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(54) THERMAL AIRFOIL TURBINE

(76) Inventor: Luis Indefonso Solórzano, Cutler Bay, FL (US)

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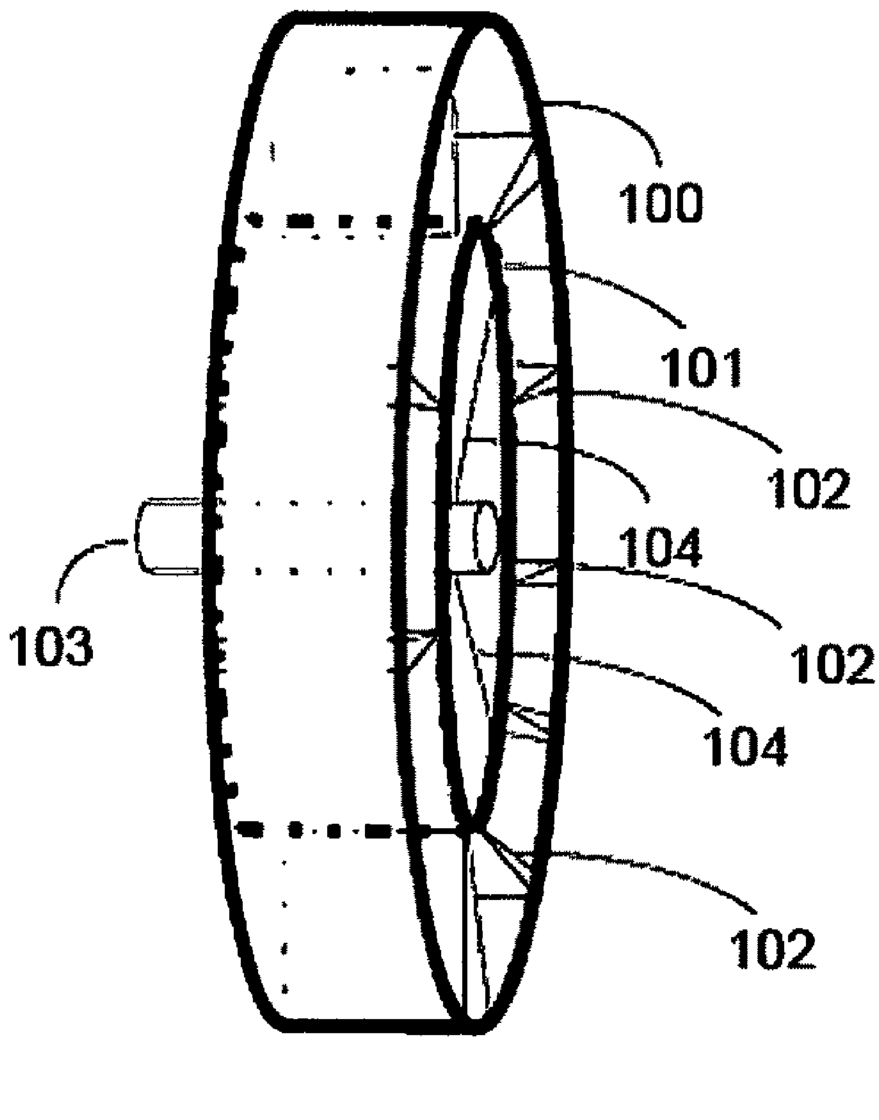
(57) ABSTRACT

The Thermal Airfoil Turbine, as it is conceived, is used to generate mechanical energy, from the thermal energy of an airflow, the energy applied by the airflow to the airfoils in the Thermal Airfoil Turbine, is less by a large factor, usually ten or more than the power generated when the Thermal Airfoil Turbine spins at a certain rotational velocity. This generated power comes from the thermal energy lost, by the airflow passing through the Thermal Airfoil Turbine. It must be emphasized that the difference between this Generator and others that uses airflow, is that the others work with the kinetic energy of the airflow, reducing its velocity so to use it in producing power, on the contrary the Thermal Airfoil Turbine intends not to reduce this velocity at all, producing its power from transforming the thermal energy of the airflow into mechanical energy.



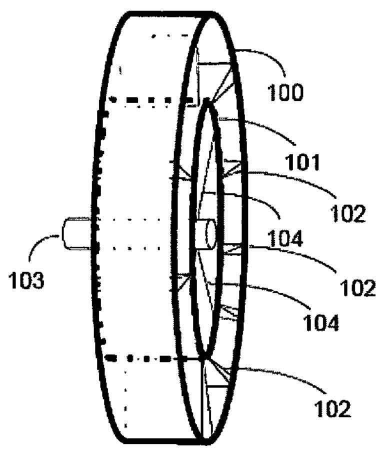


FIGURE 1

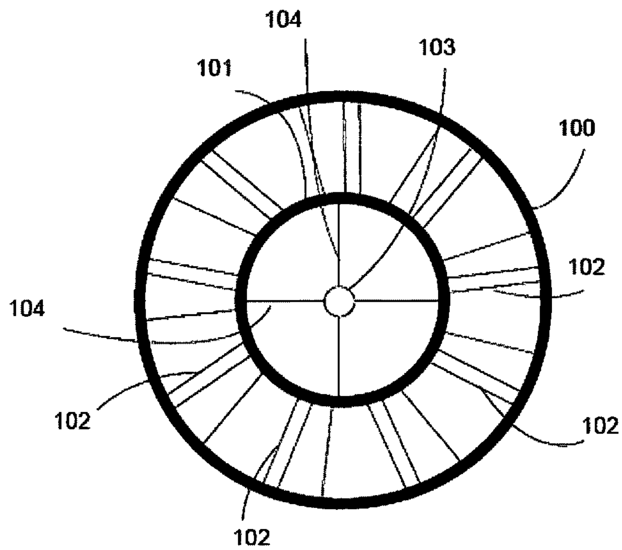


FIGURE 2

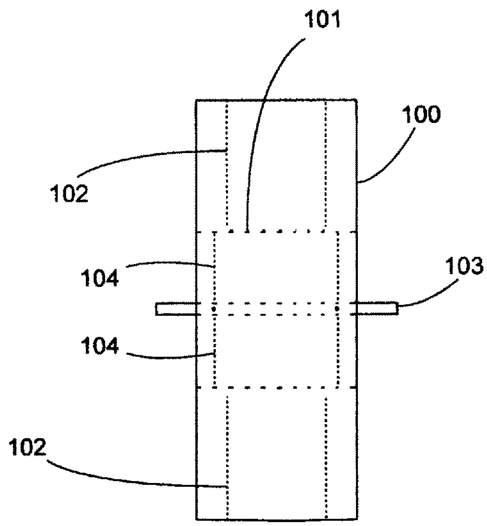


FIGURE 3

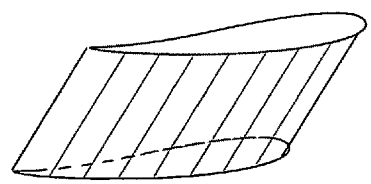


FIGURE 4
(102)

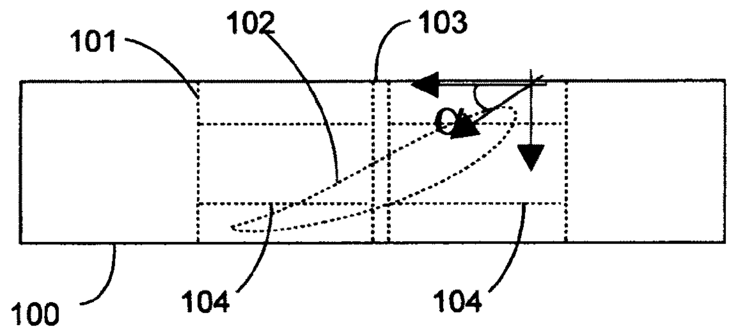


FIGURE 5

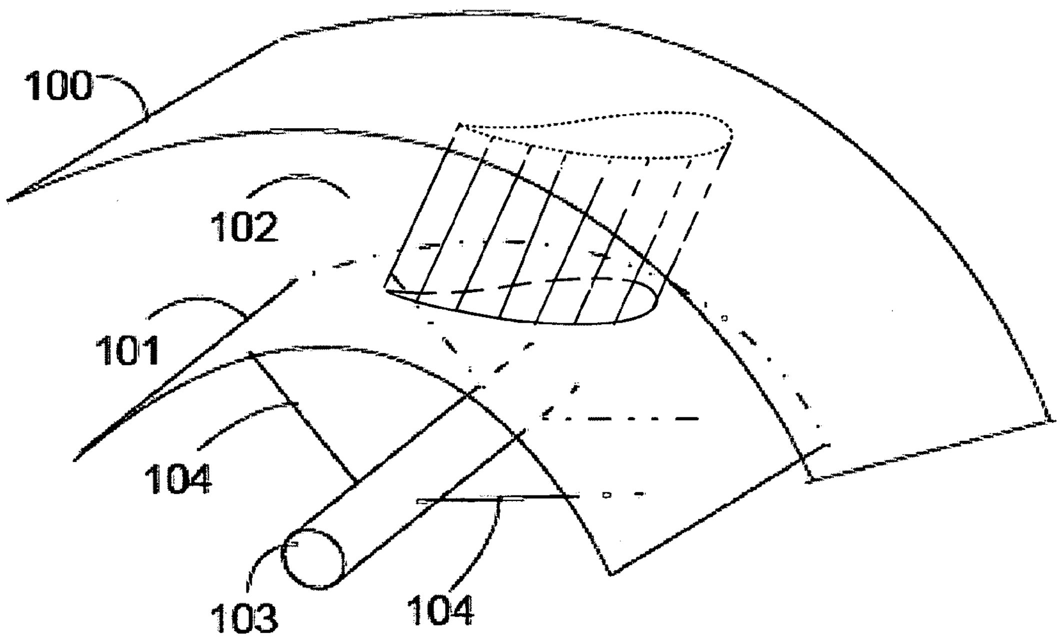


FIGURE 6

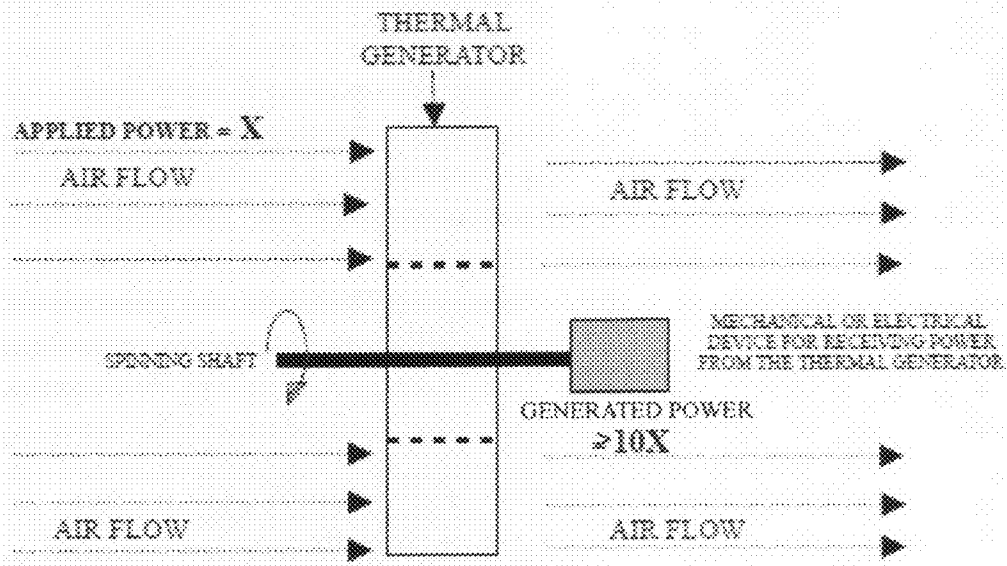


FIGURE 7

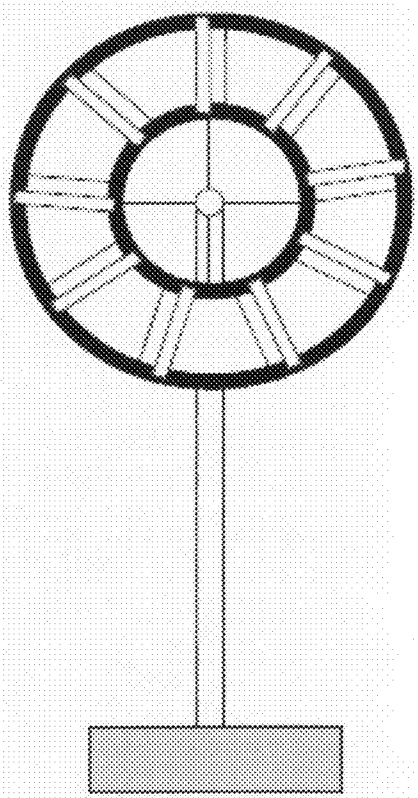


FIGURE 8

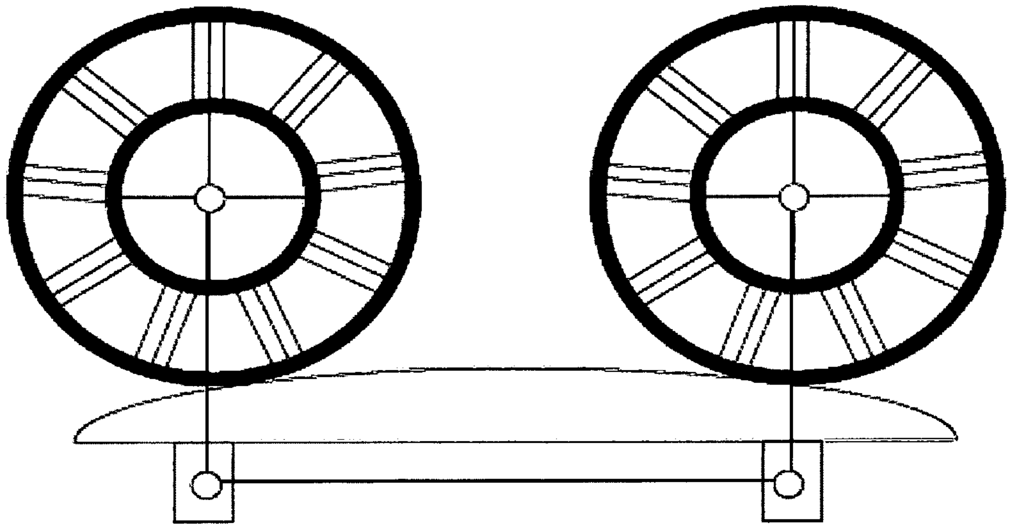


FIGURE 9A

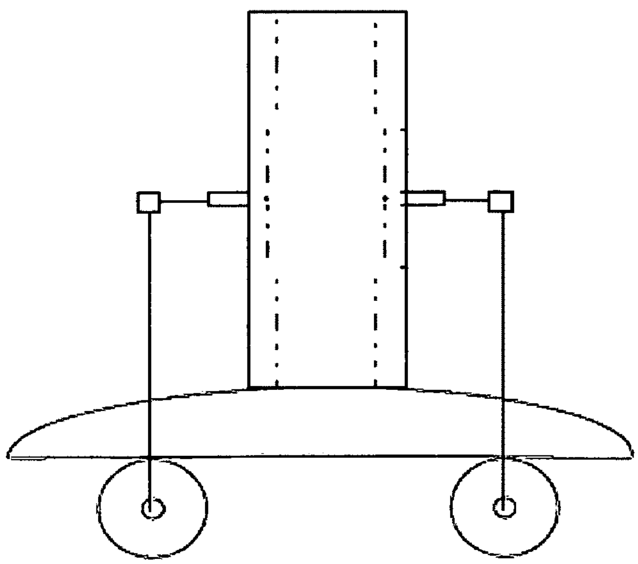


FIGURE 9B

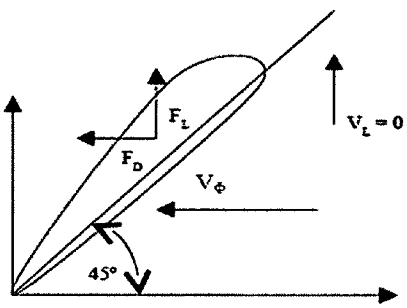


FIGURE 10

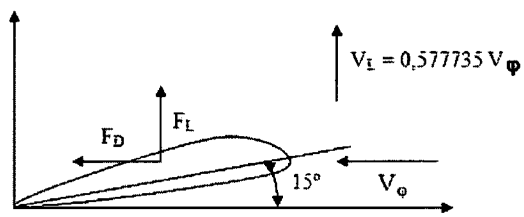


FIGURE 11

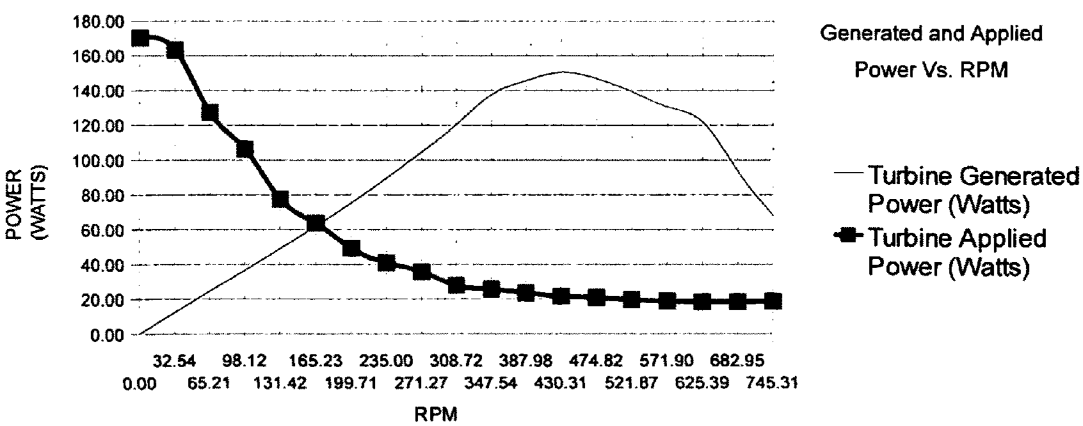


FIGURE 12

THERMAL AIRFOIL TURBINE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not Applicable

REFERENCE TO A SEQUENCE LISTING, A TABLE, OR A COMPUTER PROGRAM, LISTING COMPACT DISC APPENDIX

[0003] Not Applicable

BACKGROUND OF THE INVENTION

[0004] The invention refers to a rotating device which is able to transform the thermal power received from an incoming airflow, into mechanical power when the airflow passes through and impinges upon the airfoils of the Thermal Airfoil Turbine. This power can be recovered on the shaft of the device and with suitable gears, used either to propel a vehicle or to drive an electrical generator so as to produce electricity as well. The power generated by this Thermal Airfoil Turbine can be greater than 1, and is usually greater than 10, than that applied by the incoming airflow to the airfoils.

[0005] Everyday, climate change and global warming problems aggravate, and finding a practical and economic solution to them is certainly not an easy task. So far, there has not been presented a real solution to the serious challenges of energy shortages, pollution and global warming. As society's energy consumption is increasing day by day; there is a high demand for energy as a result. Since the earth's natural energy reserves are becoming depleted and prices of oil and natural gas are relatively high, new sources of clean, abundant and inexpensive energy are urgently required.

[0006] It turns out that by using this Thermal Airfoil Turbine as the fundamental component of an energy-conversion machine, it becomes very easy to develop new technologies for moving all sort of vehicles, and improving considerably the efficiency of aeolian devices, and that of many electrical power generators as well. And this huge increase in the energy transformation efficiency can be achieved at a very low cost and no environment pollution at all.

BRIEF SUMMARY OF THE INVENTION

[0007] The Thermal Airfoil Turbine is a particular kind of turbine made of two concentric cylinders and a certain number of airfoils, which are suitably placed on and fixed between these two cylinders, occupying part of the space separating both cylinders. The airfoils are placed forming a specific attack angle with the airflow direction. These cylinders spin around a central shaft; when these do at a certain rotational velocity, the transformation of the thermal energy of the incident airflow into mechanical energy takes place. This energy can be used to drive either a mechanical system or an electrical one if they are attached onto the generator shaft. The power that the incident airflow at a certain velocity has to apply to the airfoils spinning at a certain rotational velocity, is much less than the mechanical power generated by the rotating airfoils, and extracted from the thermal energy of the passing airflow, the relation between the generated power and the applied power usually is about ten or more.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0008] These drawings have not any specific scale.

[0009] FIG. **1**: Shows an oblique view of the Thermal Airfoil Turbine

[0010] FIG. **2**: Shows a front view of the Thermal Airfoil Turbine, with these as normally placed

[0011] FIG. **3**: Shows a lateral view of the Thermal Airfoil Turbine

[0012] FIG. **4**: Shows an oblique view of an airfoil, as used in the Thermal Airfoil Turbine

[0013] FIG. **5**: Shows a view from above of the Thermal Airfoil Turbine at the upper side, showing only the airfoil on top of the inner cylinder of the Thermal Airfoil Turbine, so as to highlight the angled position of the airfoils.

[0014] FIG. **6**: Shows an oblique view of a section of the Thermal Airfoil Turbine, so as to highlight the angled position of the airfoils

[0015] FIG. **7**: Shows a working diagram of the Thermal Airfoil Turbine, so as to highlight the mechanical operation of this device

[0016] FIG. **8**: Shows a possible application of the Thermal Airfoil Turbine, used as the main or fundamental component of an Aeolian Generator

[0017] FIG. **9**A: Shows the front view of a possible application of the Thermal Airfoil Turbine used as a fundamental component of a moving Vehicle

[0018] FIG. **9**B: Shows a lateral view of a possible application of the Thermal Airfoil Turbine used as a fundamental component of a moving Vehicle.

[0019] FIG. **10**: Shows an airfoil statical placed with an exaggerated attack angle of 45°, within an airflow of horizontal velocity $V\phi$.

[0020] FIG. **11**: Shows how the airflow of horizontal velocity $V\phi$ "sees" the former airfoil when it moves at a vertical velocity V_L=0.577735 $V\phi$.

[0021] FIG. **12**: Shows the power generated and power applied of a turbine, with certain specific sizes and configuration (quantities showed in [0043]).

DETAILED DESCRIPTION OF THE INVENTION

[0022] The Thermal Airfoil Turbine is a particular type of air turbine, that transform the thermal energy from a passing airflow into mechanical energy, when the turbine rotates at a specific velocity, the power generated and received in the shaft of this turbine can be greater than (and is usually ten or more) the power received for the airfoils from an entering airflow, when spinning at a specific range of rotational velocities. This magnified output power can be delivered to either a mechanical or an electrical element, attached to a rotational shaft, as shown in FIG. **7**.

[0023] This air turbine is made with two concentric cylinders (**100** and **101**), with a certain number of aerodynamic airfoils (**102**), suitably placed and occupying partially the space between these two cylinders. The airfoils must be very well fitted between these two cylinders, without gaps between the airfoils and the cylinders. However it is possible to make this turbine, following another construction pattern, for instance with the outside cylinder static and the one inside rotating, or any other construction pattern that works well equally.

[0024] The airfoils must be placed between these two cylinders, forming a certain angle with the airflow direction. This angle is normally known as the attack angle. Its value can be greater than zero, equal to zero or less than zero, but for a better efficiency of the Thermal Airfoil Turbine, it is convenient to use an exaggerated value of the attack angle, as great as 45° for instance, because at such large attack angles, the Thermal Airfoil Turbine produces much more relative power gain, as shown mathematically further down [0033] to [0039]. By relative power gain it is meant the relationship: generated power/applied power. It should be pointed out that for aeronautical uses, the attack angle is usually about 10°.

[0025] In order to make sure that the turbine spins as smoothly as possible, the airfoils between the two cylinders should be placed symmetrically, however it is possible to place the airfoils in another disposition, and the turbine can work equally well.

[0026] The number of airfoils placed between the two cylinders of the turbine, must be as large as possible, in order to obtain a maximum of generated power. However the airfoils must be separated one to each other, a medium distance at least the width of the airfoils. The separation distance between the airfoils is to avoid aerodynamic interference between them.

[0027] In theory, the size of the two cylinders of the Thermal Airfoil Turbine has no restrictions, that is to say, it can be as large or as small as necessary. In practice, however there could be restrictions in manufacturing too small or too large elements.

[0028] Similarly, there are no theoretically restrictions as to the materials that can be employed to fabricate the airfoils and the cylinders. In practice, however, in order to achieve a light structure for the turbine and its easy handling, it is recommended to use plastic materials, resin, acrylic, among other materials for manufacturing the airfoils. For manufacturing the cylinders, a light alloy or light metal such as aluminum, or a light hard plastic can be used.

[0029] In order to support the weight of the whole turbine, its rotational shaft (**103**) must be strong enough, so it can be made of a good steel rod or similar material.

[0030] The rotational shaft must be placed in the center of the turbine, and fixed to the inner cylinder (**101**) with light and strong rods (**104**) of equal length, normally it is enough **8** of these rods for this use. Alternatively another type of fixation system can be used to attach the center rotational shaft to the inner cylinder.

[0031] The airfoils between the two cylinders, must be fixed to these ones, with screws and nuts, or can be fixed with a strong glue or any other suitable method as well.

[0032] It is recommended that all the inner and outer surfaces of the cylinders, equally the surfaces of the airfoils, have to be as smooth as possible, so as to reduce to a minimum the drag force, exerted by the airflow against all the surfaces, in order to keep to a minimum the power losses due to the drag force.

[0033] It must be understood, that the airfoils referred to in this abstract, can have any geometrical shape that works in the sense explained, i.e. it causes the effect of transforming the thermal energy of the passing airflow, into mechanical power in the shaft, in a factor 1 or greater than 1 the input power received for the airfoils from the airflow entering the turbine. Usually, however, the best airfoils are those aeronautical ones, which have been widely studied in Aeronautics and have a large and well known bibliography.

[0034] When the turbine rotates, the airfoils' relative attack angle α_A that the airflow "sees", is different from the airfoils' real attack angle α_R, depending on the rotational velocity. For instance, let's suppose that the airfoils' real attack angle α_R is 45°. In this condition when the angular velocity (RPM) of the turbine is zero, the airflow (with a horizontal linear velocity $V\phi$), "sees" the airfoils with a relative attack angle α_A, which is equal to the real attack angle α_R (that is to say, 45°). However, when the turbine reaches an RPM such that it makes the mean peripheral velocity equal to $V\phi$ (RPMh), the airflow will "see" an airfoils' relative attack angle α_A equal to zero. For another rotational velocity varying between zero and RPM h, the airfoils' relative attack angle α_A will vary between 45° and zero. All this is explained below in paragraphs [0033] to [0039].

[0035] When the airflow passes through the turbine's airfoils, the airflow above the airfoils will get a greater velocity than that passing under the airfoils. So that the above pressure is less than the down pressure in the airfoils (Bernoulli equation), as a consequence the temperature above the airfoils get lower than the temperature below these. That is to say, the airflow looses thermal energy when passing through the turbine's airfoils. Part of this thermal energy lost is transmitted directly to the airfoils, and transformed into kinetic energy when the turbine rotates. Finally this energy is transmitted to the shaft of the turbine. Another part of the thermal energy lost in the upper side of the airfoils, is returned to the environment, when the airflow coming from the upper side of the airfoils, joins and hits the airflow passing downward the airfoils. With these mechanism the energetic equilibrium in the system is restored.

[0036] The particular RPM at which the turbine generates a maximum relative power gain (generated power/applied power) is a value lying somewhere between zero and RPM h. In this situation, supposing that the real attack angle α_R is 45°, the airflow will "see" an apparent attack angle α_A which is very little, of the order of 15° (this happens only for the RPM that generates maximum relative power gain). In this situation the drag force, and so the airflow's drag power applied to the airfoils will be very little. However, since the lift force of the airfoils in this situation, is far greater than the drag force, then the generated power will be far greater than the drag power, that is to say that there takes place a transformation of power due to the interaction between the Thermal Airfoil Turbine airfoils and the incoming airflow. This power transformation causes a relative power gain very large (usually greater than 10).

[0037] The power generated by the turbine versus its rotational velocity RPM follows a curve that begins with zero RPM and zero generated power. Then, it goes to a maximum value of generated power at an intermediate value of RPM, and finally, it ends with zero generated power at a maximum value of RPM. (Graph **1**)

[0038] The curve of the applied power begins with a maximum value at RPM equal to zero, and then the applied power diminishes as RPM increases. Finally this curve ends up with a minimum value of the applied power which is greater than zero. (Graph **1**)

[0039] A brief and approximate calculation and only for explaining the working basis of my Thermal Airfoil Turbine, is given below. Let us suppose that a static airfoil is placed initially within an exaggerated attack angle of 45°, in an airflow of velocity V_ϕ, as shown in FIG. **10**.

[0040] In this situation the Drag Force F_D is very large. Then we have,

Applied power=F_D*V_ϕ;Generated power=$F_L*V_L=F_L*0=0$

[0041] Now consider that we let the airfoil move vertically with a velocity V_L=0.577735 V_ϕ. That is to say,

$$\frac{V_L}{V_\varphi} = 0.577735 = Tg30^\circ.$$

In this condition the flow with velocity V_ϕ"sees" the airfoil with an attack angle=45°−30°=15° and the new condition that the airflow will "see" is shown in FIG. **11**.

[0042] So in this new condition:

Power applied by the airflow to the airfoil=$F_D*V_\phi=P_A$

Power generated by the airfoil=$P_G=V_L*F_L=0.577735V_\phi*F_L$

[0043] So that

$$\text{Power Gain} = \frac{0.577735V_\varphi \times F_L}{F_D \times V_\varphi} = \frac{0.577735F_L}{F_D}$$

[0044] It is a well known fact in the Aeronautics science that many airfoils in this condition (attack angle of 15°) have a force relation

$$\frac{F_L}{F_D}$$

which is 30, 50 or even much more, so that if we use for example

$$\frac{F_L}{F_D} = 50,$$

then Power Gain=0.577735*50=28.88. And this is just a huge power gain!

[0045] I must emphasize that there is an exact geometrical calculation for the former analysis (see appendix **1**), but the numerical differences compared to the approximate calculation I have given above are not so large.

[0046] With these calculation bases and correcting for a circular movement, and applying geometrical formulas out of the scope of this abstract (see Appendix **1**), it is possible to obtain numerical values and curves. For instance for Turbine #**1**, with the following measures:

[0047] Diameter of outer cylinder: 0.5 m

[0048] Diameter of inner cylinder: 0.32 m

[0049] Length of cylinders: 16 cm

[0050] Number of airfoils: 9

[0051] Static angle of airfoils: 45°

[0052] Airfoils Dimensions Large: 8.9 cm×Width: 14 cm×Thick: 1.5 cm

[0053] Airflow velocity: 16 m/s

[0054] And with the following experimental measurements for the airfoils used in Turbine #**1**:

TABLE 1

MEASURED AND EXTRAPOLATED VALUES OF AN AIRFOIL

ATTACK ANGLE	F_L (Gr)	F_D (Gr)	EFFICIENCY = FL/FD	
0	38.73	4.65	8.33	MEASURED VALUES
2.5	58.09	5.19	11.19	
5	83.66	5.81	14.4	
7.5	100.71	6.61	15.24	
10	120.84	7.59	15.92	
12.5	143.3	8.83	16.23	
15	165.78	9.91	16.72	
17.5	182.03	11.62	15.67	
20	195.98	13.48	14.54	
22.5	197.17	15.52	12.7	EXTRAPOLATED VALUES
25	199.26	20.98	9.5	
27.5	200.31	25.17	7.96	
30	201.36	31.46	6.4	
32.5	202.41	41.95	4.83	
35	203.46	52.44	3.88	
37.5	204.51	73.41	2.79	
40	205.56	89.14	2.31	
42.5	205.56	115.36	1.78	
45	206.6	120.61	1.71	

[0055] With all of the previous quantities, and applying corrections for the circular movement, and geometrical formulas outside of the scope of this abstract (see Appendix **1**), the following table and FIG. **12** result were obtained for Turbine #**1**:

TABLE 2

Calculated power for Turbine 1

RPM	Turbine Generated Power (Watts)	Turbine Applied Power (Watts)	Turbine Relative Gain Power
745.31	68.03	18.55	3.67
682.95	93.55	18.27	5.12
625.39	121.79	18.24	6.68
571.90	130.53	18.68	6.99
521.87	139.35	19.49	7.15
474.82	146.76	20.77	7.06
430.31	150.58	21.54	6.99
387.98	145.75	23.49	6.20
347.54	137.74	25.55	5.39
308.72	120.68	27.78	4.34
271.27	104.74	35.67	2.94
235.00	89.75	40.95	2.19
199.71	75.53	49.27	1.53
165.23	61.88	63.62	0.97
131.42	49.07	77.48	0.63
98.12	36.51	106.30	0.34
65.21	24.51	127.25	0.19
32.54	12.37	163.27	0.08
0.00	0.00	170.20	0.00

[0056] The Turbine #**1** was made and measured with the previous mentioned parameters and with a real attack angle of 42.5°, and a maximum relative power gain (generated power/applied power) of 10 was obtained. It is worthwhile to notice, that in all the previous calculation, the efficiency of the airfoils (F_L/F_D) was very low, reaching a maximum value of 16.72. In aeronautical terms this is a very low value for an airfoil efficiency.

With the previous mentioned bases, I claim the following items:

1. The Thermal Airfoil Turbine, that is to say, a turbine like device that uses airfoils as power active elements, to be used as a power producing device, with a relation between the generated power and the applied power greater than 1 (usually 10 or more) as described in the detailed description of the invention, or other device with any change, that can be used equal, as an airfoil power producing device, with a relation between the generated power and the applied power greater than 1.

2. Any kind of Moving Vehicle, that uses the Thermal Airfoil Turbine as claimed in claim **1**, as a total or partial powering aid for the propulsion of the Vehicle, such as represented in FIGS. **9**A and **9**B.

3. Any power generating machine, that uses the Thermal Airfoil Turbine as claimed in claim **1**, as the basis for generating power, such as an Aeolian Generator, FIG. **8** (which uses a Thermal Airfoil Turbine, as claimed in claim **1**) or any other power generating machine, which uses the Thermal Airfoil Turbine as claimed in claim **1**, for the same purpose.

4. Any apparatus or machine that uses the Thermal Airfoil Turbine as claimed in claim **1** as the basis for air conditioning or cooling systems.

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