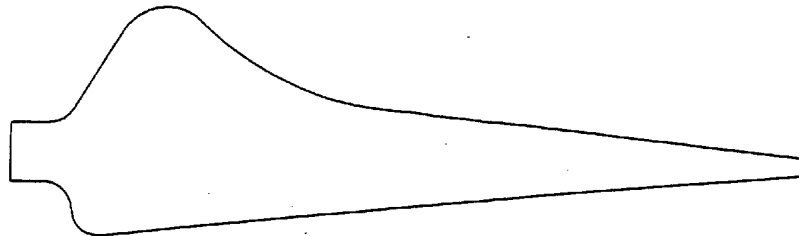


Fig. 1

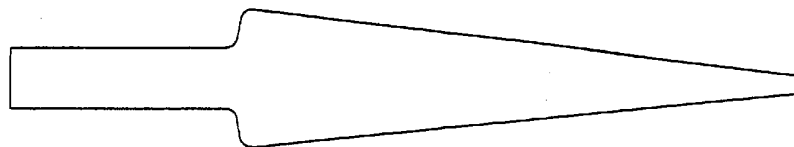


Fig. 2



Fig. 3

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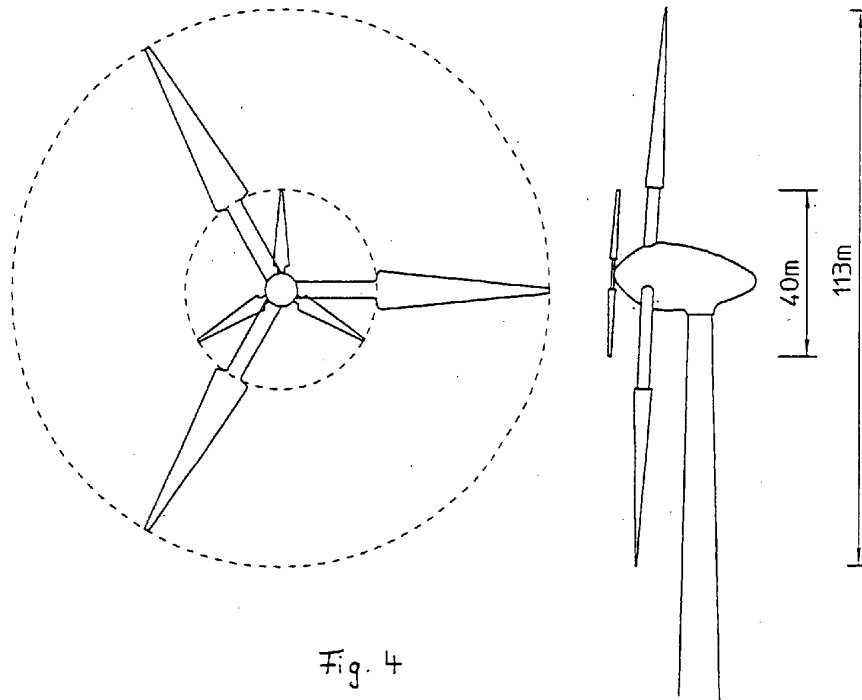


Fig. 4