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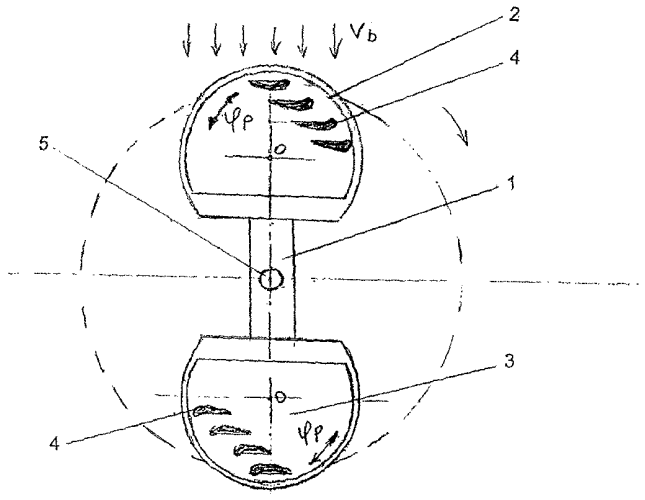
For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) **Title:** VERTICAL AXIS WIND TURBINE



(57) **Abstract:** This invention relates to wind power engineering, namely to rotary wind motors which may be used in wind electrical generators or equipments for conversion of wind energy into electrical energy. An object of the present invention is to increase efficiency, power of wind motor and to improve starting acceleration of the rotor. Wind motor comprises rotor (1) with power elements which are realized in the form of two symmetrically arranged blocks (2) and (3) of aerodynamic cascades whereinto each block advantageously consists of four blades 4 realized in the form of a turbine-type configuration of blades. Blocks (2) and (3) of aerodynamic cascade are mounted on central vertical shaft (5). Cascaded blade profiles (4) are in the form of subsonic aerodynamic profiles Moreover parameters of cascaded blade profiles in turbine-type configuration have the following values: lead of blade - 0.5 b; mounting angle of cascaded block - 0°; cascaded blade deflection - 0.5 b; value of the shading factor - ≤ 0.5; in which: b - value of the chord of blade profile.

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VERTICAL AXIS WIND TURBINE

This invention relates to wind power engineering, namely to rotary wind motors which may be used in wind electrical generators or equipments for conversion of wind energy into electrical energy.

Rotor of prior art for wind motor is known from Russian Federation patent application No. 2135824, IPC[6] F03D7/06, filing date 09.10.1996, publication date 27.08.1999. Known rotor of wind motor comprises two S-shaped blades mounted on vertical shaft. S-shaped blades are fastened on rotatable paralel cross-arms which are rigidly connected with vertical shaft. Moreover the fastening points of blades are aligned with the axis of symmetry of the blade behind of its centre of gravity in direction away from the vertex of the S-shaped blade.

A disadvantage of the above described known rotary wind motor resides in the complexity of rotary design, low power range and relatively low efficiency.

Another rotary wind motor with vertically positioned shaft is known, e.g., from Russian Federation patent application No. 2096259, IPC[6] B63H13/00, filing date 15.11.1993, publication date 20.11.1997 (prototype), which is provided with lower and upper disc type washers and mechanism for rotating of blades. Axis of washers is aligned with vertical axis of rotation. On lower end faces of blades there are fastened position locators with possibility to engage them with holes made in said washers. The said mechanism for rotating of blades comprises an element, which is fixed to the rotor shaft, situated on lower washer.

A disadvantage of the said known rotary wind motor resides in insufficient reliability, insuficient power range and insufficiently high efficiency.

An object of the present invention is to increase efficiency and power owing to provision of high rotation speed of rotor and to improve starting acceleration of the rotor.

According to the present invention there is provided a rotary wind motor which

comprises rotor with power elements, e. g., in the form of blades fixed to the vertical shaft, characterized by that the power element is realized in the form of aerodynamic cascade block arranged in turbine type configuration of blades in cascade, mainly in the form of two symmetrically positioned blocks of aerodynamic blades containing four blades in each row.

It is advisable to realize cascaded blades in the form of subsonic aerodynamic blades. Moreover, it is advisable to have the values of parameters of blades in turbine-type configuration in the following range:

- lead of blade - $0.4 \div 0.6\ b$;
- mounting angle of cascaded block - $0 \div 5^{\circ}$;
- cascaded blade deflection – $0.4 \div 0.6\ b$;
- value of the shading factor - $0.3 \div 0.5$;

in which:

b – value of the chord of blade profile.

The invention may be better understood from the following detailed description of an embodiment thereof due reference being made to the accompanying drawings, in which:

Figure 1 shows schematic view cascaded configuration of blades;

Figure 2 is a top view of wind motor rotor; and

Figure 3 is a blade profile.

Wind motor comprises rotor 1 with power elements which are realized in the form of two symmetrically arranged blocks 2 and 3 of aerodynamic cascades whereinto each block advantageously consists of four blades 4 realized in the form of a turbine-type configuration of blades. Blocks 2 and 3 of aerodynamic cascade are mounted on central vertical shaft 5. Blade profiles are in the form of subsonic aerodynamic profiles (Figure 3). Efficiency of the suggested design of rotary cascaded wind motor is determined by selection of the lead (γ) of blade, mounting angle (φ_p) of cascaded block, cascaded blade deflection (χ), value of the shading factor ($K_з$) and value of the chord of blade profile (b). It is established that values of the said parameters may be in the

range of:

- lead (γ) of blade - $0.4 \div 0.6\ b$;
- mounting angle (φ_p) of cascaded block - $0 \div 5^o$;
- cascaded blade deflection (χ) $- 0.4 \div 0.6\ b$;
- value of the shading factor ($K_з$) - $0.3 \div 0.5$;

in which:

b – value of the chord of blade profile.

However it is established in the process of testing of models equipped with subsonic aerodynamic blade profiles that the optimum values of the said parameters are as follow:

- $\gamma = 0.5\ b$;
- $\varphi_p = 0^o$;
- $\chi = 0.5\ b$;
- $K_з \leq 0.5$;

Value of the chord (b) of blade profile is determined in dependance of number (Z) of blade profiles, selected values of shading factor ($K_з$) and diameter (D) of the rotor of wind motor. It is established that that the optimum numer of cascaded blocks equals to two, but optimum range of number (Z) of blade profiles in each block does not exceed four. However the number of cascaded aerodynamic blocks of wind motor may be determined on conditions that the value of the shading factor $K_з \leq 0.5$. According to the requirements of strength and power efficiency the most expedient number of blocks equals to two or three.

Rotary cascaded wind motor may be used in the most efficient way as a large power windmill having dimensions: diameter $D \geq (6 \div 10)$ m; height $H = (1.0 \div 1.5)\ D$.

Single-unit power ($\tilde{N}$) of one row of aerodynamic blade profiles at optimum mode of operation may be determined by experimental dependence:

$$\tilde{N} = N/S = a \times \rho \times U_п^3/10^3\ (kw/m^2),$$

in which:

N - total power of one row of two blocks,

S - total area of blades arranged in one row of two blocks;

$U_л$ - peripheral velocity of blades arranged in one row of two blocks (m/sec);

ρ - air density (kg/m^3);

a - efficiency factor of aerodynamic characteristics of cascaded blade profiles; this factor is determined during testing of full-scale wind motors being equipped with specific blade profiles.

Rotor of wind motor is rotating under action of wind actuating electrical generator or other equipment (not shown), ensuring conversion of wind energy into electrical or mechanical energy.

The wind motor equipped with cascaded block in turbine-type configuration of aerodynamic blade profiles according to the results of testing of models allows:

- significantly to increase efficiency of wind motor due to more effective making use of aerodynamic characteristics of blade profiles in turbine-type configuration; practically the efficiency is more than 0.8 ($\xi_{max} \geq 0.8$);
- to increase power of wind motor due to keeping up specific speed of rotor because of widening of the variable range of value of the shading factor ($K_з$) up to $K_з \leq 0.5$ instead of $K_з \leq 0.3$ since it was in connection with rotary wind motors of prior art;
- to improve starting acceleration of the wind motor due to making use of turbine-type configuration of cascades.

Further improvement of power parameters of wind motor may be achieved by improving aerodynamic properties of subsonic blade profiles used in turbine–type cascades of wind motors by means of using of mechanization devices for blades, e.g., by means of using of leading-edge flap, trailing-edge flap, discharging facilities of boundary layer etc.

The rotary wind motor in accordance with the present invention is industrially applicable due to the fact that the said wind motor may be manufactured and widely used in production of windmills for converting wind energy into electrical or mechanical energy.

CLAIMS

1. A rotary wind motor which comprises rotor with power elements in the form of blades fixed to the vertical shaft, characterized in that the power element is realized in the form of aerodynamic cascade block arranged in turbine type configuration of blades in cascade.

2. Rotary wind motor according to Claim 1 characterized in that the rotor of the motor comprises two symmetrically positioned blocks of aerodynamic blades containing four blades in each row.

3. Rotary wind motor according to Claim 1or 2 characterized in that the cascaded blade profiles are realized in the form of subsonic aerodynamic blades, but the values of parameters of blades in turbine-type configuration are in the following range:

- lead of blade - $0.4 \div 0.6\ b$;
- mounting angle of cascaded block - $0 \div 5^{\circ}$;
- cascaded blade deflection – $0.4 \div 0.6\ b$;
- value of the shading factor - $0.3 \div 0.5$;

in which: b – value of the chord of blade profile.

4. Rotary wind motor according to any of preceding Claims characterized in that the optimum values of parameters of cascaded blades in turbine-type configuration have the following values:

- lead of blade - $0.5\ b$;
- mounting angle of cascaded block - 0°;
- cascaded blade deflection – $0.5\ b$;
- value of the shading factor - ≤ 0.5;

in which: b – value of the chord of blade profile.

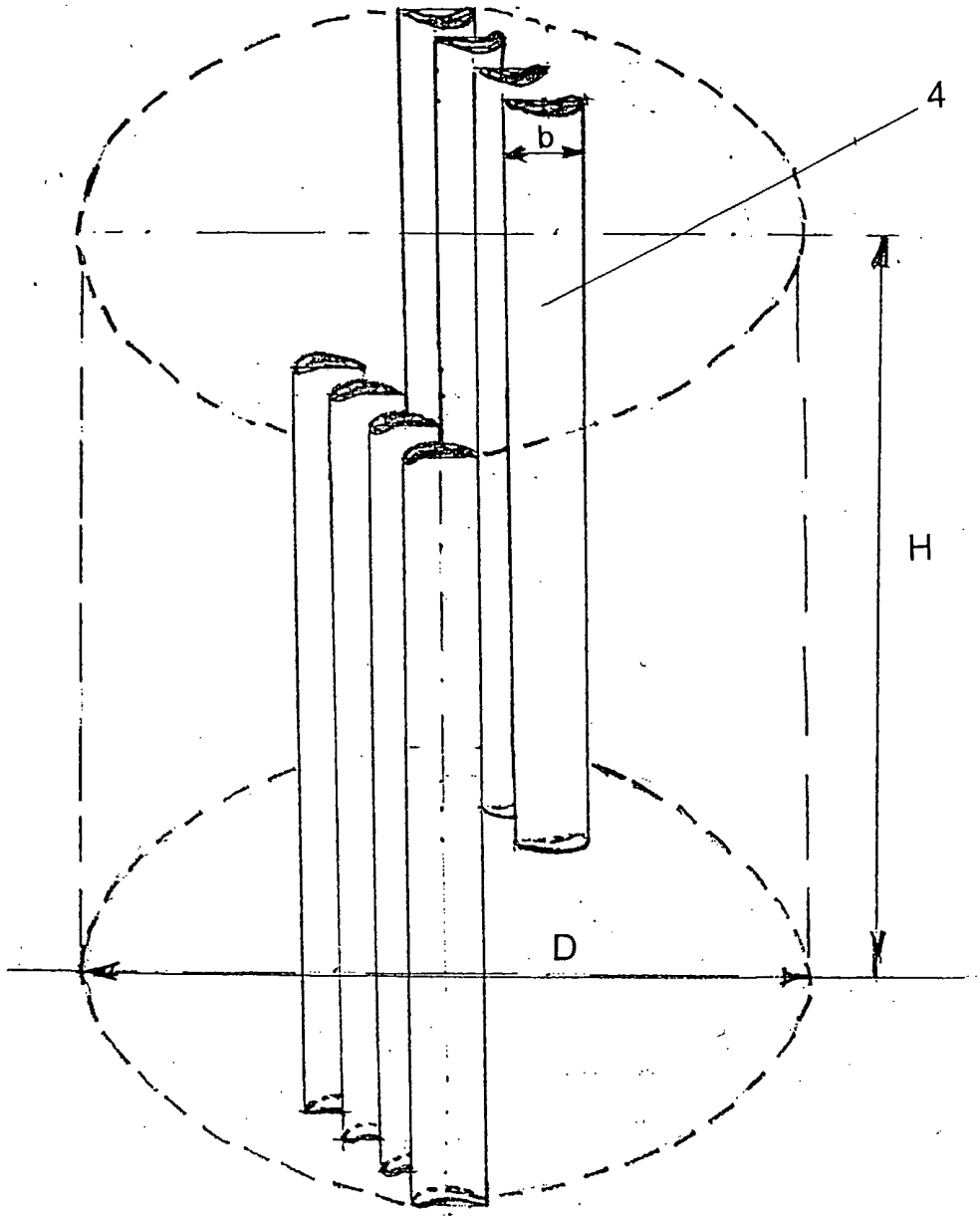

Fig. 1

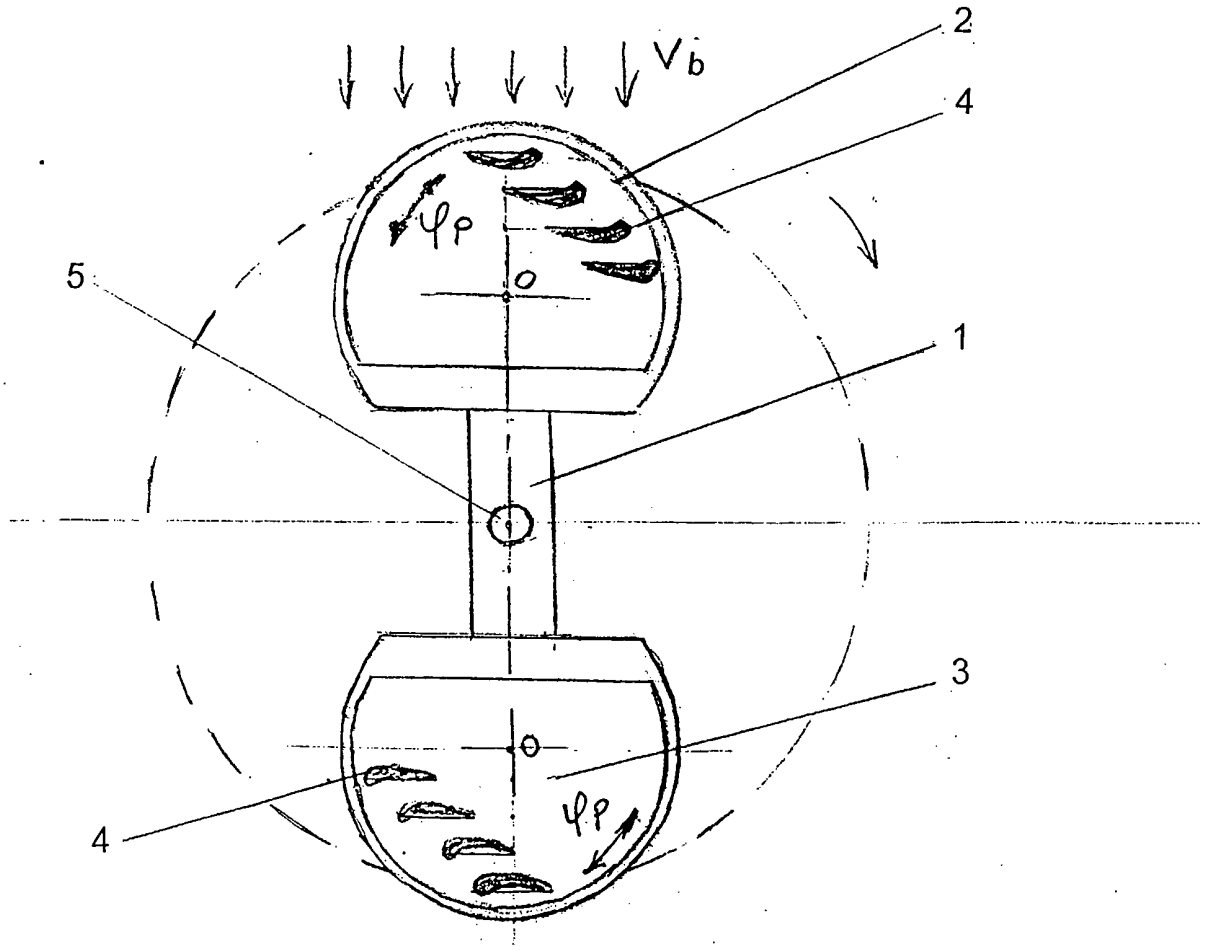

Fig. 2

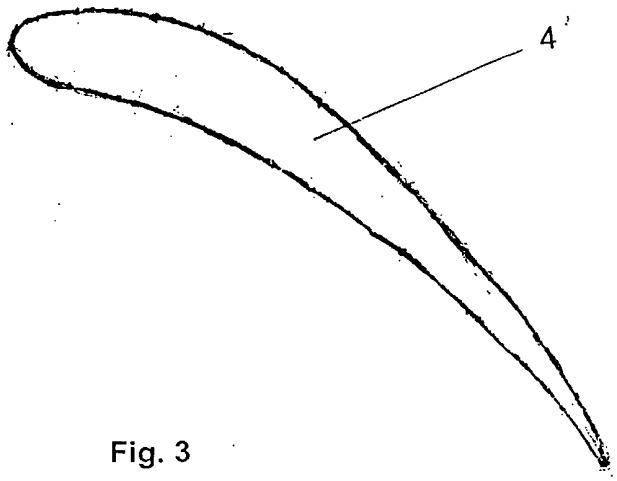

Fig. 3

INTERNATIONAL SEARCH REPORT

International Application No
PCT/LV 01/00008

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F03D3/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 007, no. 145 (M-224), 24 June 1983 (1983-06-24) & JP 58 057082 A (SHIGEFUMI MORI), 5 April 1983 (1983-04-05)	1,2
A	abstract	3,4
X	WO 96 01368 A (GUNDER HANS ERICH ;GUNDER HEIDE (DE)) 18 January 1996 (1996-01-18)	1,2
A	page 10, paragraph 2; figure 3	3,4
X	EP 0 679 805 A (VERASTEGUI RAUL ERNESTO) 2 November 1995 (1995-11-02) abstract; figures	1
X	WO 80 00733 A (WIENER BRUECKENBAU ;HERDIN R (AT)) 17 April 1980 (1980-04-17) abstract; figures	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
8 February 2002	15/02/2002

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
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