

(21) Application No: 1000388.7

(22) Date of Filing: 11.01.2010

(71) Applicant(s):
Paul Bennett
61 Burbage Road, Burbage, LEICESTER, LE10 2TS,
United Kingdom

(72) Inventor(s):
Paul Bennett

(74) Agent and/or Address for Service:
Serjeants
25 The Crescent, King Street, LEICESTER, LE1 6RX,
United Kingdom

(51) INT CL:
F03D 11/04 (2006.01) **F03D 3/00** (2006.01)

(56) Documents Cited:
EP 2039929 A1 **EP 1886016 A1**
DE 019928897 A1 **DE 102008051255 A1**
JP 2005090257 A **US 20040047723 A1**
AU 2008202743 A1 (GILBEE) See entire document,
particularly figs 1 & 6 and description of page 9, line 17
to page 10, line 31.

(58) Field of Search:
INT CL **F03D**
Other: **EPODOC, WPI, NPL, XPAIP, XPIOP, XPESP,**
INSPEC, TXTE, Internet

(54) Title of the Invention: **Wind turbine powered generator**
Abstract Title: **Vertical axis wind powered generator**

(57) A vertical axis wind-powered generator is designed to be mounted at the apex of a pitched roof, taking support from the roof structure itself. A vertical turbine shaft 13 is rotatably mounted by vertically spaced bearings 19 and 20. The lower of those bearings 19 is secured to a cross-beam 21 of the roof structure and the upper one of the bearings 20 is secured to the apex of the roof structure where rafters 22 meet. A drive portion 13b of the turbine shaft 13 extends up through the roof cladding to above roof height and supports a circular array of vertically aligned asymmetric aerofoil vanes 11 which are drivingly connected to the drive portion 13b of the turbine shaft 13 through radial spoke members 12. A generator 33 is located in the roof space and is directly driven by a portion 13a of the turbine shaft 13 between the bearings 19 and 20.

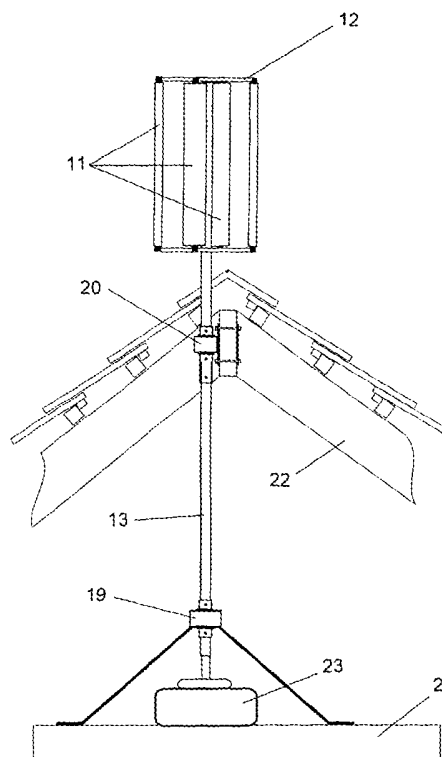
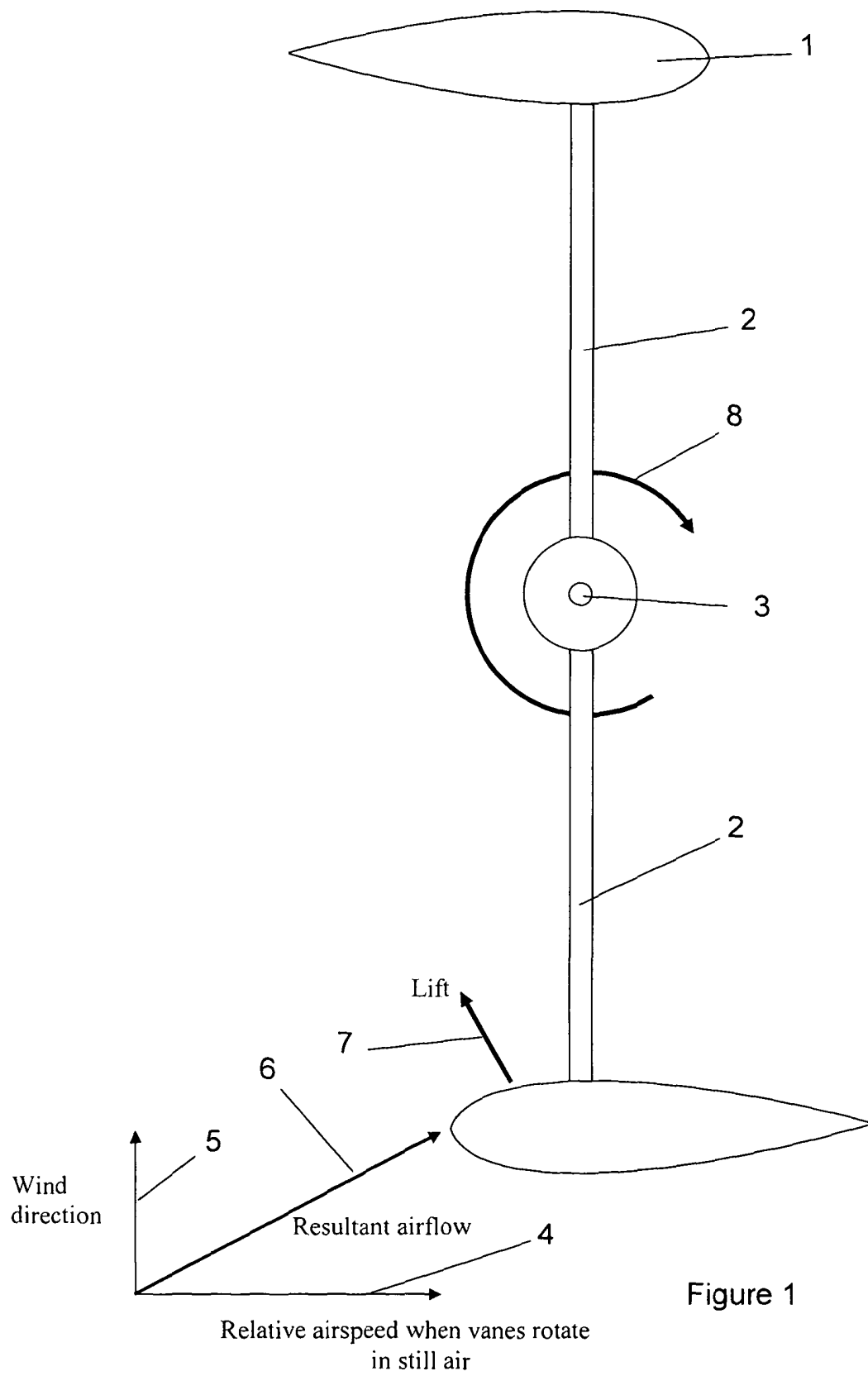
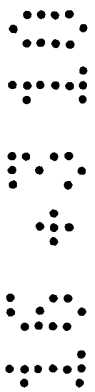
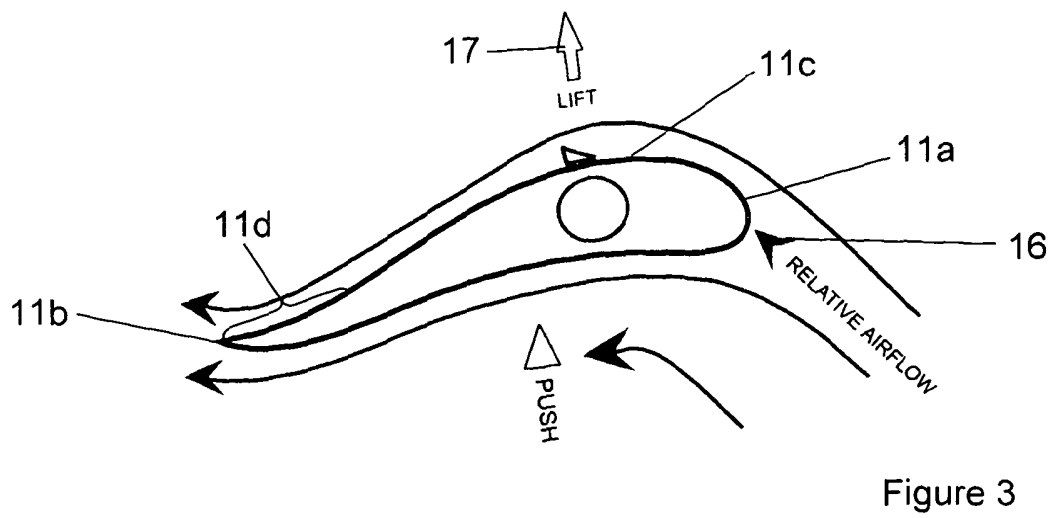
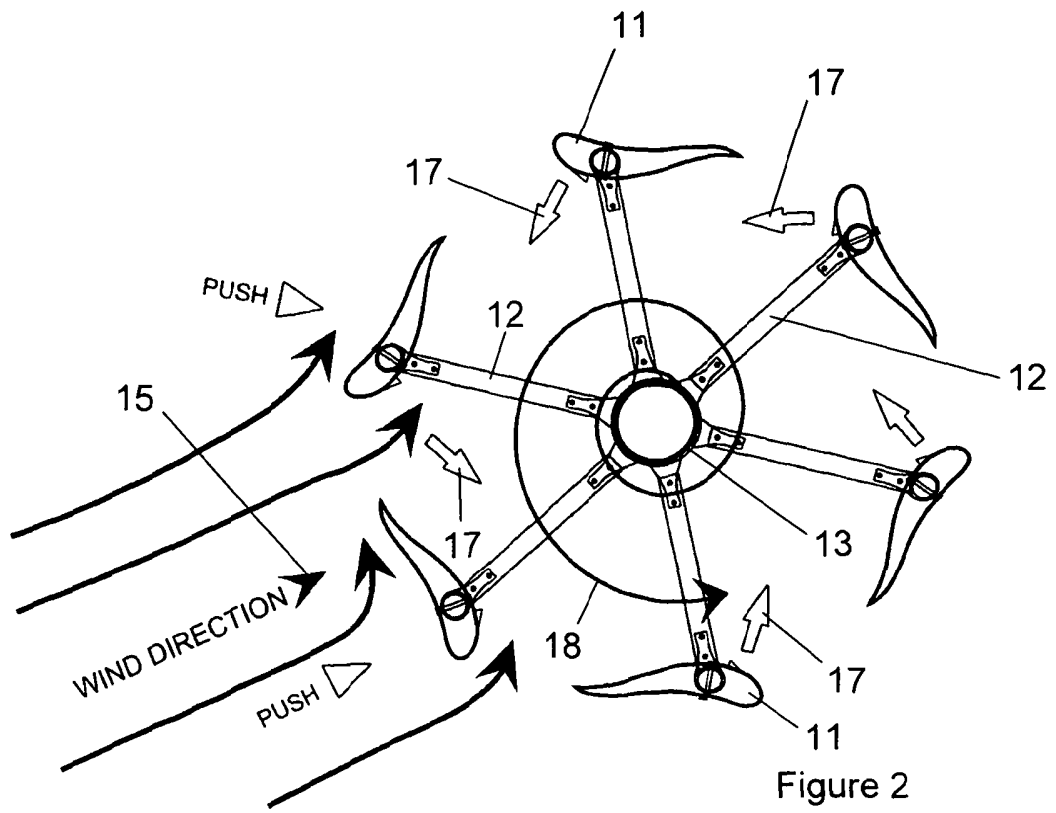


Figure 4b

Prior Art





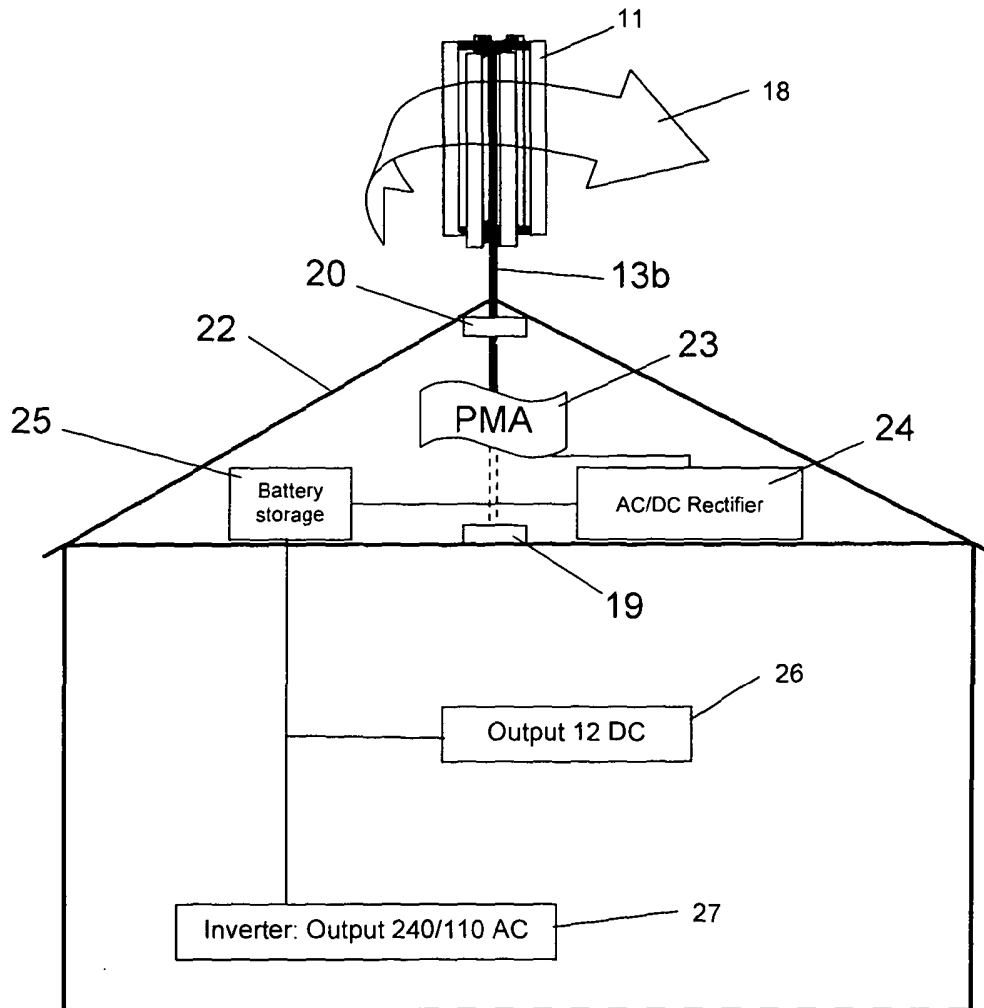


Figure 4a

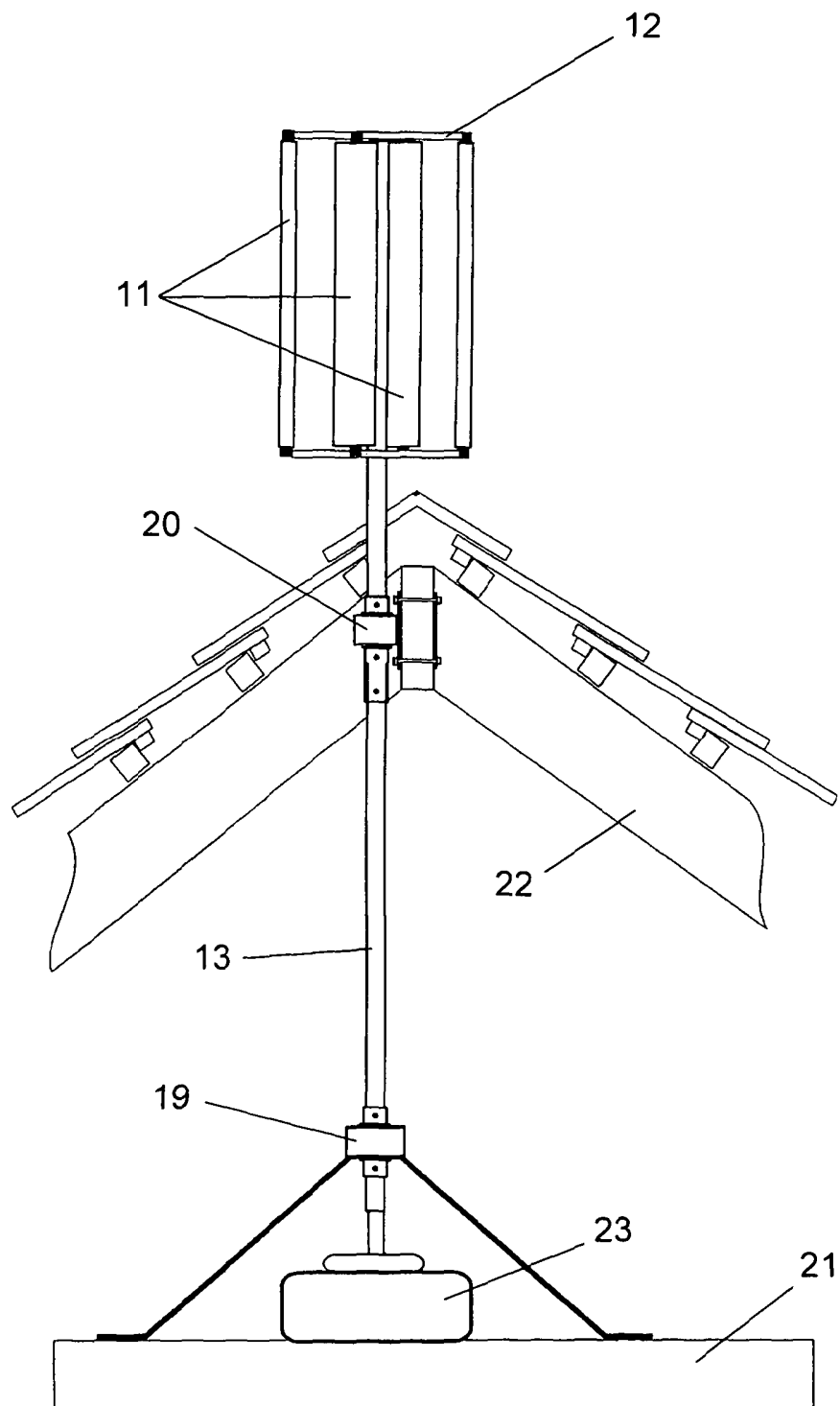


Figure 4b

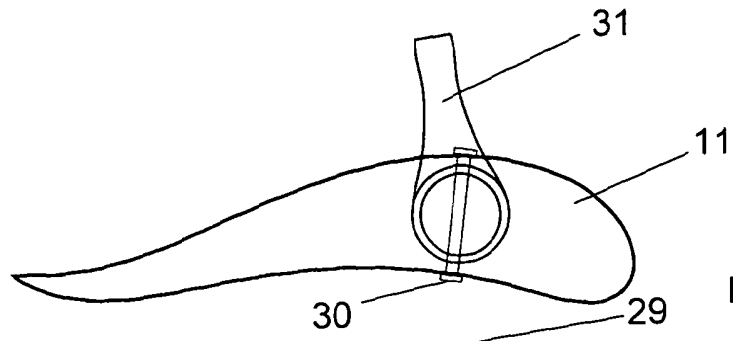


Figure 5a

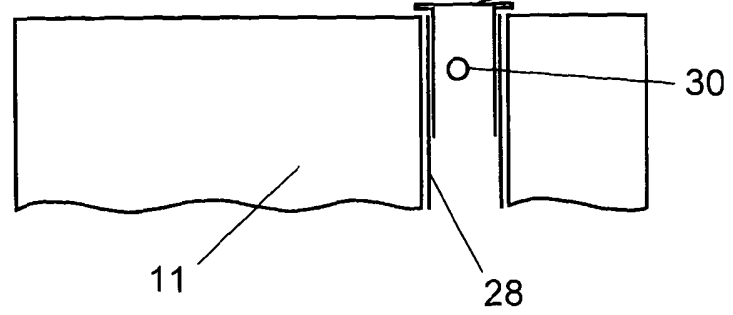


Figure 5b

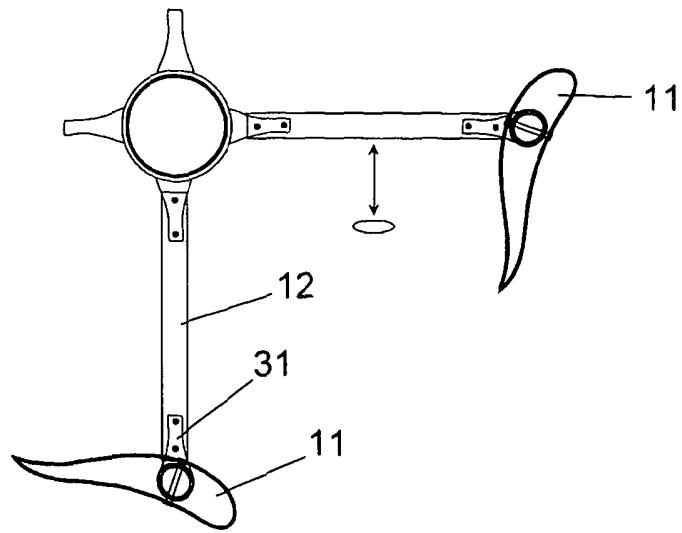


Figure 6



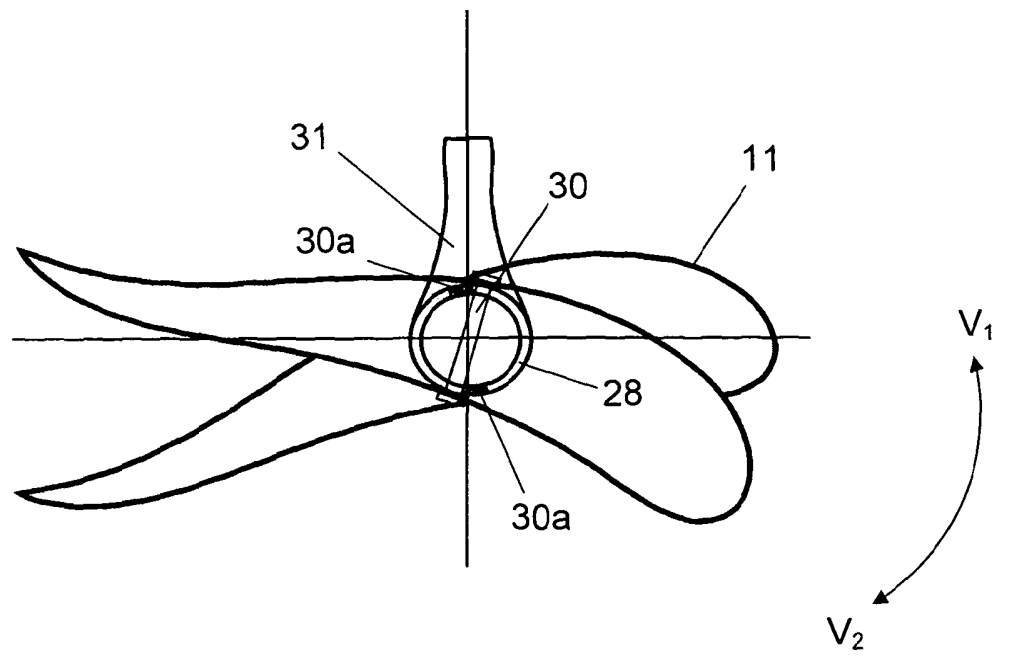
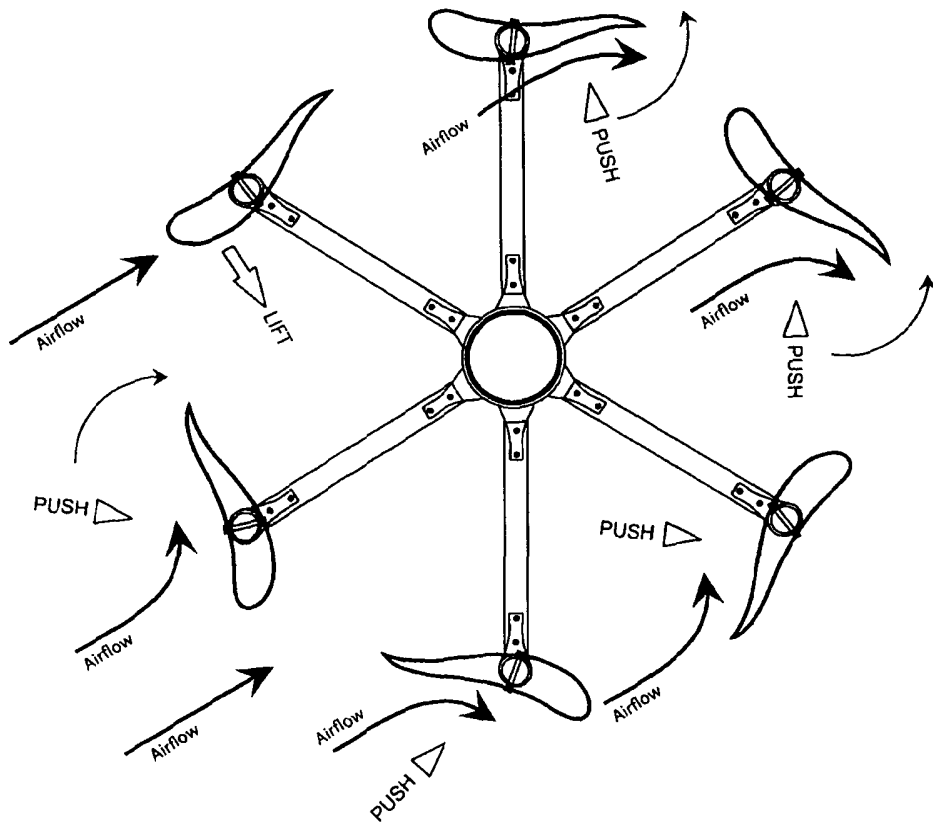


Figure 7





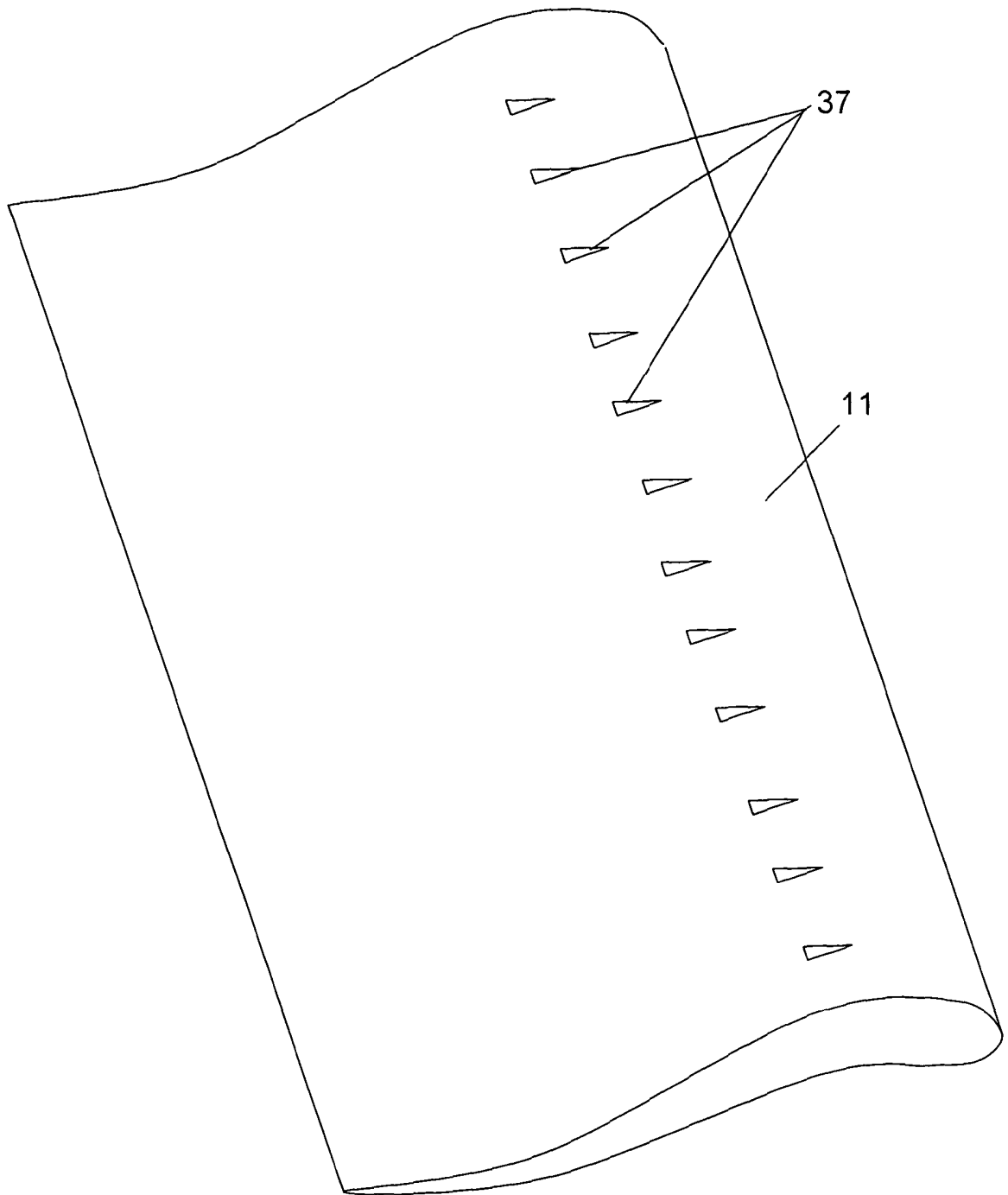


Figure 9

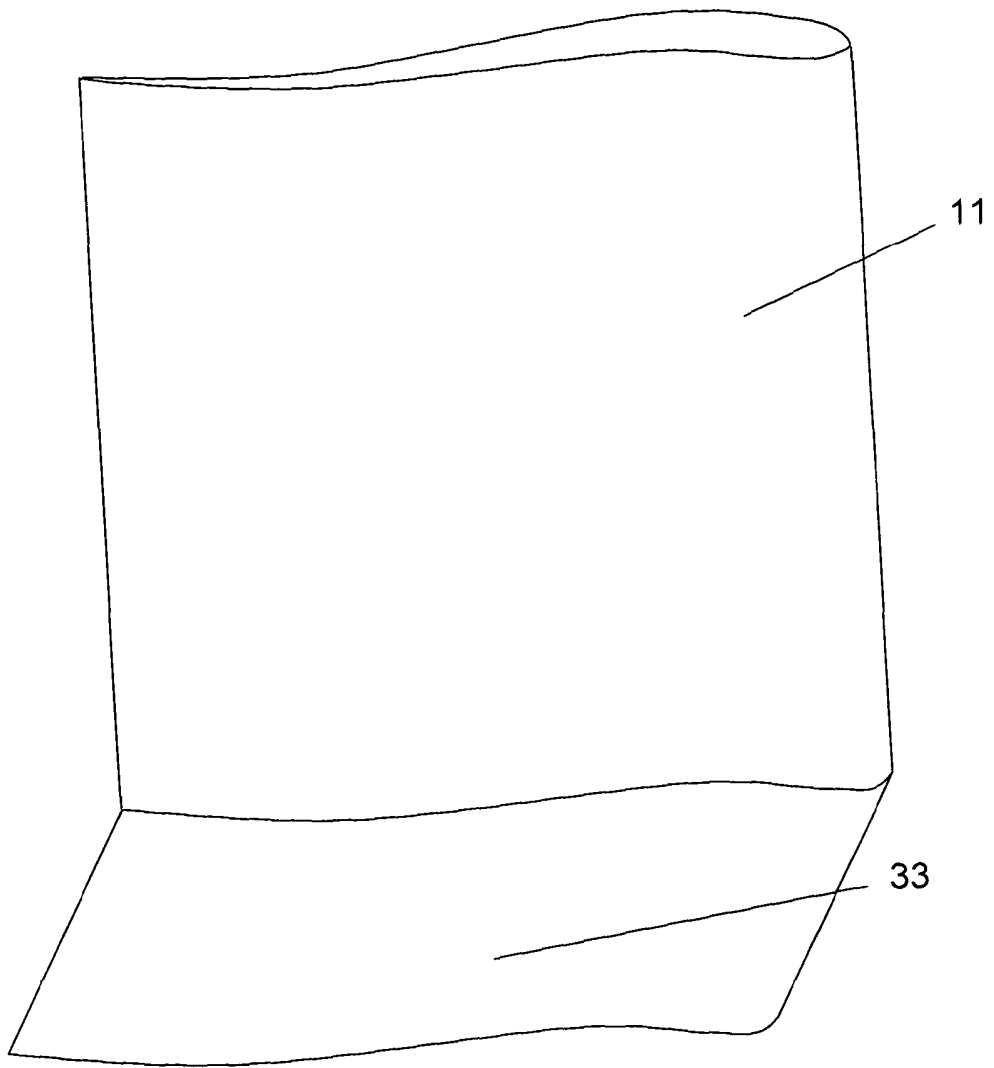


Figure 10

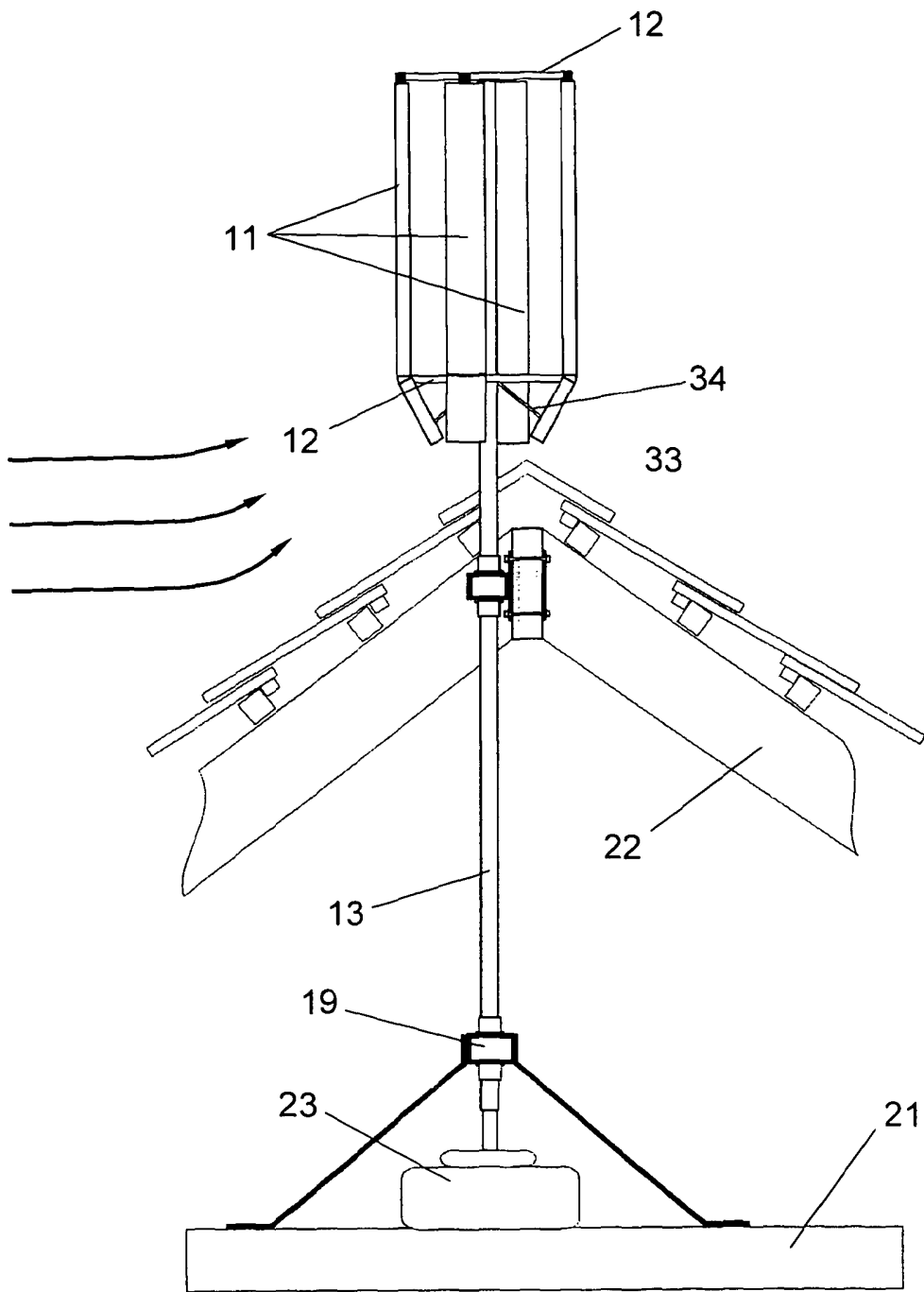


Figure 11

TITLE

Wind Turbine Powered Generator

DESCRIPTION

5 Field of the Invention

The invention relates to wind-powered electrical power generation and to turbine powered generators which are sized small enough to be mounted on the rooftops of domestic houses.

10 Background Art

Wind-powered generators are known for the commercial wind-powered generation of electricity. In general, such generators have a horizontal spindle axis carrying radially extending blades like a propeller. The same horizontal axis propeller design has been used on smaller domestic sized wind-powered generators, but in that market competes with vertical axis wind-powered generators (VAWGs) in which an array of blades each of aerofoil section extend vertically or helically around a vertical shaft to which they are connected by radially extending spokes. Such VAWGs are effective for converting the kinetic energy of wind into electrical energy over a range of wind speeds and have the advantage that unlike horizontal axis wind-powered generators (the propeller design generators) they do not have to be rotated to face into the wind. They are omni-directional and can convert the kinetic energy of winds coming from any angle. Also they are quieter in use than horizontal axis generators and do not produce the distressing throbbing noise caused by the very high blade tip speeds of some larger horizontal axis generator models.

25

One class of VAWG developed by a designer called Darrieus uses aerofoil section blades extending parallel to but radially outwardly from a turbine shaft which they drive. The blades have to be rotating before they generate lift, but when they spin at a speed greater than the ambient wind speed the lift that they generate makes their rotation self-sustaining, and the kinetic energy of the wind can be used to generate electrical power.

30

US-A-2008/0309090 discloses one such Darrieus VAWG. The blades are symmetrical about a radial vertical plane through the vertical turbine shaft. The generator is designed to be bolted to a horizontal flat surface. As with other Darrieus VAWGs, the design presents problems of initial start-up which according to US-A-
5 2008/0309090 is solved by the aerodynamic design of the individual spokes connecting the vertical blades to the turbine shaft, and by an automatic clutch for coupling the rotating blades to the electrical generator only when the free-wheeling rotational speed of the vanes is sufficient to overcome a negative starting torque.

10 It is an object of the invention to provide a VAWG which can be mounted on the apex of a pitched roof in order to provide electrical power generation on a domestic scale. It is a further objective to avoid the problems associated with the initial start up of known Darrieus VAWGs.

15 The Invention

The invention provides a VAWG having the characteristics of claim 1 herein. The structure is well suited for mounting on the apex of a pitched roof, for example the roof of a domestic house, because it takes its support from the roof structure itself. It
20 does not require the use of stays or guy ropes above roof level, as the support can all be provided within the roof structure itself. By using asymmetric aerofoil sections for the rotating vanes which drive the spindle shaft the VAWG of the invention can be self-priming in that it starts to rotate from stationary even in relatively light cross-winds. To achieve that self-starting characteristic, the asymmetric aerofoil vanes are
25 presented at an angle of attack, relative to their direction of movement around the axis of the drive shaft, which in a cross-wind creates a component of lift that is tangential to the circular array of aerofoil vanes.

The drive portion of the drive shaft may be permanently connected to drive the
30 electric generator or may, as in US-A-2008/0309090, be connected to the generator through an automatic clutch which engages the drive to the generator only when an initial start-up speed has been attained.

The aerofoil section used for the rotating vanes of the VAWG of the invention is preferably one with a reflex trailing edge. The concave surface of the reflex trailing edge is preferably presented on the radial inner side of the aerofoil vane, being the
5 side of the aerofoil vane which faces the turbine shaft in use. Preferably the aerofoil vanes are mounted on the spoke members which extend radially from the drive portion of the turbine shaft on bushings which enable the angle of attack to be varied. The optimum angle of attack will be a function of the expected average wind speed, the aerofoil profile and the load characteristics of the electric generator. Ideally each
10 vane can be individually adjusted on initial assembly to a chosen angle of attack and then locked at that angle.

The VAWG of the invention is capable of working over a range of wind speeds and all wind directions. Its operation is unaffected by constantly changing wind direction
15 such as is experienced in local weather conditions. Efficiency is however greatly increased if each aerofoil vane is provided, over at least the top camber of its radially inner surface, with at least one vortex generator and preferably one or more rows of vortex generators which extend outwardly from the top camber surface in the direction of lift. The vortex generators, used for example on many aircraft wing
20 aerofoil sections, create a vortex stream of air over each vane radially inwardly facing surface, thereby keeping the air in close proximity to the aerofoil top camber surface. The vortex generators reduce the range of angles during the complete 360° of rotation of the individual vanes over which the aerofoils generate no lift or experience a stall condition. They do that by keeping the air attached to the aerofoil top camber surface
25 at higher angles of attack.

The invention benefits from the natural increase in wind velocity as a cross-wind blows laterally over a pitched roof, but in addition to that localised increase in wind velocity such a cross-wind tends to acquire a vertical component on each side of the
30 apex of the roof (upwardly on the windward side and downwardly on the leeward side). A slight modification in the shape of the aerofoils can take direct benefit from the vertical component of wind velocity. Preferably each aerofoil vane has a bottom

portion which is the same section as the remainder of the aerofoil vane but which is angled inwardly towards the spindle shaft axis. If the aerofoil vane is made from a constant section extrusion of, for example, aluminium or a thermoplastic material then that bottom portion may be connected to the remainder by a type of mitre joint, and supported by a jury strut.

Drawings

Figure 1 is a horizontal section through a known Darrieus VAWG having a single pair of diametrically opposed vanes of symmetrical aerofoil section;

Figure 2 is a similar horizontal section through a VAWG according to the invention having three pairs of diametrically opposed vanes of asymmetric aerofoil section;

Figure 3 is a section through one of the vanes of Figure 2 showing the push and lift effects of airflow over the vane;

Figure 4a is a schematic section through a house having a pitched roof with a VAWG according to the invention mounted on the apex of the roof;

Figure 4b is an installation detail illustrating the mounting of the VAWG of Figure 4a;

Figures 5a and 5b are mutually perpendicular sections through one of the vanes of Figures 2 to 4, illustrating its adjustable angle of attack mounting;

Figure 6 is a partial horizontal section similar to that of Figure 2 but through a VAWG according to the invention having two pairs of diametrically opposed vanes with the adjustable angle of attack mountings of Figure 5;

Figure 7 is a section similar to that of Figure 5a but through a VAWG according to the invention with an automatically variable angle of attack aerofoil;

Figure 8 is a partial horizontal section similar to that of Figure 6 but through a VAWG according to the invention having three pairs of diametrically opposed vanes with the automatically adjustable angle of attack mountings of Figure 7;

- 5 Figure 9 is a perspective view of the top (lift) surface of a vane of a VAWG according to the invention showing a single row of vortex generators;

Figure 10 is a perspective view of a vane of a VAWG according to the invention having a downwardly and inwardly angled bottom vane portion; and

10

Figure 11 is an axial section similar to that of Figure 4b through another VAWG according to the invention mounted on a pitched roof, the VAWG having two pairs of diametrically opposed vanes each as shown in Figure 10.

- 15 Figure 1 illustrates a known Darrieus VAWG. A pair of symmetrical aerofoil section vanes 1 are mounted on spokes 2 for rotation about a spindle shaft 3. Darrieus VAWGs have been also proposed with two or more pairs of vanes in a circular array around the spindle shaft 3. At the bottom left of the Figure there is shown an arrow 4 which shows the relative airspeed past the vanes 1 when the vanes rotate about the spindle shaft 3 in still air. An arrow 5 represents a wind speed and direction, so that a resultant air flow over the vane 1 in air other than still air is shown by an arrow 6. The consequence is a lift force on the vane 1 in the direction of the arrow 7.
- 20

- If the spindle shaft 3, spokes 2 and vanes 1 of Figure 1 are rotated in the direction of an arrow 8, the lift exerted on the opposed vanes includes a component which drives the rotation forwardly, converting the kinetic energy of the wind into a rotational torque on the spindle shaft 3 sufficient to drive an electric generator and create a useful electrical power output. A Darrieus VAWG must, however, include some component or element effective to drive the shaft 3 in the direction of the arrow 8 until a self-sustaining speed is reached. That self-sustaining speed will vary depending on the wind speed.
- 25
- 30

Figure 2 is a similar section through a VAWG according to the invention. Elements directly comparable to corresponding elements of Figure 1 have the same reference numbers but increased by 10. The VAWG of Figure 2 has six vanes 11 arranged in three diametrically opposed pairs around a spindle shaft 13 and connected to the spindle shaft 13 by spokes 12, but any circular array of any even or odd number of vanes 11 would be equally feasible. The vanes 11 of Figure 2 have asymmetric aerofoil sections as shown in more detail in Figure 3, with each aerofoil section comprising a leading edge 11a, a trailing edge 11b, a top camber 11c and a reflex portion 11d leading to the trailing edge 11b. In use the reflex portion 11d faces radially inwardly, towards the spindle shaft 13. Figures 2 and 3 illustrate the wind direction 15 and the resulting lift 17 on the various aerofoil sections 11.

The mounting of the VAWG of Figure 2 on a house roof is illustrated in Figure 4. The roof is a pitched roof. The spindle shaft 13 has a mounting portion 13a within the roof structure and a drive portion 13b extending through the roof cladding and protruding above the apex of the roof. The mounting portion is rotatably mounted between two vertically spaced bearings 19 and 20, of which one, 19, is secured to horizontal ceiling joists 21 of the roof and the other, 20, is secured to the roof rafters 22 where they meet at the apex of the roof. The roof structure itself therefore provides a strong and secure mounting for the VAWG.

Within the roof structure is a generator 23 which converts the rotation of the spindle shaft 13 into electrical energy. A suitable generator as a permanent magnet generator producing a 3-phase AC output at rotational shaft speeds in excess of 150 rpm.

Figure 4 illustrates how the output of the generator 23 can be rectified at 24 to DC voltage which is used to charge batteries 25. The result could be either or both of a 12 volt DC output 26 and an inverter 27 output of 240 volt or 110 volt AC.

The individual vanes 11 of Figure 2 may be presented by their supporting spokes 12 at a variety of different angles of attack. Each vane 11 has a pivot shaft 28 passing laterally through its broadest section beneath the top camber 11c and retained by end

caps 29 secured in place by rivets 30, as shown in Figures 5a and 5b. The pivot shaft 28 supports a stub mounting arm 31 as shown in Figures 5a and 6, and the angle between the stub mounting arm 31 and the vane 11 can be adjusted and clamped (by means not illustrated) so as to vary the angle of attack of the vane 11. The stub
5 mounting arm 31 is attached to the radially outer end of an associated spoke 12 by bolts or rivets. The spoke 12 may have an elliptical section as shown in Figure 6 for minimal air disturbance as the VAWG rotates.

Although the angle of attack of the vanes 11 of the VAWG of Figures 1 to 6 is
10 variable, the vanes are set at a fixed angle of attack during manufacture or at installation and locked at a preselected angle which is chosen to suit the expected local wind conditions. As an alternative the vanes may be able to pivot from the desired angle of attack as illustrated in Figures 7 and 8 with the trailing edge pivoting outwards and the leading edge pivoting inwards towards the centre. The vane
15 mounting shown in Figure 7 is similar to that of Figure 5a except that the vane is not locked at a fixed angle and the pivotal axis as defined by the pivot shaft 28 is set further towards the rear of the vane in Figures 7 and 8 than in Figure 5a. Also the rivets 30 pass through short slots 30a in their pivot shafts 28, to permit a limited angular movement of each vane 11 relative to its stub mounting arm 31 during the
20 normal rotation of the VAWG in use. The surface area exposed to the wind of the leading portion of each vane forwardly of the pivot shaft 28 is less than the surface area exposed to the wind of the trailing portion aft of the pivot shaft, so that the force of a wind pushing directly against each vane tends to rotate that vane to exert the maximum push from the wind. The leading edge portion of the aerofoil forward of
25 the pivot shaft has a greater mass than the mass of the aerofoil portion aft of the pivot shaft to such a degree that as the VAWG rotation speed increases the leading edge pivot outwards and the trailing edge inwards to the pre-set optimum angle of attack to benefit from the lift generated by the pressure differential generated by the aerofoil.

30 Figures 2 and 3 show vortex generators 32 on the top camber portion 11c of the aerofoil section of the vanes 11, although their presence has not so far been explained. The same vortex generators may if desired be included on the vanes 11 of Figures 7

and 8. A complete row of those vortex generators 32 is illustrated in Figure 9. They create a vortex stream in the air flowing over the top camber portion 11c of the vane 11, and the vortex stream keeps the air in close engagement with the aerofoil surface at the high angles of attack, thus increasing the lift and power generated by the
5 VAWG.

As a cross-wind blows over a pitched roof there is a tendency for the wind speed to increase as it crosses over the apex of the roof pitch. That is to the advantage of the VAWG of the invention, as the higher wind speed gives a greater localized amount of
10 kinetic wind energy in the precise location of the rotary vanes 11 when the wind direction is across the roof pitch. In the zones slightly on the windward and leeward sides of the apex, however, there is another effect. The wind acquires a vertical component of velocity caused by the angle of the roof pitch. A small modification of the VAWG of the invention, as illustrated in Figures 10 and 11, takes advantage of
15 this slight change in the wind direction. A bottom portion 33 of each vane is angled downwardly and inwardly towards the spindle shaft 13, so as to present an aerofoil surface more normal to the air flow as shown in Figure 11. The bottom portion 33 has the same aerofoil section as the remainder of the vane 11 and is connected to the vertical main portion of the vane 11 by a type of mitre joint where the portions meet
20 and by a jury strut 34 extending from the lower spoke 12.

Claims

1. A vertical axis wind-powered generator (VAWG) for mounting on the apex of a pitched roof, comprising:

5 a turbine shaft rotatably mounted by a pair of vertically spaced bearings, of which a lower one is provided with means for securing it to a cross-beam of a roof structure below roof apex height, and an upper one is provided with means for securing it to the apex of the roof structure with an integral drive portion of the shaft extending up through the roof cladding;

10 a circular array of vertically aligned asymmetric aerofoil vanes drivingly connected to the drive portion of the turbine shaft by radial spoke members, each aerofoil vane being presented at an angle of attack, relative to its direction of movement around the axis of the drive shaft, which in a cross-wind creates a component of lift that is tangential to the circular array of aerofoil vanes; and

15 an electric generator within the roof structure between the vertically spaced bearings and driven by the turbine shaft.

3. A VAWG according to claim 1, wherein the aerofoil section of each vane is one with a reflex trailing edge.

20

3. A VAWG according to claim 2, wherein each vane has a reflex trailing edge with a concave surface which faces the turbine shaft in use.

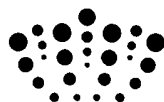
4. A VAWG according to any preceding claim, wherein the aerofoil vanes are connected to their associated radial spoke members by bushings which enable the angle of attack of the aerofoil vanes to be altered and then locked at a fixed angle of attack during power generation.

25

5. A VAWG according to any preceding claim, wherein each aerofoil vane is provided with at least one row of vortex generators which extend outwardly from a top camber surface of the aerofoil vane in the direction of lift.

30

6. A VAWG according to any preceding claim, wherein each aerofoil vane comprises a main vertical portion and a bottom portion having the same aerofoil section but which is angled inwardly towards the spindle shaft axis.
- 5 7. A VAWG substantially as described herein with reference to any of Figures 2 to 9.



Application No: GB1000388.7

Examiner: Mr Gareth Price

Claims searched: 1 to 7

Date of search: 12 May 2010

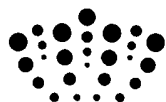
Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
Y	1, 5	AU 2008202743 A1 (GILBEE) See entire document, particularly figs 1 & 6 and description of page 9, line 17 to page 10, line 31. A roof mounted, air powered electrical energy generating device having a shaft 4 held in position by bearing mounts 5, a lower mount shown on a roof purlin, an upper mount shown near the apex of a roof structure. A generator 7 is provided in the roof space.
Y	1, 5	US 2004/047723 A1 (HORJUS) See abstract and figures 4 & 9 particularly. Also see description of page 2, para 29; page 3, para 34. A wind turbine having a vertical shaft with lower bearing 124 and upper bearing 128, and wind catching parts.
Y	1	JP 2005090257 A (SHINKO) See EPODOC and WPI abstracts (acc. no: 2005-081092 [09]) and figures 1 and 6 particularly. A vertical shaft wind powered electricity generation apparatus having blades vertically attached to a shaft by spokes 13a, 13b. As seen in fig 6, the blades are asymmetric.
Y	1	EP 2039929 A1 (YAN) See abstract, figures 1 & 2 particularly and description, particularly page 4, paragraph 27. A vertical axis wind turbine having vertical axis 1, support limbs 21 and 22, and a plurality of asymmetric aerofoil blades.
Y	5	EP 1886016 A1 (VESTAS) See entire document. Wind turbine blades having vortex generators 10 mounted to their surface.
A	-	DE 19928897 A1 (DOEHR) See EPODOC and WPI abstracts (acc. no: 2000-284483 [25]) and figure 1 particularly. A system for using wind power plants on roofs, having a main shaft extending through the roof space.
A	-	DE102008051255 A1 (MARTIN) See WPI abstract (acc. no: 2010-E10471 [28]) and figures. A wind power plant for use in roof for supply of power.

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	P	Document published on or after the declared priority date but



combined with one or more other documents of same category.	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^X :

Worldwide search of patent documents classified in the following areas of the IPC

F03D

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

EPODOC, WPI, NPL, XPAIP, XPIOP, XPESP, INSPEC, TXTE, Internet

International Classification:

Subclass	Subgroup	Valid From
F03D	0011/04	01/01/2006
F03D	0003/00	01/01/2006