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WO-A1-2006/089425
DE-A1- 3 928 538
GB-A- 2 275 970
GB-A- 2 378 225
US-B1- 6 191 496

DESCRIPTION

Technical field of the invention

[0001] The invention relates to a wind turbine with vertical axis, and a wind power plant.

Background art

[0002] A rising number of solutions having specific embodiments and performance being disclosed in the art, which intend to exploit and convert the energy of the streaming air into other type of energy. In fact it is intended to convert into electric or other type of energy - the most widely known systems are for example those used for pumping or heating water.

[0003] In the framework of the alternative energy programs the more effective exploitation of the wind energy becomes more and more considerable worldwide. The wind turbines having horizontal axis are the most widely spread constructions primarily in the case of a great performance demand; constructions having three blades are most frequently used, operation of which is well known in the art.

[0004] A disadvantage of the latter is that its effective operation may be achieved in great heights only, due to the highest speed of the wind in these levels.

[0005] Further disadvantage is due to a feature involving a constant need to orientate the plane of the blades always perpendicularly to the velocity vector of the wind and to change the angle of blades, in order to obtain the optimal and effective energy producing level.

[0006] Such a multidirectional movement makes great demands upon the system, that is the adequate technical requirements can be met by very expensive solutions only.

[0007] A further disadvantage of such a wind turbine system is that its construction requires a high quantity of materials to be located at great heights as well.

[0008] Wind turbines with horizontal axis can exploit the energy to be converted in a surface defined by its plane of blades only.

[0009] Furthermore, these systems can exploit the wind energy effectively in a narrow range of wind speed only.

[0010] To overcome these disadvantages of the systems with horizontal axis many solutions have been proposed in the art using wind turbines with vertical axis.

[0011] Such type of solutions is disclosed for example in the patent documents US4365.929, US 6749393, US2005079054, DE4122919, JP2006037898, WO2006/089425A1, US6,191,496B1 and GB2 378 225. WO2006/089425A1A discloses a wind turbine comprising a stator assembly having a plurality of stator blades for tangentially redirecting wind into an enclosure formed by the stator blades, and a rotor assembly positioned within the enclosure formed by the stator blades. The rotor assembly has a plurality of rotor blades disposed circumferentially on a plurality of stacked disks, each disk defining at least one opening thereon for redirecting the wind axially through each of the disks.

US 6,191,496B1 relates to a vertically rotating wind turbine comprising a wind collecting base with top and bottom surface areas, the latter being greater, and with an upward tapered base. A vertically rotating shaft is connected to an energy transfer element, and a plurality of vertical torque generating elements are attached to a round top plate. Vertical wind directing element direct the wind into the torque generating elements.

GB2 378 225 discloses a wind turbine comprising a vertical driven shaft supporting curved blades via a central drum having apertures. The blade trailing faces are corrugated, improving performance and the leading faces are cambered. Radially outside the blades lie adjustable inlet guide vanes and outside that a building supporting the turbine assembly forms large wind collecting vanes, divide the building periphery into segments and forming convex sided ducting. Incoming airflow enters the segments on the side of the building facing the wind and is controlled by slats pivotally mounted on the large vanes and by the guide vanes and fed to turn the blades. Excess airflow passes through the central drum ensuring all of the blades are active. The building forms part of the turbine, may be multi-storey and also houses accommodation e.g. offices, factories or a sports, civic and conference centre.

A further prior art solution is disclosed by document

DE102005041600. Common disadvantage of these solution is that their construction is very complicated and expensive.

[0012] The main aspect of the present invention is to provide a wind turbine having vertical axis on the basis of the theoretical solutions of a new mathematical concept relating to the energetic system of fluid mechanics.

[0013] Therefore, the object of the present invention is to provide a wind power plant operating always in the same manner, in contrast with the prior art plants, without a feed-back regulation and independently of actual wind direction, and having a minimum flow resistance - that is having a high effectiveness - due to a balance between the torques affected on the inlet and outlet sides of the plant and to its novel geometrical configuration, and having a simple construction and a low cost of maintenance, and further having an ability to work effectively even in weak wind circumstances and sites, and being insusceptible to both sudden changes and distribution of wind load as a function of height.

Disclosure of the invention

[0014] The object of the present invention is achieved by providing a wind turbine with vertical

axis according to claim 1.

Description of the drawings

[0015]

Fig. 1.

is a vertical sectional view of the wind turbine with vertical axis according to the invention,

Fig. 2.

a sectional view taken along the plane A-A of Fig . 1.,

Fig. 3.

is a perspective side view of the second embodiment of the wind turbine with vertical axis according to the invention

Fig. 4.

a sectional view taken along the plane A-A of Fig. 3.,

Fig. 5.

a sectional view taken along the plane B-B of Fig. 4.,

Fig. 6.

is a top side view of whirl triggers of the wind turbine with vertical axis according to the invention,

Fig. 7.

is a perspective view of a whirl trigger showed in Fig. 6.,

Fig. 8.

is a perspective side view of the third embodiment of the wind turbine with vertical axis according to the invention,

Fig. 9.

a sectional view of the wind turbine in Fig. 8., taken along the plane C-C,

Fig. 10.

a sectional view of the wind turbine in Fig. 9., taken along the plane D-D,

Fig. 11.

is a schematic operational diagram of the wind turbine according to the invention.

Detailed description of preferred embodiments

[0016] Fig 1. is a vertical sectional view of the wind turbine with vertical axis according to the invention, where the wind turbine is supported by the ground 8 level. Central control station and devices to operate the wind turbine are located in a building 20 arranged along the ground 8 level.

[0017] A base element 9 supporting the upper machinery of the wind turbine is arranged on the ground 8 level, and said upper machinery is topped by an upper console 10.

[0018] The axis 3 of the wind turbine is held by a bearing 4 of the upper console 10 and a bearing 5 fixed in the building 20, and connected to a generator 7 arranged in the building 7 in manner known itself, so that the generator 7 is driven by the axis 3.

[0019] Baffle means 1 adapted also for vertical load bearing are placed on the base element 9 arranged on the ground 8 level. Baffle means 1 are fixedly attached to the base element 9. Upper ends of the baffle means 1 are rigidly cross braced by the upper consoles 10.

[0020] Supporting rings 11 having a diameter d_1 are placed on the axis 3 held by a bearing 4 of the upper console 10 and a bearing 5 fixed in the building 20, preferably spaced apart by equal distances along said axis 3 and parallelly to each other, and their mounting plane is perpendicular to said axis 3. (see Fig. 1. and 3.)

[0021] Arcuate beams 2 supporting and fixing turbine blades 12 are clamped to supporting rings 11 mounted on the axis 3. (Fig. 2.)

[0022] The number of the turbine blades 12 and that of the arcuate beams 2 attached thereto is arbitrary, but at least two are necessary.

[0023] The surface of the turbine blades 12 are formed as a shape determined by at least one quadric and/or trigonometric and/or hyperbolic mathematical curve.

[0024] The axis 3 with the supporting rings 11 mounted thereon and holding the arcuate beams 2 provided with turbine blades 12 form a single unit that is the rotor F, and these elements in operation rotate at the same rotational speed.

[0025] Arcuate beam 2 and supporting ring 11 provided on the axis 3 have a construction having a structure known itself, for example of a grid structure made of aluminium or plastic material.

[0026] The turbine blade 12 is arranged on the arcuate beam 2 so that its generatrices are adjoining the inner part of the arcuate beam 2.

[0027] There is a wind passage S formed between edges placed on the inner diameter d_1 of the adjacent blades 12, and said passage S has a size depending on the geometrical configuration of the turbine blades 12 and that of the baffle means 1 surrounding said rotor F.

[0028] It is to be noted, that in case of high performance wind turbines an arbitrary number of parting vanes C might be arranged in a plane perpendicular to the generatrices of the turbine blades 12, and said vanes C have a plane perpendicular to the generatrices of the blades 12. (Fig. 3.)

[0029] The diameters of each component are very important factors. Inner arcs of baffle means 1 start in a diameter d_3 being larger than the diameter d_2 of the turbine blades 12.

[0030] Viewing perpendicularly to the generatrices of the baffle means 1 there are located concave and convex arcs.

[0031] The outermost points of the arcs of the baffle means 1 are arranged in a circle having a diameter d_4 .

[0032] Baffle means 1 are positioned vertically and symmetrically spaced apart with equal angles therebetween.

[0033] In case of a wind turbine having less performance the construction of the baffle means 1 is formed by a grid structure having a vertical sheet covering and its material can be selected optionally.

[0034] There is a strict mathematical function between the diameter d_2 of the rotor F as well as the outer d_3 and inner d_4 diameters of the baffle means 1, determined by the wind speed and the performance rating of the wind turbine. In case of a relatively lower wind speed it is advantageous to choose the diameter d_4 of the baffle means 1 greater and the diameters d_2 and d_3 lesser, since the incoming air volume will be greater in this case albeit that the number of baffle means remains, and the same volume as the incoming air volume must enter between the turbine blades 12 having reduced diameter d_2 . Because of the equation of continuity these two volumes must be equal, a much greater entering air speed can be obtained at diameter d_3 , resulted in a kinetic energy raised in a quadratic ratio. One of the most advantageous effects of the present invention in comparison of the prior art solutions is its effective feasibility and applicability also under low wind circumstances.

[0035] Operation of the wind turbine according to the invention will be described later in details in reference of Fig. 11.

[0036] Fig 2. shows a high power embodiment of the wind turbine with vertical axis disclosed in relation of Fig. 1. according to the invention.

[0037] The solution depicted in Fig. 4. contains eight baffle means 1 and efficiency enhancers 13 - baffle and supporting means in itself as well - arranged along a diameter less than diameter d_4 but larger than diameter d_3 of the baffle means 1.

[0038] Efficiency enhancers 13 form a closed polygon according to the number of baffle means 1, increasing the construction's strength and efficiency.

[0039] The corners of the polygon of efficiency enhancers 13 adjoin the side surface of the

baffle means 1 perpendicularly to the generatrices of the baffle means 1.

[0040] A preferred embodiment of the efficiency enhancer 13 is shown in Fig. 5.

[0041] Efficiency enhancer 13 has a framework comprising tubes or section profiles known in itself, which are attached to two adjacent baffle means 1 preferably by means of welded joints.

[0042] The framework of the efficiency enhancer 13 includes supporting elements a surrounded by a casing b, where the number of supporting elements a is preferably eight, although this number may optionally be chosen.

[0043] Longitudinal structural elements and generatrices of casing b of the efficiency enhancer 13 are placed in planes being perpendicular to the shell of the baffle means 1. (Fig. 4.)

[0044] Each supporting element a of the efficiency enhancer 13 is perpendicular to the baffle means 1 and is arranged parallelly to the plane of the supporting ring 11 and arcuate beam 2, therefore it is advantageous to arrange the efficiency enhancer 13 in the plane of the supporting ring 11 and arcuate beam 2.

[0045] Optional number of efficiency enhancers 13 may be mounted parallelly to each other in the baffle means 1.

[0046] The material used to build the efficiency enhancers 13 is a function of the performance of the wind turbine, that is in case of higher demand of performance the efficiency enhancers 13 are made of steel reinforced concrete, like the baffle means 1.

[0047] In this embodiment a supporting roller cam G surface can be arranged between the outer diameter d_2 of the rotor F and the inner diameter d_3 of the baffle means 1 (Fig. 3.). Supporting roller cam G surfaces provide an accurate distance control between the outer diameter d_2 of the rotor F and the inner diameter d_3 of the baffle means 1 even in case of very long (high) rotors F and extreme wind load.

[0048] The number of supporting roller cam G surfaces to be built in along the rotor F will be determined by the expected load wind the and planned performance of the wind turbine.

[0049] In an embodiment according to Fig. 3. there are built three supporting roller cam G surfaces.

[0050] A base member of the supporting roller cam G surface is a supporting ring 1 supported by baffle means 1 and engaging a race ring u arranged on the outer periphery d_2 of the rotor F.

[0051] In an embodiment of a high power wind turbine shown in Fig. 6. twin vanes 16 having shorter arc length are arranged symmetrically between turbine blades 12. Arc length of the

twin vanes 16 is shorter than the arc length of the turbine blades 12 and outermost generatrices running parallelly to the axis 3 of this vanes 16 are placed on the diameter d_2 of the rotor F, the number of the vanes 16 is equal to the number of turbine blades 12.

[0052] As mentioned above, in case of a high power wind turbine it is preferable to apply whirl triggers 14 on the baffle means 1 arranged perpendicularly to the axis 3 and in the same plane as the efficiency enhancers 13.

[0053] Whirl triggers 14 of this embodiment are depicted in Fig. 7. It is clearly shown in the figure, that a whirl trigger 14 is a body delimited by four surfaces.

[0054] The operation of the second embodiment is substantially equal to that of the embodiment shown in Fig 1., except that the air flow moving between the turbine blades is modified by the efficiency enhancers 13 and whirl triggers 14, which results in an increased performance.

[0055] Fig 9. depicts the structure of a wind turbine having an arbitrary performance.

[0056] The height of a wind turbine shall be determined by the dynamic stability. In this embodiment at least one retaining and dividing floor 17 is formed along a predetermined height of the baffle means 1 in order to achieve dynamic stability, made of a known constructional material, preferably of a material equal to the material of the baffle means 1. For high power wind plants, that is over 1 MW, this material is preferably steel reinforced concrete.

[0057] Retaining and dividing floors 17 might be arranged in an arbitrary number perpendicularly to the baffle means 1 and axis 3 as well, forming a construction being unitary as regards both to fluid dynamics and strength mechanics, the sizes of which is determined substantially by the size of the axis 3 and the outer diameter d_4 of the baffle means 1.

[0058] Floors 17 are spaced apart from each other by the same distance h determining also the length of the axis between the floors 17.

[0059] Wind turbine showed in Fig. 1. and 2. is substantially placed between two floors 17 (see Fig. 9.), but it is possible to arrange different embodiments of wind turbines between two floors 17. The upper console 10 may be omitted in this case, indeed, since its role is taken up by floor 17.

[0060] A floor 17 is shown in Fig. 10., having a through hole 18 in the middle and receiving the axis 3 preferably bearing fitted in the hole 18.

[0061] The floor 17 is preferably disc shaped, and advantageously it is formed as an ellipsoid of rotation or any other body suitable according to fluid dynamics. In this embodiment the height limit is determined by the length of the axis 3. For that very reason it is preferred to apply an axis 3 divided according to the distance h of the floors 17, but in this case the bearing

arrangement requires a special structural construction, as follows.

[0062] Due to the floor 17 used on this embodiment more than one sections F1, F2, F3...Fn of the rotor F may be arranged along the overall height. Since the wind force affecting the turbine blades 12 arranged between two parallel floors 17 may be different, different air flowing circumstances must be taken into account between different floors 17. Having regard to this fact in planning, the axis 3 can be formed by sections F1, F2, F3...Fn according to distance h , so that a given section F1 shall be gear fitted in the central hole 18 formed in the respective upper floor 17, and the lower end of the section F1 shall be connected to the upper end of a lower section F2 preferably by means of an elastic coupling supporting the section F1 in axial direction, but allowing only a small lateral movement. In this embodiment, the bearing is fixed in the holes 18 by means of a resilient structural element. This way a flexural buckling of the axis 3 consisting of sections F1, F2, F3...Fn might be omitted even in case of a great wind load affecting differently along the height of the wind turbine.

[0063] Operation of the wind turbine with vertical axis 3 according to the invention will now be described in reference of FIG. 11.

[0064] The principal advantage of the wind turbine with vertical axis 3 according to the invention is that it can be used at every wind speed and the performance of the generator - i.e. hot water supply - increases along with increasing wind speed, and it has an earthquake proof construction.

[0065] An air mass arriving to a surface determined by the diameter d_4 and a respective height enters into the wind plant through openings f_1 determined by the baffle means 1. Entering air will be accelerated by both the curvature of the baffle means 1 and by the cross sectional area narrowing from an opening surface f_1 to an opening f_2 being smaller than surface f_1 . The accelerated air mass having now increased speed and having, therefore, increased impulse enters the turbine blades 12 through opening f_2 , exerts a torque to the rotor F while receiving a change of flow direction, and flows into the opposite turbine blades 12 through a passage S delimited by the axis 3 and supporting rings 11, where its impulse shall be changed and receiving a further change of flow direction exerts a further torque on the turbine blades 12.

[0066] Due to the arrangement of the system the curves and openings f_1 , f_2 of the baffle means 1, as well as the diameter d_2 of rotor F and curves of the turbine blades 12 provide a laminar flow at every speed, and the torque obtained will be equal on the turbine blades 12 both in the inlet and outlet, therefore symmetrically exerted to the axis 3.

[0067] The openings of the baffle means 1 have an inverse behaviour at the outflow side, indeed, as compared to the inflow circumstances.

[0068] Spent air exiting the outflow side opening f_2 expands up to the opening f_1 having greater surface, then it will be carrying away by an air flow flowing freely beside the wind plant,

which phenomenon decreases the flow resistance and increases the effectiveness of the wind turbine.

[0069] The main advantage of the wind power plant according to the present invention is that it provides a wind power plant operating always in the same manner, in contrast with the prior art plants, without a feed-back regulation and independently of actual wind direction, and having a minimum of flow resistance - that is having a high effectiveness - due to a balance between the torques affected on the inlet and outlet sides of the plant and to its novel geometrical configuration, and has a simple construction and a low cost of maintenance, and further has an ability to work effectively even in weak wind circumstances and sites, and being insusceptible to both sudden changes and distribution of wind load as a function of height.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

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Patentkrav

- 1.** Vindmølle med vertikal akse (3), med en rotor (F) og en generator (7)
- 5 forbundet med aksens (3), og en støttestruktur der holder rotorens (F) akse (3) ved hjælp af lejer, hvilken rotor (F) består af en akse (3) udstyret med et øvre leje monteret i toppen af en øvre konsol (10) og med et lavere leje monteret i en bygning (20) bygget på jordniveau (8), og støtteringe (11) vinkelret forbundet med aksens (3) anbragt med afstand langs aksens (3), og en flerhed af buede bjælker (2) udstyret med ringene (11) og som støtter vindmøllevinger (12), og omfattende skærmorganer (1) indrettet rundt om rotoren (F), **kendetegnet ved, at** en vindpassage (S) er dannet mellem kanter placeret på inderdiameteren (d_1) af de tilstødende vinger (12), og passagen (S) har en størrelse der afhænger af den geometriske konfiguration af vindmøllevingerne (12) og konfigurationen af
- 10 skærmorganerne (1) der omgiver rotoren (F), hvilke vindmøllevinger (12) er dannet som en form bestemt med mindst en kvadratisk og/eller trigonometrisk og/eller hyperbolsk matematisk kurve, og et valgfrit antal skillevinger (C) er indrettet i et plan der er vinkelret på frembringerne af vindmøllevingerne (12), og skærmorganerne (1) har afbøjnings- og støtteelementer som
- 20 effektivitetsfremmere (13) indrettet mellem inderdiameteren (d_3) og yderdiameteren (d_4) derpå, og antallet deraf svarer til antallet af skærmorganerne (1), og effektivitetsfremmerne (13) danner en lukket polygon.
- 2.** Vindmølle ifølge krav 1, **kendetegnet ved, at** den omfatter en støtterullebane
- 25 (G) indrettet langs aksens (3) og mellem rotorens (F) yderdiameter (d_2) og skærmorganernes (1) inderdiameter (d_3), og banen (G) består af en støttering (t) dannet på skærmorganerne (1) og forbundet med en løbering indrettet på rotorens (F) yderdiameter (d_2).
- 30 **3.** Vindmølle ifølge et hvilket som helst af kravene 1 eller 2, **kendetegnet ved, at** dobbeltvinger (16) med kortere buelængde er indrettet symmetrisk mellem vindmøllevingerne (12) ved rotorens (F) yderdiameter (d_2), og antallet heraf svarer til antallet af vindmøllevinger (12).

4. Vindmølle ifølge krav 3, **kendetegnet ved, at** hvirveludlødere (14) afgrænset af fire overflader er indrettet i samme plan som effektivitetsfremmere (13).

5. Vindmølle ifølge et hvilket som helst af kravene 1 til 4, **kendetegnet ved, at**
5 den kan bygges med en valgfri højde, og gulve (17) er dannet med mellemrum med samme afstande (h) langs højden, og rotor (F) bestående af støtteringe (11) fastgjort med mellemrum og med bueformede bjælker (2) der støtter vindmøllevingerne (12) er indrettet mellem gulvene (17), og aksene (3) på rotor(erne) (F) er lejefastgjort i et hul (18) på gulvet (17).

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6. Vindmølle ifølge krav 5, **kendetegnet ved, at** gulvet (17) har form som en ellipsoide.

7. Vindmølle ifølge et hvilket som helst af kravene 1 til 6, **kendetegnet ved, at**
15 den omfatter elastiske elementer der kompenserer for forskellige bevægelser af dele af dens akse (3), hvilket resulterer i en jævn rotation.

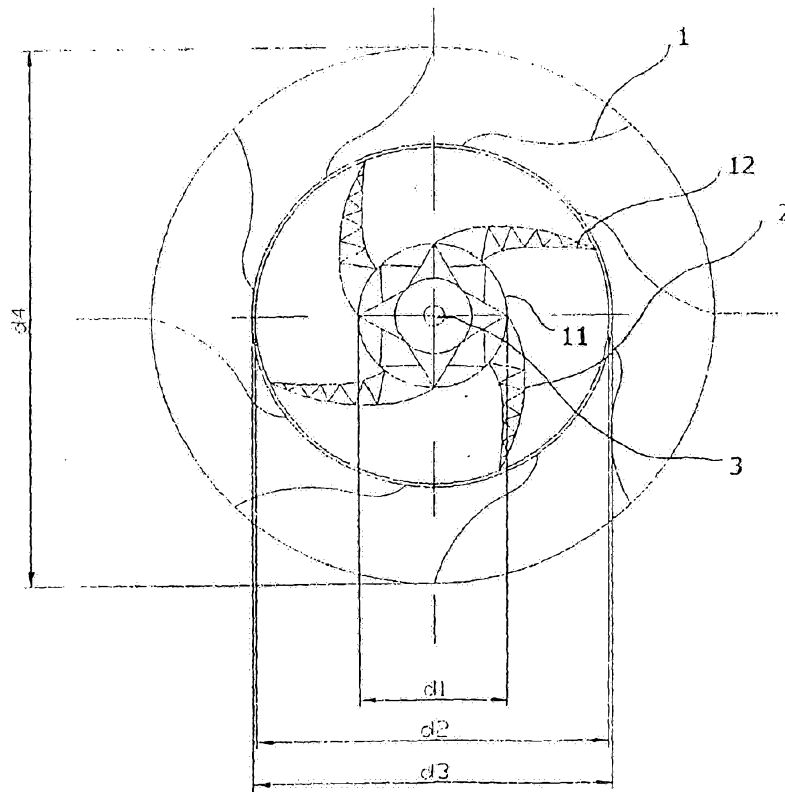


Fig. 2

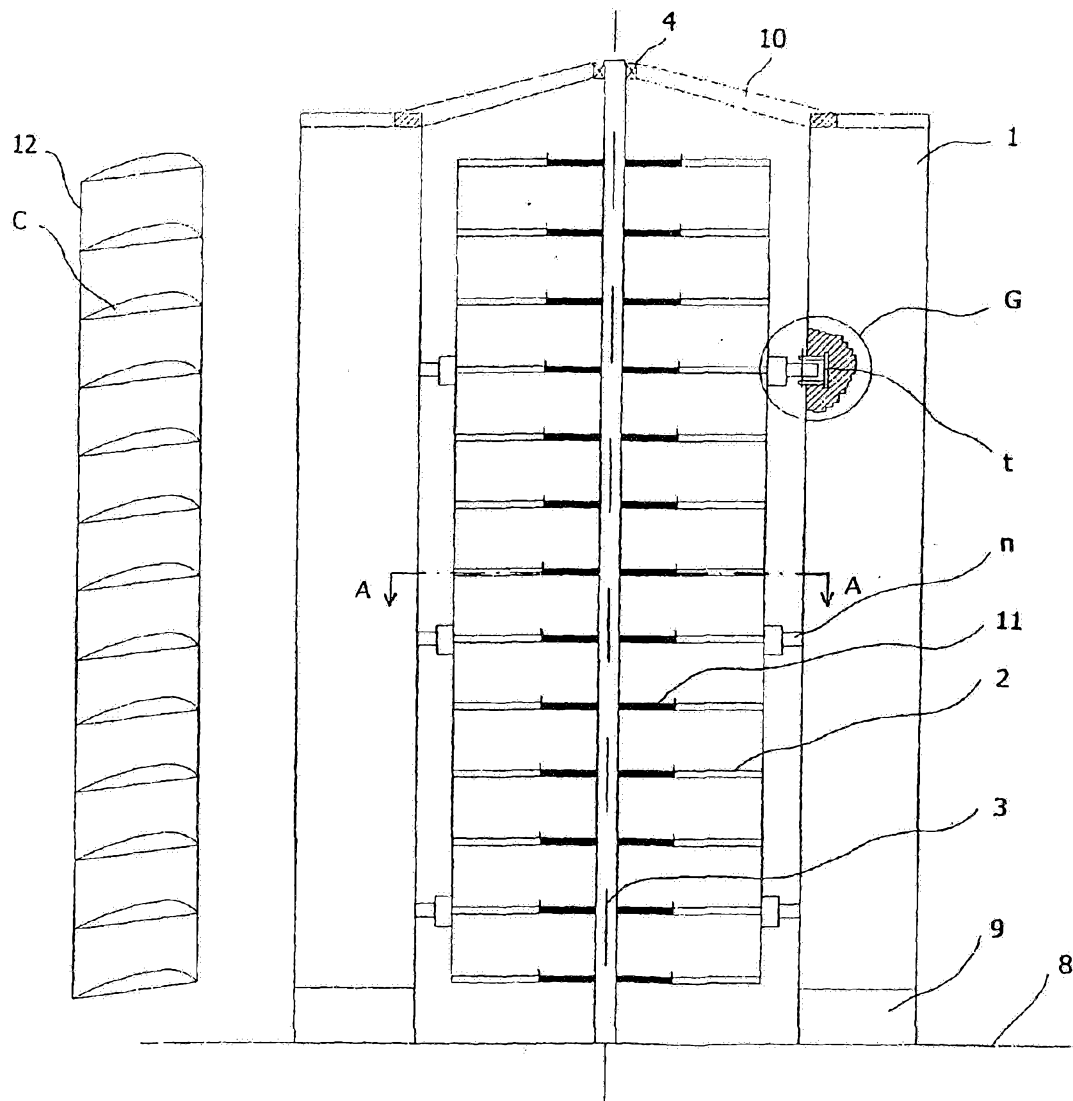


Fig. 3

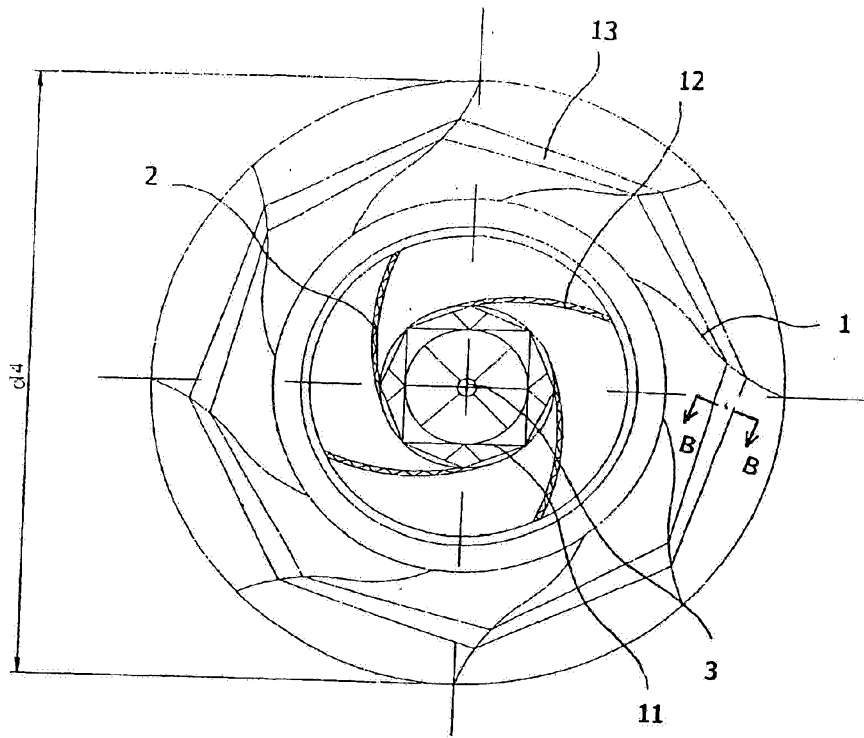


Fig. 4

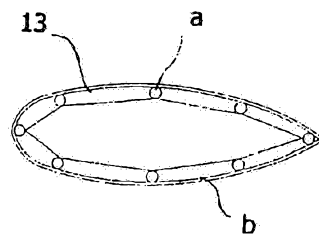


Fig. 5

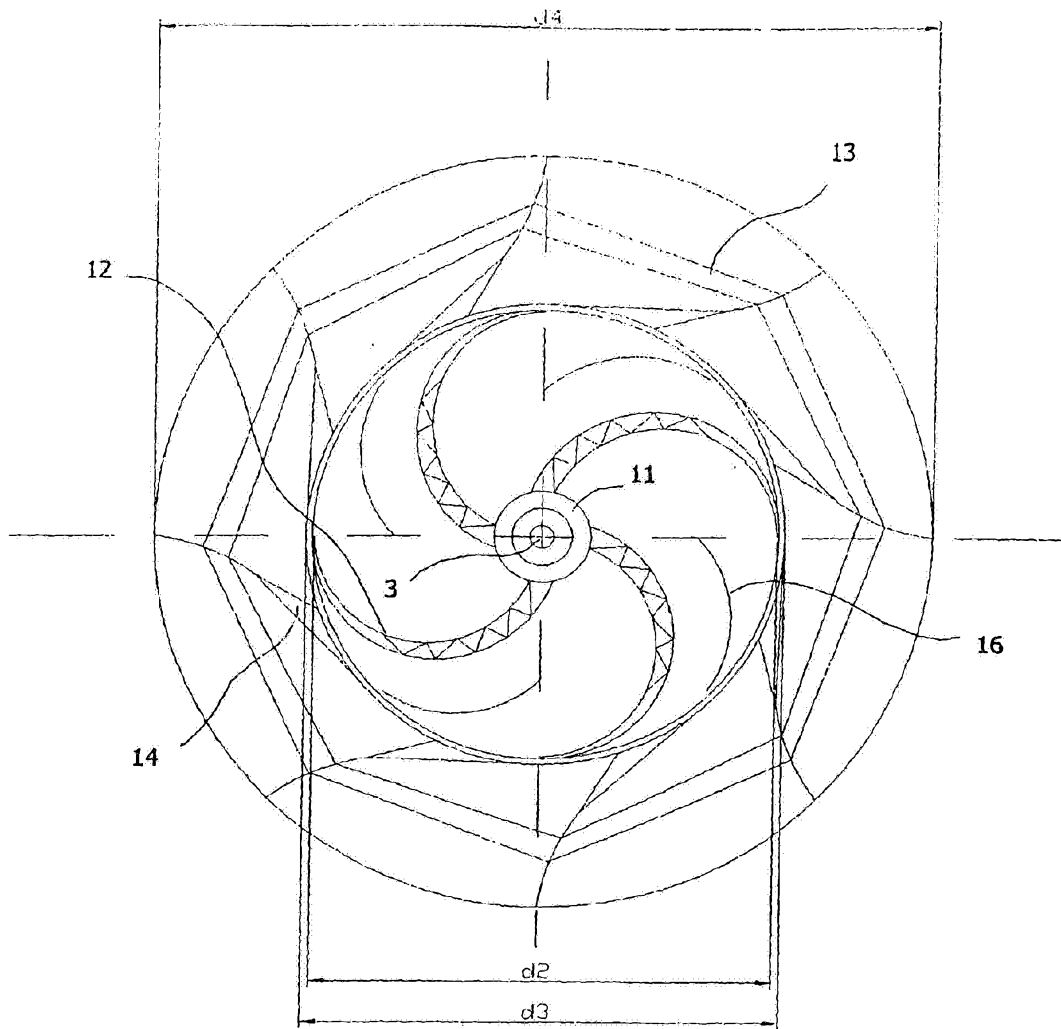


Fig. 6

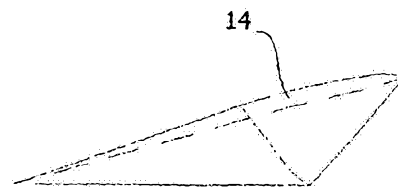


Fig. 7

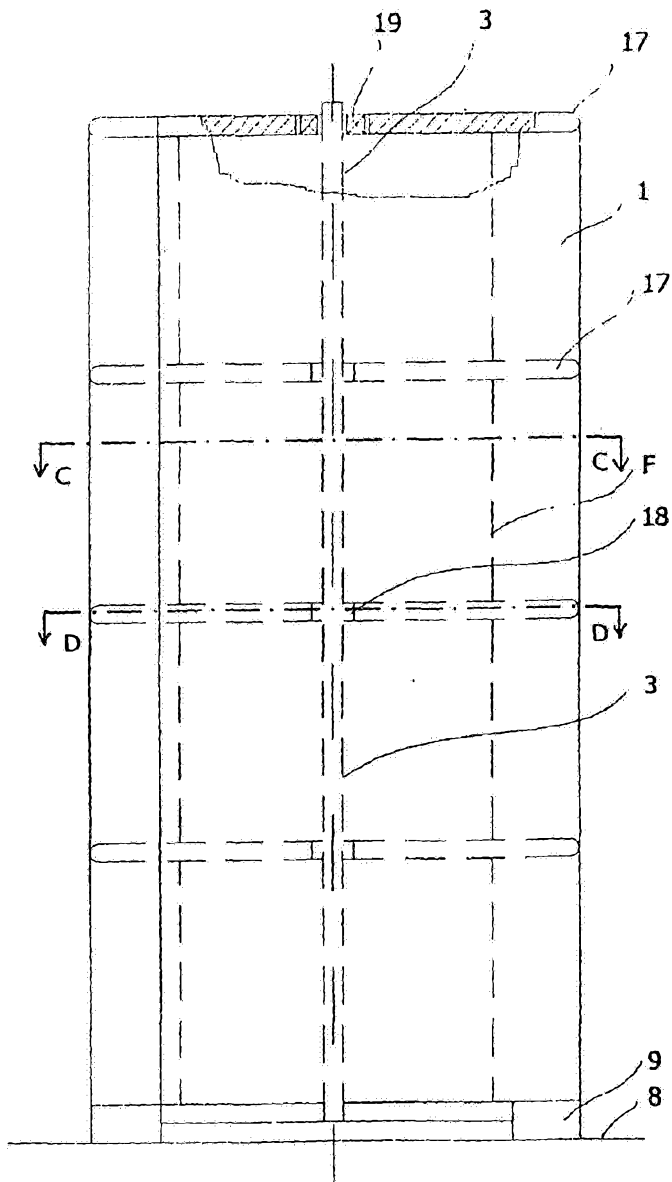


Fig. 8

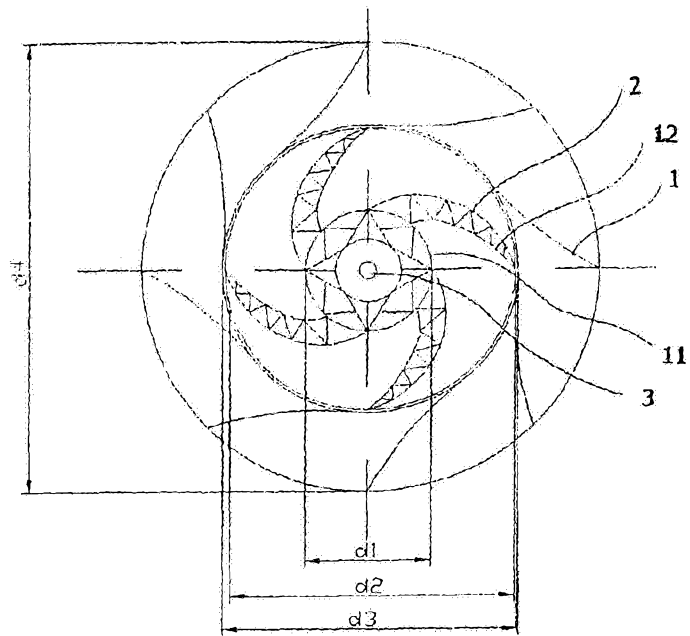


Fig. 9

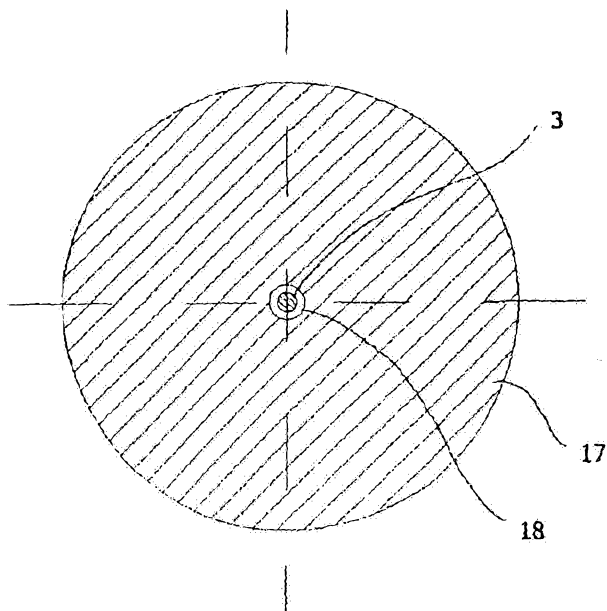


Fig. 10

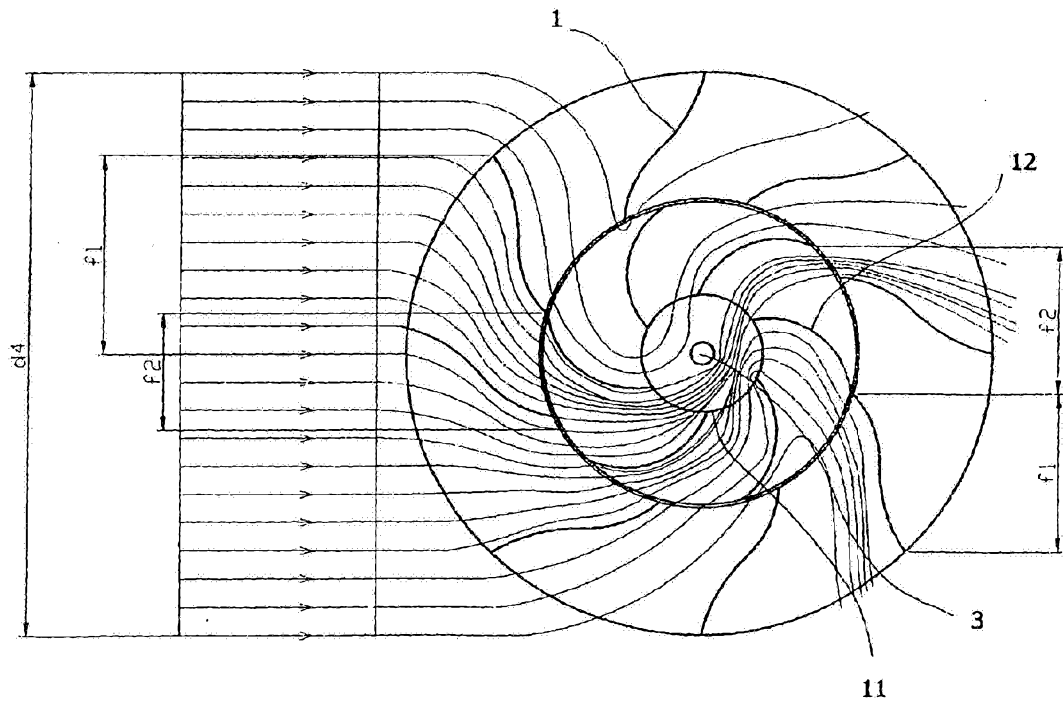


Fig. 11