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(54) FLUID DIRECTING SYSTEM FOR TURBINES

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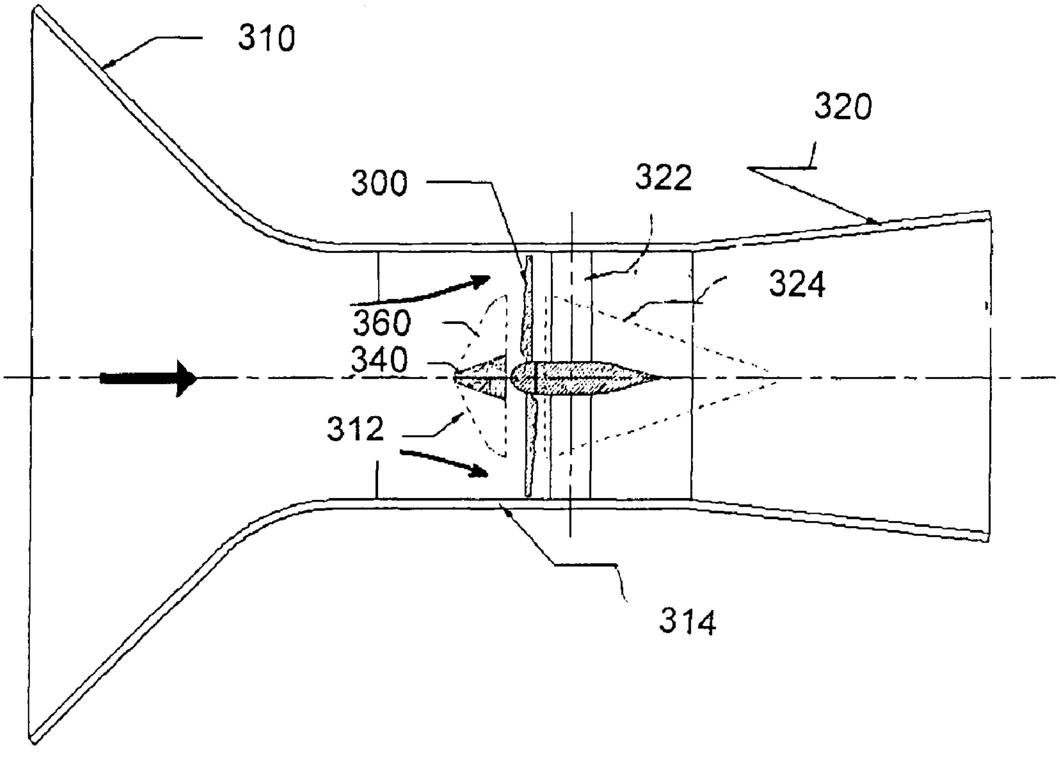
(57) ABSTRACT

A directing system for directing fluid entering an axial flow turbine along an inlet flow direction. The turbine includes a plurality of turbine blades. The directing system includes a base structure, a plurality of directing segments attached to the base structure, downstream of the base structure, and a directing segment adjustment system for adjustably positioning the directing segments between a retracted configuration and a deployed configuration. The directing segments, in the deployed configuration, extend beyond the base structure in a direction transversal to the inlet flow direction and deflect the fluid towards an outer circumference of the plurality of turbine blades corresponding to a higher torque area of the blades. A directing system for directing fluid entering a cross-flow turbine is also disclosed. In the cross-flow turbine, the fluid is directed towards a centerline of the rotor of the turbine, which is a high torque area of the turbine blades.



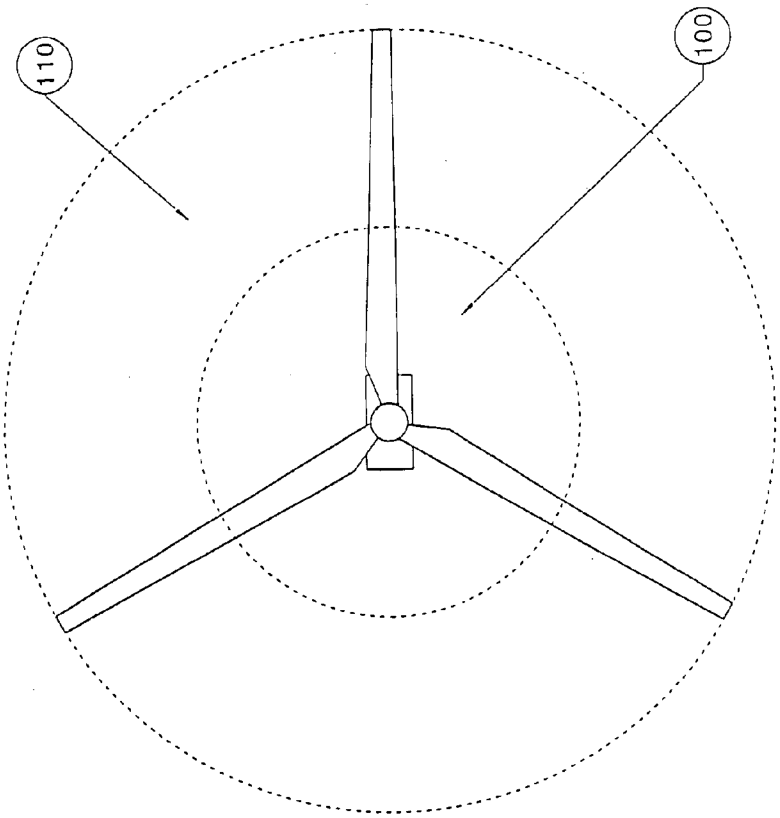


Figure 1
(PRIOR ART)

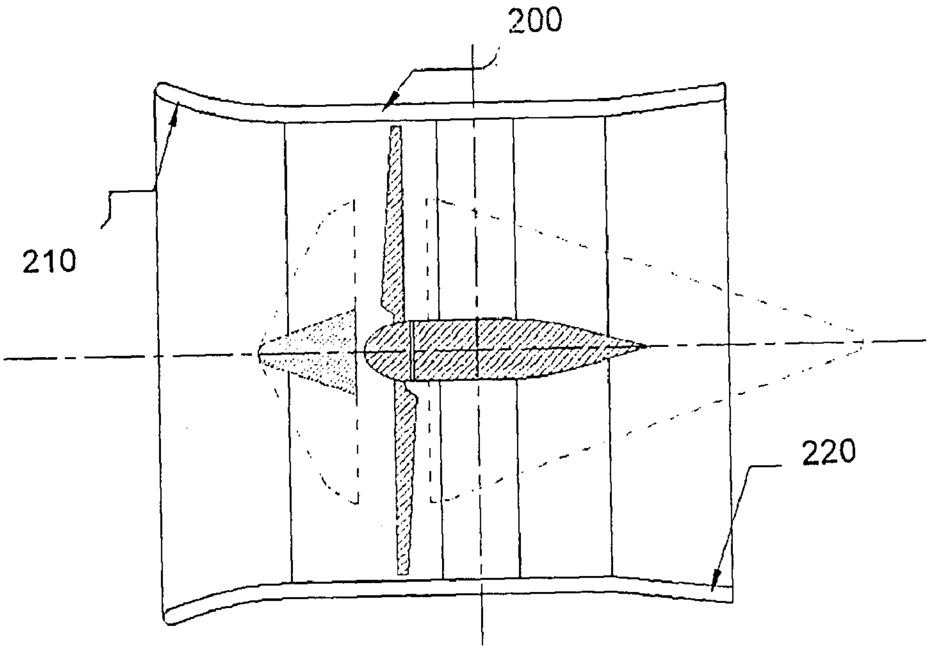


Figure 2

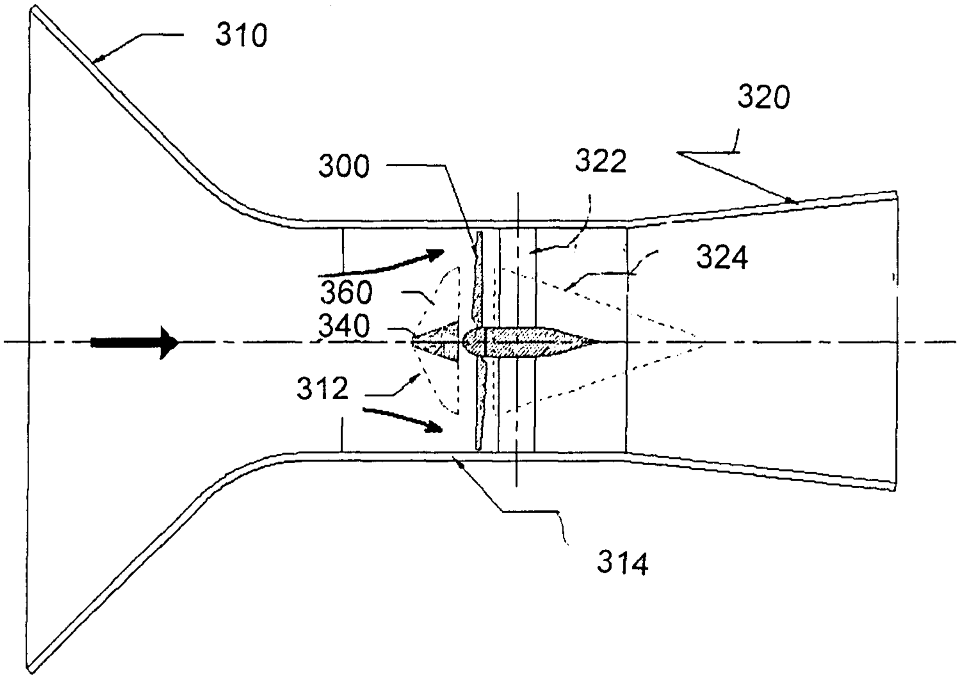


Figure 3

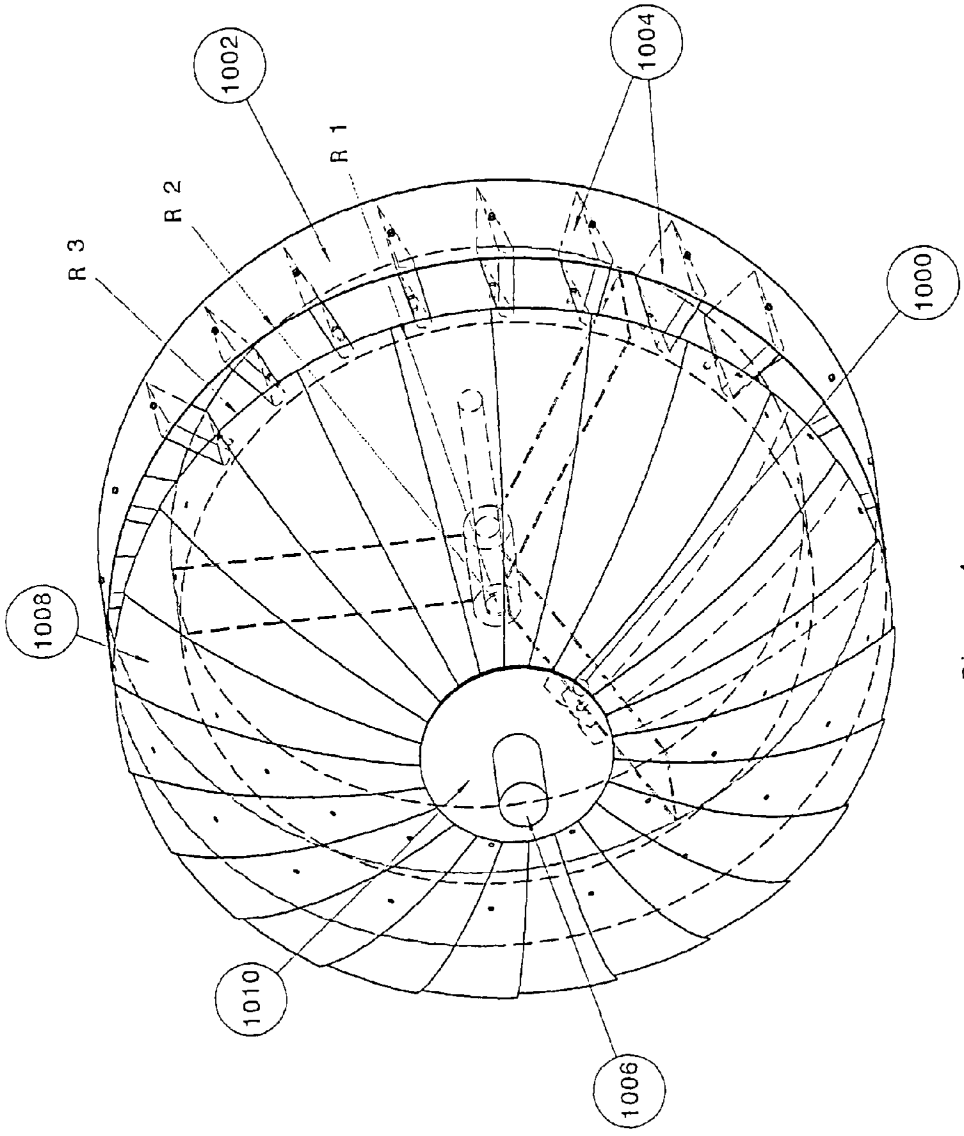


Figure 4

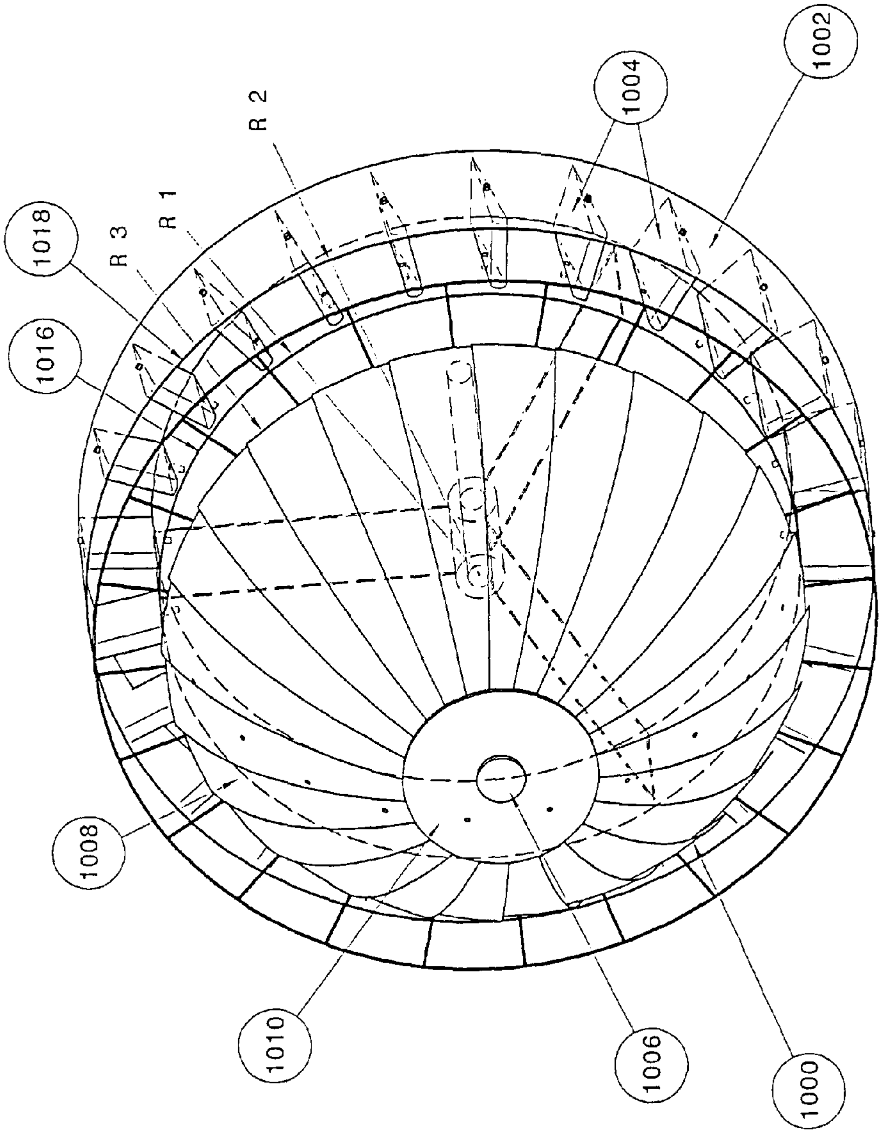


Figure 5

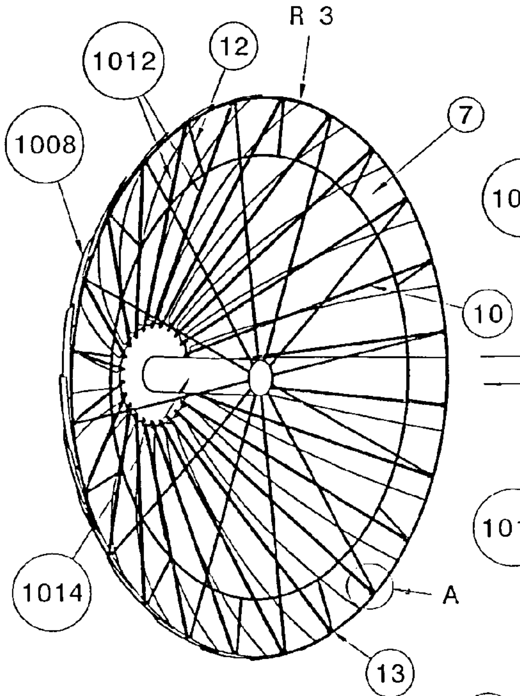


Figure 6A

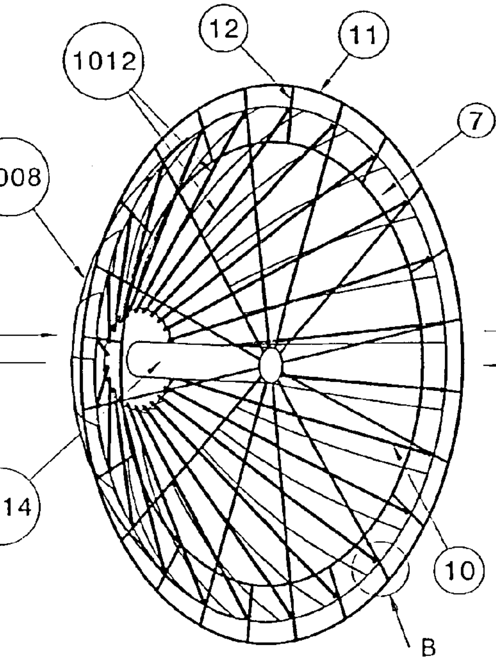


Figure 6B

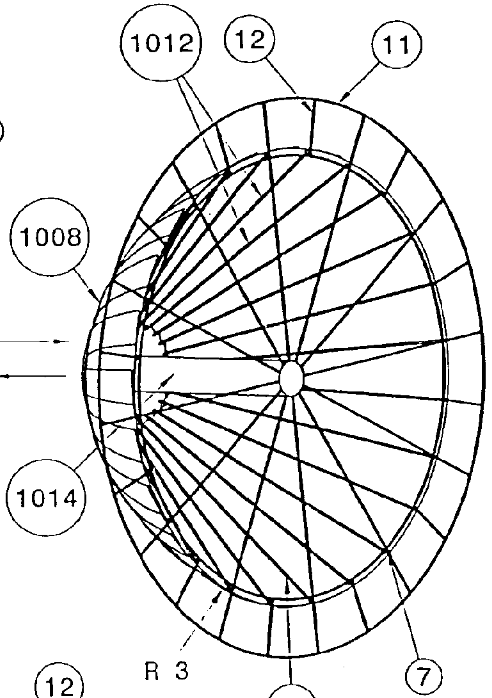
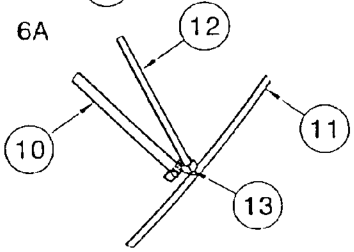
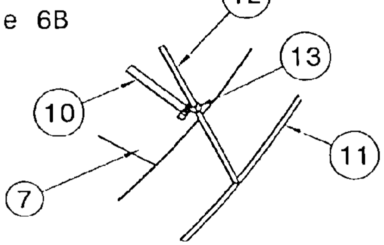


Figure 6C



Detail A

Figure 6D



Detail B

Figure 6E

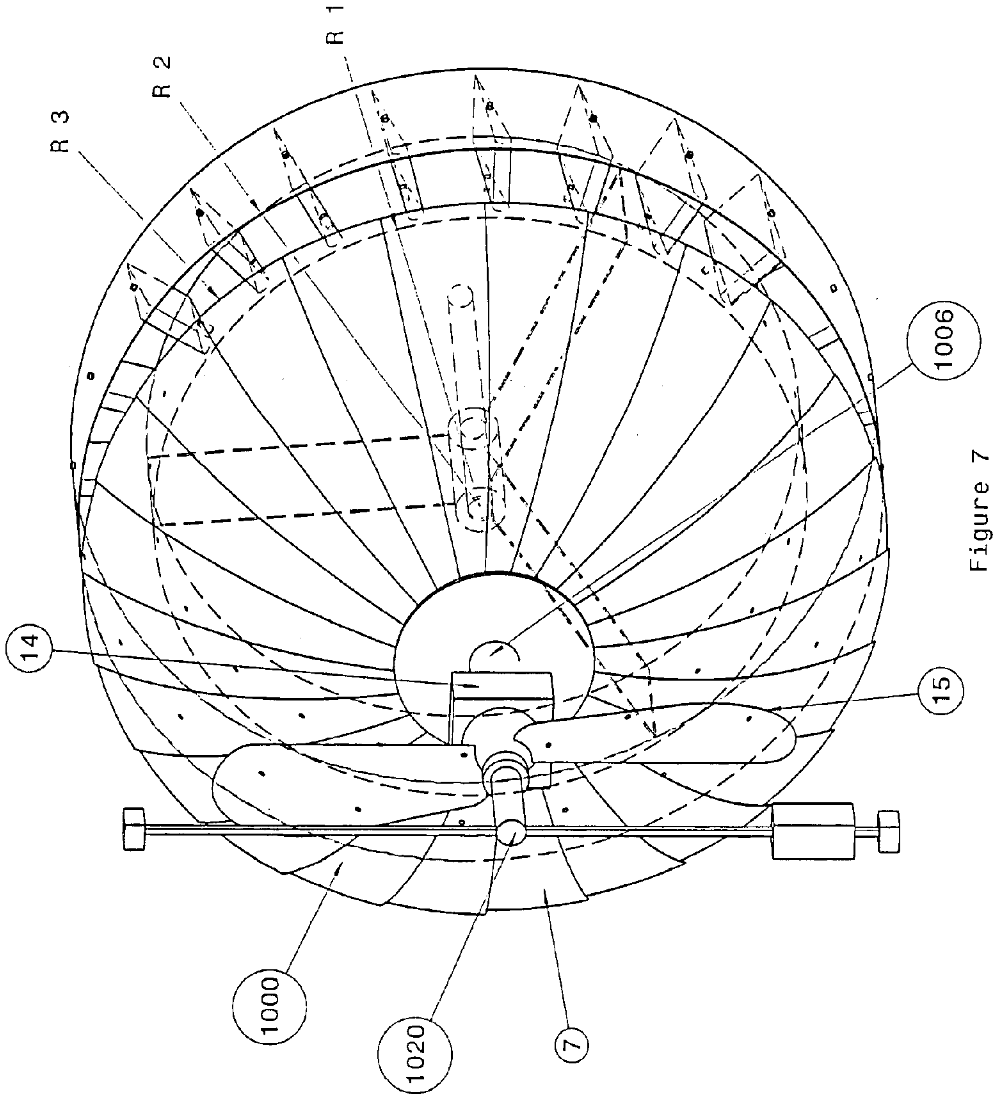


Figure 7

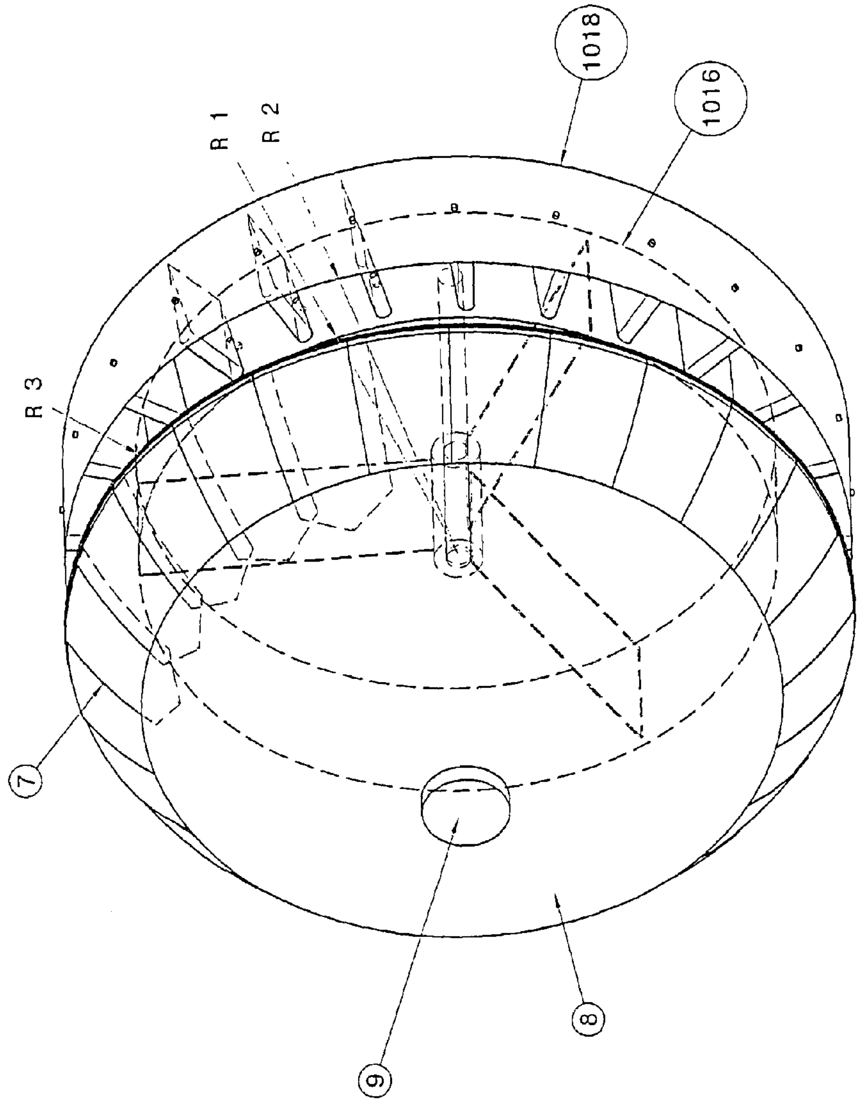


Figure 8

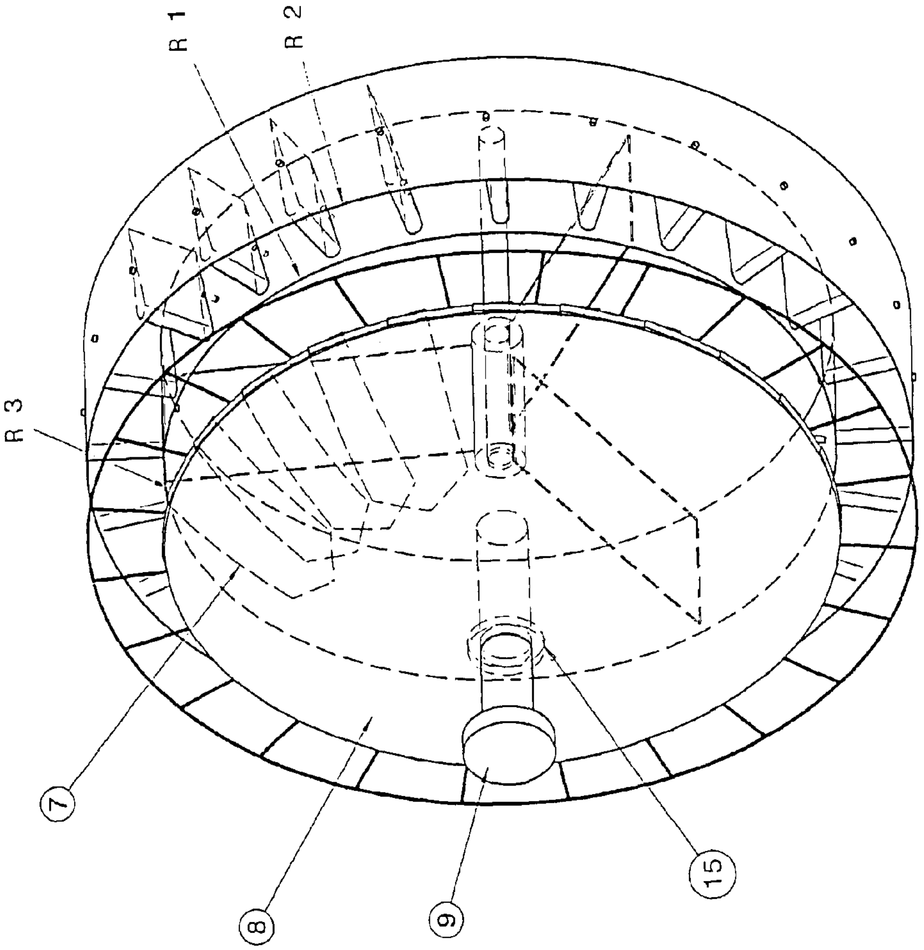


Figure 9

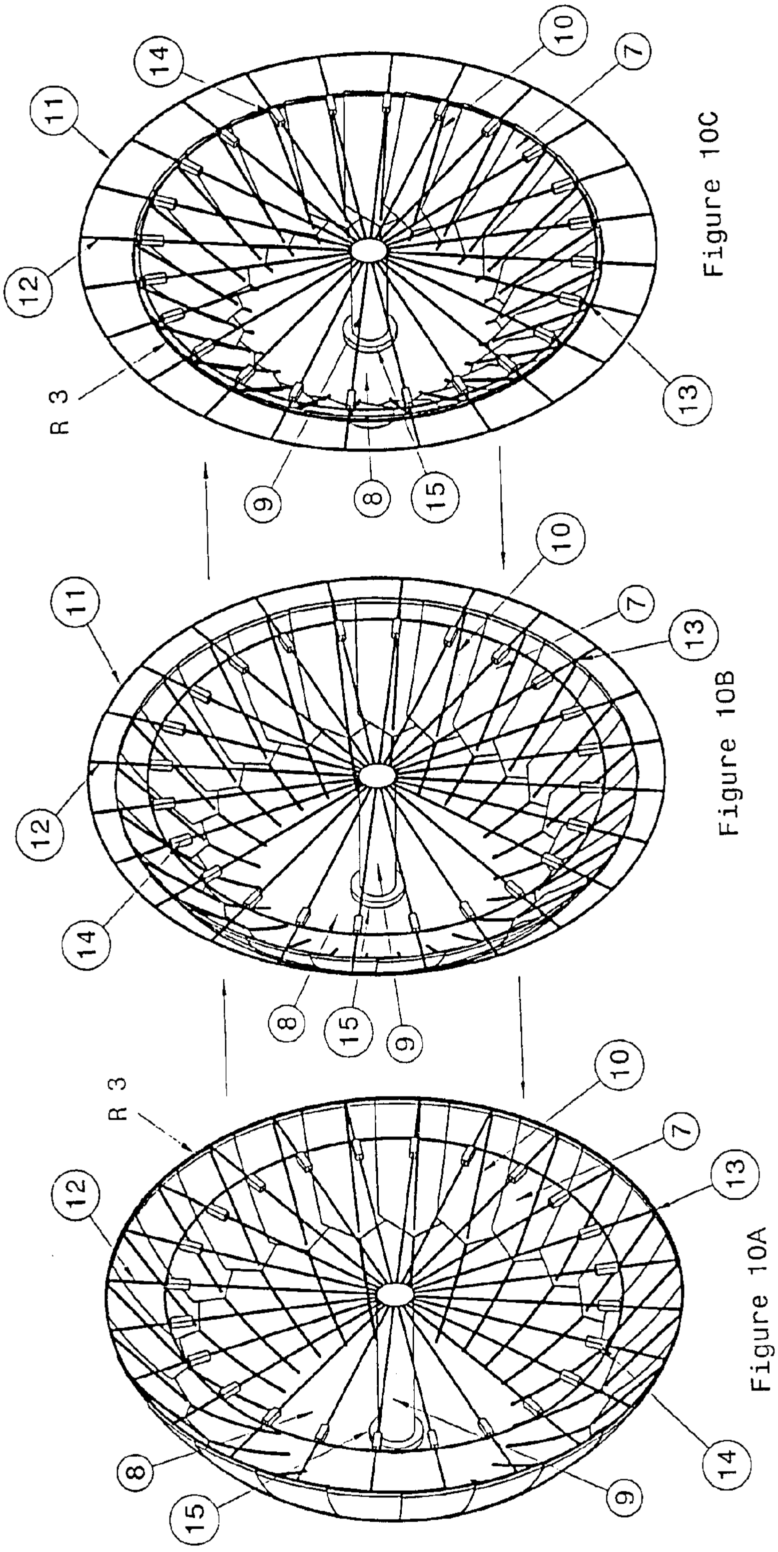


Figure 10C

Figure 10B

Figure 10A

Figure 10

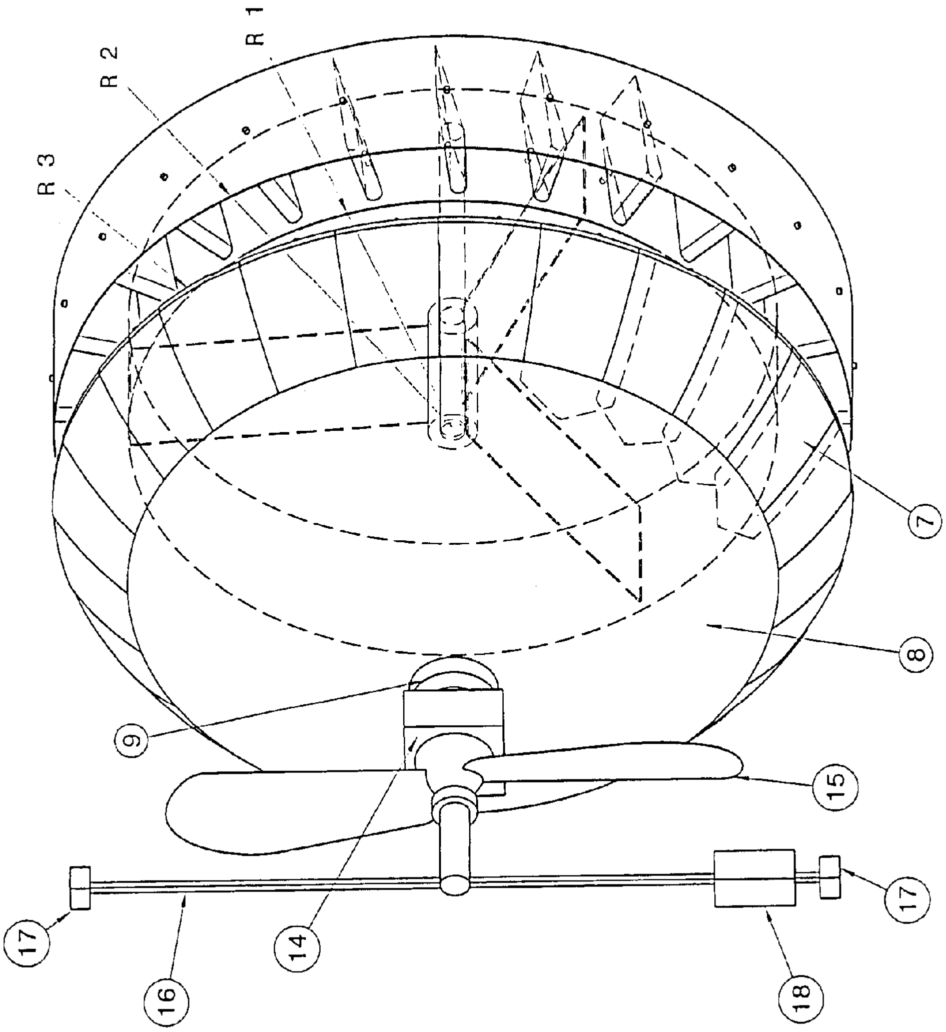


Figure 11

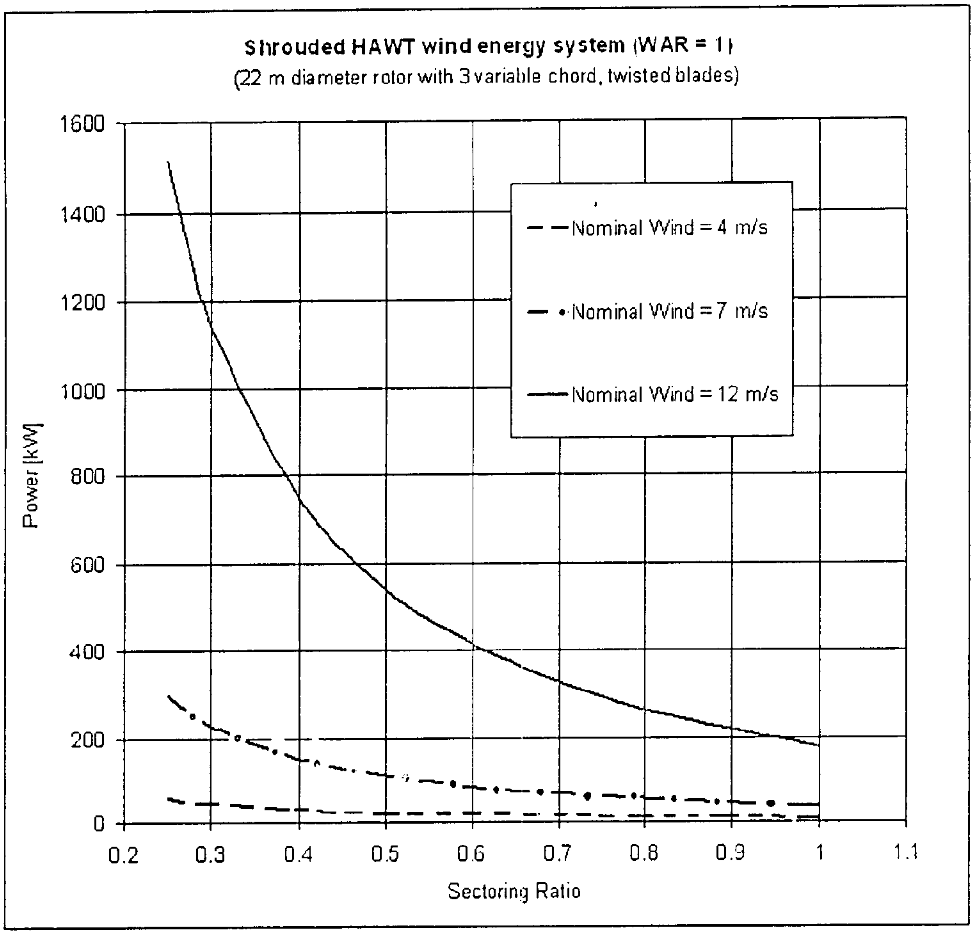

Shrouded HAWT wind energy system (WAR = 1)
(22 m diameter rotor with 3 variable chord, twisted blades)
1600
1400
1200
1000
800
600
400
200
0
Power [kW]
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
Sectoring Ratio
Nominal Wind = 4 m/s
Nominal Wind = 7 m/s
Nominal Wind = 12 m/s

Figure 12

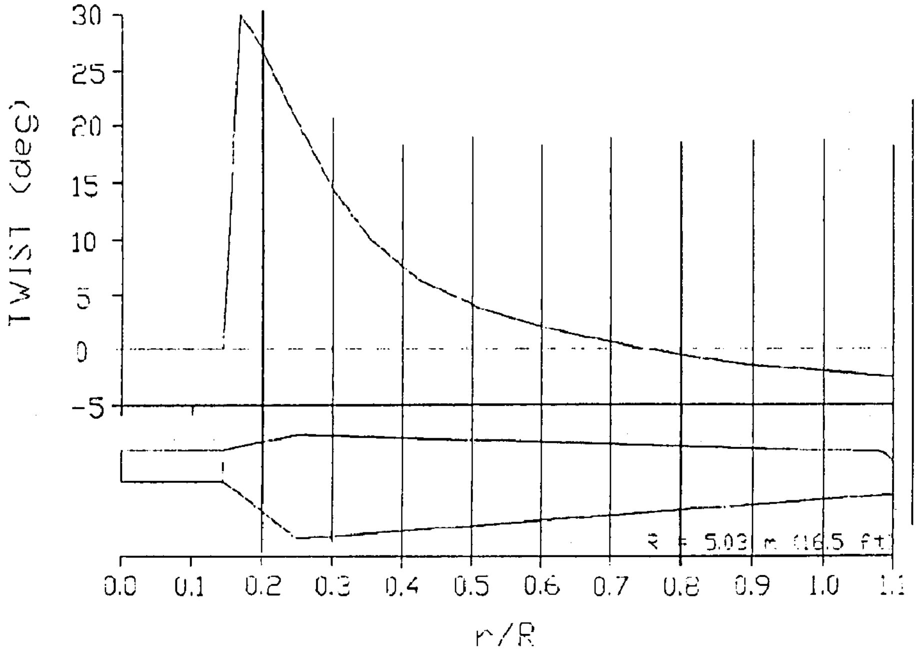

TWIST (deg)
30
25
20
15
10
5
0
-5
R = 5.03 m (16.5 ft)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
r/R

Figure 13

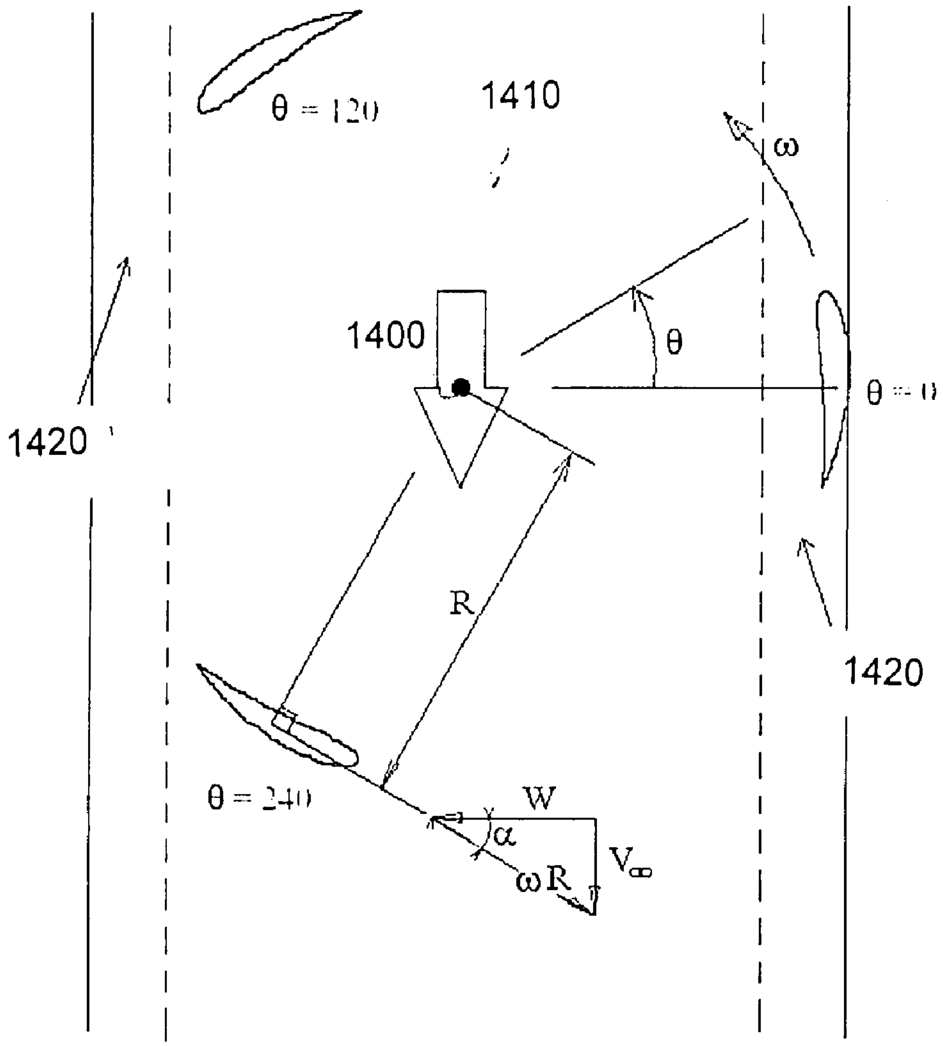


Figure 14

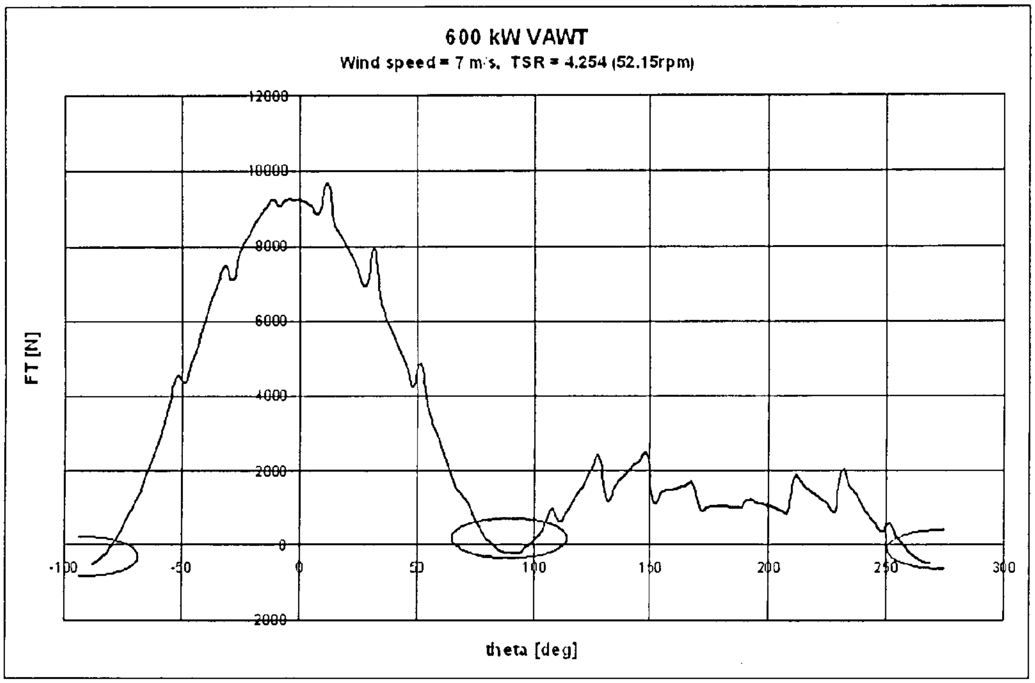

600 kW VAWT
Wind speed = 7 m/s, TSR = 4.254 (52.15rpm)
FT [N]
12000
10000
8000
6000
4000
2000
0
-2000
-100
-50
0
50
100
150
200
250
300
theta [deg]

Figure 15

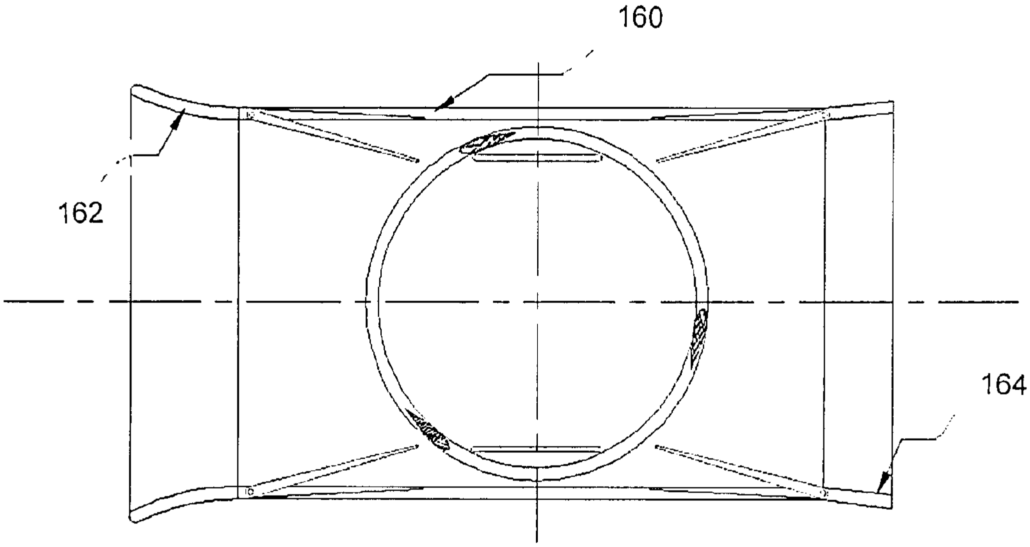


Figure 16

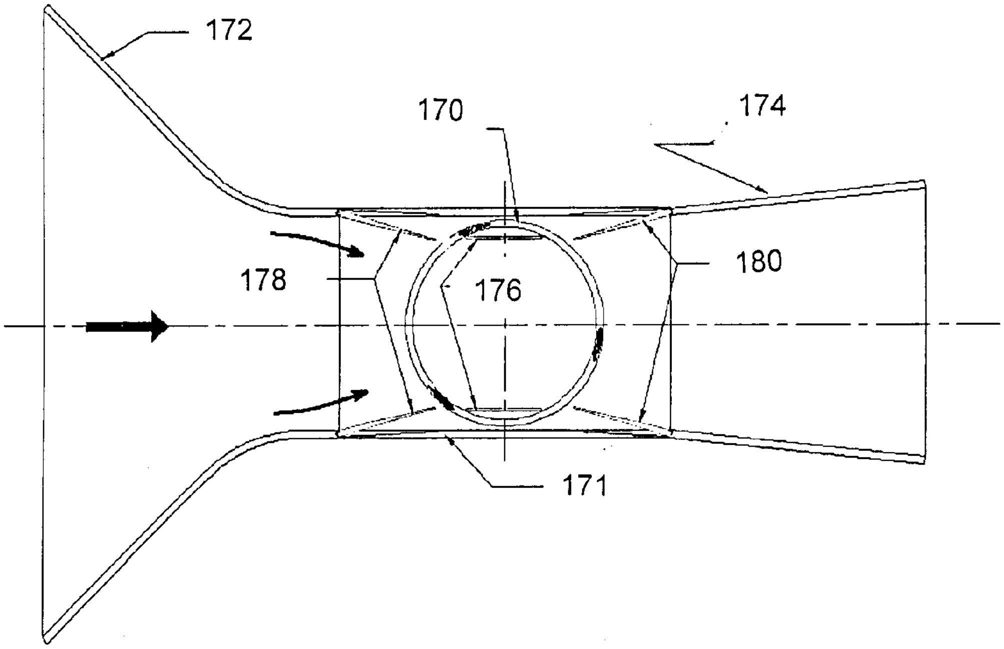


Figure 17

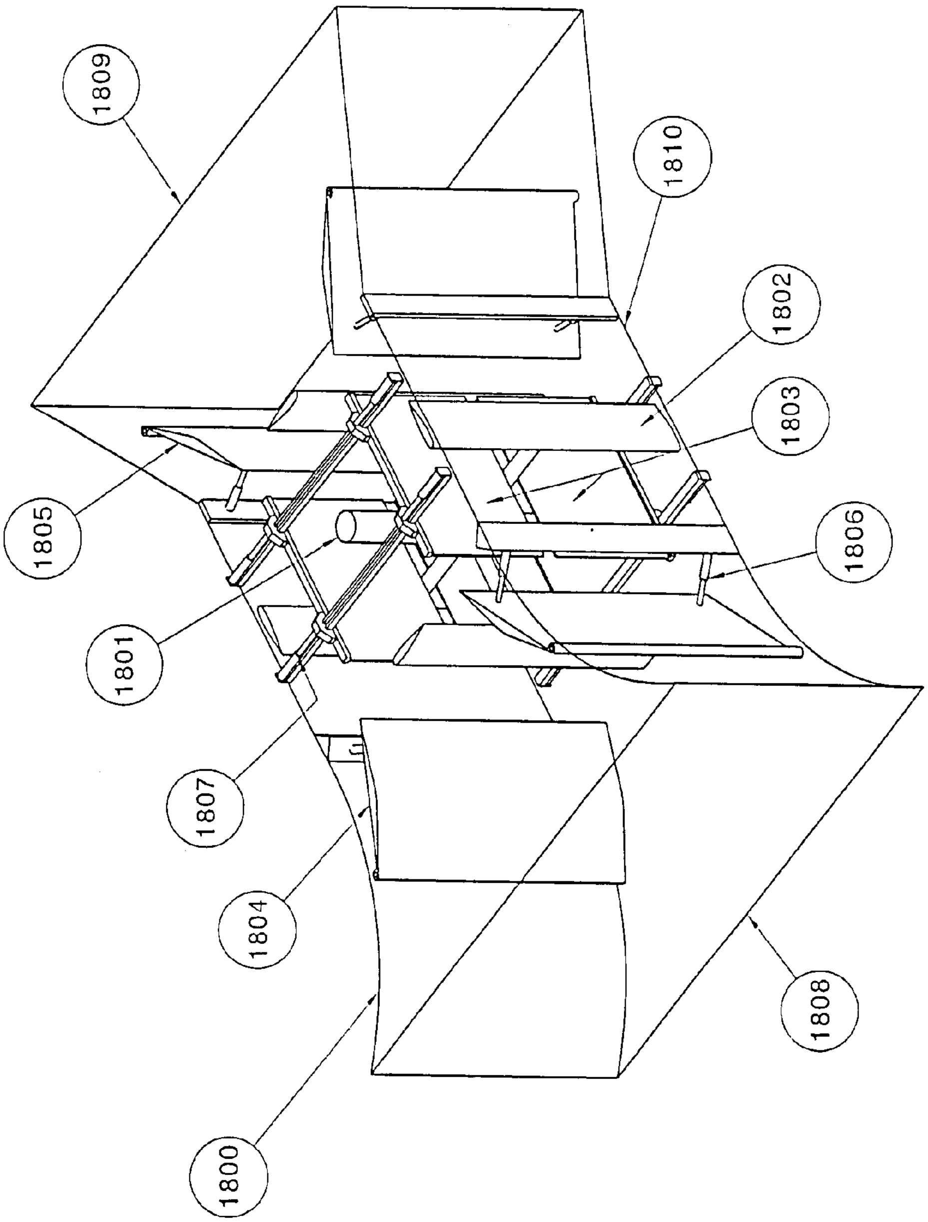


Figure 18

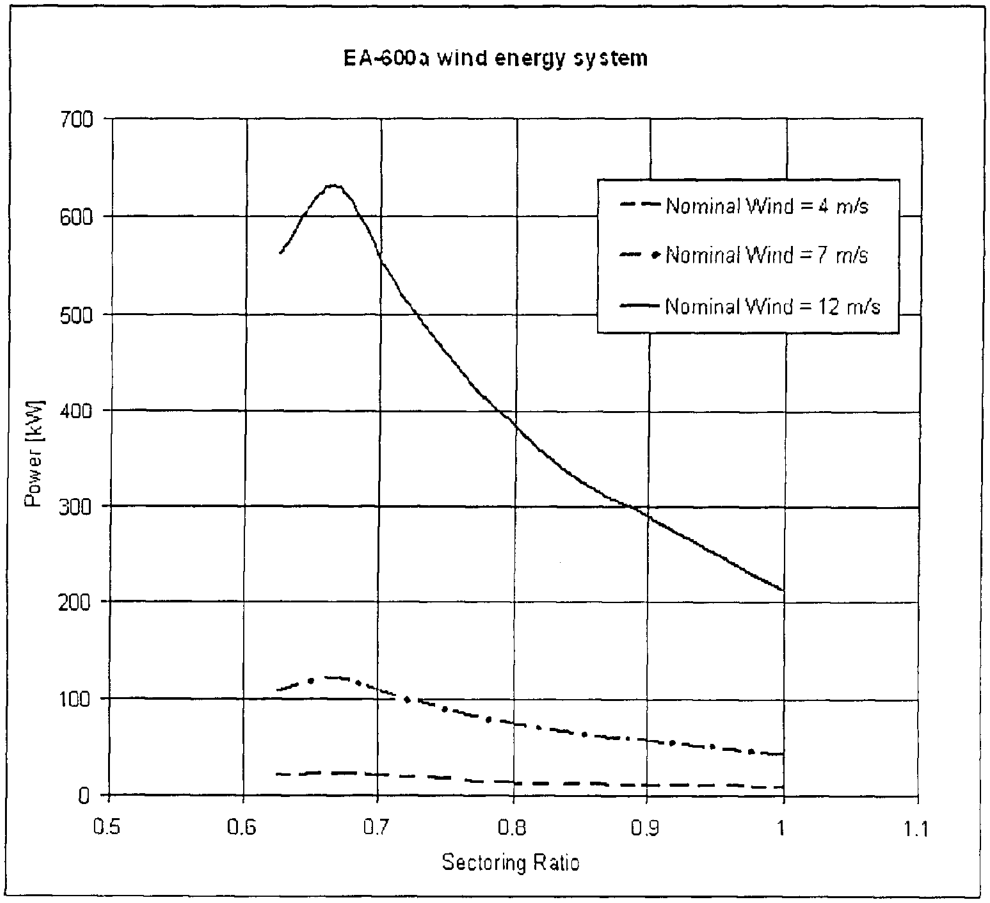

EA-600a wind energy system
Power [kW]
700
600
500
400
300
200
100
0
0.5
0.6
0.7
0.8
0.9
1
1.1
Sectoring Ratio
Nominal Wind = 4 m/s
Nominal Wind = 7 m/s
Nominal Wind = 12 m/s

Figure 19

FLUID DIRECTING SYSTEM FOR TURBINES

FIELD OF THE INVENTION

[0001] The present invention generally relates to both wind and water turbines. More specifically, the present invention relates to a fluid directing system for directing a fluid entering an axial flow or cross-flow turbine.

BACKGROUND OF THE INVENTION

[0002] Wind turbines are generally rated at the wind speed at which they will produce the rated power or essentially the maximum power rating of the generator. At lower wind velocities the turbine will produce only a fraction of the rated power.

[0003] Low winds contain less energy than high winds so automatically they produce less useful energy. The rotor efficiency or percentage of energy converted from the wind into useful torque also drops as the Reynolds number of the blades decreases at low wind speeds. There is a definite need for a rotor design that could increase the power obtained from air streams at all speeds and most particularly for velocities below the turbine rated speed. The additional power generated by the blades once the rated velocity is exceeded is lost.

[0004] The fact that wind speeds vary all the time is a problem for windmill designers and windmill operators. Existing wind turbines designs offer little control over immediate wind speed variations. Most existing turbines are equipped with a hydraulic driven blade pitch adjustment. These systems adjust the blade pitch to average wind velocity as calculated over a time period and not to the instantaneous wind speed.

[0005] At all wind speeds, and particularly at high wind speeds, wind gusts cause considerable operating problems. The energy in the gust will rapidly increase the rotor and generator rotational speed. This can cause voltage fluctuations in the power produced that must be removed electrically. In order to limit the rotational speed, the blade pitch can be adjusted but the blades are massive and the hydraulically driven pitch adjustment is not rapid. Consequently, the brake is often applied to limit the increase in rotor speed.

[0006] Existing turbine designs treat all the swept area of the rotor as equal. Although the wind energy available to the blades is constant over the entire swept area most of the energy is generated in the high torque zone that corresponds to the area closer to the tips of the blade. The energy of the wind traveling close to the center shaft or the core of the swept area is essentially wasted.

[0007] A technology that addresses the difficulties above would greatly improve turbine efficiency, improve the electrical stability of the production and decrease the production costs for electricity.

[0008] There is thus presently a need for a system to increase the energy produced by a turbine at all operating wind or fluid speeds.

[0009] There is also a need for a system that divides the swept area of a rotor into high torque and low torque sectors.

[0010] There is also a need for a system to increase and control the wind velocity by adjusting the size of the swept area. This is achieved by blocking or sectoring part of the swept area.

[0011] There is also a need for a system to increase the velocity pressure at the face of the blades that is non-sectored, and install an outer shroud to prevent the increased velocity pressure from spilling over the edges of the blades and an inner shroud to prevent air bleeding into the low torque zone of the rotor.

[0012] There is also a need for a system to control the wind velocity through the non-sectored area of the rotor blades.

[0013] There is also a need for a system to increase the wind velocities at the blades by rotor-sectoring to maximize velocity pressure, blade Reynolds number and the rotor efficiency coefficient.

[0014] There is also a need for a system to establish an effective closed loop control based on wind speed and the dimensions of the sectored swept area that maintains constant the rotational speed of the rotor and electrical generator.

[0015] There is also a need for a system to direct the airflow at a maximum wind pressure to the outermost radius of the rotor whereby maximizing the torque produced per unit of air mass.

[0016] There is also a need for a system to develop a design of rotor sectoring that can be retrofitted to existing turbines.

SUMMARY OF THE INVENTION

[0017] An object of the present invention is to provide a directing system that satisfies at least one of the above-mentioned needs.

[0018] According to the present invention, there is provided a directing system for directing fluid entering an axial flow turbine along an inlet flow direction, the turbine comprising a plurality of turbine blades, the directing system comprising:

- **[0019]** a base structure;
- **[0020]** a plurality of directing segments attached to the base structure;
- **[0021]** a directing segment adjustment system for adjustably positioning the directing segments between:
  - **[0022]** a retracted configuration; and
  - **[0023]** a deployed configuration;
- **[0024]** and
- **[0025]** a shroud surrounding a circumference of the turbine blades,

wherein the directing segments, in the deployed configuration, extend beyond the base structure in a direction transversal to the inlet flow direction and deflect the fluid towards an outer circumference of the plurality of turbine blades.

[0026] According to the present invention, there is also provided a directing system for directing fluid entering a cross-flow turbine along an inlet flow direction, the turbine comprising a rotor, the rotor comprising a plurality of turbine blades, the directing system comprising:

- **[0027]** an inlet directing fluid towards the turbine;
- **[0028]** a plurality of directing segments attached to the inlet; and
- **[0029]** a directing segment adjustment system for adjustably positioning the directing segments between:
  - **[0030]** a retracted configuration; and
  - **[0031]** a deployed configuration,

wherein the directing segments, in the deployed configuration, extend beyond the inlet in a direction transversal to the inlet flow direction and deflect the fluid towards a centerline of a rotor of the turbine.

[0032] The present invention provides an apparatus, which is able to displace part of a fluid stream just prior to reaching the turbine rotor. This displacement moves the fluid from a section of the swept area producing low torque to a section producing higher torque. The two fluid volumes are combined to increase the fluid velocity and velocity pressure over the high torque area. This principle is common to all axial flow and cross-flow turbines.

[0033] In the case of axial flow turbines, the apparatus consists of a central conically or semi-circular shaped cone that directs the fluid stream from the center towards the periphery of the rotor. The cone retracts or deploys overlapping wall segments creating an annular shaped channel for the fluid stream to pass through the rotor blades. The exterior of the turbine is shrouded to prevent the velocity pressure increase from spilling over the tips of the turbine blades. In its retracted position, the sectoring cone occupies preferably between 50 and 75% of the total swept area of the rotor.

[0034] Located behind the walls of the sectoring cone, where it is protected from the fluid stream, a mechanism is installed that permits to expand or deploy overlapping wall segments. As the segments are expanded, the sectored or blocked area of the rotor is increased to 100%. A sectoring of 90 to 99% of the available swept area is applied when the nominal fluid velocity is low, whereas a sectoring of 0 to 10% of the available swept area corresponds to a high nominal fluid speed.

[0035] In the case of cross-flow turbines, aerodynamic side deflectors are installed that can be extended or rotated into the fluid stream. The side deflectors are attached to the turbine shrouds that serve as a housing in front of the upstream and downstream faces of the rotor. The shrouds or sidewalls are required to prevent the increase in velocity pressure from spilling around the edges of the rotor blades.

[0036] Actuators attached to the turbine frame push against the deflectors that rotate into the fluid stream and decrease the width of the opening. As the deflectors advance, the low torque sectors of the rotor decrease and the fluid stream is concentrated in the high torque sector. When the deflectors are fully extended the high torque area receives almost all the fluid whereas the low torque sector receives very little or no fluid.

[0037] Inside the vertical axis rotor itself are located two sets of straight vertical side plates or inner walls. These side plates move back and forth, synchronized with the displacement of the side deflectors to create a more defined channel with less turbulence. These side plates necessitate the use of a true H-type vertical rotor configuration whereby the blades are supported close to their midpoints and with little cross bracing.

[0038] For both the axial and cross-flow turbines, the velocity pressure of the fluid stream over the high torque area is increased providing considerable more power. Although the swept area of the rotors has been decreased, the increase in fluid velocity or velocity pressure provides a much greater contribution to energy production. The adjustment of the swept area also controls the fluid stream velocity to the blades providing maximum efficiency for the rotor at all nominal fluid speeds. The control of the fluid stream speed in turn provides for steady rotor rotational speeds for more stable and efficient electrical power generation.

BRIEF DESCRIPTION OF DRAWINGS

[0039] These and other objects and advantages of the invention will become apparent upon reading the detailed description and upon referring to the drawings in which:

[0040] FIG. **1** is a schematic view of the zones (sectors) of low and high torques on the swept area of an axial flow turbine.

[0041] FIG. **2** is a side cut view of a directing system according to a preferred embodiment of the present invention for a shrouded axial flow turbine.

[0042] FIG. **3** is a side cut view of a directing system according to another preferred embodiment of the present invention for an augmented axial flow turbine.

[0043] FIG. **4** is a perspective view of a one-piece directing system according to another preferred embodiment of the present invention, with segments deployed.

[0044] FIG. **5** is a perspective view of the directing system shown in FIG. **4**, with segments retracted.

[0045] FIGS. **6**A to **6**E are three perspective interior views and two detailed views respectively of the directing system shown in FIGS. **4** and **5** in fully deployed, 50% deployed and retracted configurations respectively.

[0046] FIG. **7** is a perspective view of a directing system according to another preferred embodiment of the present invention, equipped with a variable speed compressor fan.

[0047] FIG. **8** is a perspective view of a two-piece directing system according to another preferred embodiment of the present invention, with segments deployed.

[0048] FIG. **9** is a perspective view of a two-piece directing system according to another preferred embodiment of the present invention, with segments retracted.

[0049] FIGS. **10**A to **10**C are perspective interior views of the directing system shown in FIGS. **8** and **9** in fully deployed, 50% deployed and retracted configurations respectively.

[0050] FIG. **11** is a perspective view of a two-piece directing system according to another preferred embodiment of the present invention, equipped with a variable speed compressor fan.

[0051] FIG. **12** is a graph of power vs. sectoring ratio at three nominal wind speeds for a shrouded axial flow turbine with a directing system according to a preferred embodiment of the present invention.

[0052] FIG. **13** is a graph of chord and twist angle distribution along the blade used for a simulation of operation of a standard twisted horizontal axis wind turbine rotor.

[0053] FIG. **14** is a schematic view illustrating zones (sectors) of low and high torques on the swept area of a cross-flow turbine

[0054] FIG. **15** is a graph illustrating the azimuthal variation of tangential force (FT) of a generic cross-flow turbine

[0055] FIG. **16** is a top cut view of a directing system according to a preferred embodiment of the present invention in use with a shrouded cross-flow turbine.

[0056] FIG. **17** is a top cut view of a directing system according to another preferred embodiment of the present invention in use with an augmented cross-flow turbine.

[0057] FIG. **18** is a perspective view of a directing system according to another preferred embodiment of the present invention.

[0058] FIG. **19** is a graph of power vs. sectoring ratio at three nominal wind speeds for a shrouded axial flow turbine with a directing system according to a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0059] Although the invention is described in terms of specific embodiments, it is to be understood that the embodiments described herein are by way of example only and that the scope of the invention is not intended to be limited thereby.

[0060] As shown in FIGS. **2** to **11** and as better shown in FIGS. **4** and **5**, according to the present invention, there is provided a directing system **1000** for directing fluid entering an axial flow turbine **1002** along an inlet flow direction. The turbine **1002** comprises a plurality of turbine blades **1004**. The directing system **1000** includes a central base structure **1006**, and a plurality of directing segments **1008** attached to the central base structure **1006**. The directing system also includes a directing segment adjustment system **1010** for adjustably positioning the directing segments **1008** between a retracted configuration (shown in FIG. **5**) and a deployed configuration (shown in FIG. **4**). The directing segments **1008**, in the deployed configuration, extend beyond the base structure **1006** in a direction transversal to the inlet flow direction and deflect the fluid towards an outer circumference of the plurality of turbine blades **1004**.

[0061] Preferably, the base structure **1006** is fixed to a central rotating shaft of the turbine **1002**.

[0062] Preferably, as better shown in FIGS. **6**A to **6**C, the plurality of directing segments **1008** are overlapping segments radially positioned around the base structure **1006**. The directing segment adjustment system **1010** comprises a set of tension rods **1012** holding the directing segments **1008** in place and a motorized threaded nut system **1014** traveling along a threaded portion of the central rotating shaft and controlling pressure being applied on the tension rods **1012**.

[0063] Preferably, as shown in FIG. **5**, the turbine blades **1004** are housed between an inner annular shroud **1016** and an outer annular shroud **1018**. The base structure **1006** can extend radially up to the inner annular shroud **1016** and the directing segments **1008** extend to a maximum diameter corresponding to a diameter of the outer annular shroud **1018**.

[0064] Preferably, a diameter of the base structure is at least 0.3 times a diameter of a rotor of the turbine.

[0065] Preferably, as shown in FIG. **7**, the directing system **1000** further includes a compressor fan **1020** positioned upstream of the base structure **1006** and increasing velocity of the fluid entering the turbine.

[0066] Preferably, the directing segment adjustment system comprises a controller and the directing system further comprises a fluid velocity measurement system located upstream of the base structure. The measurement system produces a signal indicative of fluid velocity entering the turbine. The controller then adjusts the directing segment adjustment system based on the signal indicative of fluid velocity entering the turbine.

[0067] According to the present invention, there is also provided a rotor-sectoring apparatus for axial flow turbines for use with at least one turbine to increase the velocity pressure of the air stream contacting the blades of the wind turbine, the rotor-sectoring apparatus comprising:

[0068] (a) an inner and outer turbine shrouds constituting a shrouded annular turbine section, the section comprising an entrance and an exit said entry having a nominal diameter equal to said exit;

[0069] (b) an entrance and exit adapters to said shrouded annular section with the entrance and exit diameters being slightly larger than said shrouded section to reduce the loss of velocity pressure as the wind stream enters and exits said shrouded section;

[0070] (c) an aerodynamically shaped sectoring cone positioned upstream of the rotor having overlapping walls that permit the diameter of the base of said sectoring cone to increase and decrease while retaining its aerodynamic configuration and same shape;

[0071] (d) a sectoring cone positioned on the downwind side of the rotor blades to maximize the velocity pressure recovery after the rotor blades;

[0072] (e) the adjustable upstream sectoring cone having a maximum diameter equal to the diameter of the outer shroud and minimum diameter equal to the diameter of the inner shroud;

[0073] (f) a retracting mechanism that retracts and deploys the overlapping cone segments;

[0074] (g) a set of tension rods that hold the overlapping segments in place and transmit a change of height of the cone into a change in the diameter of its base;

[0075] (h) a motorized threaded nut that travels back and forth along a threaded portion of the rotor shaft to adjust the diameter of the sectoring cone by applying or relieving pressure to the segment tension rod holding disk;

[0076] (i) a wind velocity measurement located upstream of the sectoring cone and that transmits a continuous signal for adjusting diameter of the sectoring cone;

[0077] (j) an electronic controller programmed to read the wind speed from the wind velocity instrument and adjust the position of the motorized nut to control the wind speed at the face of the said rotor blades; and

[0078] (k) a compressor fan with an adjustable speed drive that fits over the end of the rotor shaft and serves to increase the velocity pressure at the face of the said rotor blades.

[0079] Preferably, the shrouded wind turbine rotor has a minimum of three blades and a maximum of 50 blades all having the same nominal diameter as the shrouded section.

[0080] Preferably, the rotor-sectoring device produces an annular shaped channel at the face of the rotor blades of variable dimensions by increasing or decreasing the diameter of the sectoring device.

[0081] Preferably, the rotor-sectoring apparatus is capable of adjusting its diameter between 0.30 and 1.0 times the diameter of the turbine rotor.

[0082] Preferably, the sectoring cone is of such dimensions that it can be mounted on the shaft of the turbine rotor in order to rotate with the turbine into the wind.

[0083] Preferably, the rotor-sectioning cone has an aerodynamic form that maximizes the wind pressure at the face of the rotor blades.

[0084] In another embodiment of the present invention, the rotor-sectioning cone preferably uses the rotational speed of the rotor shaft to deploy the overlapping segments.

[0085] Preferably, the rotor-sectioning cone increases its diameter without increasing the distance between the base of the cone and the rotor.

[0086] Preferably, the rotor-sectioning device directs the air stream to the optimum section of the rotor blades to develop the maximum torque per unit of air volume at all wind speeds.

[0087] Preferably, the rotor-sectioning cone can increase the power generated significantly by a conventional HAWT or axial flow turbine at evaluated wind speeds of 4.0, 7.0 and 12.0 m/s.

[0088] Preferably, the rotor-sectioning apparatus can increase the power output of existing HAWT wind turbines by retrofitting the apparatus to the existing rotor or turbine.

[0089] Preferably, the rotor-sectioning apparatus performs satisfactorily with non-augmented or augmented axial flow wind turbines.

[0090] Preferably, the rotor-sectioning apparatus incorporates a motorized fan on the end of the rotor shaft to increase the velocity pressure at the face of the rotor blades.

[0091] The aforesaid and other objectives of the present invention are realized by generally providing a rotor-sectoring apparatus for use with a wind turbine to increase the velocity pressure of the air contacting the blades. The rotor-sectoring apparatus comprises shrouded rotor with a curve-shaped adapter at the entrance and conical or curved adapter at the exit, a sectoring cone with overlapping segments supported by the shaft of the rotor, a cone deployment mechanism employing tension arms located behind the sectoring cone segments, a series of overlapping outer segments with outside radius when extended essentially the same as the radius of the turbine rotor, an actuator mounted on the rotor shaft to deploy the segments in synchronous fashion, a wind measurement device located upstream of the rotor-sectoring apparatus entrance, and an actuator or series of actuators which respond to a controller programmed to hold the wind speed constant by adjusting the deployment of the cone segments.

[0092] The idea behind the concept consists in using an adequate flow control system to direct the incoming air stream towards those zones of the rotor swept area that are the most efficient in terms of energy conversion. Certainly, this concept may be applied to conventional non-augmented wind turbines as well as to augmented wind turbines which are operated inside a wind augmenting system. A wind augmentation system ensures an increase in the velocity pressure of the wind in front of the turbine rotor. The increase in velocity pressure may be small of the order of fractions of inches of water or may be quite large of the order of several feet of water and requiring the application of a large convergent-divergent.

[0093] In the case of a HAWT (Horizontal Axis Wind Turbine) turbine, the sectoring can be done with the aid of a cone-like or semi-circular body, with variable geometry capability, installed in front of the rotor. The cone will direct the air flux toward the high torque zone and will prevent it to pass through its low efficiency central zone, while also accelerating the air stream. Since the flow regime upstream of the rotor, even in an augmenting system, is basically a subsonic incompressible one (V<100 m/s), the body placed in front of the rotor for sectoring purposes preferably has a semi-spherical shape.

[0094] In the case of a HAWT rotor (propeller type), the application of the concept described here aims at directing the air flux toward its periphery (zone of high torque **110**) as shown in FIG. **1**, and avoid passing it through the central zone of the rotor where, due to the small distance from the rotation axis the blades have reduced tangential speed, thus poor aerodynamic efficiency (low torque zone **100**). The construction principle of the rotor swept area "sectoring" concept is illustrated in FIG. **2** for the case of a shrouded HAWT (including a shroud inlet **210**, turbine shroud **200** and shroud outlet **220**) and FIG. **3** for the case of a HAWT employing an augmented wind energy system (including a turbine **300**, convergent inlet **310**, a diffuser **320**, upwind cone **312** adjustable between wrapped **340** and deployed **360** configurations, a strut **322**, a turbine section **314**, and an adjustable downwind cone **324**).

[0095] With shrouded turbines, the entrance and exit adapters are located at the ends of the shrouds or turbine section and in the case of augmented turbines after the convergent and before the diffuser. Both adapters are designed specially to reduce the entrance and exit losses. The length, width and shape of the entrance and exit adapters are designed using standard air handling design practices and do not increase the velocity pressure of either the incoming or outgoing air stream. The inside diameter of both is essentially the diameter of the shroud. The entrance and exit areas are preferably between 1.2 and 1.7 times the rotor area.

[0096] The shroud has essentially the same diameter as the rotor to avoid air stream bypassing the rotor blades. As the air stream enters the shroud the sectoring cone reduces progressively the swept area and this increases the velocity pressure upstream of the blades. The role of the shroud is to prevent the increase in velocity pressure from spilling around the blade tips and uniform the wind direction upstream and downstream of the blades. The length of the shroud is a function of the velocity pressure upstream of the blades. At higher velocities the shroud needs to be longer than at lower velocities, as the velocity pressure is higher.

[0097] The parameter used to compare the relative amounts of the swept area that is sectored is the sectoring ratio or SR. SR is defined as the fraction of the non-swept area (open flow area) of the rotor blades as a fraction of the total swept area of the rotor.

[0098] In order to minimize the travel of the sectoring cone tension rods and the amount of overlap of the segments, the retracted position of the cone will stop once the determined high torque zone is completely open to the air stream. As a general rule, the length of travel of the tension rods corresponds to a SR of 0.70 to 0.0. At a SR of 0.0 the rotor swept area is fully sectored and airflow is stopped, at 0.50 the sectored area is equal to 50% of the rotor swept area.

[0099] In order to simplify the deployment mechanism the sectoring cone can be built in two-pieces instead of one-piece. The head of the cone is fixed and only the base of the cone deploys. This shortens the length of the cone arms and provides a more precise control of the SR.

[0100] It has been determined that the velocity pressure increases as the SR decreases or rather as the cone overlapping segments open or deploy. Deployment of the cone segments is not a problem even for large diameter rotors as the diameter of the fixed cone increases with the diameter of the rotor. The centrifugal force will also assure that the tension rods are always under tension.

[0101] The force required to retract the segments is obtained by installing a motorized nut on a threaded section of the rotor shaft. As the nut turns it will increase the overall height of the cone. The circular collecting plate at the apex of the cone that holds the tension arms in place will be raised or lowered through the displacement of the motorized nut along the threaded shaft.

[0102] As the base of the cone is fixed the tension applied to the tension rods that hold the segments in place will force a decrease in the area of the base of the sectoring cone. This in turn adjusts the sectoring ratio of the rotor. As the position of the base of the sectoring cone is fixed the distance between the edges of the overlapping segments and the rotor blades remains constant at all values of SR.

[0103] In a further embodiment, the sectoring cone design rather than being one-piece can be designed as two unequal pieces as shown in FIGS. **8** to **11**. The first piece is immovable, has a fixed diameter and is mounted on the end of the rotor shaft or to the frame supporting the turbine rotor. The second piece is a series of deployable overlapping segments and is installed in the wind shadow of the first piece. The form of the deployable segments is basically the same form as the lower section of the first half. As a result the deployable segments when fully retracted are protected or covered from the air stream.

[0104] As the segments deploy the diameter of the cone increases and the extremities of the segments approach the rotor blades. The most outer edge of the segments may be rounded or streamlined in the direction of the airflow in order to reduce turbulence at the blades. As the segments deploy the distance between the outer edge and the face of the blades remains constant. A motorized nut located on the shaft of the sectoring cone pushes the head of the cone farther away from the blades. The pressure of the oncoming wind will always push the cone towards the blades. When fully deployed, the segments will reduce the sectored area up to 100% of the total swept area of the rotor.

[0105] In the cases of one-piece, two-piece or multiple-piece assemblies of the sectoring cone, the actuators, which deploy the segments, may be pneumatic, hydraulic or electric. As they deploy, the segments slide along tracks designed to withstand the forces exerted by the incoming wind. As the sectoring cone is normally circular and fixed to the rotor shaft it creates an annular shaped sectored area, which grows in diameter as the segments deploy. This annular configuration is important as it directs the air stream equally to the outermost radius of the blades and it is an efficient form for increasing the velocity pressure by decreasing the swept area and this with minimal friction losses.

[0106] In a further embodiment the sectoring device may be attached to the shaft of an existing three-blade rotor. This will require the addition of an outer shroud to prevent the loss of the additional wind pressure generated by the sectoring device spilling over the tips of the blades. A second inner shroud is added to prevent the increase in velocity pressure from entering the low torque zone centered on the rotor shaft. This device provides the same benefits: it increases the total energy of the wind through the blades, it directs the air stream to the optimum area of the high torque zone and it allows for a precise control of the velocity through the blades.

[0107] In a further embodiment a sectoring device is added to the downstream face of the rotor. This reduces the frictional losses, turbulence and loss of velocity pressure downstream of the rotor blades.

[0108] The upstream air speed measurement consists of an instrument mounted on an extension to the rotor shaft. It is wireless and mounted on a bearing to avoid rotating with the shaft. As wind speeds of 12 m/s are common an extension of 3 meters will permit a reaction time for the controller and actuators responsible for deploying the outer segments of the order of 0.25 seconds.

[0109] As a preferred embodiment, adjustable liners may be installed on the inner rim of the rotor and deploy at the same vertical speed as the cone segments. The role of these inner liners is simply to reduce turbulence as the air flows between the blades close to the inner rim. The inner segments are not required to section the rotor. They are installed on the inner rim to reduce the friction losses as the wind passes between the rotor blades. Essentially both the inner liners and sectoring cone segments deploy together to provide a more even channel flow through and after the blades.

[0110] In another preferred embodiment a motorized variable speed compressor fan is attached to the rotor shaft above the sectoring cone. The compressor fan accelerates the speed and volume of the air stream being displaced from the low torque zone to the high torque zone.

[0111] The turbines can be augmented or non-augmented although the results with augmented turbines are more impressive given the higher wind speeds. The rotors of existing turbines can be replaced by this new technology to improve their performance. Otherwise this technology is implemented in the manufacture of new sectored and shrouded air and water turbines. By the principle of dynamic similarity, the results obtained when air is the fluid in motion is also applicable when water is the fluid in motion.

[0112] FIGS. **2** and **3** show the principal sections of the rotor-sectoring device, which include firstly the axial flow turbine rotor, the rotor blades and their swept area and secondly the sectoring cone apparatus. FIGS. **4** and **5** illustrate the sectoring cone outer shroud (**1**), the rotor blades mounted on a blade shaft (**2**) the sectoring cone inner shroud (**3**), the rotor spokes (**4**) the rotor hub (**5**) and the turbine drive shaft (**6**). In illustrating the sectoring cone, FIGS. **4** and **5** show the adjustable outer edge of the overlapping segments forming the body of the cone (**7**), the segment tension rod retaining disc (**8**) and the shaft of the sectoring apparatus (**9**).

[0113] FIGS. **4** and **5** also show the non-dimensional references of the variable outside radius of the sectoring cone (R**3**), the outside radius of the rotor blades (R**2**) and the inside radius of the rotor blades (R**1**). FIG. **2** shows the non-dimensional reference to the adjustable variable outside radius of the sectoring cone (R**3**). The reference to the adjustable edge of the overlapping segments (**7**) and the reference (R**3**) to the adjustable outside radius of the sectoring cone is synonymous.

[0114] FIGS. **6**A to **6**E show the deployment mechanism of the sectoring cone that includes curved tension rods that hold the overlapping segments in position (**10**), the outer rim of the sectoring cone (**11**), the spokes of the sectoring mechanism (**12**) and the sliding connection that permits the overlapping segments to deploy and retract by allowing the slip connection to travel along the spokes of the sectoring mechanism (**13**).

[0115] FIG. **7** illustrates a sectored HAWT with a motorized drive (**14**) for a compressor fan (**15**) mounted on the end of the rotor shaft.

[0116] FIG. **8** illustrates a fully deployed two-piece sectoring apparatus. The overlapping segments (**7**) are deployed from the fixed upper cone (**8**) and the sectoring cone shaft (**9**).

[0117] FIG. **9** illustrates a two-piece sectoring device with the segments fully retracted. A motorized nut (**15**) turns on the shaft of the sectoring device to allow it to remain at a constant distance from the blades as the segments deploy.

[0118] FIGS. **10**A to **10**C illustrate the inside framing of the two-piece sectoring mechanism. The segment actuators (**14**) are fixed to the vertical spokes of the sectoring device. As the actuators extend the segments deploy, as the actuators retract the segments retract. FIG. **10**A illustrates fully or 100% deployed segments, FIG. **10**B a 50% deployment of segments and FIG. **10**C a 0.0% deployment of segments. The segment guides (**10**) hold the segments in place, the outer ring (**11**) fastens the base of the cone to the inside face of the shroud, the actuator support rods (**12**) support the actuators, the actuator rods (**13**) extend and retract from the actuator housing (**14**).

[0119] FIG. **11** illustrates a two-zone sectoring apparatus equipped with a motorized fan drive (**14**), compressor fan (**15**) two upstream wind measurement devices (**17**), the vertical holding rod (**16**) that keeps the measurement devices outside the effects of the compressor fan, and the dead weight (**18**) that keeps the holding rod stationary. It is the shaft that connects the vertical holding rod to the turbine rotor shaft that is equipped with an internal roller bearing that permits the holding rod to remain vertical.

[0120] Operational performance of the present invention is described in the non-limitative following examples that were derived from recognized computer simulation software applied by recognized experts in the field of wind turbines.

[0121] To assess quantitatively the effects of using the swept area sectoring system on augmented HAWT and VAWT (Vertical Axis Wind Turbine, described in more detail below), two computer programs, which have the capability to calculate the performance (power output) of such wind turbines, have been used. For HAWT analysis the code used was WT Perf, and for VAWT analysis, the CARDAAV code has been used.

The WT Perf Code

[0122] WT Perf uses blade-element momentum (BEM) theory to predict the performance of HAWT. It was developed at National Renewable Energy Laboratory (NREL) from the code PROP, originally set up by Oregon State University decades ago. The staff at the National Wind Technology Center from the National Renewable Energy Laboratory, USA, has recently modernized PROP by adding new functionalities developed into the current WT Perf.

The CARDAAV Code

[0123] CARDAAV is a computer code developed by Ion Paraschivoiu for the prediction of the aerodynamic qualities and the performances of the vertical axis wind turbines.

[0124] CARDAAV is based on the Double-Multiple-Streamtube model with variable upwind- and downwind-induced velocities in each streamtube (DMSV). Due to this model and to a quite large number of options regarding the geometrical configuration, the operational conditions and the control of the simulation process, CARDAAV proves to be an efficient software package, appropriate for the needs of VAWT designers. It computes the aerodynamic forces and power output for VAWTs of arbitrary geometry at given operational conditions.

[0125] The numerous parameters that are necessary to fully describe the analyzed VAWT provide a rather large freedom in specifying its geometry. Among the most important in this category are: the rotor height and diameter, the number of blades and the type of airfoil defining their cross-section, the diameter of the central column (tower), the size and position of the struts, the size of the spoilers, etc. Virtually any blade shape can be analyzed, including, of course, the straight one. Moreover, the blade can be made of segments having different chord lengths and cross-sections (airfoils). The airfoil data-base of the code includes some of the well known symmetrical NACA shapes (NACA **0012**, NACA **0015**, NACA **0018**, NACA **0021**) as well as several of those specially designed for VAWTs at Sandia National Laboratories (SNLA **0015**, SNLA **0018**, SNLA **0021**). If the user wants to perform the analysis with an airfoil that is not among those already available, this can be done quite simply, by including the values of its experimentally determined lift and drag coefficients in the actual airfoil data base. These data must be given for several Reynolds numbers that correspond to those attained on the revolving blades and cover (at each Re) the full 360° range for the angle of incidence ($0° \leqq \alpha \leqq 360°$).

[0126] Among the principal operating parameters that are readily modifiable to meet the needs of a specific analysis one can mention: the wind speed, the rotational speed of the rotor, the local gravity acceleration and the working fluid properties (density, viscosity—usually for air). Either constant rotational speed at different wind speeds or different rotational speeds at a constant wind speed can be considered when performing an analysis. By specifying the adequate value for the atmospheric wind shear exponent, a power law type variation of the wind speed with height will be taken into account during the computations.

[0127] In what regards the control parameters, the code requires the number of half cycle (azimuthal) divisions and vertical divisions which define the total number of stream tubes that are going to be considered in the computations as well as the number of integration points over the width of each tube. In the same category, the user has to specify the maximum number of iterations in the computation of the upwind and downwind interference factors along with the convergence criteria (relative error levels that must be satisfied when computing the interference factors and the dynamic stall). The decision on whether to apply or not the aerodynamic corrections related to the blade-tip effects and those due to the occurrence of the dynamic stall must be taken when the control parameters are specified. Four dynamic stall models are available, three derived from Gormont's method and the "indicial" model.

[0128] The important number of parameters and options (mentioned above) give CARDAAV a rather large capacity and flexibility in computing the performances of various Darrieus type VAWTs. Depending on the actual values given to these parameters, the code performs the computations on a particular configuration by neglecting or taking into account the effects of the dynamic stall as well as several "secondary effects", such as those due to the rotating central column, the struts and spoilers. The dynamic stall has a significant influence on the aerodynamic loads and the rotor performances at low tip-speed ratios, whereas the "secondary effects" are important at moderate and high tip-speed ratios.

[0129] Running under the Microsoft Windows environment, CARDAAV is user-friendly, being provided with a graphical interface so that all the input data that need to be frequently changed for a comprehensive performance analysis (rotor geometry, operational and control parameters) is easily modified. The local induced velocities, Reynolds number and angle of attack, the blade loads and the azimuthal torque and power coefficients are the output data. These results can be directly visualized on the computer's display or stored in ASCII files or in a format compatible with the graphic software TECPLOT (Amtec Engineering Inc.) for further post processing and interpretation.

[0130] Numerous validations have demonstrated the capacity of CARDAAV to compute with a fair accuracy the aerodynamic loads and global performances (torque, power) of the usual types of vertical axis wind turbines, including those of Darrieus H-type. The CARDAAV results compare quite well with the experimental ones over a large range of tip speed ratios (TSR).

[0131] The simulation was performed using as the reference a standard 22-meter diameter HAWT blade. The simulations were carried out on shrouded rotors at wind speeds of 4, 7 and 12 m/s. The sectoring ratio was varied between 1.0

and 0.25. The effect and advantages of sectoring the rotor are clearly illustrated by the test results as shown in FIG. **12**.

[0132] The form of the sectoring device for the simulation was a cone shape. The effect of changing the form of the sectoring device was not evaluated, only the effect of the change in swept area. Many different forms of sectoring device are applicable including parabolas, cones and semicircles and the form may improve slightly the result. However the important variable remains the change in the sectored area that has the effect of increasing the wind pressure at the face of the blades and the application of this wind pressure to the optimum high torque zone of the rotor.

[0133] The simulated results of sectoring were achieved using a standard 22-meter HAWT blade. The cord and twist angle distribution are depicted in FIG. **13**.

[0134] The results of the simulations are listed in Table 1 and depicted as continuous curves in FIG. **12**.

TABLE 1

Power generated versus sectoring ratio
22 meter HAWT rotor at wind speeds of 4.0, 7.0, and 12 m/s

SR	4.0 m/s	7.0 m/s Power generated (kW)	12.0 m/s
1.0	10	30	190
0.9	20	30	210
0.8	20	40	225
0.7	30	50	260
0.6	30	70	300
0.5	40	100	550
0.4	40	150	750
0.3	50	220	1150
0.25	55	300	1500

Example 1

A HAWT Sectored Rotor at 4.0 m/s

[0135] At 4.0 m/s the sectoring ratio was varied between 1.0 and 0.25. The power produced increased from 10 to 55 kW or an increase of 5.5 fold.

Example 2

A HAWT Sectored Rotor at 7.0 m/s

[0136] At 7.0 m/s the sectoring ratio was varied between 1.0 and 0.25. The power produced increased from 30 to 300 kW or an increase of 10 fold.

Example 3

A HAWT Sectored Rotor at 12.0 m/s

[0137] At 12.0 m/s the sectoring ratio was varied between 1.0 and 0.25. The power produced increased from 190 to 1500 kW or an increase of 7.7 fold.

[0138] As a person skilled in the art would understand a plurality of types of axial flow or horizontal axis turbines may be used with the device of the present invention. Also for each wind turbine different combinations may be used for example a different number and/or configuration of blades, the space between the wind section and the wind turbine, etc.

[0139] As a person skilled in the art would understand the parameters of the sectoring cone may differ from the examples shown in this document. Similarly the mechanism for adjusting the opening of the aperture or flow channel may differ based on the fluids, operating conditions and turbine apparatus.

Embodiments for Cross-Flow Turbines

[0140] According to the present invention, as shown in FIG. **18**, there is also provided a directing system **1800** for directing fluid entering a cross-flow turbine along an inlet flow direction. The turbine comprises a rotor. The rotor comprises a plurality of turbine blades **1802**. The directing system **1800** comprises an inlet **1808** directing fluid towards the turbine, and a plurality of directing segments **1804** attached to the inlet **1808**, downstream of the inlet. A directing segment adjustment system **1806** is also provided for adjustably positioning the directing segments **1804** between a retracted configuration and a deployed configuration. The directing segments, in the deployed configuration, extend beyond the inlet **1808** in a direction transversal to the inlet flow direction and deflect the fluid towards a centerline **1801** of a rotor of the turbine.

[0141] Preferably, the plurality of directing segments **1804** are two inlet side deflectors pivotably attached to the inlet and the directing segment adjustment system **1806** comprises a pair of actuators for pivoting the two side deflectors with respect to the inlet.

[0142] Preferably, the directing system further comprises an outlet **1809** directing fluid away from the turbine, a second set of two outlet side deflectors **1805** pivotably attached to the outlet and a second pair of actuators for pivoting the second set of the two outlet side deflectors with respect to the outlet.

[0143] Preferably, the directing system further comprises a set of adjustably positionable side baffle plates **1803** concentrically positioned within an outer circumference of the rotor of the turbine.

[0144] Preferably, the directing system further comprises a set of baffle plate actuators for adjustably positioning the side baffle plates **1803** based on a corresponding configuration of the inlet side deflectors or directing segments **1804**.

[0145] Preferably, the set of adjustable baffle plates are supported by a set of support bars **1807** attached to a shroud surrounding the turbine.

[0146] Preferably, the directing segment adjustment system comprises a controller and the directing system further comprises a fluid velocity measurement system located upstream of the inlet and producing a signal indicative of fluid velocity entering the turbine, and wherein the controller adjusts the directing segment adjustment system based on the signal indicative of fluid velocity entering the turbine.

[0147] According to the present invention, there is also provided a rotor-sectoring device for use with at least one wind turbine to increase the velocity pressure and maximize the torque produced by the wind contacting the blades of the wind rotor, the rotor-sectoring device comprising:

[0148] (a) a shrouded tunnel section, the tunnel section comprising four walls an entry and an exit, the entry having an area equal or slightly lower than the exit;

[0149] (b) an entrance and exit adapters, the adapters designed to minimize the loss of velocity pressure as the air stream enters and leaves the wind turbine;

[0150] (c) a set of two pivoting side deflectors located both upstream and downstream of the wind rotor;

[0151] (d) a set of actuators that deploy or retract the upstream side deflectors into the air stream, the width or cross section of the air stream being controlled by the actuators or the side wall deflectors;

[0152] (e) a set of actuators that deploy or retract the downstream side deflectors into the air stream, the width or cross section of the air stream being controlled by the actuators or the side wall deflectors;

[0153] (f) a set of adjustable position side baffle plates located within the circumference defined by said turbine rotor and traveling back and forth in synchronous fashion with the adjustable side deflectors and thereby controlling the size of the flow channel;

[0154] (g) a set of actuators to position the side wall baffles in synchronous fashion with the side wall deflectors;

[0155] (h) a wind measurement instrument located upstream of the entrance adapter and providing a continuous measurement of wind speed to a programmable controller;

[0156] (i) the programmable controller adjusting the position of the deflectors and the side baffles to control the sectoring ratio and the speed through the adjustable flow aperture.

[0157] Preferably, the rotor-sectoring device produces a square or rectangular shaped channel at the face of the rotor blades of variable dimensions by increasing or decreasing the width of said sectoring device.

[0158] Preferably, the rotor-sectoring apparatus is capable of adjusting the area of the flow aperture of the turbine rotor.

[0159] Preferably, the sectoring cone is of such dimensions that it can be mounted on the shrouds of the turbine rotor in order to rotate with the turbine into the wind.

[0160] Preferably, the rotor-sectioning device has an aerodynamic form that maximizes the wind pressure at the face of the rotor blades.

[0161] Preferably, the rotor-sectioning cone optimizes the production of power by limiting the flow aperture to dimensions that maximize the torque produced by decreasing the low torque zone.

[0162] Preferably, the rotor-sectioning device directs the air stream to the optimum section of the rotor blades to develop the maximum torque per unit of air volume at all wind speeds.

[0163] Preferably, the rotor-sectioning cone can increase the power generated significantly by a conventional VAWT or cross-flow turbine at evaluated wind speeds of 4.0, 7.0 and 12.0 m/s.

[0164] Preferably, the rotor-sectioning apparatus can increase the power output of existing VAWT wind turbines by retrofitting the apparatus to the existing VAWT rotor or turbine.

[0165] Preferably, the rotor-sectioning apparatus performs satisfactorily with non-augmented or augmented axial flow wind turbines.

[0166] Preferably, the rotor-sectioning apparatus, by dynamic similitude, will provide very similar overall performance when either water or air are the fluids passing through the turbine.

[0167] The blades of a cross-flow turbine such as a VAWT do not provide a continuous level of torque over each revolution. Whether the rotor is shrouded or operating in an open channel the torque developed varies as the blades travel around their 360-degree path. Similar to the HAWT, as shown in FIG. **14**, there exists a low torque area **1420** and a high torque area **1410**. When looking at a vertical cross-flow rotor along the direction of its shaft, the high torque sector of the upwind and downwind arcs is centered on the 12 o'clock and 6 o'clock positions. The low torque sectors are centered on the 3 o'clock and 9 o'clock positions. Thereby, in the case of a VAWT rotor, the zones of "low torque" (hence low power production) are situated on the two sides of the rotor swept area, whereas the "high torque" zone coincides with the central part of the rotor swept area as shown by FIG. **14**.

[0168] The azimuthal variation of the tangential force FT of a generic VAWT is illustrated in FIG. **15**.

[0169] The purpose of installing a sectoring apparatus on a VAWT is to direct air away from the low torque area and into the high torque area. Computer simulations have permitted to determine that the power produced will continue to increase until the area sectored represents 67% of the total swept area. Above 67% the power output falls rapidly.

[0170] The sectoring device creates an adjustable rectangular or square opening at the upwind and downwind faces of the rotor. The side deflectors are adjustable to decrease the width of the aperture. Essentially this removes airflow from the walls or the low torque areas and directs it to the high torque area located along the rotor centerline. The reduction in the area of the aperture increases the wind velocity pressure.

[0171] The rotor is shrouded in order to prevent the air from spilling around the edge of the blades. A bell shaped lip on the upwind entrance and an angled or round lip on the downwind exit serve to minimize the entrance and exit friction losses.

[0172] It is important that the side deflectors attached to the turbine shrouds have a suitable aerodynamic shape for each application and fluid. For an application where choking of the fluid stream becomes a problem a baffle plate is installed in line with the turbine shaft to cut the non-sectored area into two equal parts. The walls of this baffle have a slight outward radius.

[0173] In order to reduce velocity pressure losses when the air is traveling between the rotors two adjustable baffles are installed inside the rotor parallel to the direction of wind flow. As the side deflectors move to increase or decrease the width of the aperture their horizontal displacement and the horizontal displacement of the baffles are synchronized. The effect is to create a more continuous flow channel up to and through the rotor blades.

[0174] The sectoring of VAWT is applicable for augmented and non-augmented turbines. In all cases the rotor is shrouded or ducted. FIGS. **16** and **17** show the construction principle for non-augmented (including a turbine shroud **160**, shroud inlet **162** and shroud outlet **164**) and for augmented turbines (including a turbine **170**, convergent inlet **172**, diffuser **174**, side plates **176**, adjustable upwind vanes **178**, adjustable downwind vanes **180**) respectively.

[0175] FIG. **18** shows the principal sections of the rotor-sectoring apparatus for cross-flow turbines which are the rotor shaft (**1801**), the rotor airfoils (**1802**), the adjustable baffle walls (**1803**), the upwind flow deflectors (**1804**), the downwind flow deflectors (**1805**), the upwind and downwind flow deflector actuators (**1806**), the adjustable baffle wall actuators (**1807**), the entrance flow adapter (**1808**), the exit flow adapter (**1809**) and the shrouds covering the top bottom and sides of the turbine section. The top shroud is not shown for purposes of clarity and comprehension.

[0176] Operational performance of the present invention is described in the non-limitative examples that are computer simulations prepared using recognized computer simulation programs by competent recognized experts in the fields of simulating wind turbines. The tools, method and techniques are discussed in the previous section of this document.

[0177] The examples described below have been executed with a vertical airfoil with characteristics as shown in Table 2. The rotor has been equipped with shrouds and the effect of the rotor-sectoring device was evaluated at wind speeds of 4.0, 7.0 and 12.0 m/s.

TABLE 2

Power versus SR at 4.0, 7.0 and 12.0 m/s

SR	4.0 m/s	7.0 m/s	12.0 m/s
	Power generated in kW		
1.0	10	50	200
0.9	15	60	290
0.8	25	75	380
0.7	30	110	560
0.67	35	120	625

Example 1

A VAWT and Sectored Rotor at 4.0 m/s

[0178] At 4.0 m/s the sectoring ratio was varied between 1.0 and 0.67. The power produced increased from 10 to 35 kW or an increase of 3.5 fold.

Example 2

A VAWT and Sectored Rotor at 7.0 m/s

[0179] At 7.0 m/s the sectoring ratio was varied between 1.0 and 0.67. The power produced increased from 50 to 120 kW or an increase of 2.5 fold.

Example 3

A VAWT and Sectored Rotor at 12.0 m/s

[0180] At 12.0 m/s the sectoring ratio was varied between 1.0 and 0.67. The power produced increased from 200 to 625 kW or an increase of 3.1 fold.

[0181] The results obtained are shown as curves in FIG. **19**.

[0182] As a person skilled in the art would understand a plurality of types of cross-flow or vertical axis turbines may be used with the device of the present invention. Also for each wind turbine different combinations may be used for example a different number and/or configuration of blades, the space between the wind section and the wind turbine, etc.

[0183] As a person skilled in the art would understand the parameters of the sectoring cone may differ from the examples shown in this document. Similarly the mechanism for adjusting the opening of the aperture or flow channel may differ based on the fluids, operating conditions and turbine apparatus.

[0184] While illustrative and presently preferred embodiments of the invention have been described in detail hereinabove, it is to be understood that the inventive concepts may be otherwise variously embodied and employed and that the appended claims are intended to be construed to include such variations except insofar as limited by the prior art.

1. A directing system for directing fluid entering an axial flow turbine along an inlet flow direction, said turbine comprising a plurality of turbine blades, said directing system comprising:

a base structure;

a plurality of directing segments attached to the base structure;

a directing segment adjustment system for adjustably positioning the directing segments between:

 a retracted configuration; and

 a deployed configuration;

and

an outer shroud surrounding a circumference of the turbine blades,

wherein the directing segments, in the deployed configuration, extend beyond the base structure in a direction transversal to the inlet flow direction and deflect the fluid towards an outer circumference of the plurality of turbine blades.

2. The directing system as described in claim **1**, wherein the base structure is fixed to a central rotating shaft of the turbine.

3. The directing system as described in claim **2**, wherein the plurality of directing segments are overlapping segments radially positioned around the base structure, and the directing segment adjustment system comprises:

a set of tension rods holding the directing segments in place; and

a motorized threaded nut system traveling along a threaded portion of the central shaft and displacing the base structure in relation to an axial displacement of the directing segments.

4. The directing system as described in claim **2**, wherein the turbine blades are housed between an inner annular shroud and the outer shroud, the base structure extends radially up to the inner annular shroud and the directing segments extend to a maximum diameter corresponding to a diameter of the outer shroud.

5. The directing system as described in claim **1**, wherein a diameter of the base structure is at least 0.3 times a diameter of a rotor of the turbine.

6. The directing system as described in claim **1**, further comprising a compressor fan positioned upstream of the base structure and increasing velocity of the fluid entering the turbine.

7. The directing system as described in claim **1**, wherein the directing segment adjustment system comprises a controller and the directing system further comprises a fluid velocity measurement system located upstream of the base structure and producing a signal indicative of fluid velocity entering the turbine, and wherein the controller adjusts the directing segment adjustment system based on the signal indicative of fluid velocity entering the turbine.

8. A directing system for directing fluid entering a cross-flow turbine along an inlet flow direction, said turbine comprising a rotor, said rotor comprising a plurality of turbine blades, said directing system comprising:

an inlet directing fluid towards the turbine;

a plurality of directing segments attached to the inlet; and

a directing segment adjustment system for adjustably positioning the directing segments between:

 a retracted configuration; and

 a deployed configuration,

wherein the directing segments, in the deployed configuration, extend beyond the inlet in a direction transversal to the inlet flow direction and direct the fluid towards a centerline of a rotor of the turbine.

9. The directing system as described in claim **8**, wherein the plurality of directing segments are two inlet side deflectors pivotably attached to the inlet and the directing segment adjustment system comprises a pair of actuators for pivoting the two side deflectors with respect to the inlet.

10. The directing system as described in claim **9**, further comprising an outlet directing fluid away from the turbine, a second set of two outlet side deflectors pivotably attached to the outlet and a second pair of actuators for pivoting the second set of the two outlet side deflectors with respect to the outlet.

11. The directing system as described in claim **8**, further comprising a set of adjustably positionable side baffle plates concentrically positioned within an outer circumference of the rotor of the turbine.

12. The directing system as described in claim **11**, further comprising a set of baffle plate actuators for adjustably positioning the side baffle plates based on a corresponding configuration of the inlet side deflectors.

13. The directing system as described in claim **12**, wherein the set of adjustable baffle plates are supported by a set of support bars attached to a shroud surrounding the turbine.

14. The directing system as described in claim **8**, wherein the directing segment adjustment system comprises a controller and the directing system further comprises a fluid velocity measurement system located upstream of the inlet and producing a signal indicative of fluid velocity entering the turbine, and wherein the controller adjusts the directing segment adjustment system based on the signal indicative of fluid velocity entering the turbine.

15. The directing system as described in claim **1**, wherein the base structure is fixed to a fixed shaft supported by a turbine frame.

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