Office de la Propriété Intellectuelle du Canada
Un organisme d'Industrie Canada

Canadian Intellectual Property Office
An agency of Industry Canada

CA 2633876 A1 2009/12/05

(21) 2 633 876

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(22) Date de dépôt/Filing Date: 2008/06/05

(41) Mise à la disp. pub./Open to Public Insp.: 2009/12/05

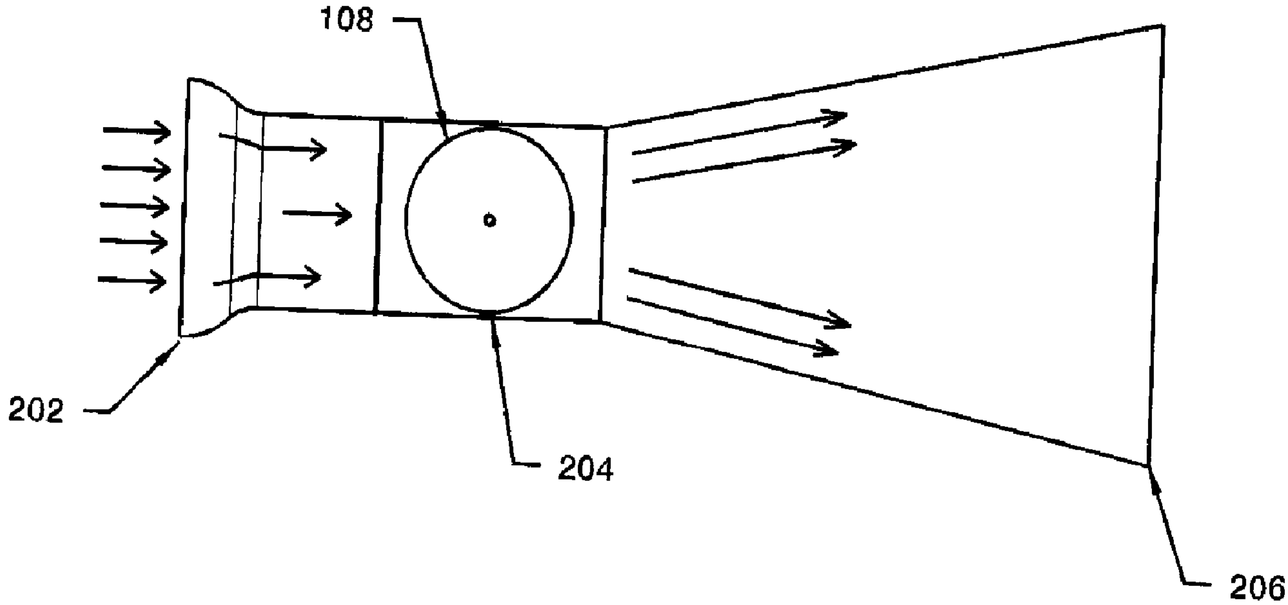
(51) Cl.Int./Int.Cl. *F03D 3/04* (2006.01), *F03D 11/00* (2006.01)

(71) Demandeur/Applicant:
ORGANOWORLD INC., CA

(72) Inventeurs/Inventors:
CHURCHILL, FREDERICK, CA;
PERRON, JEAN, CA;
FORTIN, GUY, CA

(74) Agent: ROBIC

(54) Titre : DISPOSITIF POUR EOLIENNE
(54) Title: WIND TURBINE APPARATUS



(57) Abrégé/Abstract:
The present invention provides a wind turbine apparatus which is able to increase the wind velocity and consequently increase the rotation speed of the wind turbine. The wind turbine apparatus comprises a convergent section, a wind turbine section and a divergent section. The wind enters into the wind turbine through the convergent section, passes through the wind turbine and exits through the divergent section. The combination of the convergent section and the divergent section creates a Venturi effect and increases the wind velocity and thus the rotation speed of the wind turbine.

File number: 11359-001
Revision: as filed
Date: 05-06-2008

WIND TURBINE APPARATUS

Abstract

The present invention provides a wind turbine apparatus which is able to increase the wind velocity and consequently increase the rotation speed of the wind turbine. The wind turbine apparatus comprises a convergent section, a wind turbine section and a divergent section. The wind enters into the wind turbine through the convergent section, passes through the wind turbine and exits through the divergent section. The combination of the convergent section and the divergent section creates a Venturi effect and increases the wind velocity and thus the rotation speed of the wind turbine.

File number: 11359-001
Revision: as filed
Date: 05-06-2008

Title of the Invention

[0001] Wind turbine apparatus

Cross-Reference to Related Applications

[0002] There are no cross-related applications.

Field of the Invention

[0003] The present invention generally relates to wind turbine and more particularly to an apparatus to increase the wind velocity and consequently the amount of energy generated by a wind turbine.

Background of the Invention

[0004] There is a global interest in the development of alternative energy sources especially of wind power. The idea of harnessing the "free" energy in the air by using the passing wind to rotate a shaft in order to produce useful work has long been studied. During the past several years, however, the recognition of the limited supply of fossil fuels and the soaring costs of energy in general have created a renaissance in wind turbines all seeking to extract energy from the passing air with sufficient efficiency to constitute practical sources of electrical and mechanical power.

[0005] In its simplest form, a wind turbine comprises a shaft which carries blades or other means of catching the wind and rotating the shaft from which mechanical or electrical power is generated. Within given limits the velocity with which the shaft rotates is roughly proportional to the velocity of the wind acting on the shaft's rotators and to the amount of energy produced. The faster the shaft rotates for a given velocity of wind and a given load, the greater is the efficiency with which wind energy is converted into mechanical or electrical energy.

File number: 11359-001
Revision: as filed
Date: 05-06-2008

[0006] It has thus been one approach to increasing the efficiency of wind generating machines to increase the efficiency of the rotation of the working shaft for a given wind velocity.

[0007] The electrical power generated by wind turbines is often transmitted considerable distances to centres of population, and one reason for this is that people usually live in sheltered terrain where the wind resource is more modest. The less concentrated energy in the wind in such areas reduces the economics of its energy capture with conventional wind turbines.

Objects of the Invention

[0008] A first object of the present invention is to provide an apparatus to increase the energy generated by a wind turbine.

[0009] A second object of the present invention is to provide an apparatus increasing the wind velocity of the wind entering a wind turbine.

[0010] It is another object of the present invention to provide a wind turbine apparatus which is usable in regions having relatively low wind velocity.

[0011] Other and further objects and advantages of the present invention will be obvious upon an understanding of the illustrative embodiments about to be described or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

Summary of the Invention

[0012] The aforesaid and other objectives of the present invention are realized by generally providing a turbine apparatus for use with a wind turbine to increase the wind velocity contacting the wind turbine, the wind turbine apparatus comprising a convergent section, the convergent section comprising an entry and an exit, the entry having an area higher than said exit, the convergent section having a first ratio being the entry area on the exit area; a wind turbine section adjacent to the exit of the convergent section, the wind turbine section comprising the wind turbine; a divergent section adjacent to the wind turbine section, the divergent section comprising an entry and an exit, the entry having an area lower than the exit, the divergent section having a second ratio being the exit area on the entry area; wherein wind enters through the convergent section and exits through the divergent section and wherein the wind turbine apparatus has a third ratio being the exit area of the divergent section on the entry area of the convergent section.

[0013] The convergent section of the wind turbine apparatus is defined as a section having an entry which is larger than its exit. The exit of the convergent section is in contact with the entry of the wind turbine section. The length and the design of the convergent section are chosen to minimise the loss head due to the flow acceleration and to make uniform the velocity profile at the convergent exit so that a pressurisation is created at the entry of the wind turbine section.

[0014] The divergent section is defined as a section having an entry which is smaller than its exit. The combination of the convergent section, the wind turbine section and the divergent section must be such that a Venturi effect is created. The Venturi effect derives from a combination of Bernoulli's principle and the equation of continuity. Indeed, the wind velocity must increase through the wind turbine section, to satisfy the equation of continuity, while its pressure must decrease due to conservation of energy. The speed of wind rise through the wind turbine section, due to the pressure on the upwind side of the wind turbine section, and the pressure drop on the downwind side as the wind diverges to leave the wind turbine section.

[0015] The parameters used to compare the convergent section and the divergent section are the first ratio, the second ratio and the third ratio. The first ratio is the ratio of the entry area over the exit area of the convergent section. The second ratio is the ratio of the exit area over the entry area of the divergent section. The third ratio is the ratio of the exit area of the divergent section over the entry area of the convergent section. There are also preferable ratios concerning the length of the convergent section and of the divergent section, which are the fourth ratio and the fifth ratio. The fourth ratio is the ratio of the length of the convergent section over the largest of the width or the height of the convergent section. The fifth ratio is the ratio of the length of the divergent section over the width of the divergent section.

[0016] It has been determined that the first ratio is preferably higher than 1.5 and more preferably higher than 2.25. It is important to get a pressure differential between the entry of the convergent section and the entry of the wind turbine in order to maximize the Venturi effect created.

[0017] It has been determined that the second ratio is preferably higher than 4.0. It has been determined that the third ratio is preferably between 1.5 and 10, and more preferably between 1.5 and 6.5.

[0018] It has been determined that the fourth ratio is preferably between 0.5 and 2.5. The fifth ratio is preferably between 1.0 and 4.0. The length of the divergent section is preferably longer than the length of the convergent section.

[0019] In a preferred embodiment, the convergent shape is given by the Berger theory as well as the inflexion point and the length in order to minimise the loss head and make uniform the velocity profile at the convergent exit.

[0020] The shape of the cross-section of the different sections may vary (circular, rectangular ...). However, the shape of the cross-section of the divergent section should preferably be similar to the shape of the cross-section of the exit of the wind turbine section to keep a laminar flow in the divergent section.

File number: 11359-001
Revision: as filed
Date: 05-06-2008

[0021] It is to be noted that the wind turbine section may have a shape that differs from the divergent section and/or the convergent section. In this case a transition section is installed between the wind turbine section and the divergent section and/or the convergent section to preserve a laminar flow.

[0022] In a further embodiment, the convergent section comprises two flat walls that are parallel to each other and two other walls that are curved to form a constriction of section.

[0023] The angle between the walls of the divergent section and the longitudinal axis of the wind turbine apparatus should be chosen to prevent a stall of the wind. A stall is a condition in aerodynamic where the angle between the relative incoming wind and the surface on which the wind flows increases beyond a certain point such that the wind stops to follow the profile of the surface (in this case the walls of the divergent section). It is preferable to maintain a laminar flow within the divergent section because a turbulent flow in this section would decrease the wind velocity and consequently the efficiency of the wind turbine. The angle at which a turbulent flow occurs is referred to as the critical angle. The critical angle is dependant upon the profile and the geometry of the surfaces of the divergent section. The critical angle may vary but is preferably greater than 8 degrees and less than 30 degrees relative to the incoming wind. It is to be noted that the different walls of the divergent do not need to be all at the same angle relatively to the longitudinal axis of the wind turbine apparatus but all should be within the aforesaid parameters.

[0024] In a further embodiment, the entry of the convergent section and the exit of the divergent section comprise panels to minimize the entrance losses and the exit losses. In order to minimize the entrance losses and the exit losses, the panels should preferably have a smooth profile and be tangential to the wind turbine apparatus. A smooth profile refers to a profile that does not have sharp edges.

[0025] The wind turbine section is preferably only slightly larger than the overall size of the wind turbine so as to force the wind to pass through the wind turbine and not around the wind turbine. The space between the inside walls of the wind turbine section and the wind turbine is preferably just what is needed so that the wind turbine will not touch the walls and allowing the wind turbine to rotate without resistance. Indeed, if a large space is kept between the wind turbine and the walls of the wind turbine section, a portion of the wind will pass where there is less resistance or around the wind turbine and therefore reduce its efficiency.

[0026] In a further embodiment, the orientation of the entire wind turbine apparatus may be rotatable so that the longitudinal axis of the wind turbine apparatus is parallel to the actual flow of the wind. This rotation allows the maintenance of the alignment of the centerline of the convergent parallel to the direction of the prevailing wind. The wind turbine section, the convergent section and the divergent section are mounted together as one assembly that rotates 360 degrees around a central axis. For example, the wind turbine apparatus may sit on a support connected to a mechanism that is able to rotate. The mechanism may comprise wheels, rollers or the like, located between the wind turbine apparatus and the support, that follow a circular track and that are possibly motorized to maintain precise positioning. In high wind conditions, the pressure of the wind against the wall of the divergent is sufficient to keep the unit aligned parallel to the wind. The wind apparatus can be installed on a tower or a rooftop. It is to be noted that other means that the examples detailed in the present document may be provided so that the wind turbine apparatus rotates in such a way as to insure that the longitudinal axis of the wind turbine apparatus is parallel to the actual flow of the wind.

[0027] The material of the wind turbine apparatus should be resistant enough to support is own weight. The material, or the combination of materials, may be, for example, metal, composite or polymers. The wind turbine apparatus may, for example, be made of aluminum and comprises structural reinforcement made of steel. Structural reinforcements may be used to support the wind turbine apparatus.

[0028] Depending on the desired capacity of the turbine, the dimensions of the convergent and divergent can be considerable. A large proportion of their weight and the forces generated against the walls by the wind can be supported by a central mast and cable structure. The mast is part of the assembly and rotates with the assembly to keep the convergent facing the wind. The overall appearance of the mast and cables resembles that of a section of a suspension bridge that rotates around the middle. However, smaller wind turbine apparatus may be installed on roofs and/or near populated centers.

[0029] The wind turbine apparatus of the present invention may be used in a plurality of environments, even where there is no high velocity wind. The wind turbine apparatus of the present invention generate less noise than usual wind turbines because the wind turbine is enclosed in the wind turbine apparatus. It is thus possible to install the wind turbine apparatus of the present invention near population. It could be possible to install the wind turbine apparatus on roof of buildings.

[0030] In a further embodiment, the wind turbine section could comprise more than one turbine. It is to be noted that there is less energy available for each supplementary wind turbine, indeed, the wind velocity is smaller at the exit of a wind turbine than at the entry. If a plurality of wind turbines is comprised in the wind turbine section, the characteristics of the wind turbine apparatus should be carefully chosen so that there is still a Venturi effect induced on the wind turbines.

[0031] The features of the present invention which are believed to be novel are set forth with particularity in the appended claims.

Brief Description of the Drawings

[0032] The above and other objects, features and advantages of the invention will become more readily apparent from the following description, reference being made to the accompanying drawings in which:

[0033] Figure 1 is a schematic view of the wind turbine apparatus.

File number: 11359-001
Revision: as filed
Date: 05-06-2008

[0034] Figure 2 is a schematic cross-section view of the present invention showing the direction of the wind and places where the superficies are calculated.

[0035] Figures 3a to 3c are a perspective view, a top view and a side view illustrating the parameters of the wind turbine apparatus.

[0036] Figure 4 is a perspective view showing the wind turbine apparatus mounted on support plate and supported by a mast.

[0037] Figure 5 is a perspective view of another embodiment of the wind turbine apparatus.

[0038] Figure 6 is a perspective view of an embodiment of the wind turbine apparatus comprising entry panels and exit panels.

Detailed Description of the Preferred Embodiment

[0039] A novel wind turbine apparatus will be described hereinafter. Although the invention is described in terms of specific illustrative embodiment(s), it is to be understood that the embodiment(s) described herein are by way of example only and that the scope of the invention is not intended to be limited thereby.

[0040] Figure 1 shows the principal sections of the wind turbine apparatus 100 which are the convergent section 102, the wind turbine section 104 and the divergent section 106. As shown in Figure 2, the wind (illustrated by the arrows) enters into the wind turbine apparatus 100 through the convergent section 102 and exits at the end of the divergent section 106. The wind passes through the wind turbine 108.

[0041] Four embodiments of the present invention are described in the non limitative following examples that are simulations executed in a wind tunnel.

File number: 11359-001
Revision: as filed
Date: 05-06-2008

[0042] The examples described here below have been executed in a low velocity refrigerated wind tunnel in a closed loop operating at sea level. The wind tunnel test section in which the simulations are realized is 0.914 meters wide by 0.762 meters high. The temperature during the simulation was set to the ambient temperature, 20°C. The wind velocity for these examples is of 8 m/s (meter/second).

[0043] In each example, the static pressure is measured during a simulation at the entry of the wind turbine section 204 and at the entry of the convergent section 202. A pressure sensor is disposed at each of these places during each simulation. The average wind velocity at the entry of the wind turbine section, 204, is calculated using the static pressures and the Bernoulli equation.

[0044] To determine the effect of the wind turbine apparatus, simulations have been executed with the wind turbine apparatus but without the wind turbine. Thus it is possible to compare the wind velocity with and without the wind turbine. To evaluate the wind augmentation ratio of the wind turbine section, the wind velocity calculated for the wind turbine section (as shown in Figure 2) is compared to the wind velocity in the refrigerated wind tunnel test section.

[0045] The dimensions of the wind turbine section in which the simulations were realized are indicated in the Table 1 below. The wind turbine used for the simulations is a vertical axis turbine (see Table 2). The wind turbine is composed of two aluminium disks of 3,175 mm thick and three wooden blades, extending between the disks, of 9,21 cm length. The blades have a symmetrical airfoil shape, technically known as the NACA 0015 profile where the blade thickness is 15% of the blade chord.

File number: 11359-001
Revision: as filed
Date: 05-06-2008

[0046] TABLE 1 – Characteristics of the wind turbine section

	Units	Wind Turbine Section
Height	cm	10,16
Width	cm	29,85
Length	cm	38,38
Area	cm^2	303,23

[0047] TABLE 2 – Characteristics of an embodiment of the wind turbine

	Units	Turbine
Height	cm	9.84
Diameter	cm	29.21
Type	--	NACA 0015
Chord	cm	5.08
Blade	--	3

[0048] As the person skilled in the art would understand, a plurality of types of wind turbines may be used with the device of the present invention, for example, a horizontal axis wind turbine or a vertical axis wind turbine. 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 turbine section and the wind turbine, etc...

[0049] As the person skilled in the art would understand, the parameters of the convergent section and of the divergent section may differ than the examples shown in this document. Similarly, the wind turbine section may differ depending of the wind turbine used with the wind turbine apparatus.

[0050] The following examples have been executed with two types of convergent sections and two types of divergent sections, their characteristics being detailed in Tables 3 to 6. Figures 3a to 3c illustrate the parameters of the convergent section and of the

File number: 11359-001
Revision: as filed
Date: 05-06-2008

divergent section. The convergent section has a length 160, a width 162 and a height 164. The divergent section has a length 150, a width 152, a height 154, a vertical angle 158 and a horizontal angle 156.

[0051] TABLE 3 – Characteristics of the first embodiment of the convergent section, also referred to as C2

	Units	Convergent section C2	
		Entry	Exit
Height	cm	17.78	10.16
Width	cm	38.38	29.85
Length	cm	30.91	
Area	cm^2	682.39	303.23
Cont. factor of C2	--	2.25	

[0052] TABLE 4 – Characteristics of the second embodiment of the convergent section, also referred to as C3

	Units	Convergent section C3	
		Entry	Exit
Height	cm	22.86	10.16
Width	cm	39.80	29.85
Length	cm	32.79	
Area	cm^2	909.87	303.23
Cont. factor of C3	--	3	

File number: 11359-001
Revision: as filed
Date: 05-06-2008

[0053] TABLE 5 – Characteristics of the first embodiment of the divergent section, also referred to as D2

	Units	Divergent section D2	
		Entry	Exit
Height	cm	10.16	58.75
Width	cm	29.85	60.33
Area	cm^2	303.23	3544.11
Length	cm	93.98	
Vertical Angle	°	14.50	
Horizontal Angle	°	9.20	
Cont. factor of D2	--	11.69	
Cont. factor C2-D2	--	5.19	
Cont. factor C3-D2	--	3.90	

[0054] TABLE 6 – Characteristics of the second embodiment of the divergent section, also referred to as D3

	Units	Divergent section D3	
		Entry	Exit
Height	cm	10.16	65.74
Width	cm	29.85	67.31
Area	cm^2	303.23	4424.64
Length	cm	93.98	
Vertical Angle	°	16.45	
Horizontal Angle	°	11.25	
Cont. factor of D3	--	14.59	
Cont. factor C2-D3	--	6.48	
Cont. factor C3-D3	--	4.86	

File number: 11359-001
Revision: as filed
Date: 05-06-2008

Example 1

[0055] In this first example, a C2 convergent section is used with a D3 divergent section. The first ratio is 2.25, the second ratio is 14.59 and the third ratio is 6.48. The speed velocity between the entry of the convergent section 102 and the wind turbine section 104 has increased by a factor of 2.06 and the rotation of the wind turbine is of 418 rpm (rotation per minute).

Example 2

[0056] In the second example, a C3 convergent section is used with a D3 divergent section. The first ratio is 3, the second ratio is 14.59 and third ratio is 4.86. The speed velocity between the entry of the convergent section 102 and the wind turbine section 104 has increased by a factor of 2.21 and the rotation of the wind turbine is of 431 rpm (rotation per minute).

Example 3

[0057] In this third example, a C2 convergent section is used with a D2 divergent section. The first ratio is 2.25, the second ratio is 11.69 and third ratio is 5.19. The speed velocity between the entry of the convergent section 102 and the wind turbine section 104 has increased by a factor of 1.67 and the rotation of the wind turbine is of 300 rpm (rotation per minute).

Example 4

[0058] In this last example, a C3 convergent section is used with a D2 divergent section. The first ratio 3.00, the second ratio is 11.69 and third ratio is 3.90. The speed velocity between the entry of the convergent section 102 and the wind turbine section 104 has increased by a factor of 1.76 and the rotation of the wind turbine is of 428 rpm (rotation per minute).

[0059] In Figure 4, the wind turbine section 210 of the wind turbine apparatus 200 is disposed on a support 202. The support 202 is mounted on legs 204. A rotating mechanism (not shown) is located between the wind turbine section 210 and the support plate 202, allowing the wind turbine apparatus 200 to rotate. The embodiment shown in the Figure 4 further comprises a mast 206 and cables 208.

[0060] Figure 5 illustrates another embodiment of the convergent section 202. The latter comprises two flats walls 204 and two curved walls 206.

[0061] Now referring to Figure 6, the wind turbine apparatus further comprises entry panels 214 and exit panels 216 connected respectively to the convergent section 210 and to the divergent section 212.

[0062] While illustrative and presently preferred embodiment(s) 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.

File number: 11359-001
Revision: as filed
Date: 05-06-2008

Claims

1) A turbine apparatus for use with at least one wind turbine to increase the wind velocity contacting said wind turbine, said wind turbine apparatus comprising:
   a. a convergent section, said convergent section comprising an entry and an exit, said entry having a area higher than said exit, said convergent section having a first ratio being the entry area over the exit area;
   b. a wind turbine section adjacent to said exit of said convergent section, said wind turbine section comprising said wind turbine or turbines;
   c. a divergent section adjacent to said wind turbine section, said divergent section comprising an entry and an exit, said entry having a area lower than said exit, said divergent section having a second ratio being the exit area over the entry area;

   wherein wind enters through said convergent section and exits through said divergent section and wherein said wind turbine apparatus has a third ratio being said exit area of said divergent section over said entry area of said convergent section.

2) The wind turbine apparatus as claimed in claim 1, wherein said first ratio is higher than 1.5.

3) The wind turbine apparatus as claimed in claim 1, wherein said second ratio is higher than 4.0.

4) The wind turbine apparatus as claimed in claim 1, wherein said third ratio is comprised between 1.5 and 10.

5) The wind turbine apparatus as claimed in claim 1, wherein said convergent section has a length and a width and wherein said wind turbine apparatus has a fourth ratio being said length of said convergent over said width of said convergent, said ratio being comprised between 0.5 and 2.5.

File number: 11359-001
Revision: as filed
Date: 05-06-2008

6) The wind turbine apparatus as claimed in claim 1, wherein said divergent section has a length and a width and wherein said wind turbine apparatus has a fifth ratio being said length of said divergent over said width of said divergent, said ratio being comprised between 1.0 and 4.0.

7) The wind turbine apparatus as claimed in claim 1, wherein said convergent section has a length and said divergent has a length, said divergent length being higher than said convergent length.

8) The wind turbine apparatus as claimed in claim 1, wherein, in use, the wind velocity profile is uniform at said exit of said convergent.

9) The wind turbine apparatus as claimed in claim 1, wherein the angle between the longitudinal axis of the wind turbine apparatus and each of the walls of said divergent is comprised between eight degrees and thirty degrees.

10) The wind turbine apparatus of claim 1, wherein said convergent section comprises two walls that are flat and parallels to each other and two other walls that are curved to form a constriction.

11) The wind turbine apparatus of claim 1, further comprising entry panels that are adjacent and tangential to said convergent section.

12) The wind turbine apparatus of claim 1, further comprising exit panels that are adjacent and tangential to said divergent section.

13) The wind turbine apparatus as claimed in claim 1, wherein said wind turbine apparatus comprises a longitudinal axis and wherein said wind turbine apparatus may be rotated so that said longitudinal axis is parallel to the direction of the wind.

14) The wind turbine apparatus as claimed in claim 13, further comprising a support comprising rotating mechanism on which said wind turbine apparatus is disposed.

15) The wind turbine apparatus as claimed in claim 1, further comprising structural reinforcement.

16) The wind turbine apparatus as claimed in claim 15, wherein said structural reinforcement is a mast and a plurality of cables connecting said mast to said wind turbine apparatus.

* * *

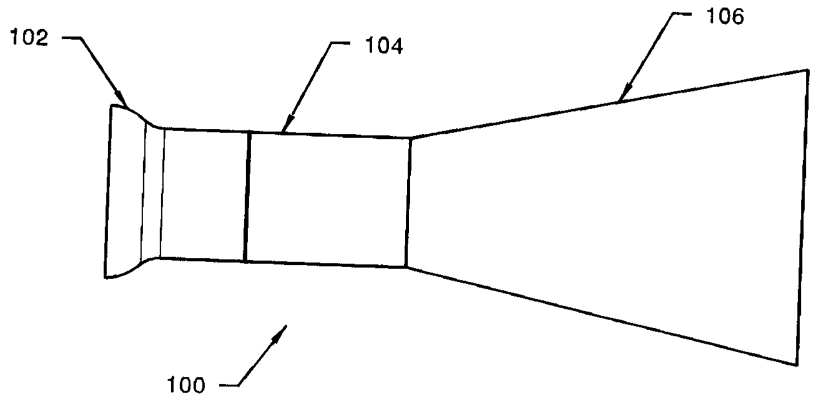


FIGURE 1

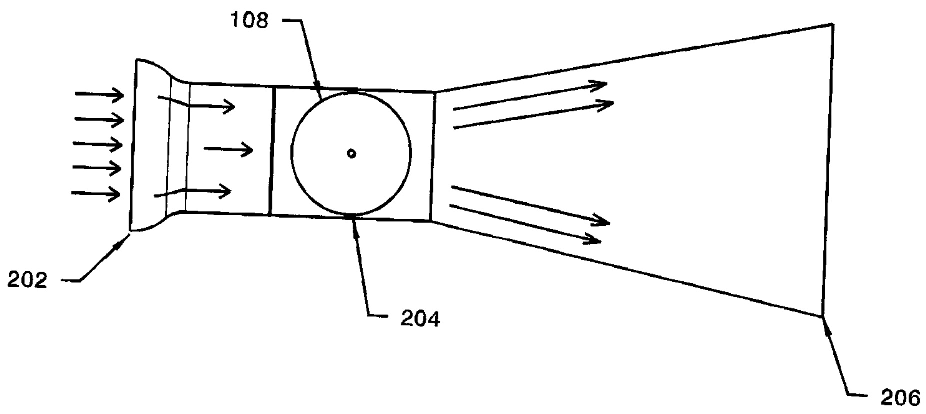


FIGURE 2

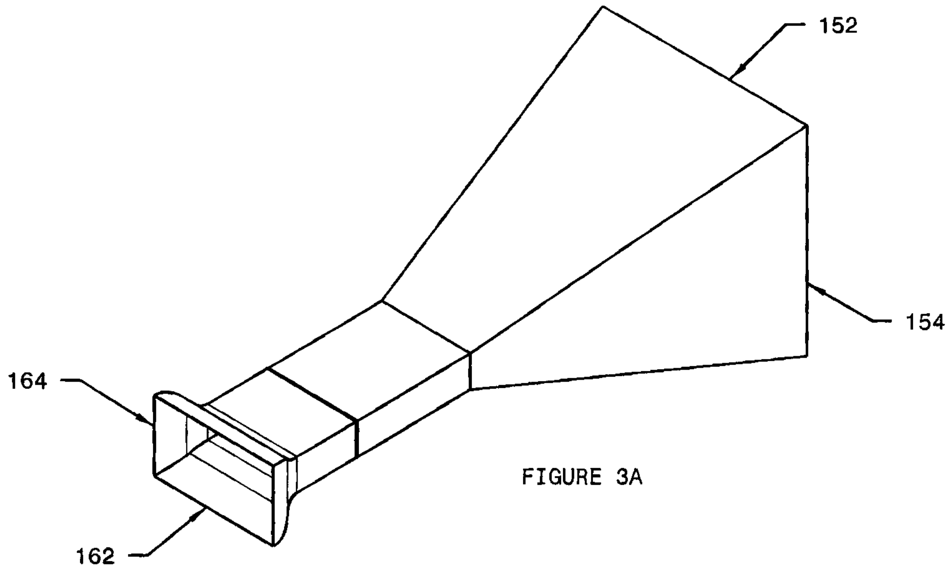


FIGURE 3A

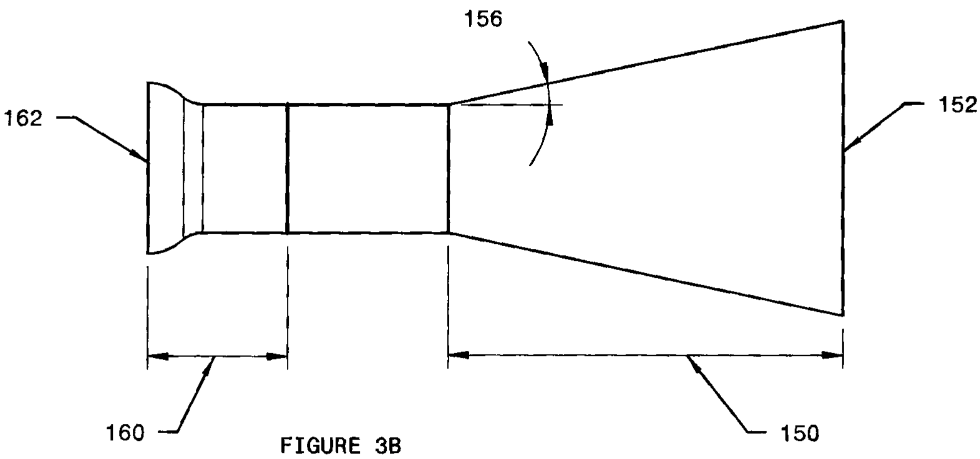


FIGURE 3B

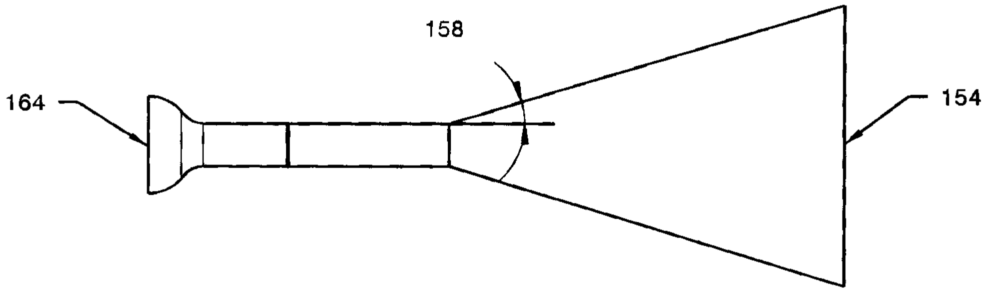


FIGURE 3C

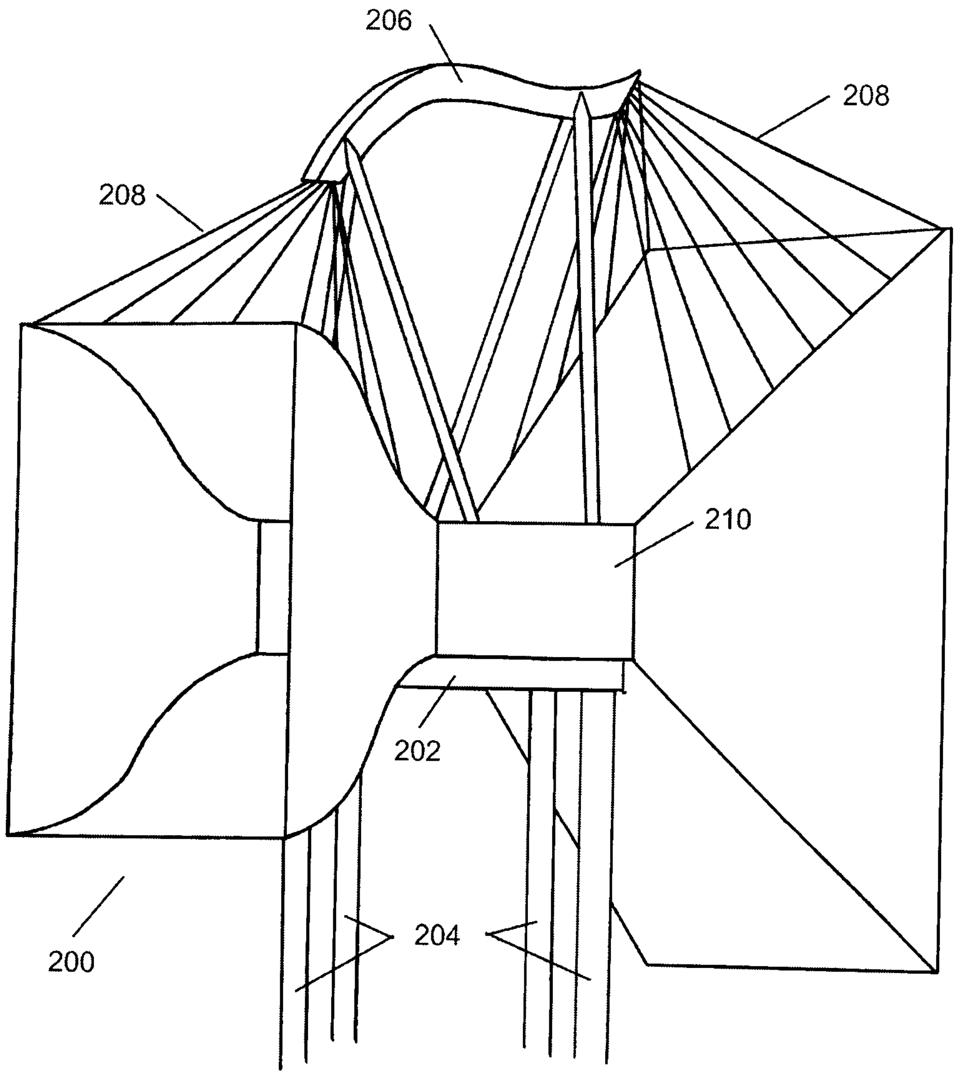


FIGURE 4

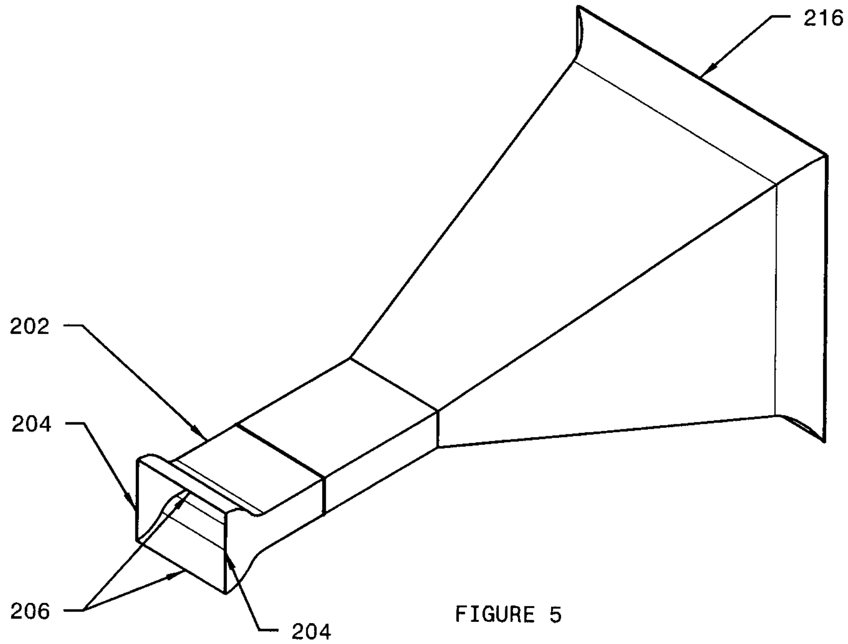


FIGURE 5

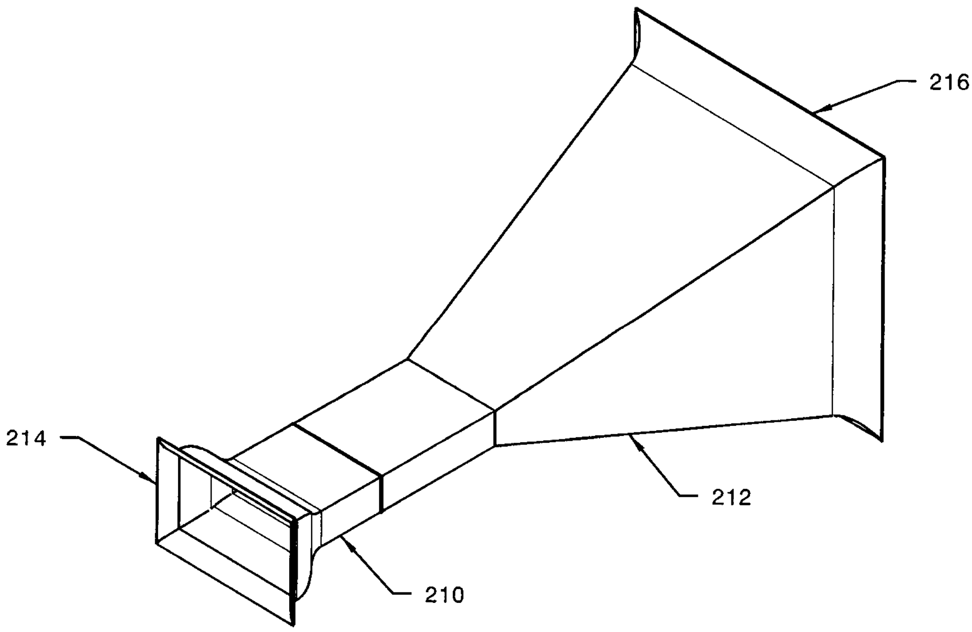
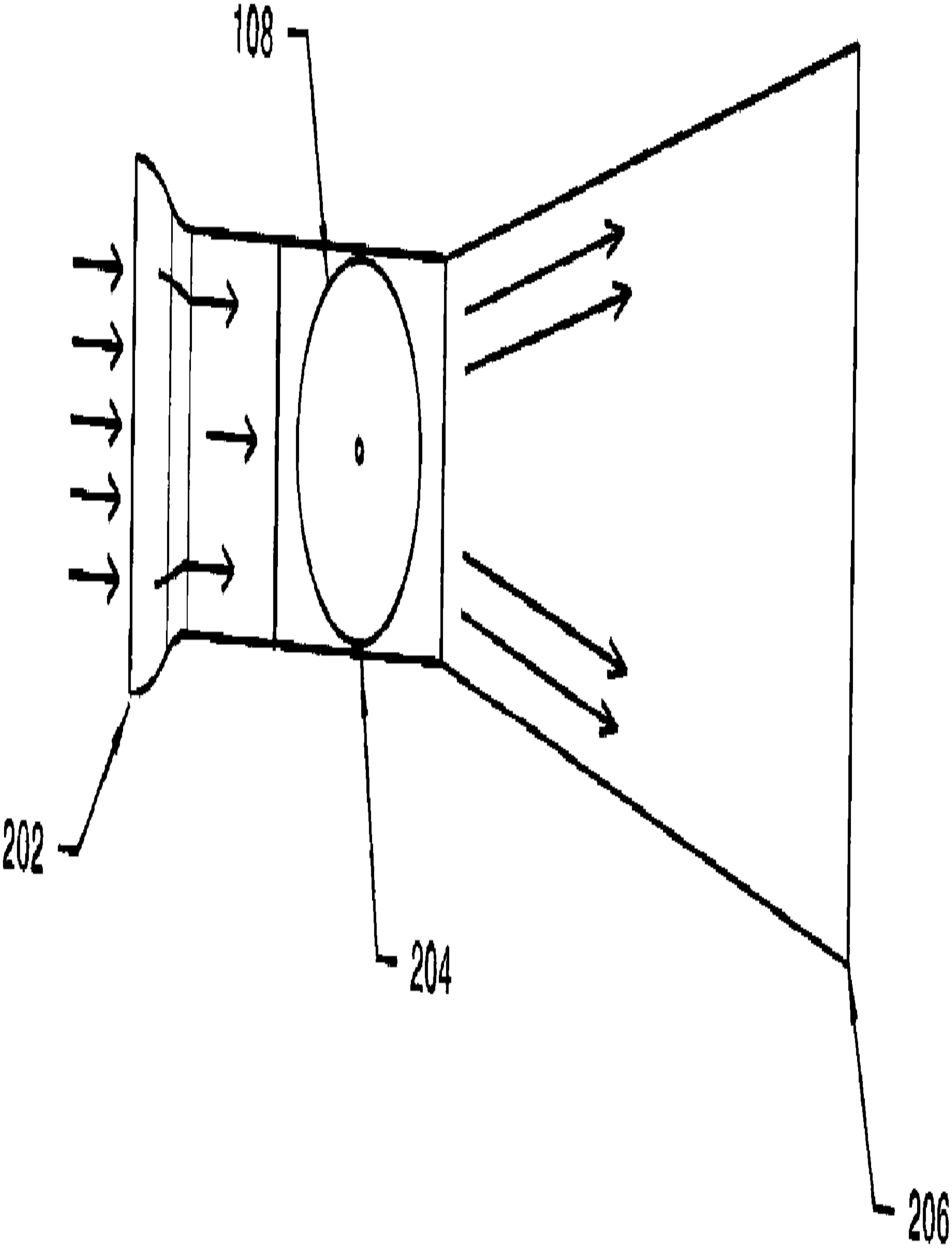


FIGURE 6


108
202
204
206