(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 June 2008 (19.06.2008)

PCT

(10) International Publication Number
WO 2008/070917 A1

(51) International Patent Classification:
F03D 1/00 (2006.01) *F03D 11/00* (2006.01)
F03D 1/06 (2006.01)

(21) International Application Number: PCT/AU2007/001919

(22) International Filing Date: 13 December 2007 (13.12.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2006906944 13 December 2006 (13.12.2006) AU

(71) Applicant (*for all designated States except US*): **AERO-GENESIS AUSTRALIA PTY LTD** [AU/AU]; 109 Marmong Street, Marmong Point NSW 2284 (AU).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): **WOOD, David** [AU/AU]; 109 Marmong Street, Marmong Point NSW 2284 (AU).

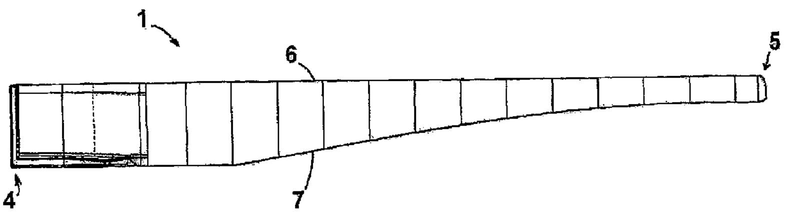
(74) Agent: **FRASER OLD & SOHN**; PO Box 560, Milsons Point, NSW 1565 (AU).

(81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(54) Title: WIND TURBINE & WIND TURBINE BLADE



(57) Abstract: A wind turbine blade to be mounted to a wind turbine hub configured to be mounted for rotation in a hub plane of rotation so as to generate electricity is provided. The blade extends lengthwise between a hub mounting root end and a blade tip end. The blade extends a blade width between a leading edge and trailing edge such that when mounted to the hub the blade is twisted at the root end by an angle of between 19° to 21° relative to the plane of rotation of the hub and wherein the blade is twisted at atip end to rotate in a plane parallel to the plane of rotation of the hub to within ±1°.

WO 2008/070917 A1

WIND TURBINE & WIND TURBINE BLADE

Field of the Invention

The present invention relates to wind powered turbines and, in particular to a wind turbine blade and a wind turbine using the blades.

The invention has been developed primarily for use in 2kW to 10kW horizontal axis wind turbine electricity generators and will be described hereinafter with reference to this application. However, it will be appreciated that the invention is not limited to this particular field of use.

Background Art

Horizontal axis wind turbines are well known, the windmill being a most exemplary example. The principle of operation of a windmill has been expanded from pumping water or grinding to the generation of electricity. In use, at least a pair of turbine blades are mounted symmetrically about a rotating turbine hub. In response to an incident wind, the hub is caused to rotate. The hub is connected either directly or indirectly to an electrical generator shaft (rotor) such that rotation of the shaft generates an electrical output from the generator.

Wind turbine blade design is commonly based on blade element theory (BET), whether by manufacturers of large or small turbine blades. In the blade element theory, a turbine blade is longitudinally divided into a number of elements and each element is assumed to behave as an aerofoil section at the same velocity and angle of attack.

Once this is done, the lift and drag coefficients for the aerofoil can then be used to determine the torque acting on each element. The sum of the torque on all of the blade elements provides a total torque from which a total power output is derived. Reference is made to the "Wind Energy Handbook", Burton et al (John Wiley & Sons) 2001, the disclosure of which is incorporated herein in its entirety by cross-reference. An extensive description of blade element theory is provided by Burton et al. and it will be understood that this teaches the determination of the power output and optimisation of the blade shape for maximising the generated power in given wind conditions.

Most large wind turbine (for example 20kW+) blades have a circular or substantially circular blade root to allow the most secure connection to the wind turbine hub. The blade section gradually transforms to the circular or substantially circular root shape as the blade length decreases and the hub approaches. Unfortunately, such blade designs and arrangements cause an overly significant decrease in starting performance when used on relatively small turbine blades.

Genesis of the Invention

It is the genesis of the invention to provide a wind turbine that optimises both the starting characteristics of the turbine and the power extracted therefrom at a nominal speed, or to provide a useful alternative.

Summary of the Invention

According to a first aspect of the present invention there is provided a wind turbine blade configured to be mounted to a wind turbine hub configured to be mounted for rotation in a hub plane of rotation so as to generate electricity, the blade extending lengthwise between a hub mounting root end and a blade tip end, and extending a blade width between a leading edge and trailing edge, such that when mounted to the hub the blade is twisted at the root end by an angle of between 19° to 21° relative to the plane of rotation of the hub and wherein the blade is twisted at a tip end to rotate in a plane parallel to the plane of rotation of the hub to within ±1°.

According to a second aspect of the present invention there is provided a wind turbine including a turbine hub configured to be rotatably mounted for rotation in a hub plane of rotation so as to inductively generate electricity, and two or more wind turbine blades each according to the first aspect of the invention and being mounted symmetrically about the hub.

According to a third aspect of the invention there is provided a wind turbine blade configured to be mounted to a wind turbine hub configured to be mounted for rotation in a hub plane of rotation so as to generate electricity, the blade extending lengthwise between a hub mounting root end and a blade tip end, and extending a blade width between a leading edge and trailing edge, such that when mounted to the hub the blade is twisted by an angle of between -1° to 25° about a blade longitudinal axis extending lengthwise along the blade relative to the plane of rotation of the hub and wherein the blade tip end is configured to rotate in a plane parallel to the plane of rotation of the hub to within ±1°.

According to another aspect of the invention there is provided a wind turbine blade configured to be mounted to a wind turbine hub configured to be mounted for rotation in a hub plane of rotation so as to generate electricity, the blade extending lengthwise between a hub mounting root end and a blade tip end, and extending a blade width between a leading edge and trailing edge, such that when mounted to the hub the blade is twisted at the root end by an angle of between 19° to 21° relative to the plane of rotation of the hub wherein the turbine blade is twisted by an angle of between -1° to 25° about a blade longitudinal axis extending lengthwise along the blade.

It can therefore be seen that there is provided a wind turbine blade and a horizontal axis wind turbine employing the blades 1 which each advantageously optimise the starting characteristics of a 2kW to 10kW horizontal axis wind turbine generator and also optimise the power extracted from the horizontal axis wind turbine generator at a nominal operating rotations speed.

Brief Description of the Drawings

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a schematic top view of a wind turbine blade according to the preferred embodiment;

Fig. 2 is a schematic side view of the blade of Fig. 1;

Fig. 3 is an end view of the blade of Fig. 1;

Fig. 4 is a top view of the blade of Fig. 1 as mounted to one part of a wind turbine hub;

Fig. 5 is a side view of the blade and hub of Fig. 4;

Fig. 6 is an end view of the blade and hub of Fig. 4;

Fig. 7 is a schematic top view of a pair of blades of Fig. 1 mounted to a wind turbine hub;

Fig. 8 is a schematic side view of the blades of Fig. 7;

Fig. 9 is an end view of the blades of Fig. 7;

Fig. 10 is a schematic perspective view of a horizontal axis wind turbine having the blades shown in Fig. 7 mounted thereto;

Fig. 11 is a graph of the chord length as a function of blade length for the blade of Fig. 1; and

Fig. 12 is a graph of the blade twist as a function of blade length for the blade of Fig. 1.

Detailed Description

Referring to the drawings generally, it will be appreciated that like reference numerals refer to like components.

Referring to Figs. 1 to 3 generally, there is shown various views of a wind turbine blade 1 according to the preferred embodiment of the invention. The blade 1 is configured to be mounted to a horizontal axis wind turbine hub 2 as shown in Figs. 4 to 9. The hub 2 is configured to be rotatably mounted for rotation in a hub plane of rotation to a horizontal axis of a wind turbine generator 3, as shown in Fig. 10.

Rotation of the hub 2 causes rotation of a 2kW to 10kW horizontal axis wind turbine generator 11 which causes an inductive electricity generator rotor (not illustrated) to rotate to thereby inductively generate electricity. An inductive electrical generator 11 is disposed in the horizontal axis wind turbine housing 3 (or nacelle) best shown in Fig. 10.

A pair of turbine blades 1 are symmetrically disposed about the hub 2. The blades 2 are disposed about the hub with a 180° angular spacing and are therefore equi-spaced about the hub axis of rotation. Each wind turbine blade 1 extends lengthwise between a hub mounting root end 4 and a blade tip end 5. Each wind turbine blade also extends a blade width between a blade leading edge 6 and a blade trailing edge 7.

When mounted to the hub 2, each wind turbine blade is twisted at the root end 4 by an angle of between 19° to 21° relative to the plane of rotation of the hub 2.

Each turbine blade 1 is configured such that each blade tip end 5 may be twisted to rotated in a plane of rotation of the hub to within ±1°. In the embodiment shown, each blade tip end 5 is configured to rotate in a plane parallel to the plane of rotation of the hub 2 to within 0.5°.

The chord length of each turbine blade 1 varies along the blade length as shown in Figs. 1 and 2. Fig. 11 is a graph of the chord length of each wind turbine blade as a function of the blade length. The data forming the graph of Fig. 11 is as follows:

Radius (mm)	Chord (mm)
300.83	250.00
452.50	250.00
604.17	250.00
755.83	250.00
907.50	229.66
1059.17	207.31
1210.83	185.17
1362.50	163.84
1514.17	143.91
1665.83	125.99
1817.50	110.67
1969.17	98.55
2120.83	90.23
2272.50	86.31
2424.17	86.31
2500.00	86.31

It can be seen that the chord length of each turbine blade 1 is substantially constant at the blade root end 4 and the chord length is also substantially constant at the blade tip end 5. In this preferred embodiment, the chord length of each turbine blade 1 is constant over approximately the first 33% of the length of the turbine blade 1 from the blade root end 4 towards the blade tip end 5. The chord length of each turbine blade is also substantially constant over approximately 6% of the length of the turbine blade 1 from the blade tip end 5 toward the blade root end 4.

In the preferred embodiment of the blade 1 shown in Figs. 1 to 9, each blade length from the blade root end 4 to the blade tip end 5 is 2.5 metres. The maximum chord length, as shown in Fig. 11, is 250mm at the blade root end 4 and about 90mm at the tip end 5 of each blade 1. Although not clearly shown, the hub mounting root end 4 of each blade 1 is substantially rectangular in cross-section.

As best shown in Fig. 10, each blade 1 when mounted to the wind turbine hub 2 and horizontal axis wind turbine generator 11 is configured such that each blade leading edge 6 forms a substantially straight line from the hub mounting end 4 to the blade tip end 5. Further, each blade leading edge 6 is configured to be disposed upwind relative to the trailing edge 7 in an "up-wind" wind turbine where the blades 1 are faced directly into the wind. Although not illustrated, it will be appreciated that the horizontal axis wind turbine generator 11 can be a "down-wind" type wind turbine in which the blades face away from the wind and are partly shadowed by the horizontal axis wind turbine generator 11 and/or its support post.

Each wind turbine blade 1 is twisted along a blade longitudinal axis extending lengthwise along the blade 1 by an angle of between -1° and 21° relative to the plane of rotation of the hub 2. In the preferred embodiment shown, each wind turbine blade 1 is twisted at the blade root end 4 by an angle of 20° with respect to the plane of rotation of the hub 2. Each wind turbine blade 1 is twisted at the blade tip 5 end by an angle of between -0.5° to 0° relative to the plane of rotation of the hub.

Fig. 12 shows the blade twist relative to the plane of rotation of the blades 1 when mounted to the hub 2 and the horizontal axis wind turbine generator 11, shown in Fig. 10 for example. The data forming the graph of Fig. 11 is as follows:

Radius (mm)	Twist (°)
300.83	24.73
452.50	23.40
604.17	20.95
755.83	17.84
907.50	14.44
1059.17	11.07
1210.83	7.97
1362.50	5.33

1514.17	3.25
1665.83	1.76
1817.50	0.83
1969.17	0.36
2120.83	0.18
2272.50	0.05
2424.17	-0.10
2500.00	-0.16

In the preferred embodiment, each wind turbine blade 1 is preferably moulded from fibreglass, however, any preferred wind turbine blade construction techniques can be employed. Likewise, it will be appreciated that the blade length can be any preferred and that any preferred inductive electrical generator or horizontal axis wind turbine generator can be used. It will be appreciated that active or passive yaw control of the turbine generator 11 can be employed as desired, as can any preferred gearbox mechanism with any preferred gearbox ratio, or the hub 2 may be directly rotatably mounted to the horizontal axis wind turbine generator if desired.

It can therefore be seen that the wind turbine blade 1, and the horizontal axis wind turbine 11 employing the blades 1, advantageously optimise the starting characteristics of a 2kW to 10kW horizontal axis wind turbine generator 11. The horizontal axis wind turbine generator 11 also advantageously optimises the power extracted from the horizontal axis wind turbine generator 11 at a nominal operating rotations speed.

The foregoing describes only one embodiment of the present invention and modifications, obvious to those skilled in the art, can be made thereto without departing from the scope of the present invention.

CLAIMS:

1. A wind turbine blade configured to be mounted to a wind turbine hub configured to be mounted for rotation in a hub plane of rotation so as to generate electricity, the blade extending lengthwise between a hub mounting root end and a blade tip end, and extending a blade width between a leading edge and trailing edge, such that when mounted to the hub the blade is twisted at the root end by an angle of between 19° to 21° relative to the plane of rotation of the hub and wherein the blade is twisted at a tip end to rotate in a plane parallel to the plane of rotation of the hub to within ±1°.

2. A wind turbine blade according to claim 1 wherein the chord length of each blade varies along the blade length such that the blade root end has a substantially constant cord length.

3. A wind turbine blade according to claim 1 wherein the blade tip end has a substantially constant cord length.

4. A wind turbine blade according to claim 2 or 3 wherein the chord length of the turbine blade is substantially constant over 20% to 35% of the length of the blade from the blade root end towards the blade tip end.

5. A wind turbine blade according to claim 2 or 3 wherein the chord length of the blade is substantially constant over 5% to 20% of the length of the blade from the blade tip end towards the root end.

6. A wind turbine blade according to claim 1 wherein the blade is twisted at the blade root end by an angle of 20° with respect to the plane of rotation of the hub.

7. A wind turbine blade according to claim 1 wherein the twist of the turbine blade at the tip end is between -0.5° to 0° such that the blade tip rotates in a plane parallel to the plane of rotation of the hub to within 0.5°.

8. A wind turbine blade according to claim 1 wherein the turbine blade length is 2.5 metres and the maximum chord length is 250mm at the blade root end and between 85mm and 90mm at the blade tip end.

9. A wind turbine according to claim 1 wherein the turbine blade leading edge forms a substantially straight line from the hub mounting end to the blade tip end.

10. A wind turbine blade according to claim 1 wherein the root end of the turbine blade is substantially rectangular in cross-section.

11. A wind turbine blade according to claim 1 wherein the turbine blade is twisted by an angle of between -1° to 25° about a blade longitudinal axis extending lengthwise along the blade.

12. A wind turbine blade according to claim 1 wherein the chord length of the blade as a function of the blade length is:

Radius (mm)	Chord (mm)
300.83	250.00
452.50	250.00
604.17	250.00
755.83	250.00
907.50	229.66
1059.17	207.31
1210.83	185.17
1362.50	163.84
1514.17	143.91
1665.83	125.99
1817.50	110.67
1969.17	98.55
2120.83	90.23
2272.50	86.31
2424.17	86.31
2500.00	86.31

13. A wind turbine blade according to claim 1 wherein the twist of the blade relative to the plane of rotation of the hub as a function of blade length is:

Radius (mm)	Twist (°)
300.83	24.73
452.50	23.40
604.17	20.95
755.83	17.84
907.50	14.44
1059.17	11.07
1210.83	7.97
1362.50	5.33
1514.17	3.25
1665.83	1.76
1817.50	0.83
1969.17	0.36
2120.83	0.18
2272.50	0.05
2424.17	-0.10
2500.00	-0.16

14. A wind turbine including a turbine hub configured to be rotatably mounted for rotation in a hub plane of rotation so as to inductively generate electricity, and two or more wind turbine blades each according to claim 1 and being mounted symmetrically about the hub.

15. A wind turbine according to claim 14 including three wind turbine blades disposed symmetrically about the hub such that the angle between each blade is 120°.

16. A wind turbine blade configured to be mounted to a wind turbine hub configured to be mounted for rotation in a hub plane of rotation so as to generate electricity, the blade extending lengthwise between a hub mounting root end and a blade tip end, and extending a blade width between a leading edge and trailing edge, such that when mounted to the hub the blade is twisted by an angle of between -1° to 25° about a blade longitudinal axis extending lengthwise along the blade relative to the plane of rotation of the hub and wherein the blade tip end is configured to rotate in a plane parallel to the plane of rotation of the hub to within ±1°.

17. A wind turbine blade configured to be mounted to a wind turbine hub configured to be mounted for rotation in a hub plane of rotation so as to generate electricity, the blade extending lengthwise between a hub mounting root end and a blade tip end, and extending a blade width between a leading edge and trailing edge, such that when mounted to the hub the blade is twisted at the root end by an angle of between 19° to 21° relative to the plane of rotation of the hub wherein the turbine blade is twisted by an angle of between -1° to 25° about a blade longitudinal axis extending lengthwise along the blade.

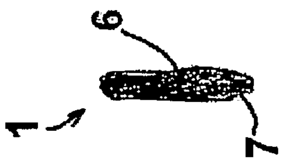


Fig. 3

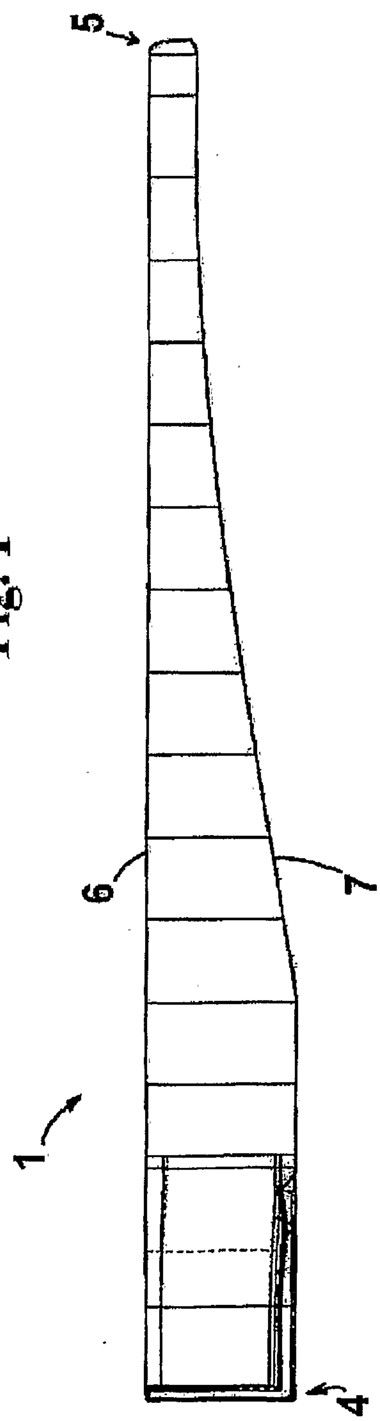


Fig. 1

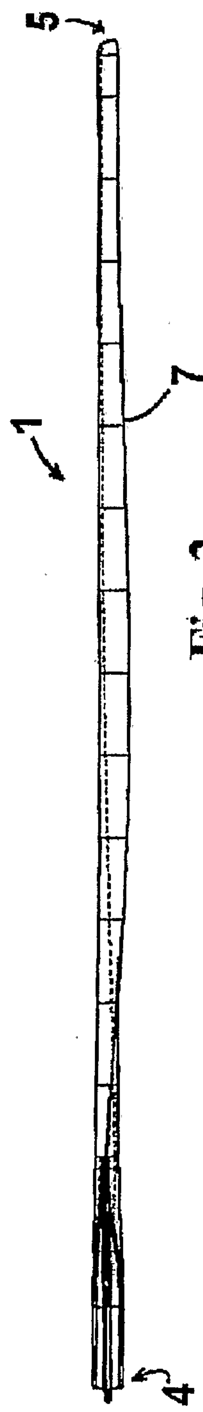


Fig. 2

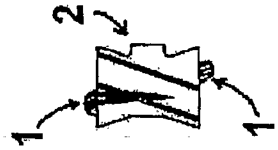


Fig. 6

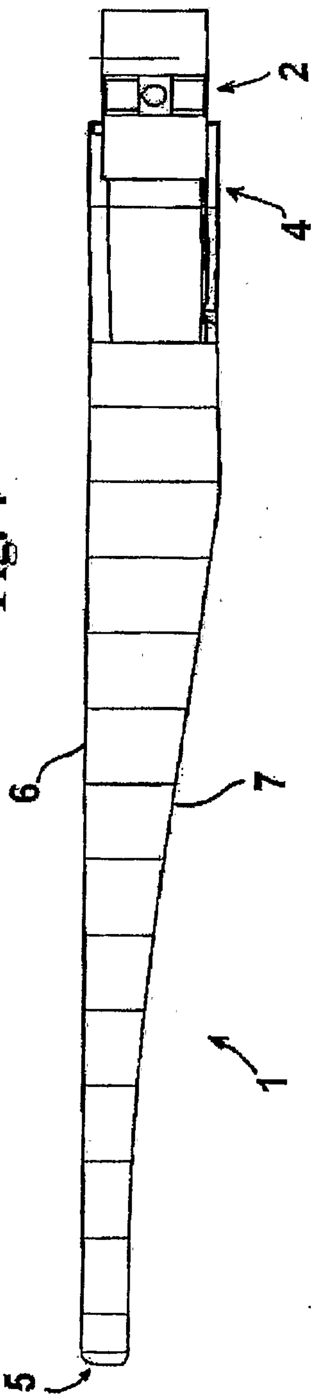


Fig. 4

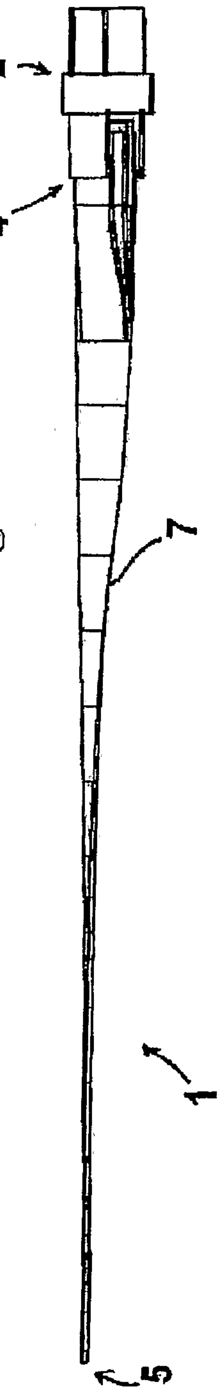


Fig. 5

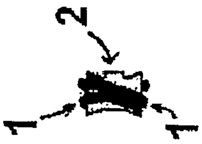


Fig. 9

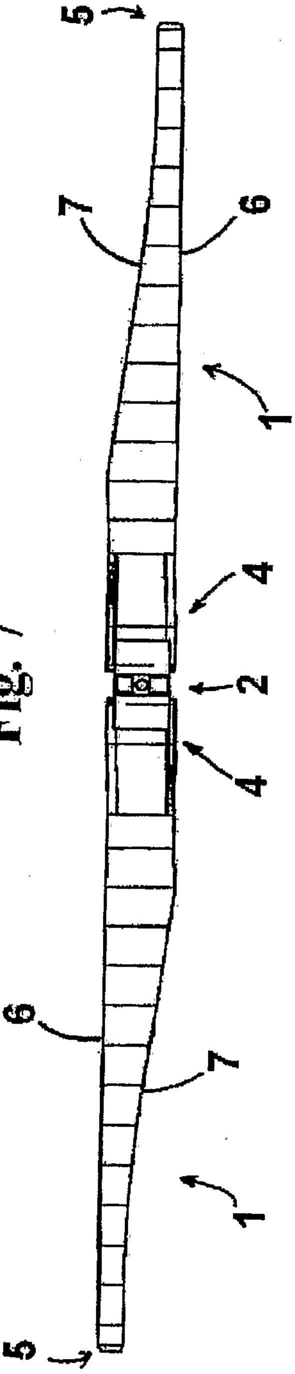


Fig. 7

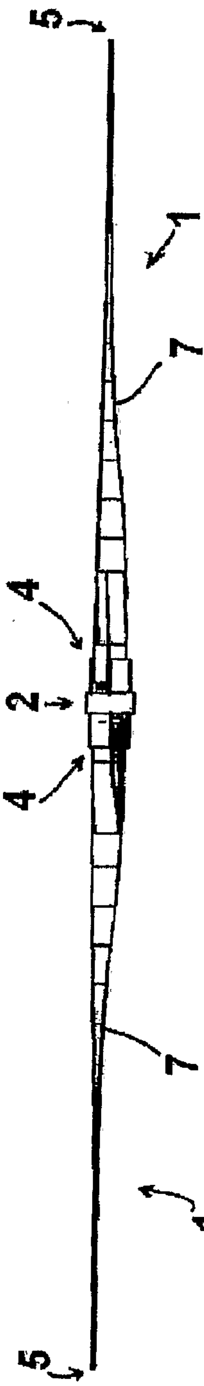


Fig. 8

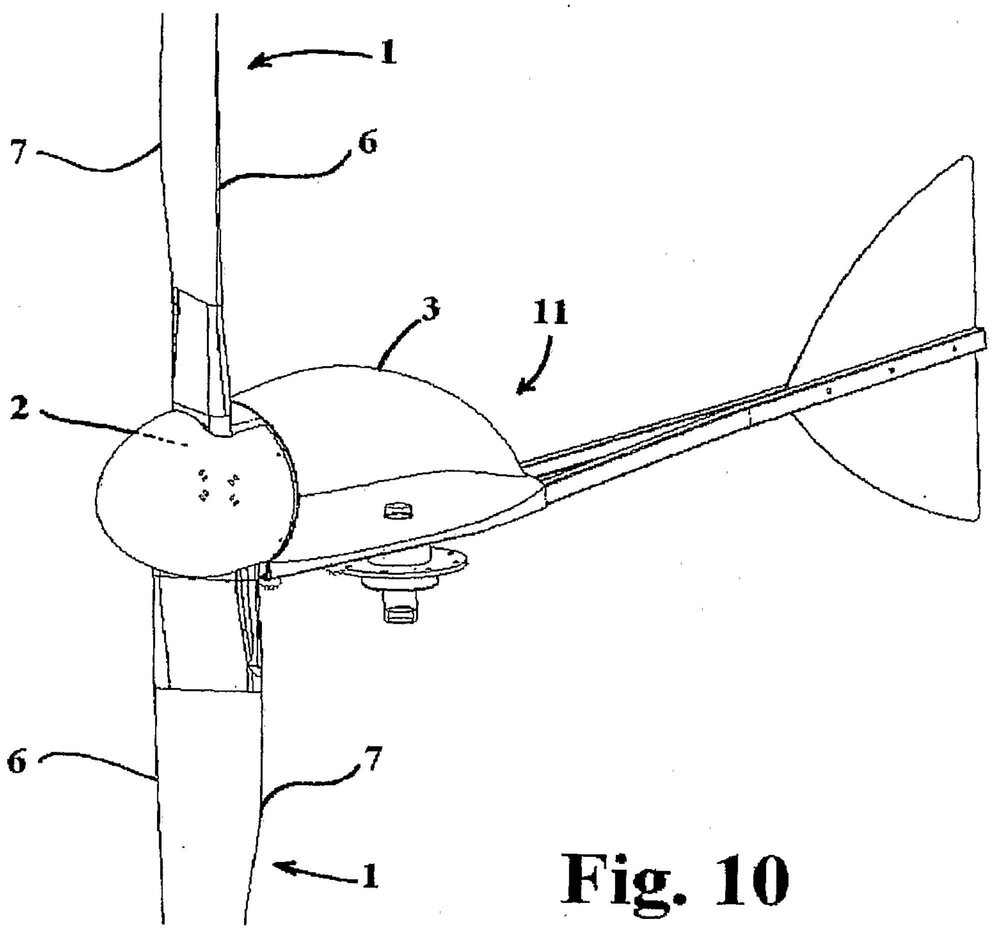


Fig. 10

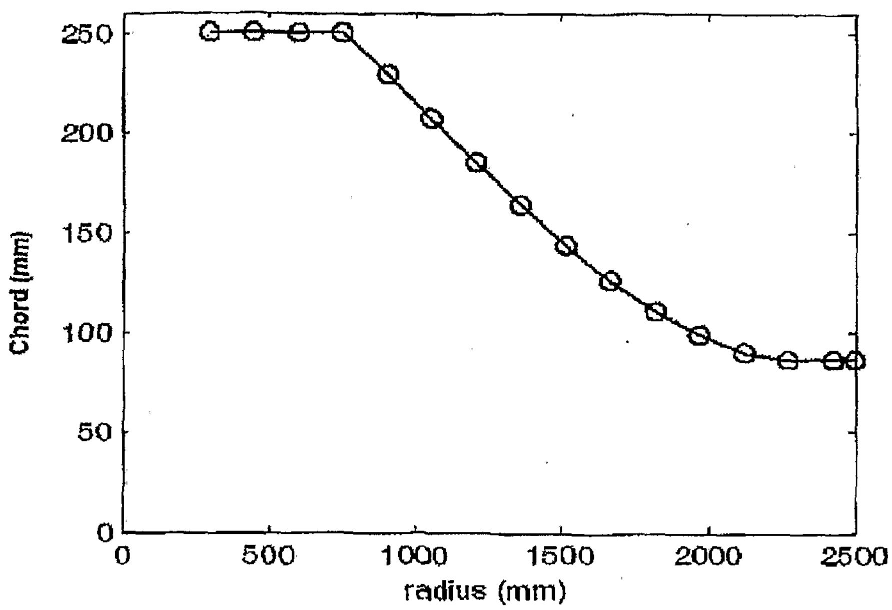

250
200
150
100
50
0
Chord (mm)
0
500
1000
1500
2000
2500
radius (mm)

Fig. 11

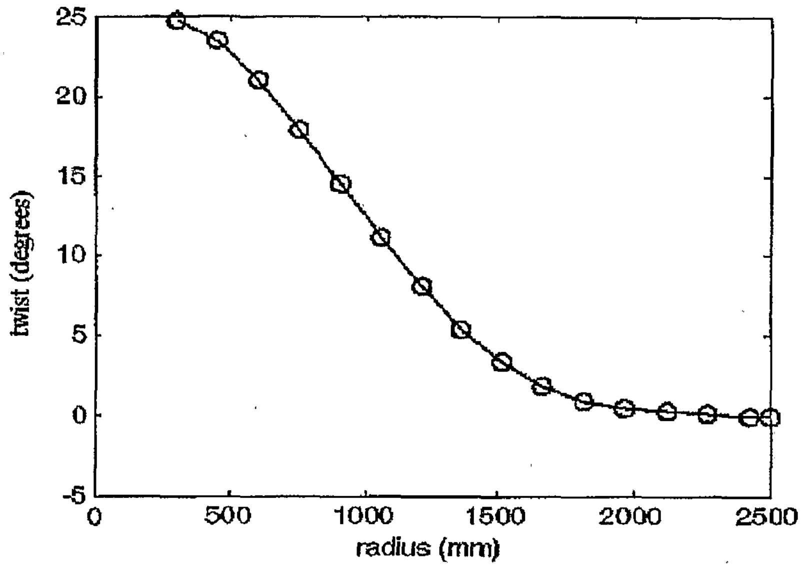

25
20
15
10
5
0
-5
twist (degrees)
0
500
1000
1500
2000
2500
radius (mm)

Fig. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2007/001919

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.Int. Cl. ***F03D 1/00*** (2006.01) ***F03D 1/06*** (2006.01) ***F03D 11/00*** (2006.01)

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)

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)
DWPI IPC: F03D 1/(all), 3/(all), 5/(all), 11/(all) & keywords: blade, vane, airfoil, aerofoil, rotor, sail, angle, twist, spiral, skew, warp and like terms.
USPTO & Espace keywords: wind, turbine, airscrew, windmill, blade, vane, airfoil, angle, twist, spiral and like terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5474425 A (LAWLOR) 12 December 1995	
A	US4976587 A (JOHNSTON ET AL.) 11 December 1990	
A	US 4557666 A (BASKIN ET AL.) 10 December 1985	
A	US 1802094 A (STUART) 21 April 1931	

[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
19 March 2008	10 APR 2008

Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address: pct@ipaustralia.gov.au
Facsimile No. +61 2 6283 7999

Authorized officer
ZBIGNIEW BIELAWSKI
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No : (02) 6283 2218

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2007/001919

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2595763 A3 (TOURNIER) 18 September 1987	

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2007/001919

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 the Extra 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 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.:
   1-15

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.

Supplemental Box
(To be used when the space in any of Boxes I to IV is not sufficient)

Continuation of Box No: III

This International Application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

In assessing whether there is more than one invention claimed, I have given consideration to those features which can be considered to potentially distinguish the claimed combination of features from the prior art. Where different claims have different distinguishing features they define different inventions.

This International Searching Authority has found that there are different inventions as follows:

- Claims 1-15 are directed to a wind turbine blade configured such that when mounted to a wind turbine hub the blade is twisted at a root end by an angle of between 19° to 21° relative to the plane of rotation of the hub (feature A) and the blade is twisted at a tip end to rotate in a plane parallel to the plane of rotation of the hub to within ±1° (feature B). It is considered that the combination of features (A) and (B) comprises a first distinguishing feature.

- Claim 16 is directed to a wind turbine blade configured such that when mounted to a wind turbine hub the blade is twisted by an angle of between -1° to 25° about a blade longitudinal axis (feature C) and the blade is twisted at a tip end to rotate in a plane parallel to the plane of rotation of the hub to within ±1° (feature B). It is considered that the combination of features (C) and (B) comprises a second distinguishing feature.

- Claim 17 is directed to a wind turbine blade configured such that when mounted to a wind turbine hub the blade is twisted at a root end by an angle of between 19° to 21° relative to the plane of rotation of the hub (feature A) and the blade is twisted by an angle of between -1° to 25° about a blade longitudinal axis (feature C). It is considered that the combination of features (A) and (C) comprises a third distinguishing feature.

PCT Rule 13.2, first sentence, states that unity of invention is only fulfilled when there is a technical relationship among the claimed inventions involving one or more of the same or corresponding special technical features. PCT Rule 13.2, second sentence, defines a special technical feature as a feature which makes a contribution over the prior art.

The only feature common to all of the claims is a wind turbine blade configured such that when mounted to a wind turbine hub the blade is twisted. However this common feature is generic in the art. This means that the common feature can not constitute a special technical feature within the meaning of PCT Rule 13.2, second sentence, since it makes no contribution over the prior art.

Because the common feature does not satisfy the requirement for being a special technical feature it follows that it cannot provide the necessary technical relationship between the identified inventions. Therefore the claims do not satisfy the requirement of unity of invention *a posteriori*.

Although claim 1 shares feature (B) with claim 16 and feature (A) with claim 17 and claims 16 and 17 share the feature (C), the individual features (A), (B) and (C) identified above are disclosed in the following prior art as follow:

feature (A) is disclosed in US 1802094 (page 2, lines 39-52),

feature (B) is disclosed in US 4976587 (col. 3, lines 26-27) and US 4557666 (col. 5, lines 42-55),

feature (C) is disclosed in US 1802094 and US 4976587.

Therefore the individual features (A), (B) and (C) can not be considered to be a special technical feature. Consequently there is no single unifying special technical feature among the claims resulting in three separate inventions as indicated above.

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member			
US	5474425	GB	2265672	IL	105107
US	4976587				
US	4557666				
US	1802094				
FR	2595763				

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX