

(12) **UK Patent Application** (19) **GB** (11) **2 404 227** (13) **A**

(43) Date of A Publication **26.01.2005**

(21) Application No: **0317337.4**
(22) Date of Filing: **24.07.2003**

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(51) INT CL⁷:
F03D 3/06 9/00 11/00

(52) UK CL (Edition X):
F1V VB VCS V112 V210
F1T TC T102 T121 T134 T149 T311
U1S S1987 S1999

(56) Documents Cited:
GB 2386161 A **GB 2277189 A**
GB 1518151 A **WO 2003/019006 A1**
WO 2001/093238 A1 **WO 1981/001443 A1**
DE 029820809 A **DE 002948060 A**
US 6037876 A **US 5405246 A1**
US 1835018 A **US 20010001299 A1**

(58) Field of Search:
UK CL (Edition W) **F1T, F1V, G5C**
INT CL⁷ **F03D, G09G**
Other:
ONLINE:OPTICS,EPODOC,WPI,PAJ,XTUS0,XTUS1,T
XTUS2,XTUS3,XTTEP1,XTTGB1,T
XTWO1

(54) Abstract Title: **A vertical axis wind turbine**

(57) A vertical axis wind turbine 1 comprises a shaft 2, rotatable around a longitudinal axis 7, and a plurality of helically shaped rigid blades 10, preferably attached via struts 3, 4, or possibly at least one integrally formed with the blade. There may be at least one disc member, located at the blade extremities, spanning between blades 10 and the shaft 2. The blade 10 cross-sections are arcuately shaped, so their chords lie along a constant radius. The blades 10 may be shaped so: their distance from the axis 7 varies along their length; they approximate a troposkein, and; the chord length varies along their length, preferably shortening towards the ends. Upper and lower blade portions 13, 14, defined between struts 3, 4 and blade tips 15, 16, are preferably free-standing. The blades thickness to chord ratio is, preferably greater where the struts 3, 4 attach, increasing towards the tips 15, 16 or, is constant along the blade length. The blades may have a foam core and composite skin. A further embodiment comprises at least one blade having a light emitting diode array, preferably powered by the turbine, generating an image as the turbine rotates.

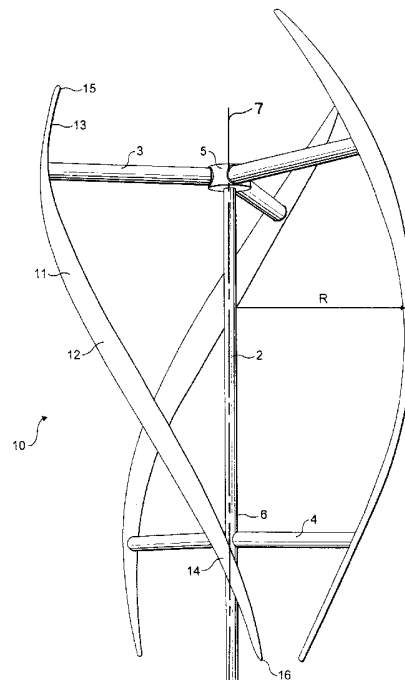


FIG. 2

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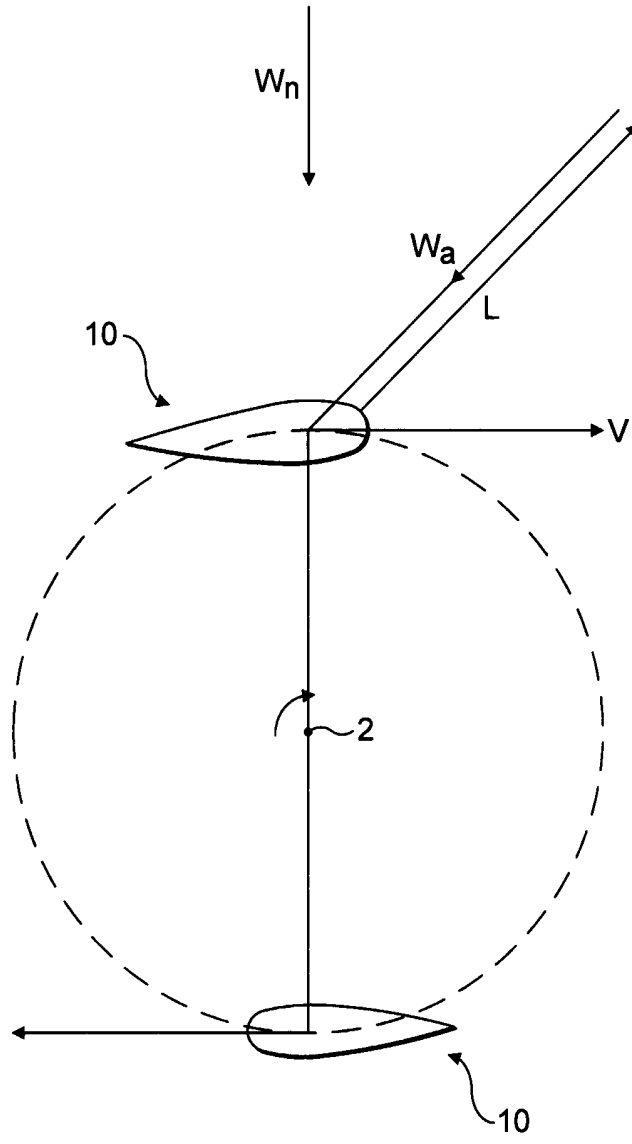
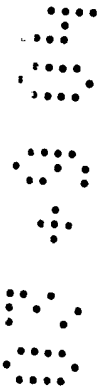


FIG. 1



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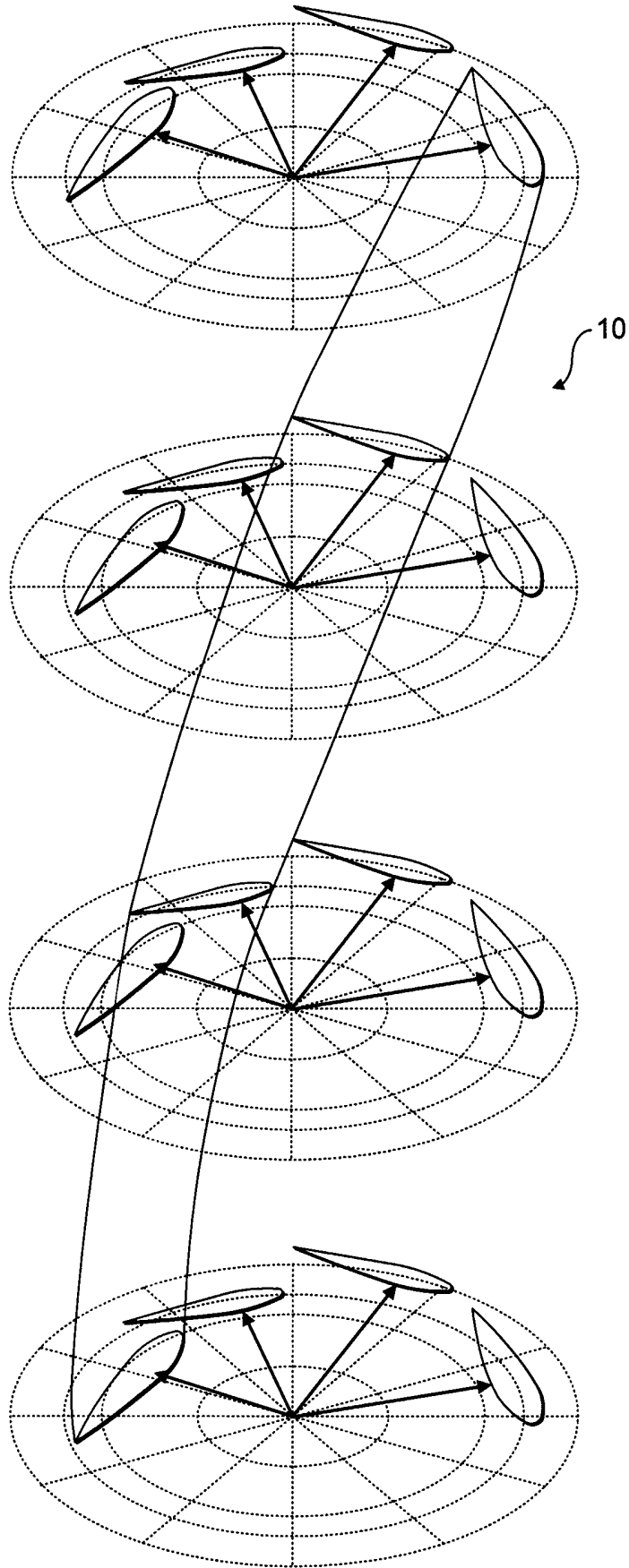


FIG. 1a

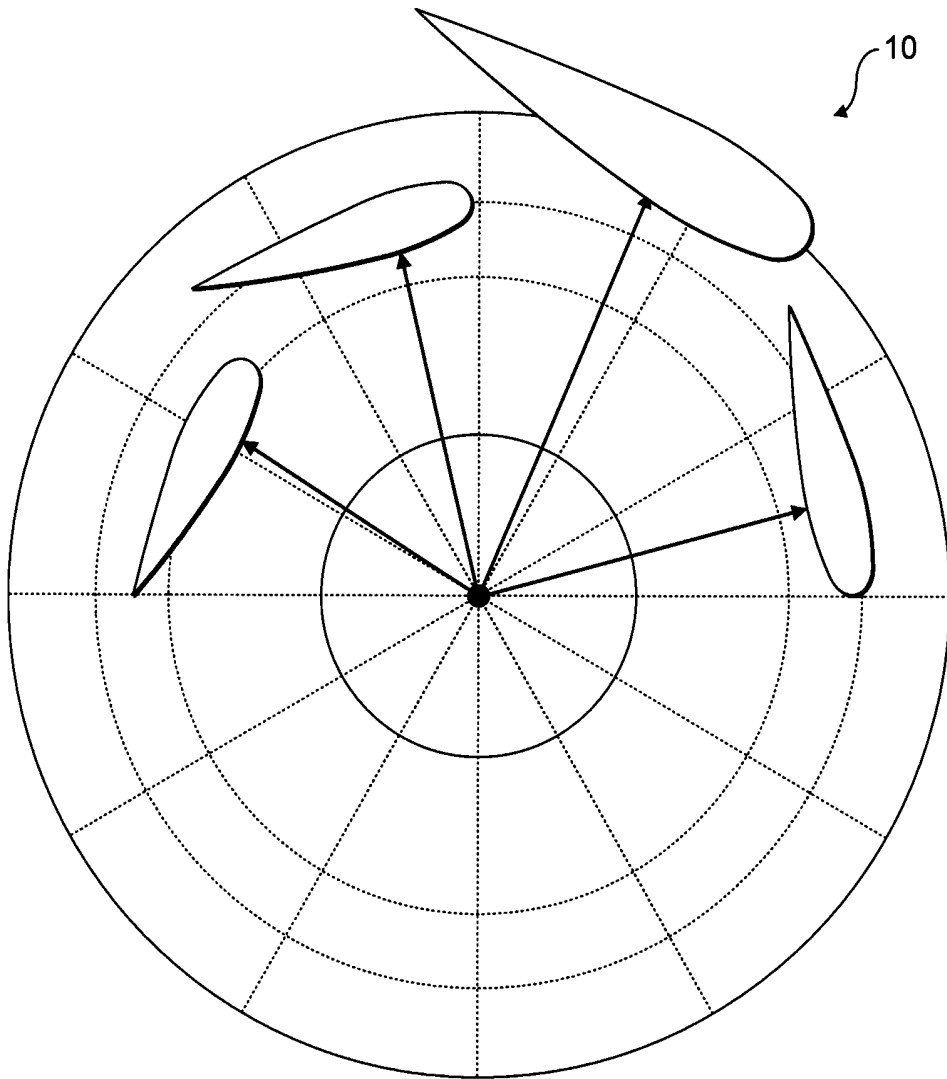


FIG. 1b



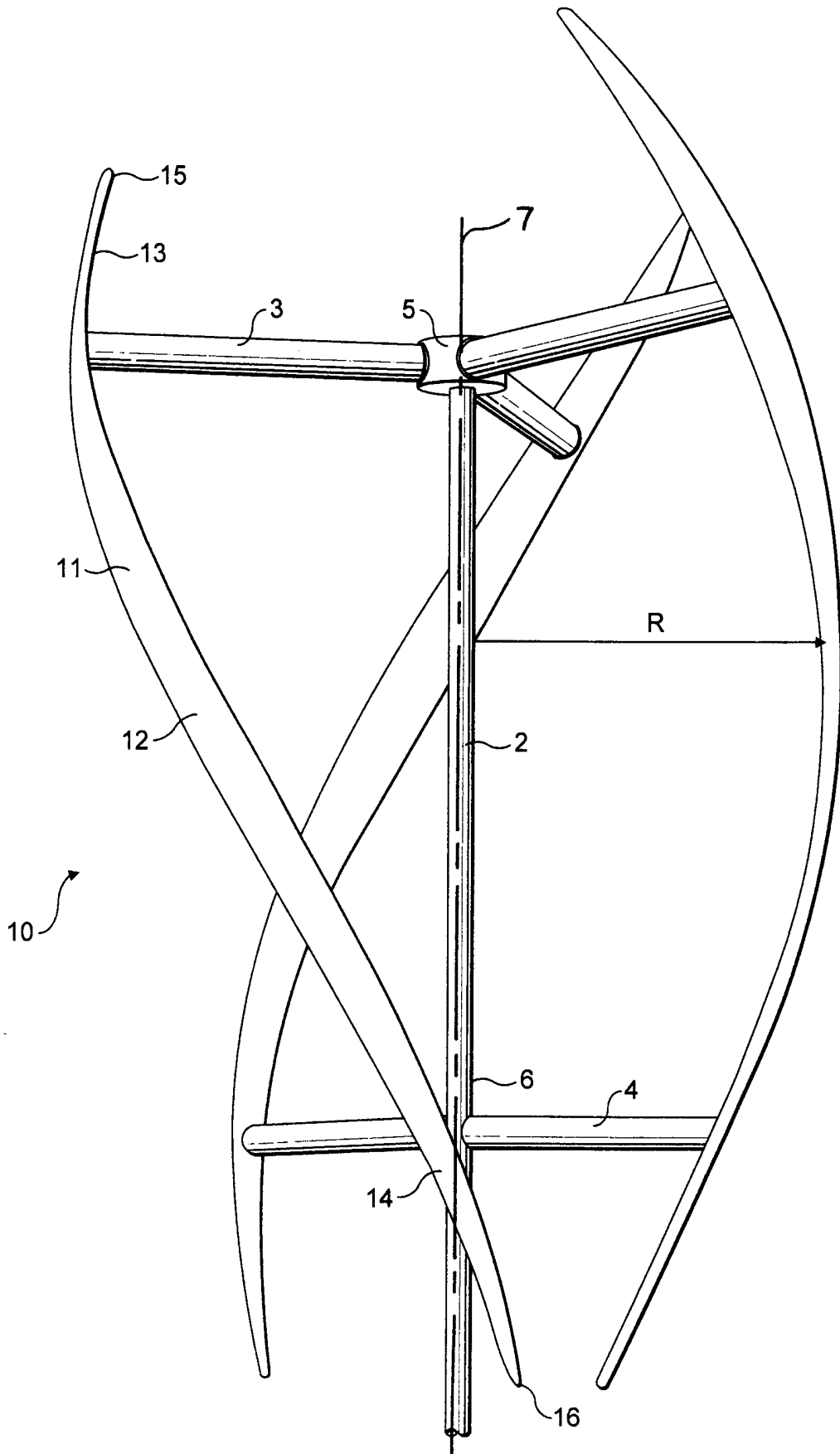
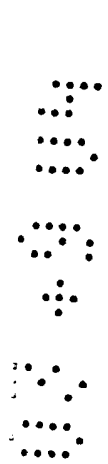


FIG. 2



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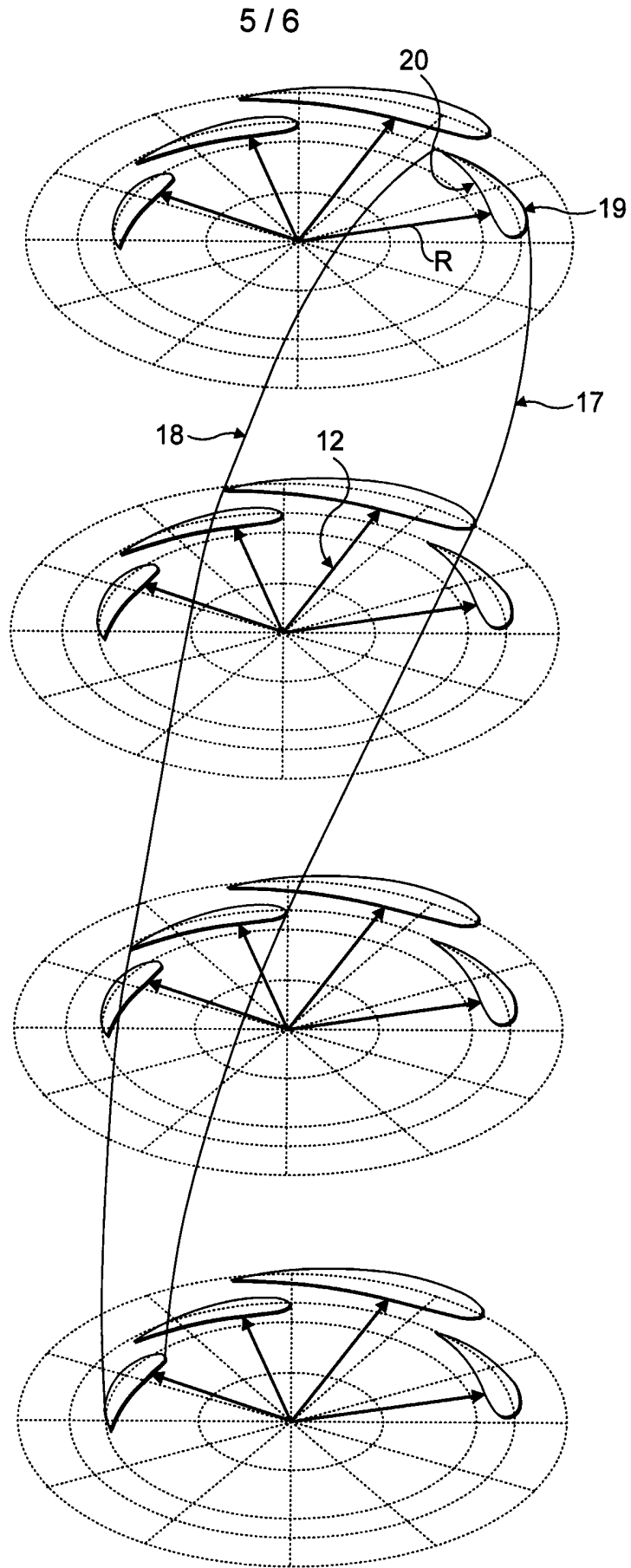


FIG. 3a

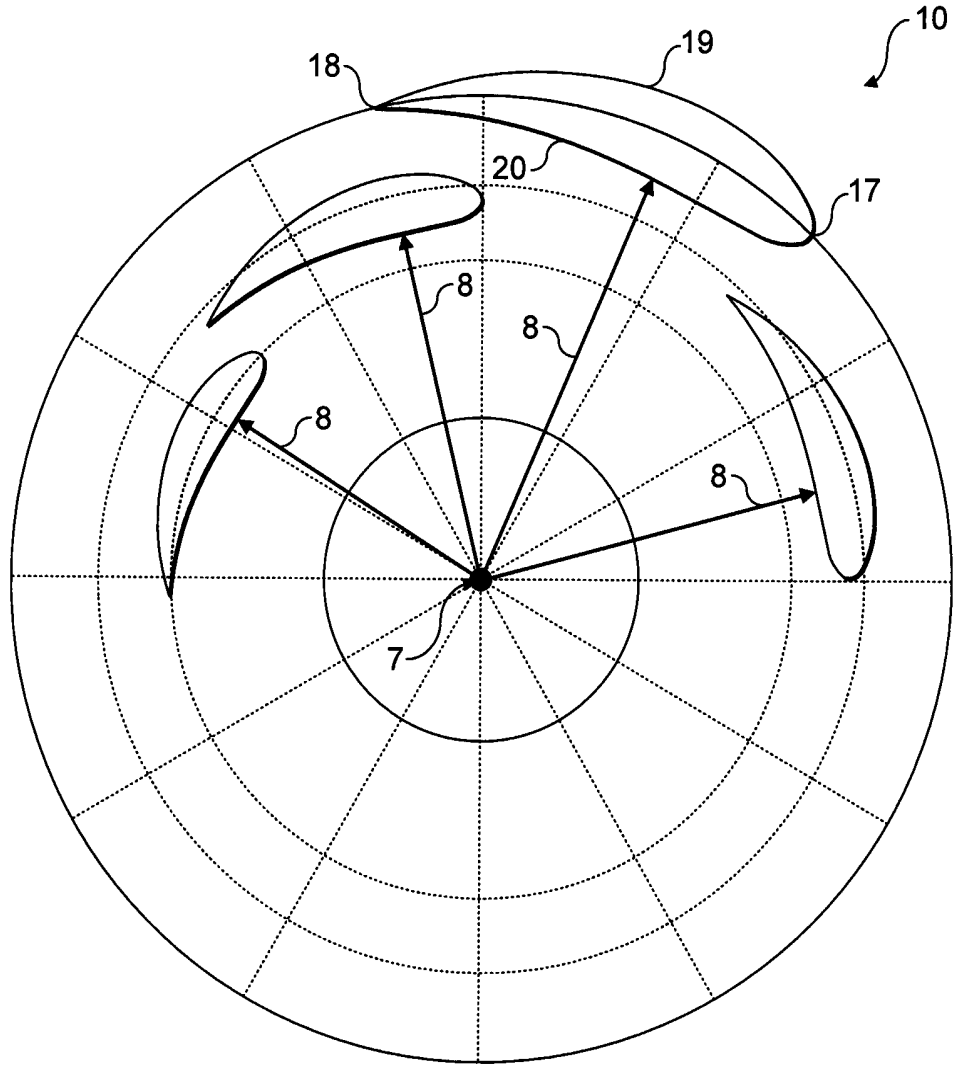


FIG. 3b

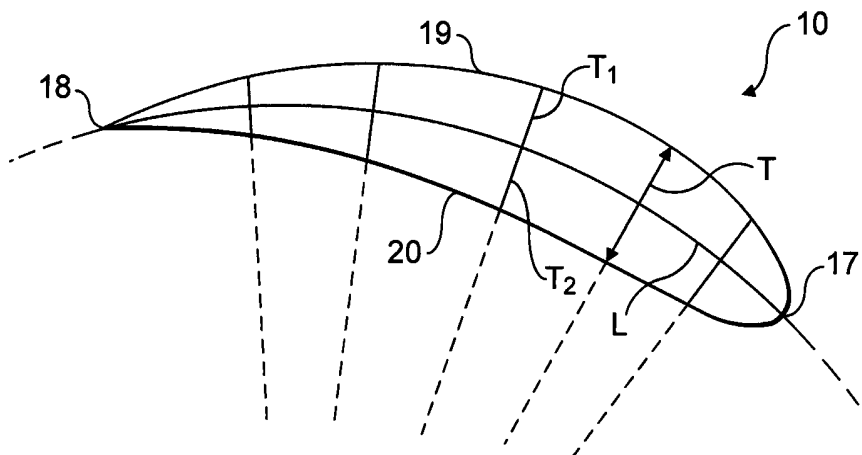
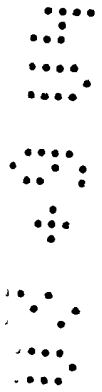


FIG. 4



VERTICAL-AXIS WIND TURBINE

This invention relates to vertical-axis wind turbines (VAWTs) used in general, but not exclusively, for
5 electricity generation.

VAWTs have been known for many years. An early example is shown in U.S. 1,835,018 in the name of Darrieus, wherein a turbine is provided having three blades rotating about a shaft which is arranged transverse to the flow of the
10 driving wind. Each blade has a section in the form of an aerofoil which produces dynamic lift when air is passed over the upper and lower aerofoil surfaces.

A schematic illustration of how a two-bladed VAWT works is shown in Figure 1. Each blade 10 is configured as an
15 aerofoil which is aligned tangentially to its local radius of rotation about a shaft 2. The nominal wind direction is shown by arrow W_n and the instantaneous velocity of the upper blade 10 is shown by arrow v . In the position shown in Figure 1 the blades 10 are moving across the wind such that
20 the apparent wind direction experienced by the blade is in a direction shown by arrow W_a . Lift produced by the aerofoil-sectioned blade opposes the apparent wind direction W_a and thus acts in the direction of arrow l . The component of force l acting perpendicularly to the radius of rotation of
25 the blade acts to rotate the blade 10 about shaft 2. The generated lift acts to rotate the shaft so that the blades 10 move alternatively from positions where they actively produce lift as they cross the wind W_n to positions where they 'coast' as the blades are aligned with the wind
30 direction W_n . The rotation of the shaft 2 can be used for the generation of electricity in a known manner. VAWTs have an

advantage over horizontal-axis wind turbines in that they do not need to be orientated into the prevailing wind direction but are able to produce a rotational movement irrespective of the wind direction. However, VAWTs have been found to
5 have certain technical problems.

VAWTs are prone to a number of problems. Firstly, very high stresses can be developed in the blades due to the centrifugal forces produced on rotation of the turbine at high rotational speeds. Secondly, the cutting of the blades
10 through the air at high rotational speeds can lead to unacceptable noise levels produced by large single vortices being shed at the blade tips. Thirdly, VAWTs can produce uneven torque from their lifting surfaces as the blades alternate between crossing the wind direction and
15 'coasting'.

U.S. 5,405,246, in the name of Goldberg, describes a vertical-axis wind turbine which includes two or more elongated blades connected to a rotor tower. Each blade is "twisted" so that its lower attachment point is displaced
20 angularly relative to its upper attachment point. The chord of each blade is tangential to the local radius as shown in Figures 1a and 1b. The ratio between the blade chord length and the blade thickness is disclosed as being constant over the length of each blade. The twisting of the blades helps
25 somewhat to even out the torque produced by the turbine during its revolution since a portion of at least one blade is crossing the wind direction at all times and thus the overall turbine is never completely in a 'coasting' state. However, it has been found that the design of turbine
30 described in U.S. 5,405,246 can be improved upon as described below in relation to the present invention,

particularly when applied to relatively compact turbines as may be desirable in urban environments.

It is an object of the present invention to produce a VAWT which addresses at least some of the problems described
5 above to produce a more efficient and acceptable design and performance compared to known VAWTs.

The present invention provides a vertical-axis wind turbine comprising a shaft rotatable about a longitudinal axis and a plurality of substantially rigid blades
10 mechanically coupled to the shaft, each of the plurality of blades comprising an elongate body having an upper end and a lower end, wherein the upper end and the lower end of each blade are rotationally off-set from each other about the longitudinal axis such that each blade has a helix-like
15 form, the section of the elongate body of each blade, taken perpendicularly to the longitudinal axis, being shaped as an aerofoil having a leading edge and a trailing edge and a chord defined between the leading edge and the trailing edge, characterised in that the aerofoil is arcuately shaped
20 such that the chord lies along a line of constant radius from the longitudinal axis.

Preferably the radial distance of each blade from the longitudinal axis varies along the length of the blade. In one embodiment the blade shape approximates a troposkein.

25 Preferably the length of the chord of each blade varies along the length of the blade. In one embodiment the length of the chord of each blade is shorter towards the upper and/or lower ends relative to a central portion of each blade.

30 Preferably, the turbine further comprises a plurality of struts mechanically coupling the blades to the shaft. In

one embodiment each blade is joined to the shaft by means of an upper strut and a lower strut. The elongate body of each blade may comprise a central portion extending between the blade's upper and lower struts, an upper portion extending
5 above the blade's upper strut and a lower portion extending below the blade's lower strut. The upper portion of each blade may define the upper end, wherein the upper end is free-standing. The lower portion of each blade may define the lower end, wherein the lower end is free-standing.

10 Optionally, the radial distance of the upper end and the lower end of each blade from the longitudinal axis is less than the length of the struts. In another embodiment the upper strut is joined to the upper end of each blade and the lower strut is joined to the lower end of each blade.

15 Preferably, the thickness-to-chord ratio of each blade is greater at or near a junction with the struts compared to the thickness-to-chord ratio of the central portion.

In one embodiment the thickness-to-chord ratio of each blade increases towards the upper and/or lower ends of the elongate body compared to the thickness-to-chord ratio of
20 the central portion. In another embodiment the thickness-to-chord ratio of each blade is constant along the elongate body.

Preferably, the turbine comprises three blades equi-
25 spaced about the longitudinal axis.

In one embodiment the turbine further comprises at least one strut between each blade and the rotatable shaft, wherein the strut is formed as a unitary member with the blade.

30 In another embodiment the turbine further comprises at least one disc-like member spanning between each blade and

the rotatable shaft. Preferably, the at least on disc-like member is located at an extremity of the blades.

Optionally, each blade comprises a foam core and a composite skin.

5 The present invention further provides a vertical-axis wind turbine comprising a shaft rotatable about a longitudinal axis and a plurality of substantially rigid blades mechanically coupled to the shaft, each of the plurality of blades comprising an elongate body having an upper end and a lower end, wherein the upper end and the lower end of each blade are rotationally off-set from each other about the longitudinal axis such that each blade has a helix-like form, the section of the elongate body of each blade, taken perpendicularly to the longitudinal axis, being
10 shaped as an aerofoil having a leading edge and a trailing edge and a chord defined between the leading edge and the trailing edge, characterised in that the length of the chord of each blade decreases towards the upper and/or lower ends relative to a central portion of each blade.

20 Preferably, the length of the chord of each blade decreases towards at least a downwind end of each blade.

The present invention further provides a vertical-axis wind turbine comprising a shaft rotatable about a longitudinal axis and a plurality of substantially rigid
25 blades mechanically coupled to the shaft, at least one of the blades comprising an array of light emitting diodes controllable under action of a control means to generate a viewable pre-determined image when the turbine rotates about the longitudinal axis.

30 Preferably, a control means is provided for controlling illumination of the light emitting diodes, wherein the

control means comprises variable speed control means to generate coherent viewable image when the turbine rotates at variable rotational speeds.

Preferably, the turbine generates electricity to power
5 the light emitting diodes.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:-

10 Figure 1 is a schematic illustration, in plan view, of a rotating VAWT;

Figure 1a is a schematic perspective view of a blade of a VAWT according to the prior art as described in U.S. 5,405,246;

15 Figure 1b is a schematic cross-sectional view of the blade of Figure 1a showing its cross-section at four levels;

Figure 2 is perspective view of a VAWT according to the present invention;

Figure 3a is a schematic perspective view of a portion
20 of a blade of the VAWT of Figure 2;

Figure 3b is a schematic cross-sectional view of the blade of Figure 3a showing its cross-section at four levels; and

Figure 4 is a cross-sectional view through the portion
25 of the blade shown in Figure 3a.

With reference initially to Figure 2, the present invention provides a VAWT 1 having a rotatable shaft 2 aligned substantially along a longitudinal axis 7. Three
30 blades 10 are mechanically coupled to the rotatable shaft 2 by means of struts 3, 4. Each blade 10 is attached to the

rotatable shaft 2 by means of an upper strut 3 which joins to an upper hub 5 on the rotatable shaft 2 and a lower strut 4 which joins to a lower hub 6 on the rotatable shaft 2. The struts 3, 4 are substantially horizontal and
5 perpendicular to the longitudinal axis 7.

Each blade 10 comprises an elongate body 11 which is twisted about the longitudinal axis 7 into a helix-like form. In consequence, the upper strut 3 of each blade 10 is rotationally off-set about the rotatable shaft 2 relative to
10 the lower strut 4 as shown in Figure 2. The helix-like form of the blades 10 ensures that the torque profile of the turbine 1 is smoothed out since a portion of at least one of the three blades 10 is always crossing the ambient wind W_a . The smoothed torque profile also reduces cyclic loading on
15 the turbine components since the turbine is less prone to torque peaks. This reduces the fatigue loading on the components. The design also allows the turbine 1 to exhibit increased performance characteristics at low wind speeds. This makes the turbine 1 of the present invention
20 particularly suitable for placement in urban environments where air flow speeds may be reduced and/or made more turbulent by the presence of buildings and other man-made structures.

The elongate body 11 of each blade 10 comprises a
25 central portion 12 which extends between the upper and lower struts 3, 4, an upper portion 13 which extends above the upper strut 3 and a lower portion 14 which extends below the lower strut 4. The upper portion 13 extends upwardly to an upper tip 15 which is free-standing. The lower portion 14
30 extends downwardly to a lower tip 16 which is also free-standing.

The radial distance of the elongate body 11 of each blade 10 from the longitudinal axis 7 varies along the length of the blade 10 as shown in Figure 2 and schematically in Figures 3a and 3b. Preferably, the blades 5 10 are shaped in a form of a troposkein. A troposkein is that shape adopted by a flexible member held at either end and spun about an axis passing through either end. As can be seen, the radial distance of the central portion 12 is greater than that of the upper or lower portion 13, 14. 10 Forming the blade 10 in a troposkein shape ensures that bending movements in the blade due to the centrifugal forces are kept to a minimum.

As shown in Figure 2, the upper end 15 and lower end 16 of the blade 10 are closer to the longitudinal axis 7 than 15 the blade 10 at the junctions with the upper strut 3 and lower strut 4.

The attachment of the struts 3, 4 part way along the elongate body 11 of each blade 10 is advantageous in that the struts provide more even support to the blade 10. In 20 particular, the maximum span between the struts 3, 4 is reduced compared to struts provided at the extremities of the blade 10 and thus the bending stresses in the elongate body 11 are reduced. However, the struts may, if desired be positioned at the extremities of the elongate body 11.

25 The blade section is shaped as an aerofoil as most clearly shown in Figures 3b and 4. The aerofoil section comprises a leading edge 17 and a trailing edge 18. The section also comprises an upper aerofoil surface 19 which is that surface of the blade 10 furthest from the rotatable 30 shaft 2 and a lower aerofoil surface 20 which is that surface of the blade 10 closest to the rotatable shaft 2.

A chord L is definable between the leading edge 17 and trailing edge 18 of the aerofoil section. As shown most clearly in Figures 3b and 4, the aerofoil section of the blade 10 of the present invention is shaped such that the chord L between the leading edge 17 and the trailing edge 18 is not straight but arcuate such as to lie along a circumference of constant radius from the longitudinal axis 7. In other words, the aerofoil section of each blade 10 is 'wrapped' around the longitudinal axis 7. In addition, the aerofoil section is symmetrical about the chord L. That is, along the entire aerofoil section, the distance, taken perpendicularly to the chord (that is radially from axis 7), between the chord L and the upper aerofoil surface 19 (shown in Figure 4 as T_1) is the same as the distance between the chord L and the lower aerofoil surface 20 (shown in Figure 4 as T_2). This combination of the symmetry and wrapping of the aerofoil section increases the efficiency of lift production of the VAWT compared to prior designs. This is achieved because the aerofoil section produces lift for a longer period as it rotates about shaft 2 since as the blade section crosses the wind it appears to the wind to be symmetrical along its entire chord thus optimising the net driving force available to rotate the VAWT. In comparison, using tangentially symmetrical blades as described in U.S. 5,405,246 is less efficient since the blade appears non-symmetrical to the wind since as the blade rotates the blade section effectively rotates relative to the wind direction and thus does not remain symmetrical. This phenomenon is particularly apparent where the overall diameter of the VAWT is relatively small such that the relative angle of rotation

of the blade section is more pronounced during the time it takes for the blade to cross the wind.

As shown in Figure 4, the aerofoil section defines a section thickness T . The thickness-to-chord ratio of the blades 10 preferably varies along the length of the blade. In one embodiment, the thickness-to-chord ratio is greater at or near the upper end 15 and/or lower end 16 than in the central portion 12. In particular this is advantageous where the blade 10 is tapered such that the chord L decreases towards the blade ends, as discussed below. Increasing the thickness-to-chord ratio as the chord decreases increases the range of angles of attack at which the wind can produce usable lift.

The thickness-to-chord ratio may also be enlarged in proximity to the junctions between the blade 10 and the upper struts 3 and lower struts 4. At this point, the relative wind speed reduces since the distance of the blade 10 from the longitudinal axis is less than near the midpoint of the central portion 12. This creates an apparent change in the angle of attack of the wind relative to the blade 10. Increasing the thickness-to-chord ratio of the blade 10 at this point increases the blade's lift coefficient increasing the driving force of the turbine 1. The increased thickness-to-chord ratio at these points also advantageously increases the mechanical strength of the blades 10 at the junction points of the struts 3,4 where the mechanical loads imparted by the airflow are transferred to the rotatable shaft 2.

According to a further aspect of the present invention, the length of the chord L of the blades 10 may decrease towards the upper tip 15 and/or lower tip 16 compared to the

length of the chord of the central portion 12. Thus, the length of chord L is tapered towards each tip reducing the chord of the aerofoil as the blade 10 wraps around the longitudinal axis 7. The tapering of the blade helps to
 5 reduce aerodynamic drag and improves the shedding of the air flow from the trailing edge 18. Instead of shedding a single or small number of large, intense vortices, the tapering produces a more gradual, less intense shedding of numerous vortices along the blade. This, in turn, reduces the noise
 10 associated with rotation of the turbine 1. This effect is most pronounced on the downwind end of the blade 10, which may be the upper or lower end of the blade 10 depending on the direction of the helix-like structure of the blades. As such, the blades 10 may be tapered only towards the downwind
 15 end of the blades.

In a further aspect of the present invention, the blade 10 may be formed in a unitary manner with the upper strut 3 and/or the lower strut 4. The unitary blade and spar unit may be formed with a foam core covered by a composite skin.
 20 The skin may be, for example, carbon or glass fibre or a mixture of the materials.

In one example of turbine according to the present invention, three blades 10 are provided, each having a helix-like form as shown in Figure 2. The blades span a
 25 vertical height of 3 metres. The table below indicates the relative dimensions of the chord, thickness and radius of each blade:

	Chord length L	Thickness T	Radius from axis
Upper End	75mm	25mm	950mm
Blade Centre	200mm	50mm	1000mm

Lower End	75mm	25mm	550mm
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As can be seen from the table, the lower end 16 is radially closer to the longitudinal axis 7 than the upper end 15.

5 As well as electricity production, the turbine 1 of the present invention may be used for other purposes either separately, or contemporaneously with electricity generation. In one envisaged aspect, at least one of the blades 10 of the turbine 1 is provided with an array of
 10 light emitting diodes. The light emitting diodes may be arranged along the leading edge 17, trailing edge 18 or upper aerofoil surface 19 of the blade 10. Control means is provided either as part of the turbine 1 or in an associated control device for controlling the timing and duration of
 15 illumination of each light emitting diode in the array so as to produce a visible predetermined image when the turbine 1 rotates. The light emitting diodes may be powered by electricity generated during rotation of the turbine.

Various modifications to the turbine of the present
 20 invention may be made without departing from the scope of the appended claims. In particular, less than three blades 10 or more than three blades 10 may be utilised. The blades 10 may be formed into a shape other than a troposkein. For example, the blades may lie on a right circular cylinder
 25 about the longitudinal axis. The blades 10 may be formed separately from the struts 3, 4 and then assembled therewith. The blades 10 may be joined to the shaft 2 by more than two struts. In particular, a third strut may be utilised in-between the upper and lower struts 3, 4. The
 30 third strut may be positioned at the mid-point of the length

of the blade 10. The blades 10 may not comprise free-standing tips. Instead the upper and lower struts 3, 4 may be joined to the blades 10 at the extremities of the blades 10.

5 The struts 3, 4 may be replaced by circular discs which span between the rotatable shaft 2 and the blades 10 and are rotatable about the shaft. The discs may be positioned at the upper and lower extremities of the blades 10. Alternatively, the blades 10 may extend beyond the location
10 of the discs. Use of discs can lead to enhanced airflow compared to struts. Preferably the upper and lower surfaces of the discs are planar. Alternatively, annular members may be provided spanning between the blades 10 and having spoke-like struts spanning between the blades and the rotatable
15 shaft.

Claims:

1. A vertical-axis wind turbine comprising a shaft rotatable
about a longitudinal axis and a plurality of substantially
5 rigid blades mechanically coupled to the shaft, each of
the plurality of blades comprising an elongate body having
an upper end and a lower end, wherein the upper end and
the lower end of each blade are rotationally off-set from
each other about the longitudinal axis such that each
10 blade has a helix-like form, the section of the elongate
body of each blade, taken perpendicularly to the
longitudinal axis, being shaped as an aerofoil having a
leading edge and a trailing edge and a chord defined
between the leading edge and the trailing edge,
15 characterised in that the aerofoil is arcuately shaped
such that the chord lies along a line of constant radius
from the longitudinal axis.
2. A vertical-axis wind turbine as claimed in claim 1 wherein
20 the radial distance of each blade from the longitudinal
axis varies along the length of the blade.
3. A vertical-axis wind turbine as claimed in claim 2 wherein
the blade shape approximates a troposkein.
25
4. A vertical-axis wind turbine as claimed in any preceding
claim wherein the length of the chord of each blade varies
along the length of the blade.
- 30 5. A vertical-axis wind turbine as claimed in claim 4 wherein
the length of the chord of each blade is shorter towards

the upper and/or lower ends relative to a central portion of each blade.

6. A vertical-axis wind turbine as claimed in any preceding
5 claim further comprising a plurality of struts
mechanically coupling the blades to the shaft.
7. A vertical-axis wind turbine as claimed in claim 6 wherein
10 each blade is joined to the shaft by means of an upper
strut and a lower strut.
8. A vertical-axis wind turbine as claimed in claim 7 wherein
the elongate body of each blade comprises a central
15 portion extending between the blade's upper and lower
struts, an upper portion extending above the blade's upper
strut and a lower portion extending below the blade's
lower strut.
9. A vertical-axis wind turbine as claimed in claim 8 wherein
20 the upper portion of each blade defines the upper end,
wherein the upper end is free-standing.
10. A vertical-axis wind turbine as claimed in claim 8 or
25 claim 9 wherein the lower portion of each blade defines
the lower end, wherein the lower end is free-standing.
11. A vertical-axis wind turbine as claimed in claim 9 or
30 claim 10 wherein the radial distance of the upper end and
the lower end of each blade from the longitudinal axis is
less than the length of the struts.

12. A vertical-axis wind turbine as claimed in claim 7 wherein the upper strut is joined to the upper end of each blade and the lower strut is joined to the lower end of each blade.
- 5
13. A vertical-axis wind turbine as claimed in any of claims 6 to 12 wherein the thickness-to-chord ratio of each blade is greater at or near a junction with the struts compared to the thickness-to-chord ratio of the central portion.
- 10
14. A vertical-axis wind turbine as claimed in any preceding claim wherein the thickness-to-chord ratio of each blade increases towards the upper and/or lower ends of the elongate body compared to the thickness-to-chord ratio of the central portion.
- 15
15. A vertical-axis wind turbine as claimed in any of claims 1 to 13 wherein the thickness-to-chord ratio of each blade is constant along the elongate body.
- 20
16. A vertical-axis wind turbine as claimed in any preceding claim wherein the turbine comprises three blades equi-spaced about the longitudinal axis.
- 25
17. A vertical-axis wind turbine as claimed in any preceding claim further comprising at least one strut between each blade and the rotatable shaft, wherein the strut is formed as a unitary member with the blade.
- 30

18. A vertical-axis wind turbine as claimed in any of claims 1 to 5 further comprising at least one disc-like member spanning between each blade and the rotatable shaft.
- 5
19. A vertical-axis wind turbine as claimed in claim 18 wherein the at least one disc-like member is located at an extremity of the blades.
- 10 20. A vertical-axis wind turbine as claimed in any preceding claim wherein each blade comprises a foam core and a composite skin.
- 15 21. A vertical-axis wind turbine comprising a shaft rotatable about a longitudinal axis and a plurality of substantially rigid blades mechanically coupled to the shaft, each of the plurality of blades comprising an elongate body having an upper end and a lower end, wherein the upper end and the lower end of each blade are
- 20 rotationally off-set from each other about the longitudinal axis such that each blade has a helix-like form, the section of the elongate body of each blade, taken perpendicularly to the longitudinal axis, being shaped as an aerofoil having a leading edge and a trailing
- 25 edge and a chord defined between the leading edge and the trailing edge, characterised in that the length of the chord of each blade decreases towards the upper and/or lower ends relative to a central portion of each blade.

22. A vertical-axis wind turbine as claimed in claim 21 wherein the length of the chord of each blade decreases towards at least a downwind end of each blade.
- 5 23. A vertical-axis wind turbine comprising a shaft rotatable about a longitudinal axis and a plurality of substantially rigid blades mechanically coupled to the shaft, at least one of the blades comprising an array of light emitting diodes controllable under action of a control means to generate a viewable pre-determined image when the turbine rotates about the longitudinal axis.
- 10
24. A vertical-axis wind turbine as claimed in claim 23 wherein a control means is provided for controlling illumination of the light emitting diodes, wherein the control means comprises variable speed control means to generate coherent viewable image when the turbine rotates at variable rotational speeds.
- 15
- 20 25. A vertical-axis wind turbine as claimed in claim 23 or claim 24 wherein the turbine generates electricity to power the light emitting diodes.
- 25 26. A vertical-axis wind turbine substantially as hereinbefore described with reference to or as shown in Figures 2 to 4 of the accompanying drawings.



INVESTOR IN PEOPLE

Application No: GB 0317337.4
Claims searched: 1-20 and 26

19

Examiner: Ross Maclachlan
Date of search: 23 January 2004

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X, Y	X: 1-5, and 18-19 Y: 16	US 5405246 A1 (GOLDBERG) see figures 1-4, noting "twisted" blades lying along a "troposkein" and attached to the longitudinal vertical axis via hubs 16 and 18.
X, Y	X: 1-3, 15 and 18-19 Y: 16	WO 81/01443 A1 (JOUTSINIEMI) see figures 1-4, noting helical and concave section blades.
X, Y	X: 1, 6-8, 12, 15 and, 18-19 Y: 16	US 2001/0001299 A1 (NORTHEASTERN) see figures 5 and 14, noting helical blades 12, 302, lying on a constant radius from the longitudinal axis, supported on rotatable shaft 14, 314 by one or more turbine blade support members, discs 308, or radial spokes 110.
X, Y	X: 1, 6-8, 12 and 15 Y: 16	WO 03/019006 A1 (POLEACOV) see figures 1-4 and abstract, noting helical blades with curved cross section connected to vertical axis via transverse bars.
X, Y	X: 1 and 15 Y: 16	GB 1518151 A (CHRISTIE) see all figures, noting two longitudinal helical blades with curved cross sections.
X, Y	X: 1 Y: 16	GB 2386161 A (ATKINSON) see figure 7, noting rotor elements stacked to form two helical blade stacks on vertical shaft 22.
Y	16	US 1835018 A (DARRIEUS) see figure 3, noting three blades equi-spaced about the longitudinal axis.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^w:



INVESTOR IN PEOPLE

Application No: GB 0317337.4
Claims searched: 1-20 and 26

20

Examiner: Ross Maclachlan
Date of search: 23 January 2004

F1T, F1V

Worldwide search of patent documents classified in the following areas of the IPC⁷:

F03D

The following online and other databases have been used in the preparation of this search report :

Online: OPTICS, EPODOC, WPI, PAJ



INVESTOR IN PEOPLE

Application No: GB 0317337.4
Claims searched: 21 and 22

21

Examiner: Ross Maclachlan
Date of search: 25 March 2004

Patents Act 1977 : Further Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	21-22	US 5405246 A (GOLDBERG) See figures 1-4, noting Helix-like shaped blades having decreasing chord lengths towards upper and lower ends of the blades relative to their central portions.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^W:

F1T, F1V

Worldwide search of patent documents classified in the following areas of the IPC⁷:

F03D

The following online and other databases have been used in the preparation of this search report :

Online: OPTICS, EPODOC, WPI, PAJ



INVESTOR IN PEOPLE

Application No: GB 0317337.4
Claims searched: 23 and 24

22

Examiner: Ross Maclachlan
Date of search: 25 March 2004

Patents Act 1977 : Further Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
Y	23 and, 24	GB 2277189 A (NAKAMATSU) See figure 5 and page 5 lines 1-7 noting body 1 having LEDs mounted to produce a predetermined image when rotated, and that motor M may be replaced by wind power.
Y	23 and, 24	WO 01/93238 A1 (SPACEWRITER) See figs. 1 and, 3 noting LED arrays mounted on fan blades to produce a predetermined image when the fan rotates.
Y	23 and, 24	US 6037876 A (LIMELITE) See figure 1 noting fan blades having LED arrays mounted on vertically upturned portions so as to provide an image when the fan is rotated.
Y	23 and, 24	DE 29820809 U1 (GUENTHER) See drawing and WPI Abstract Accession no. 1999-265244 [23] noting illuminated publicity images on, and powered by, vertical axis wind turbine.

Categories:

X Document indicating lack of novelty or inventive step	A Document indicating technological background and/or state of the art.
Y Document indicating lack of inventive step if combined with one or more other documents of same category.	P Document published on or after the declared priority date but before the filing date of this invention.
& Member of the same patent family	E Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^W:

F1T, F1V, G5C

Worldwide search of patent documents classified in the following areas of the IPC⁷:

F03D, G09G

The following online and other databases have been used in the preparation of this search report :

Oline: OPTICS, EPODOC, WPI, PAJ, TXTUS0, TXTUS1, TXTUS2, TXTUS3, TXTEP1, TXTGB1, TXTWO1