

AN AUGMENTED VERTICAL AXIS WIND TURBINE

TECHNICAL FIELD

This invention relates generally to augmentation to vertical axis wind augmented vertical axis
5 wind turbines for use for use in harvesting energy from air/fluid flow.

Background

Wind energy has used for powering machinery since ancient times. Since then, the need to
generate power from greener and renewable sources like the wind has become ever more
10 urgent, and wind turbines have been developed for the production of electrical power.

Different wind turbine designs have been developed for use in different scenarios and
applications. For example, they may be classified according to whether the blades of the
wind vane rotate about an axis of a shaft which is horizontally or vertically disposed.
15 Horizontal axis wind turbines (HAWTs) tend to be more commonly deployed as they tend to
be more efficient: this is a result of blade rotation in a direction perpendicular to the direction
of wind flow so that they receive energy through the entire cycle during rotation. However,
they suffer various disadvantages, not least in the sheer height, size and weight of the towers
and the blades, which makes installation, operation and maintenance extremely costly. They
20 also need careful positioning into the wind, are unlikely to work well in conditions where the
25 wind is variable in speed and direction. Such wind turbines are also potentially disruptive,
in the visual sense as well as to anything from wildlife, to the transmissions of radio signals.

A typical Vertical Axis Wind Turbine (VAWT) has vertically placed “Blades”, positioned, in
25 a circular manner around a vertical axis, which gives rise to the name VAWT. The blades of
a VAWT have blade profiles that are fashioned after aircraft wings. When the wind blows
against the “assembly of blades”, two types of forces are generated by the blades, namely lift
forces and drag forces. The purpose of fashioning the Blades after aircraft wings is to
produce lift from pulling and pushing forces that the airflow against the rotor blade generates,
30 when the blades move around in their circular path around the vertical axis. The faster the

blades move, the higher the lift is generated. Ideally, both “pulling and pushing” forces to the blades, are employed to turn the assembly of blades with greater speed.

Speed, or velocity, of the blades moving through air determines the amount of lift generated thereby. Simply put, higher blade velocity results in greater lift, and greater lift offers the opportunity to tap the rotational forces of the assembly of blades, thereby producing torque. When coupled mechanically to an alternator, the torque is converted to electricity. When a linear alternator is employed, there is no mechanical connection but a proximal, electromagnetic connection which also produces electricity. Therefore, it can be said that the ambient wind acting on the blades, at relative speed and relative angle of attack to the respective blades, starts an intricate “dance” of forces on an apparatus to move blades that in turn generate torque for the purpose of producing electricity.

Essentially, relative speed and relative angle of attack to of the direction of the air/wind to the blades are two of the most important contributions to the power output of a VAWT, with mechanical and electromagnetic configuration also contributing to the overall system efficiency.

There has been disclosure of use of articulated guide vanes to better guide the wind flow to the blades to improve efficiency of the VAWTs. However, use of articulated guide vanes with just a planar surface often results on an amount of the wind impinging on the planar surface of the articulated guide vanes being dispersed away from the intended direction of flow towards the blades. Therefore, there exists a need for a articulated guide vane for addressing the foregoing problems.

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Summary

In accordance with an aspect of the invention, there is disclosed an augmented vertical axis wind turbine comprising a support structure defining a first axis and having an outer portion circumscribing the first axis, a rotor assembly movably coupled to and configured to be supported by the support structure to enable rotational displacement thereof about the first

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axis, and an articulated guide vane assembly coupled to the support structure for circumscribing the support structure, the articulated guide vane assembly comprising a plurality of articulated guide vanes positionable for guiding fluids impinging thereupon towards the rotor assembly to thereby rotationally displace the rotor assembly about the first axis. The articulated guide vane assembly comprises a rig structure having an inner portion and an outer portion forming extremities thereof, the rig structure defining a rig plane and a vane axis adjacent the inner portion thereof, the angle of the rig plane with the rotor assembly being variable about the vane axis, the inner portion being positioned nearer to the rotor assembly than the outer portion the rig structure comprising: a pair of rig joints configured at the inner portion of the rig structure for rotational coupling to the support structure and a pair of masts extending from the pair of rig joints, and a sail coupled to the rig structure and shaped for presenting a trough to a flow of impinging fluid, the trough having a depth defined from the rig plane, the sail extending from the outer portion towards the inner portion of the rig structure to terminate at an inner edge whereat a vent is defined, the sail having a body segment extending between the inner portion and the outer portion of the rig structure and two side segments extending from opposing sides of the body segment of the sail for coupling to a respective one of the pair of masts. The body segment of the sail being substantially planar and substantially stiffened and the fluid impinging on the sail being concentrated at the trough and redirected towards the rotor assembly from the vent for exhaust therefrom, at least one of mass flow rate and flow direction of the fluid being directed at the rotor assembly being determined by the angle between the rig plane and the rotor assembly about the vane axis.

Brief Description of the Drawings

FIG. 1 shows an exemplary partial perspective of an articulated guide vane of an augmented vertical axis wind turbine with a fin assembly and cantilevered walkways in accordance with an aspect of the invention;

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FIG. 2 shows an exemplary partial front view of the articulated guide vane of FIG. 1 without the fin assembly and the cantilevered walkways;

FIG. 3 shows an exemplary partial perspective of the augmented vertical axis wind turbine in accordance with an aspect of the invention in the absence of the fin assembly and the cantilevered walkways for the articulated guide vanes;

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FIG. 4 shows an exemplary partial perspective of the augmented vertical axis wind turbine of FIG. 3 in the absence of the fin assembly, the cantilevered walkways and sail for the articulated guide vanes;

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FIG. 5 shows a partial perspective view of a support structure of the augmented vertical axis wind turbine of FIG. 3;

FIG. 6 shows a partial perspective view of a segment of the support structure of FIG. 5;

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FIG. 7 shows a plan view of a rotor assembly of the augmented vertical axis wind turbine of FIG. 3;

FIG. 8 shows a perspective view of the rotor assembly of FIG. 7;

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FIG. 9 shows a close-up partial perspective view of inner rolling elements of the support structure of FIG. 5;

FIG. 10 shows a partial front view of the inner rolling elements configured with upper inner guide rails of FIG. 7;

FIG. 11 shows a partial plan view of the articulated guide vane of FIG. 1 with the fin assembly and without the cantilevered walkways;

FIG. 12 shows another partial plan view of the articulated guide vane of FIG. 1 with the fin assembly and without the cantilevered walkways;

FIG. 13 shows a partial plan view of the articulated guide vane of FIG. 1 with both the fin assembly and the cantilevered walkways;

FIG. 14 shows a partial plan view of a sail of the articulated guide vane of FIG. 1 with one body segment interfacing two side segments when laid out on a flat surface;

FIG. 15 shows a front view of the articulated guide vane of FIG. 1 with the fin assembly and without the cantilevered walkways;

FIG. 16 illustrates a plan view configuration of the augmented vertical axis wind turbine when the respective articulated guide vanes are in a first general arrangement (General arrangement 'A') with respect to the general direction of wind;

FIG. 17 illustrates a plan view configuration of the augmented vertical axis wind turbine when the respective articulated guide vanes are in a second general arrangement (General arrangement 'B') with respect to the general direction of wind; and

FIG. 18 illustrates a plan view configuration of the augmented vertical axis wind turbine when the respective articulated guide vanes are in a third general arrangement (Hybrid of General Assemblies 'A' and 'B') with respect to the general direction of wind.

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Detailed Description

This invention, proposes augmentations in the form of articulated guide vanes to increase the power output of a typical non-augmented VAWT by 20 times or more, by substantially increasing the relative speed and relative angle of attack to an assembly of rotor blades. Larger augmentations could increase the power output by 50 times. This invention proposes use of an articulated guide vane assembly with appendages to enlarge and optimise wind capture, and to manage the airflow, momentum, pressure, velocity and mass of the air, angle of attack to the assembly of rotor blades and around the entire wind turbine, and the pressure behind the whole turbine. The design of the invention increases the kinetic energy of the wind to the rotor blades so as to increase the power output by a similarly sized non-augmented VAWT by 20 to 50 times. This could translate to a cost savings of power production by 95%. Larger models may be implemented to deliver greater power output.

15 An exemplary embodiment of the present invention, an augmented vertical axis wind turbine 20, is described hereinafter with reference to FIG. 1 to FIG. 18. The augmented vertical axis wind turbine 20 preferably comprises a support structure 22, a rotor assembly 24 and an articulated guide vane assembly 26. Within the augmented vertical axis wind turbine 20, the support structure 22 defines a first axis 28 and a central hollow 30 coinciding with the first axis 28. The support structure 22 has an outer portion 32 and an inner portion 34 forming the periphery of the central hollow 30. The rotor assembly 24 is movably coupled to and configured to be supported by the support structure 22 to enable rotational displacement thereof along the periphery of the central hollow 30 and about the first axis 28.

25 Movable coupling of the rotor assembly 24 to the support structure 22 is preferred as it enables the weight of the rotor assembly 24 to be distributed across the inner portion 34 of the support structure 22. This is opposed to having the rotor assembly 24 being supported from a central column or shaft (not shown) coinciding and parallel the first axis 28 and functioning as an axle to the rotor assembly 24 which will result in the full weight of the rotor assembly 24 being concentrated on the central column. Further, the cantilevering of the rotor assembly 24 from the central column may lead to weight and inertia eccentricity which

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may contribute to uneven or premature wear and tear when in use and failure contributed by static and dynamical imbalance of the rotor assembly 24 on such a central column.

The articulated guide vane assembly 26 is coupled to the outer portion 32 of the support structure 22 to enable the articulated guide vane assembly 26 to circumscribe the support structure 22. The articulated guide vane assembly 26 comprises a plurality of articulated guide vanes 36 positionable for guiding fluids impinging thereupon towards the rotor assembly 24 to thereby rotationally displace the rotor assembly 24 about the first axis 28. The rotating rotor assembly 24 can then be harvested for energy, for example, through the use of alternators or the like energy transducing systems.

SUPPORT STRUCTURE

Preferably, each of the support structure 22 and the rotor assembly 24 has a tubular shape extending along the first axis between a first end 38 and a second end 40. This enables the rotor assembly 24 to be configured concentric the support structure 22. To facilitate construction and subsequent maintenance of the support structure 22, the support structure 22 is segregated into a plurality of segments 42 about the first axis 28 with each of the plurality of segments 42 extending between the first end 38 and the second end 40. Each of the plurality of segments 42 is structurally independent and preferably constructed to form a standalone truss structure module. Each of the plurality of segments 42 is preferably constructed from permanently inter-coupled channels, tubes, shafts, profiles or any combination thereof. The inter-coupling of the plurality of segments 42 can be achieved through one or a combination of two or more of jointing, fastening, for example bolts and nuts, and welding. The plurality of segments 42 are then inter-coupled, either permanently through, for example, welding, or removably through the use of, for example, joints and fasteners. For ease of transport, assembly and maintenance, it is preferred that the support structure 22 comprises and is formed from six of the plurality segments 42.

Preferably, the support structure 22 further comprises an upper annular structure 43a at the first end 38 and a lower annular structure 43b at the second end 40 thereof. The support

structure 22 further comprises a plurality of posts 43c for spatially inter-displacing the upper annular structure 43a and the lower annular structure 43b with the upper annular structure 43a and the lower annular structure 43b.

5 ROTOR ASSEMBLY

- The rotor assembly 24 comprises a plurality of inner guide rails 44 with the support structure 22 comprising a plurality of inner rolling elements 46 for operationally complementing the plurality of inner guide rails 44. The plurality of inner rolling elements 46 are arranged to define a plurality of inner pathways, each corresponding with one of the plurality of inner
- 10 guide rails 44. This enables the plurality of inner guide rails 44 to engage with the plurality of inner rolling elements 46 to thereby movably couple the rotor assembly 24 to the support structure 22 and to enable travel of each of the plurality of inner guide rails 44 along the corresponding one of the plurality of inner pathways.
- 15 The plurality of inner guide rails 44 are inter-coupled to form a rigid body. Preferably, each of the plurality of inner rolling elements 46 is one of a polymeric, an elastomeric and a metallic wheel being set with one of a bush and bearings on an axle coupled to the inner portion of the support structure 22. Further preferably, each of the plurality of inner rolling elements 46 comprises a hard-wearing rubber or metallic layer, a ball or roller bearing
- 20 assembly and an elastomeric layer interfacing the rubber layer and the bearing assembly. It is further preferred that the plurality of inner rolling elements 46 are arranged for substantially impeding movement of each of the plurality of inner guide rails 44 transverse the corresponding one of the plurality of inner pathways.
- 25 Each of the plurality of inner guide rails 44 is preferably formed from one or more longitudinal tube segments shaped to form an endless circular loop. In order to reduce play and torsional strain between the support structure 22 and the rotor assembly 24, the plurality of inner guide rails 44 are grouped into at least upper inner guide rails 50 and lower inner guide rails 52 and spatially displaced from one another. The upper inner guide rails 50
- 30 comprises at least one of the plurality of inner guide rails 44 being disposed towards the first

end 38 of the rotor assembly 24 and the lower inner guide rails 52 comprises at least one of the plurality of inner guide rails 44 being disposed towards the second end 40 of the rotor assembly 24. Additional groups of the plurality of inner guide rails 44 may be employed and disposed between the upper inner guide rails 50 and the lower inner guide rails 52.

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Preferably, each of the plurality of inner pathways are substantially planar and is defined by multiple rolling element sets 54. Each of the rolling element set 54 comprises at least one of the plurality of inner rolling elements 46. Preferably, each of the upper inner guide rails 50 and the lower inner guide rails 52 has an end view cross-section comprising two spatially displaced circles formed by the inner guide rails 44 and a brace extending between the circles. With the brace being laid in a horizontal position, the cross-section will show a left circle and a right circle disposed at extremities of the brace. Each of the rolling element sets 54 will preferably have six rolling elements, three being positioned to abut the left circle at the 6, 9 and 12 o'clock positions while another three being positioned to abut the right circle at the 12, 3 and 6 o'clock positions. This configuration for each rolling element set 54 greatly reduces movement of each of the upper inner guide rails 50 and the lower inner guide rails 52 across the cross-sectional plane which is transverse the respective one of the plurality of inner pathways while still permitting displacement into the cross-sectional plane and along the plurality of inner pathways.

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Preferably, a linear alternator is coupled to and configured to interpose the rotor assembly 24 and the support structure 22 with the linear alternator for generating power from relative displacement between the rotor assembly 24 and the support structure 22.

25 ROTOR BLADES

The rotor assembly 24 comprises a plurality of rotor blades 58 extending between the upper inner guide rails 50 and the lower inner guide rails 52. Each of the plurality of rotor blades 58 defines a rotor axis 60 along the length thereof. The rotor axis 60 of each of the plurality of rotor blades 58 is substantially parallel the first axis 28. Each of the plurality of rotor

blades 58 is substantially rigid with sufficient strength to withstand flexure and torsion rated for the augmented vertical axis wind turbine 20 without approaching plastic deformation.

Each of the plurality of rotor blades 58 is formed from a single structural piece. Alternatively,
5 each of the plurality of rotor blades 58 is formed from multiple inter-coupled structural segments. Each of the plurality of rotor blades being rotatably coupled to the upper inner guide rails 50 and the lower inner guide rails 52 to enable rotational displacement of each of the plurality of rotor blades about the rotor axis thereof.

10 For each of the plurality of rotor blades 58, an upper rotor joint 62 couples one end of the rotor blade 58 to the upper inner guide rails 50 while a lower rotor joint couples the other end of the rotor blade 58 to the lower inner guide rails 52.

ARTICULATED GUIDE VANE ASSEMBLY

15 The articulated guide vane assembly 26 comprises a plurality of outer guide rails while the support structure 22 comprises a plurality of outer rolling elements arranged to define a plurality of outer pathways, each corresponding with and for the passage therealong of one of the plurality of outer guide rails. When in use, the plurality of outer guide rails engages with the plurality of outer rolling elements to thereby movably couple the articulated guide vane
20 assembly 26 to the support structure 22 and enable travel of each of the plurality of outer guide rails along the corresponding one of the plurality of outer pathways.

The plurality of outer guide rails are inter-coupled to form a rigid body. Preferably, each of the plurality of outer rolling elements is one of a polymeric, an elastomeric and a metallic
25 wheel being set with one of a bush and bearings on an axle coupled to the inner portion of the support structure 22. Further preferably, each of the plurality of outer rolling elements comprises a hard-wearing rubber or metallic layer, a ball or roller bearing assembly and an elastomeric layer interfacing the rubber layer and the bearing assembly. It is further preferred that the plurality of outer rolling elements are arranged for substantially impeding

movement of each of the plurality of outer guide rails transverse the corresponding one of the plurality of outer pathways.

Each of the plurality of outer guide rails is preferably formed from one or more longitudinal
5 tube segments shaped to form an endless circular loop. In order to reduce play and torsional
strain between the support structure 22 and the articulated guide vane assembly 26, the
plurality of outer guide rails are grouped into at least upper outer guide rails and lower outer
guide rails and spatially displaced from one another. The upper outer guide rails comprises
at least one of the plurality of outer guide rails being disposed towards the first end 38 of the
10 support structure 22 while the lower outer guide rails comprises at least one of the plurality
of inner guide rails being disposed towards the second end 40 of the support structure 22.
Additional groups of the plurality of outer guide rails may be employed and disposed
between the upper outer guide rails and the lower outer guide rails.

15 The articulated guide vane assembly 26 comprises an outer actuator and an outer rack
extending along an arcuate adjacent one of the upper outer guide rails and the lower outer
guide rails. The outer rack is engageable with an outer actuator-driven one of a pinion, bevel
and a worm gear to thereby enable control by the outer actuator for angular positioning of the
articulated guide vane assembly 26 about the first axis 28. Alternatively, an outer actuator-
20 driven linear displacement stage may be employed for angular positioning of the articulated
guide vane assembly 26 about the first axis 28.

The articulated guide vane assembly 26 further comprises an outer frame 94 inter-coupling
the plurality of outer guide rails and spatially displacing the upper outer guide rails from the
25 lower outer guide rails. The outer frame 94 is preferably formed from multiple inter-coupled
structural segments configured for inwardly fencing at least a portion of the outer structure.
The plurality of articulated guide vanes 26 are rotatably coupled to the outer frame 94 and
spatially distributed about the first axis 28. A rack and pinion assembly may be coupled to
the outer frame 94 for angular positioning of the articulated guide vane assembly 26 about
30 the first axis 28.

RIG STRUCTURE

Each of the plurality of articulated guide vanes 36 comprises a rig structure 126, configurable with the rotor assembly 24, and a sail 128. The rig structure 26 has an inner portion 130 and
5 an outer portion 132 forming extremities thereof. The inner portion 130 of the rig structure 126 is positioned nearer to the rotor assembly 24 than the outer portion 132 thereof. The rig structure 126 defines a rig plane 134 and a vane axis 135. The angle that the rig plane 134 establishes with the rotor assembly 24 is variable about the vane axis 135. The sail 128 is coupled to the rig structure 126 and is shaped for presenting a trough 136 to a flow of
10 impinging fluid. The impinging fluid can be one or a combination of wind, water or any type of liquids. In this exemplary implementation, the fluid is taken to be air, or more specifically, wind.

The sail 128 is formed from a flexible material for enabling displacement of the trough 136
15 across the rig plane 134 by the impinging fluid. The trough 136 has a depth 140 defined from the rig plane 134. The sail 128 extends from the outer portion 132 towards the inner portion 130 of the rig structure 126 to terminate at an inner edge 142 whereat a vent 144 is defined. The fluid impinging on the sail 128 is concentrated at the trough 136 and redirected towards the rotor assembly 24 from the vent 144.

20 The rig structure 126 comprises a pair of rig joints 148 configured at the inner portion 130 of the rig structure 126 and a pair of masts, specifically a first mast 150 and a second mast 152, extending from the pair of rig joints 148. The pair of rig joints 148 are for rotational coupling of the rig structure 126 to the support structure 22, preferably to the outer frame 94
25 thereof, to enable pivoting of the articulated guide vanes about their vane axis 135 and relative the support structure 22.

Each of post 43c, the first mast 150 and the second mast 152 are preferably formed from truss structures. However, use of other types of elongated structures with a solid core, a
30 hollow core or a frame-based construction are not precluded from being use in forming or

constructing the post 43c, the first mast 150 and the second mast 152. For example, each of the first mast 150 and the second mast 152 are formed from tubular shafts or truss structures with a triangular cross-sectional shape.

- 5 The sail 128 has an upper edge 156 and a lower edge 158 coupled respectively to the first mast 150 and the second mast 152. The sail 128 is preferably slidably coupled to the first mast 150 and the second mast 152. This enables the sail 128 to be collapsible from an extended state towards the outer portion 132 of the rig structure 126 to a retracted state. Preferably, each of the first mast 150 and the second mast 152 is constructed to allow flexure.
- 10 Hence, as an alternative to truss structures, the first mast 150 and the second mast 152 are constructable from metal H/I beams, composite elongates or the like structures to enable the first mast 150 and the second mast 152 to swing.

- Each of the first mast 150 and the second mast 152 can comprise and employ a pulley-line assembly to control deployment of the sail 128 between the extended state and the collapsed state. The pulley-line assemblies can be coupled to independent upper and lower cranks or to a common crank operable for communicating motion to the respective pulley line assembly. The crank can be hand-operated or coupled to a motor for operation thereof.
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20 MANDREL FURLING

- The rig structure 126 further comprises a brace structure 160 and a mandrel 162 formed along the outer portion 132 thereof for receiving the sail 128 when furled towards the outer portion 132 of the rig structure 126. The mandrel 162 enables a respective one of the plurality of articulated guide vanes 36 to be deactivated by sliding the sail 128 along the first mast 150 and the second mast while being retracted into the mandrel 162. Preferably, the brace structure 160 is substantially a C-channel with the opening of the C-channel being positioned to face the inner portion 130 of the rig structure 126. The C-channel is further shaped and dimensioned for containing the mandrel 162 therewithin for shielding the sail 128 retracted thereinto from fluids directed thereat. The brace structure 160 defines the distance
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- 30 between the first mast 150 and the second mast 152 at the outer portion 132 of the rig

structure 126. This enables the first mast 150 and the second mast 152 to spatially diverge, or outwardly flare, from the inner portion 130 towards the outer portion 132 of the rig structure 126. Consequently, the distance between the first mast 150 and the second mast 152 at the outer portion 132 of the rig structure 126 is larger than the distance of the same at the inner portion 130 thereof. The sail 128 is formed from a flexible material, for example, fabric, denim, polymeric, cellulosic, metallic mesh or any combination thereof. When the sail 128 is in the extended state, the depth 140 of the trough 136 increases the nearer it gets to the inner portion 130 of the rig structure 126.

10 SAIL

The sail 128 comprises a body segment 164 extending between the inner portion 130 and the outer portion 132 of the rig structure 126 and two side segments 166 extending from opposing sides 167 of the body segment 164 of the sail 128 for coupling to a respective one of the pair of masts 150/152. Preferably, the body segment 164 of the sail 128 is substantially planar and substantially stiffened and the fluid impinging on the sail 128 being concentrated at the trough 136 and redirected towards the rotor assembly 24 from the vent 144 for exhaust therefrom. At least one of mass flow rate and flow direction of the fluid being directed at the rotor assembly 24 being determined by the angle, specifically the vane angle 174, between the rig plane 134 and the rotor assembly 24 about the vane axis 135. Preferably, each of the body segment 164 and the two side segments 166 are substantially rectilinear in shape. Preferably, the sail 128 has a substantially rectangular, or squarish, shape to minimize crumpling of the sail 128 when furled and retracted into the mandrel 162. The difference in the distances between the first mast 150 and the second mast 152 at the outer portion 132 and the inner portion 130 of the rig structure 126 enables the sail 128 to be shaped and folded at the interface between the body segment 164 and both the side segments 166 for forming and shaping the vent 144.

The rig structure 126 further comprises a plurality of stiffeners formed with the sail 128 for shaping the trough 136. At least one of the substantially rectilinear shaping of the body segment 164 and the two side segments 166 and the use of the plurality of stiffeners enables

the body segment 164 to be kept substantially rigid and planar when in use. Each of the plurality of stiffeners is elongated and spatially inter-displaced along a medial segment 170 of the sail 128 from the outer portion 132 towards the inner portion 130 of the rig structure 126 with each of the plurality of stiffeners extending between the outer portion 132 and the inner portion 130 of the rig structure 126. Each of the plurality of stiffeners are shaped and formed to be resiliently biased to accommodate and impart flexure to the medial segment 170 of the sail 128. Further, the plurality of stiffeners are being disposed for defining folding lines parallel thereto to enable the sail 128 to be substantially kinked along the folding lines when presented to fluids impinging thereupon to thereby further shape the trough 140 of the sail 128.

Each of the first mast 150 and the second mast 152 comprises a pair of cantilevered walkways 172 outwardly extending from the respective one of the first mast 150 and the second mast 152 over a portion of the sail 128 oblique the rig plane 134. The pair of cantilevered walkways 172 at each of the first mast 150 and the second mast 152 is to reduce spillage of fluid from the sail over the pair of masts 150/152.

The first mast 150 and the second mast 152 are rotatably coupled at the pair of rig joints to the outer frame 94 to enable varying of vane angle 174 of the rig plane 34 about the vane axis 135 with reference to the rotor assembly 24. The vane axis 135 is defined substantially adjacent or coincident the pair of rig joints 148. Specifically, the vane angle 174 is referenced from the tangent of a reference circle circumscribing the periphery of the rotor assembly 24. The rig structure 126 comprises a pair of cross bars 176, an actuator, for example a linear motor and a rotary motor, and a coupling assembly for communicating displacement to the first mast 150 and the second mast 152 about the vane axis 135. Each of the cross bars 176 is configured to be positioned substantially perpendicular one of the pair of masts with extremities thereof being coupled to the actuator via the coupling assembly for controlling angular positioning of the pair of masts about the vane axis 135 by the actuator. The coupling assembly is at least one of a pulley assembly, a translational linkage and a plurality of gears interposing the actuator and the first mast 150 and the second mast 152 via

the pair of cross bars 176. The cross bars 176 are also dimensioned and positioned for the extremities of each thereof to abut the outer frame 94, or an abutment surface on the outer frame 94, to limit the angular displacement of the rig structure 126 about the vane axis 135 which in turn will prevent collision between adjacent articulated guide vanes 36 when in use.

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FIN ASSEMBLY

Preferably, the rig structure further comprises a fin assembly 182 extending between the pair of masts 150/152 adjacent the outer portion 32 of the rig structure 26. Preferably, the fin assembly 182 has an outer face 184 which outwardly faces the inner portion 130 of the rig structure 126 and two inner face 186, each forming a gradient with the rig plane 134 for at least one of guiding fluid into the sail and to reduce spillage of fluid from the sail 128 over the fin assembly 182. Preferably, the inner face 186 of the fin assembly 182 is one of planar and curved. Preferably, the fin assembly 182 is formed integral the C-channel of the brace structure 160.

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In one implementation, the articulated guide vane assembly 26 is not rotationally displaceable about the first axis 28 relative the support structure 22. In other implementations, the articulated guide vane assembly 26 is adaptable to be rotationally displaceable about the first axis 28 relative the support structure 22

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EXEMPLARY IMPLEMENTATION

In an exemplary implementation of the invention, the basic articulated guide vane assembly 26 comprises a horizontal structural member at top and at the bottom, making a pair of horizontal guide vanes adapted from the first mast 150 and the second mast 152. The set of horizontal guide vanes are pivoted at the support structure 22 enveloping the assembly of rotor blades 58 that rotate around a vertical central axis, specifically the first axis 28. At the pivoted end of the articulated guide vane assembly 28 are industry standard devices such as a hydraulic drum or winches to articulate, or yaw, the articulated guide vane assembly 28 left to right, to achieve the best angle of attack.

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Suspended between the top and bottom pair of horizontal guide vanes is the sail 128. The sail 128 is preferably made of UV resistant sail 128 cloth but is not limited to sail 128 cloth. Variations may include metallic or composite materials. The sail 128 is designed to be fashioned like a scoop, tight at the outer end and with a vent at the opening closes to the rotor assembly 24. The sail 128 can either be deployed or retracted. When needed, the sail 128 is drawn out to as close to the rotor assembly 24 as desired. When not required, the sail 128 is drawn or furled into its housing where a rotating mandrel rolls up the sail 128 cloth and stored in a sail boom housing, adapted from the C-channel of the brace structure 160.

10 The sail 128 has a straight backplane profile which is designed to create a sliding effect to maximise the momentum of the mass of air flowing off the sail 128 and out at the vent, as this increases velocity of airflow to the rotor assembly 24.

To maximise the wind capture, each articulated guide vane assembly 28 employs the cantilevered walkways extending out horizontally, on both sides and along the horizontal guide vanes, to provide resistance to air flowing over the horizontal guide vanes. The cantilevered walkways essentially add depth to the sail 128 which effectively improves wind capture. The larger the wind capture area, the higher the mass and momentum of air flow which results in higher velocity of air to the rotor assembly 24. Higher velocity of air directed to the rotor blades results in greater lift forces generated and therefore, more power, even at low wind speed.

Another embodiment is the guide vane outer fin assembly 182 that runs the full length from the outer end of the top horizontal guide vane to the outer end of the bottom horizontal guide vane. Within the fin assembly is a "C" section connecting both top and bottom outer guide vanes. The fin assembly has a flattened back on the outer most end, while a parabolic-shaped fin extending from both sides of the flattened back plate to the outer guide vane. Within the "C" section is the mandrel that furls the sail 128, keeping it out of direct sunshine and protected when not deployed.

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ARTICULATED GUIDE VANE IMPLEMENTATIONS

The articulated guide vane assembly 26 can comprise six to eight of the articulated guide vanes 36 arranged, preferably, at equal angular spacing about the first axis 28. Based on the direction of the incoming wind, each of the plurality of articulated guide vanes 36 may serve
5 to guide and shape air received at the windward side of the turbine for exhausting to the plurality of rotor assembly 24 for displacement thereof. Articulated guide vanes 36 that are not in use are “deactivated” by crumpling the sail 128 thereof into the furling.

The trough 136 also enables the build-up of air pressure therewithin to increase the mass flow
10 rate of the air being exhausted from the vent 144. Further assistance is provided by the pair of cantilevered walkways 172 at each of the first mast 150 and the second mast 152 to reduce spillover of air from the upper edge 156 and the lower edge 158 of the sail 128 which in turn mitigates pressure loss from the trough 136. Each of the rotor blades 58 is shaped to have a
15 low-pressure surface and a high-pressure surface extending from the leading edge to the trailing edge thereof along its chord. When wind, or fluid, is directed at the rotor blades 58, a low-pressure zone is created along the low-pressure surface which provides lift to the rotor blade 58.

The rotor blades 58 are not only exposed to the ambient wind condition. Geometry of
20 articulated guide vanes 36, for example the vane angle, can be manipulated to increase the wind speed, specifically the mass flow rate, of the air vented from the articulated guide vanes 36, and to optimize the angle in which the vented wind/air hits the rotor blades 58, thereby controlling the vented wind-to-rotor blade angle of attack. These enable the rotor blades 58 to displace at a speed that is greater than that of the ambient wind. Further, this reduces
25 dependence of the rotor blades 58 on solely the ambient wind which also reduces unintended forces created by the ambient wind. Also, the wind capture area offered by the articulated guide vanes 36 with extended, or deployed, sails 128 is much larger than the wind capture area of the rotor assembly 24, thus offering far greater forces to spin the blade assembly.

The articulated guide vanes have also augmentation devices such as “walkways”, specifically the cantilevered walkways 172, to capture the wind which also reduces significant losses at the outer end of the articulated guide vane where the sail housing is mounted. The sail 128 is fashioned with a flat backplane, specifically the body segment 164 of the sail 128, so that the
5 air can slide off the sail with increased momentum that causes an increase in velocity. The increase in velocity exiting the sail vent is directed to act on the rotor blades 58.

The rotor assembly 24 comprises a plurality of vertical aerodynamically formed blades. Each rotor blade 58 is a constituent of the rotor assembly 58 which comprises a connector
10 hub supported by a set of rails, that can be formed with multiple rails or a monorail assembly. The rails are held in place and supported by rail guide assemblies which can be, for example, supported by mechanical wheels or magnetically levitated.

In this invention, the augmented vertical axis wind turbine 20 can have a six articulated guide
15 vanes 36 configuration of which two thereof form the primary driving forces to turn the rotor assembly 58. The use of more than two articulated guide vanes 36 is envisioned in complex wind conditions.

In a six articulated guide vanes 36 configuration, a six posts 148 configuration is preferred
20 and in an eight articulated guide vanes 36 configuration, an eight posts 148 configuration is preferred. Fewer posts 148 are required when the preferred articulated guide vanes 36, arranged in a concentric ring, circumferentially around the vertical axis wind rotor assembly, are rotated as a whole.

25 In this invention, the increased volume and speed of the air exiting the sail and acting on the rotor assembly is the driving force of the high rotation speed of the rotor assembly 58. In this invention, the high speed of each rotor blade is due to the forces generated by the increased speed and volume of air created by the sail.

This increase in rotation speed replaces the reliance of the velocity of the ambient wind. The lift generated by the faster rotor blades 58 revolving around the first axis 281, is far more significant than if rotor assembly are to rely on the ambient wind speed. In this particular instance of a six sail/articulated guide vanes 36 configuration, each with 200m² area, velocity of air exiting the vent is 5m.s. in 3m.s. ambient velocity. This increased air velocity has sufficient force to move the rotor blade assembly at a velocity of 20m.s. Much faster than if reliant on the ambient air speed.

This increase in rotation speed offers greater lift due to higher blade velocity of the rotor blades 58 and more predictable lift due to angles of attack that are less effected by the ambient wind. High relative ambient wind can detract from the overall rotor assembly 58 efficiency due to tangential forces caused by the ambient wind. These tangential wind forces are reduced when the velocity of the rotor assembly is far greater than the velocity of the ambient wind. This is akin to wind acting on a supersonic fighter being substantially insignificant when compared with a slow WW1 Biplane. This invention reduces the inefficiencies in a typical vertical air wind turbine.

GENERAL ARRANGEMENTS

In a general arrangement "A" for the augmented vertical axis wind turbine 20 as shown in FIG. 16, the articulated guide vane assembly 26 is extended to capture air which would increase pressure at the windward side that would increase airflow and air speed to the VAWT.

In a general arrangement "B" as shown in FIG. 17, the articulated guide vanes assembly 26 is extended to the rearward position, relative to the direction of the wind, to deflect the wind which would form a lower pressure to the leeward side of the VAWT which will see lower pressure and act like a vacuum cleaner sucking air as opposed to blowing air. This would increase the airflow from the windward side to and through the VAWT. This iteration exerts lower stress to the structure than in the general arrangement "A" and would be more suitable in conditions exceed the design limits on the augmented vertical axis wind turbine 20.

It is envisioned that general arrangement "A" would be more appropriate in wind speeds of 2m/s to 18m/s and general arrangement "B" would be more appropriate in wind speed of 18m/s to 30m/s. The options are not limited to general arrangement "A" and general arrangement "B" as there are a multitude of other options, depending on wind speed, and varied weather conditions. In other arrangements, a general arrangement may be implemented to mix pressure conditions to the rotor assembly 24 as shown in FIG. 18.

Aspects of particular embodiments of the present disclosure address at least one aspect, problem, limitation, and/or disadvantage associated with existing vertical axis wind turbines. While features, aspects, and/or advantages associated with certain embodiments have been described in the disclosure, other embodiments may also exhibit such features, aspects, and/or advantages, and not all embodiments need necessarily exhibit such features, aspects, and/or advantages to fall within the scope of the disclosure. It will be appreciated by a person of ordinary skill in the art that several of the above-disclosed structures, components, or alternatives thereof, can be desirably combined into alternative structures, components, and/or applications. In addition, various modifications, alterations, and/or improvements may be made to various embodiments that are disclosed by a person of ordinary skill in the art within the scope of the present disclosure, which is limited only by the following claims.

Claims

1. An augmented vertical axis wind turbine comprising:

a support structure defining a first axis, the support structure having an outer portion circumscribing the first axis;

5 a rotor assembly movably coupled to and configured to be supported by the support structure to enable rotational displacement thereof about the first axis; and

an articulated guide vane assembly coupled to the support structure for circumscribing the support structure, the articulated guide vane assembly comprising a plurality of articulated guide vanes positionable for guiding fluids impinging thereupon towards the rotor assembly to thereby rotationally displace the rotor assembly about the first axis, the articulated guide vane assembly comprising:

10 a rig structure having an inner portion and an outer portion forming extremities thereof, the rig structure defining a rig plane and a vane axis adjacent the inner portion thereof, the angle of the rig plane with the rotor assembly being variable about the vane axis, the inner portion being positioned nearer to the rotor assembly than the outer portion the rig structure comprising: a pair of rig joints configured at the inner portion of the rig structure for rotational coupling to the support structure and a pair of masts extending from the pair of rig joints, and

15 a sail coupled to the rig structure and shaped for presenting a trough to a flow of impinging fluid, the trough having a depth defined from the rig plane, the sail extending from the outer portion towards the inner portion of the rig structure to terminate at an inner edge whereat a vent is defined, the sail having a body segment extending between the inner portion and the outer portion of the rig structure and two side segments extending from opposing sides of the body segment of the sail for coupling to a respective one of the pair of masts,

25 wherein the body segment of the sail being substantially planar and substantially stiffened and the fluid impinging on the sail being concentrated at the trough and redirected towards the rotor assembly from the vent for exhaust therefrom, at least one of mass flow rate and flow direction of the fluid being directed at the rotor assembly

being determined by the angle between the rig plane and the rotor assembly about the vane axis.

2. The augmented vertical axis wind turbine as in claim 1, the body structure of the sail
5 comprising a plurality of stiffeners formed with the sail for shaping the trough for defining the shape of the body segment and keeping the body segment substantially planar.
3. The augmented vertical axis wind turbine as in claim 2, each of the pair of masts
10 having at least one cantilevered walkway extending therefrom and being substantially perpendicular the rig plane to reduce spillage of fluid from the sail over the pair of masts.
4. The augmented vertical axis wind turbine as in claim 2, the rig structure further
15 comprising:
 - a fin assembly extending between the pair of masts adjacent the outer portion of the rig structure, the fin assembly having an outer face which outwardly faces the inner portion of the rig structure and an inner face forming a gradient with the rig
20 plane for at least one of guiding fluid into the sail and to reduce spillage of fluid from the sail over the fin assembly.
5. The augmented vertical axis wind turbine as in claim 4, the inner face of the fin assembly being one of planar and curved.
- 25 6. The augmented vertical axis wind turbine as in claim 4, the rig structure comprising:
 - a pulley system and a pair of cross bars, each of the cross bars being configured substantially perpendicular one of the pair of masts with extremities thereof being coupled to an actuator via the pulley system for controlling angular positioning
30 of the pair of masts about the vane axis by the actuator, to consequently control the spatial configuration between the sail and the rotor assembly.

7. The augmented vertical axis wind turbine as in claim 2, the sail being slidably coupled to each of the pair of mast for being slidably displaceable for collapsing towards the outer portion of the rig structure.
- 5
8. The augmented vertical axis wind turbine as in claim 1, the rotor assembly comprising:
a plurality of rotor blades extending between the upper inner guide rails and the lower inner guide rails, each of the plurality of rotor blades defining a rotor axis along the length thereof, the rotor axis of each of the plurality of rotor blades being
10 substantially parallel the first axis, each of the plurality of rotor blades being positioned about the rotor axis to present an optimal angle of attack to at least one of fluids exhausted from the vent of the sail and ambient air to generate lift thereby.
9. The rotor assembly as in claim 8, the generated lift for one of displacing and
15 contributing to displacement of the rotor assembly about the first axis to thereby operate at least one generator coupled thereto for generating electrical energy therefrom.
10. The augmented vertical axis wind turbine as in claim 1, each of the support structure
20 and the rotor assembly having a tubular shape extending along the first axis between a first end and a second end, wherein the rotor assembly is configured concentric the support structure.
11. The augmented vertical axis wind turbine as in claim 10, the support structure
25 comprising an upper annular structure at the first end and a lower annular structure at the second end thereof, and a plurality of posts for spatially inter-displacing the upper annular structure and the lower annular structure, the upper annular structure and the lower annular structure being formed from truss structures.

12. The augmented vertical axis wind turbine as in claim 10, the articulated guide vane assembly comprising a plurality of outer guide rails, and the support structure comprising a plurality of outer rolling elements arranged to define a plurality of outer pathways, each corresponding with one of the plurality of outer guide rails,
- 5 wherein the plurality of outer guide rails engages with the plurality of outer rolling elements to thereby movably couple the articulated guide vane assembly to the support structure and enable travel of each of the plurality of outer guide rails along the corresponding one of the plurality of outer pathways.
- 10 13. The augmented vertical axis wind turbine as in claim 12, the articulated guide vane assembly further comprising:
- an outer frame configured concentric the support structure; and
- a rack and pinion assembly coupled to the outer frame for angular positioning of the articulated guide vane assembly about the first axis.

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