(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
13 August 2009 (13.08.2009)

PCT

(10) International Publication Number
WO 2009/097850 A2

(51) International Patent Classification: *F03D 1/06* (2006.01)

(21) International Application Number: PCT/DK2009/000017

(22) International Filing Date: 21 January 2009 (21.01.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PA 2008 00155 5 February 2008 (05.02.2008) DK

(71) Applicant and
(72) Inventor: **FLYTKLINT, Bjarne** [DK/DK]; Sønder Allé 6, DK-9510 Arden (DK).

(74) Agent: **LARSEN & BIRKEHOLM A/S**; Skandinavisk Patentbureau, Banegårdspladsen 1, P.O. Box 362, DK-1570 Copenhagen V (DK).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published**:
— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

# (54) Title: A ROTOR, IN PARTICULAR FOR PROPELLERS OR WIND ENERGY SYSTEMS

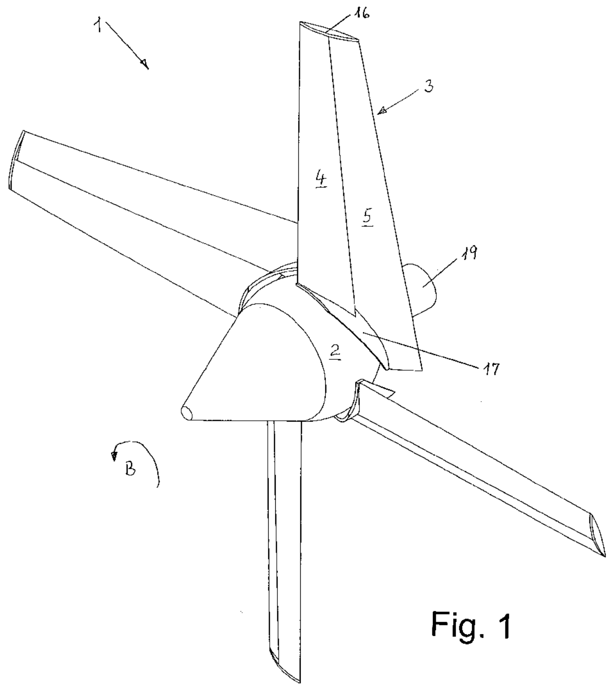



Fig. 1

(57) **Abstract**: When, according to the invention, a rotor (1) for a propeller or a windmill is equipped with two-part blades (3), which are secured to the hub (2) offset to the right of a centre line (C) through the hub, and which comprise a first blade plane (4) and a laterally offset second blade plan (5), and the blade planes are arranged in such a manner that the leading edge (7) of the first blade plane extends approximately in parallel with the centre line (C) radially outwards from the centre of the hub and forms an acute angle (A) in combination with the leading edge (8) of the second blade plane, so that the leading edge (8) is disposed behind the leading edge (7) seen in relation to the direction of rotation of the hub, and when the length of the trailing edge (10) of the second blade plane is defined by a line which extends from the centre of the hub essentially perpendicularly to the trailing edge (10) of the blade plane, and by the blade tip of the blade plane, a rotor having a high efficiency and having relatively small dimensions is achieved.

WO 2009/097850 A2

# A ROTOR, IN PARTICULAR FOR PROPELLERS OR WIND ENERGY SYSTEMS

## The prior art

The invention relates to a rotor, in particular for propellers or wind energy systems, comprising a hub having mounted two-part blades with an airfoil profile, said two-parts blade comprising a first blade plane and a laterally offset second blade plane, and wherein each of the blade planes is defined by a leading edge, a trailing edge, a blade tip and a root end.

Over the years, blades having an airfoil profile for wind energy systems have developed toward a structure, where the blade consists of a root area closest to the hub, an airfoil area most remote from the hub and a transition area between the two areas.

The airfoil area has an ideal or almost ideal blade shape, while the root area is essentially configured with a circular cross-section in order to reduce the wind load and to create a safe anchorage to the hub. The shape of the root area means that the root area does not contribute to the production of energy. Nor does the shape of the transition area contribute to the production of energy to any particular extent. Thus, the traditional blade having an airfoil profile does not utilize its full length for the production of energy.

Over the years, many attempts have been made at enhancing the ability of wind energy systems to produce energy. It is known from the aircraft industry that an aircraft built with two wings or biplanes can lift a lot more than an aircraft having just one wing.

This principle is also known in connection with blades for wind energy systems and propellers for aircraft. Thus, US Patent 1,813,877 discloses an airplane propeller which is provided with two double rotor blades which are secured to the hub and connected at the blade tip by a transverse support. The blades are configured so as to be completely uniform.

The European Patent Publication 0064742 discloses a rotor for a wind energy system which is equipped with a set of two-part blades of the airfoil type. The two-part blade is equipped with a member at the blade tips and with circular root ends, which are mounted on the hub such that the positions of the blades planes relative to the wind and the strength of the wind may be adjusted. The root ends are offset laterally relative to each other and are positioned symmetrically around a centre line, which extends from a blade tip on a blade plane across the centre of the hub and further to the blade tip of the opposite blade plane. The root end of the blade planes is short so that the airfoil part comprises almost the entire blade. The blade planes appear to be narrow relative to the hub of the rotor.

Danish Patent Application PA 2005 01451 discloses a traditional airfoil blade, where the root area is split and the two root segments are configured as airfoils. The purpose is to reduce the air resistance around the root end, while increasing the lift of the blade. On the face of it, the airfoils provided in the root area appear to be very narrow compared with the width of the blade in the airfoil area, and it must be assumed that their useful effect will be limited.

The document US 5161952 discloses a windmill rotor having a hub and having mounted two-part blades with blade plane profiles. The document discloses and describes a structure of the two-part blades, where the blade planes are disposed behind each other. The document has the primary object of teaching a solution which is capable of absorbing the stresses and moments which occur in the blades when loaded. In addition, the blade tips are coupled with a bearing with the purpose of transferring stresses and moments between the blades. The structure and position of the blade planes are not disclosed in the document with the aim of specifically utilizing the wind energy around the root end of the blade planes.

## The object of the invention

It is the object of the invention to provide a rotor structure which also ensures utilization of the wind energy which passes close by the hub and the root ends of the blade planes, and this is achieved by disposing the two-part blade to the right of a centre line through the hub, such that the leading edge of the first blade plane extends approximately in parallel with the centre line and forms an acute angle in combination with the leading edge of the second blade plane, such that the leading edge of the second blade plane is disposed offset to the right of the leading edge of the first blade plane, and that the length of the trailing edge of the second blade plane is defined by a line which extends from the centre of the hub essentially perpendicularly to the trailing edge of the blade plane, and by the blade tip of the blade plane.

This ensures that the total lift area of the blade planes is increased to a significant degree, while the tunnel effect between the two blade planes as known from sailing ships may be utilized for increasing their total traction force and ability to produce energy to an extent which is above that of the traditional blade.

This structure of the two-part blade moreover ensures that the part of the air flow passing the blades close to the root ends is directed inwards toward the hub instead of outwards toward the blade tip like with traditional blades, and that the total length of the blade may be shortened, such that the costs of the handling, manufacture and mounting of e.g. a wind energy system may be reduced, and also opens up the possibility of offering new solution concepts in connection with the construction of wind energy systems, mill parks and the like.

When, additionally, the second blade plane is configured such that the length of the trailing edge of the blade plane is defined by a line extending from the centre of the hub essentially perpendicularly to the trailing edge of the blade plane, and by the blade tip of the blade plane, it is ensured that the airfoil area of the blade plane is extended to additionally comprise an area disposed close to and down around a portion of the periphery of the hub. This increase in the airfoil area and the associated tunnel effect of the inwardly directed air flow contributes to enhancing traction force as well as energy production additionally.

When, as stated in claim 2, the two-part blades are secured at the root ends to their respective platforms, which are pivotally connected with the hub by a bearing, and the blade tips are connected with a control plate, it is ensured that the angle of the blade planes with the wind may be adjusted relative to the strength of the wind.

When, as stated in claim 3, the hub is constructed in such a manner that its diameter decreases toward the coupling member of the hub, so that the part of the hub facing toward the coupling member essentially has the shape of a hemisphere, it is ensured that a platform may be mounted pivotally on the hub, thereby allowing the angle of the blade planes with the wind to be adjusted.

When, as stated in claim 4, the angle between the leading edges of the blade planes is selected in the range of from 2 to 20 degrees, it is ensured that the length of the two-part blade may be selected freely, without reducing the inwardly directed air flow or the above-mentioned tunnel effect.

When, as stated in claim 5, the second blade plane is configured with an area which is larger than the area of the first blade plane, it is ensured that the air flow passing the first blade plane obtains as large a surface on the second blade plane to act on as is practically possible.

When, as stated in claim 6, the second blade plane is equipped with a flap on the leading edge as well as the trailing edge, it is ensured that the tunnel between the blade planes may be adjusted to an optimum effect, and that the speed of rotation of the blade may be reduced in case of strong winds.

When, as stated in claim 7, the first blade plane is suspended from bearings which are arranged in the pivotable platform and in the control plate, it is ensured that the blade plane may be adjusted independently according to the strength of the wind.

Finally, it is expedient, as stated in claim 8, to equip the rotor with from two to four two-part blades.

<u>The drawing</u>

The invention will be described more fully below with reference to the drawing, in which

fig. 1 shows a rotor according to the invention for a propeller equipped with four two-part blades, seen in perspective,

fig. 2 shows a rotor for a propeller having a two-part blade, seen from the front,

fig. 3 shows a sectional view along the line D-D in fig. 2 of the blade planes near the root end, fig. 4 shows a sectional view along the line E-E in fig. 2 of the blade planes near the blade tip,

fig. 5 shows a rotor according to the invention for a wind energy system equipped with four two-part blades, seen in perspective,

fig. 6 shows a rotor for a wind energy system having a two-part blade, seen from the front,

fig. 7 shows a sectional view along the line F-F in fig. 6 of the blade planes at start, and

fig. 8 shows the sectional view F-F of the blade planes in operation.

Description of the exemplary embodiment

The exemplary embodiment shown in figures 1 – 8 will be described below.

Fig. 1 shows a perspective view of a rotor 1 for a propeller. The rotor is shown with four two-part blades 3 mounted on a hub 2. The two-part blades comprise a first blade plane 4 and a laterally offset second blade plane 5. Both blade planes are of the airfoil type known from aircraft wings and from windmills. The direction of rotation of the rotor is indicated by the arrow B. The rotor may be driven by a motor.

For simplicity, fig. 2 shows a rotor 1 seen from the front for a propeller equipped with just a single two-part blade 3. The blade planes 4, 5 are defined by a leading edge 7, 8, a trailing edge 9, 10, a blade tip 11, 12 and a root end 13, 14. The two-part blade 3 is disposed offset to the right of the centre line C. The leading edge 7 of the first blade plane extends approximately in parallel with the centre line C radially outwards from the hub 2 and forms an acute angle A in combination with the leading edge 8 of the second blade plane, such that the leading edge 8 succeeds and is disposed offset to the right of the leading edge 7.

The blade tips 11, 12 are interconnected. The connection may be configured as a fixed connection with a control plate 16.

The root ends 13, 14 are connected with the hub 2 via a platform 17, which is pivotally connected with the hub by a bearing 18.

It will be seen in fig. 3 that the hub 2 is constructed in such a manner that the diameter of the hub decreases toward the coupling member 19 of the hub, such that the part of the hub facing toward the coupling member 19 essentially has the shape of a hemisphere. The shape of the hub ensures that the platform 17 may pivot unobstructedly in the bearing 18. The platform 17 is configured in such a manner that, irrespective of adjustment, it causes least possible disturbance, such as wind resistance and turbulence. Pivoting of the platform 17 and thereby of the angle of the blade planes relative to the passing air allows the traction force of the blade planes to be controlled.

The angle A between the leading edges 7, 8 of the blade planes, which is shown in fig. 2, has a special importance to the function and efficiency of the two-part blade. Thus, the angle and the offset of the leading edge on the second blade plane 5 contribute to increasing the active airfoil area of the blade and to establishing an overlap area 15 between the blade planes, which creates a tunnel capable of accelerating the velocity of the air flow across and inwards toward the hub at the second blade plane 5. It has been found that angle sizes of between 2 and 20 degrees are expedient and provide freedom for selecting optimum lengths of the blades.

It has moreover been found that the course of the air flow across the planes and inwards toward the hub is not disturbed to any significant degree by the surface of the planes being polluted by dirt and insects.

It has furthermore been found that the configuration of the second blade plane with a trailing edge 10 which extends from a line extending from the centre of the hub approximately perpendicularly to the trailing edge and to the blade tip in cooperation with the angle A between the leading edges and the overlap area 15, means that the wind flow makes contact with an increased surface around the hub and at the root end 14, thereby increasing the efficiency of the blade plane.

Fig. 3 shows a sectional view of a two-part blade, where the section is made along the line D-D (see fig. 2). The blade planes 4 and 5 are arranged on the hub 2, which is seen from above and rotates counterclockwise. The wind flows V1, V2 and V3 pass between the blade planes. The wind flow V1 passes along the upper side of the blade planes, where it is to traverse a longer distance than the wind flows V2 and V3 before they can meet. The velocity of V1 is increased hereby and creates a negative pressure on the upper side of the blade plane 4 and 5.

The wind flow V2 passes through the overlap area 15, which creates a tunnel between the blade planes 4 and 5, in which it is accelerated. Then, it passes across the upper side of the blade plane 5, where it creates a negative pressure together with the air flow V1, before they merge with the air flow V3 after having passed the blade.

Fig. 4 shows a sectional view of the blade planes in the vicinity of the blade tips. The passage of the wind takes place as described above and in fig. 3.

Fig. 5 shows a rotor 1 for a wind energy system in perspective. The rotor is shown with four two-part blades 3 mounted on a hub 2. The two-part blades comprise a first blade plane 4 and a laterally offset second blade plane 5. Both blade planes are of the airfoil type known from aircraft wings and from windmills. The direction of rotation of the rotor is indicated at B.

Fig. 6 shows a rotor 1 for a wind energy system equipped with just a single two-part blade 3 for simplicity. The structure is basically as stated for the propeller shown in fig. 2, with the two-part blade disposed to the right of the centre line C.

In wind energy systems, however, the upper side of the blade planes faces away from the wind direction and is inclined, so that the system not only utilizes the pressure of the wind on the inclined blade plane, but also so that the air flow around the blade plane creates a negative pressure on the upper side of the blade. The resulting force of pressure and negative pressure distributed over the entire blade provides the traction which makes the blade rotate.

The blade planes 4 and 5 are secured to a platform 17, which is pivotally connected with the hub 2 by the bearing 18, as shown in fig. 7 and fig. 8. Hereby, the two-part blade may be adjusted in an optimum angle relative to the strength of the wind.

The blade plane 4 is shown equipped with bearing connections 22, 23 with the control plate 16 and with the platform 17, respectively. The inclination of the blade plane 4 may hereby be adjusted independently in response to the strength of the wind.

The blade plane 5 is shown equipped with a flap 20 on the leading edge 8 and with a flap 21 on the trailing edge 10. The tunnel area 15 may be made wider or narrower with the flap 20, thereby contributing to optimizing the effect of the tunnel. The negative pressure on the upper side of the blade plane may be adjusted with the flap 21, as needed. If, e.g., there is a too great wind pressure, it is possible to establish a braking effect by pivoting the flap 21 up against the air flow which passes across the upper side of the blade plane. If, e.g., there is a light breeze, the flap may be pivoted toward the lower side of the plane, so that the upper side is curved, and the air flow across the upper side of the blade has to traverse a longer distance. This increases the negative pressure, and thereby the traction of the blade. The flaps are shown mounted in the control plate 16 and at the root end 14.

The two-part blade makes it possible to construct propellers and wind energy systems in which the length of the blades is shortened considerably relative to the traditional blade. It is hereby possible to reduce the costs of the manufacture and mounting of systems, without the performance being reduced for that reason. A rotor may be equipped with two, three or four two-part blades. If the size of the blades plays an important role, the rotor may be equipped with four two-part blades, thereby making the dimensions as small as possible, without jeopardizing the performance.

A system may e.g. be constructed by disposing a plurality of rotors side by side or above each other in a common frame. Incorporation of a generator in each hub makes it possible to construct very compact systems.

Correspondingly, a system may be built together with a building which may form the base and/or the engine house for the system.

Of course, the rotor may also be mounted as an independent mill on its own tower.

## PATENT CLAIMS

1. A rotor (1), in particular for propellers or wind energy systems, comprising a hub (2) having mounted two-parts blades (3) with an airfoil profile, said two-part blades comprising a first blade plane (4) and a laterally offset second blade plane (5), and wherein each of the blade planes is defined by a leading edge (7, 8), a trailing edge (9, 10), a blade tip (11, 12) and a root end (13, 14), c h a r a c t e r i z e d in that the two-part blade (3), when viewing the hub (2) from the front, is disposed offset to the right of a centre line (C) through the hub (2), such that the leading edge (7) of the first blade plane extends approximately in parallel with the centre line and forms an acute angle (A) in combination with the leading edge (8) of the second blade plane, such that the leading edge (8) succeeds and is disposed offset to the right of the leading edge (7) seen in the direction of rotation of the hub, and that the length of the trailing edge (10) of the second blade plane is defined by a line which extends from the centre of the hub essentially perpendicularly to the trailing edge (10) of the blade plane, and by the blade tip (12) of the blade plane.

2. A rotor according to claim 1, c h a r a c t e r i z e d in that the blade planes (4, 5) of the two-part blades are secured at the root to a platform (17), which is pivotally connected with the hub (2) by a bearing (18), and that the blade tips (11, 12) are connected with a control plate (16).

3. A rotor according to claim 1 or 2, c h a r a c t e r i z e d in that the diameter of the hub decreases toward the coupling member (19) of the hub, so that the part of the hub facing toward the coupling member essentially has the shape of a hemisphere.

4. A rotor according to claim 1 or 2, c h a r a c t e r i z e d in that the size of the angle (A) between the leading edges (7, 8) of the blade planes is in

the range of from 2 to 20 degrees.

5. A rotor according to claim 1, 2 or 4, c h a r a c t e r i z e d in that the surface area of the second blade plane (5) is larger than the surface area of the first blade plane (4).

6. A rotor according to claim 1, 2, 4 or 5, c h a r a c t e r i z e d in that the blade plane (4) is arranged pivotally in the bearings (22) and (23).

7. A rotor according to claim 1, 2, 4 or 5, c h a r a c t e r i z e d in that the blade plane (5) is equipped with a flap (20) on the leading edge (8) and with a flap (21) on the trailing edge (10).

8. A rotor according to any one of the preceding claims, c h a r a c t e r – i z e d in that the rotor is equipped with from two to four two-part blades (3).

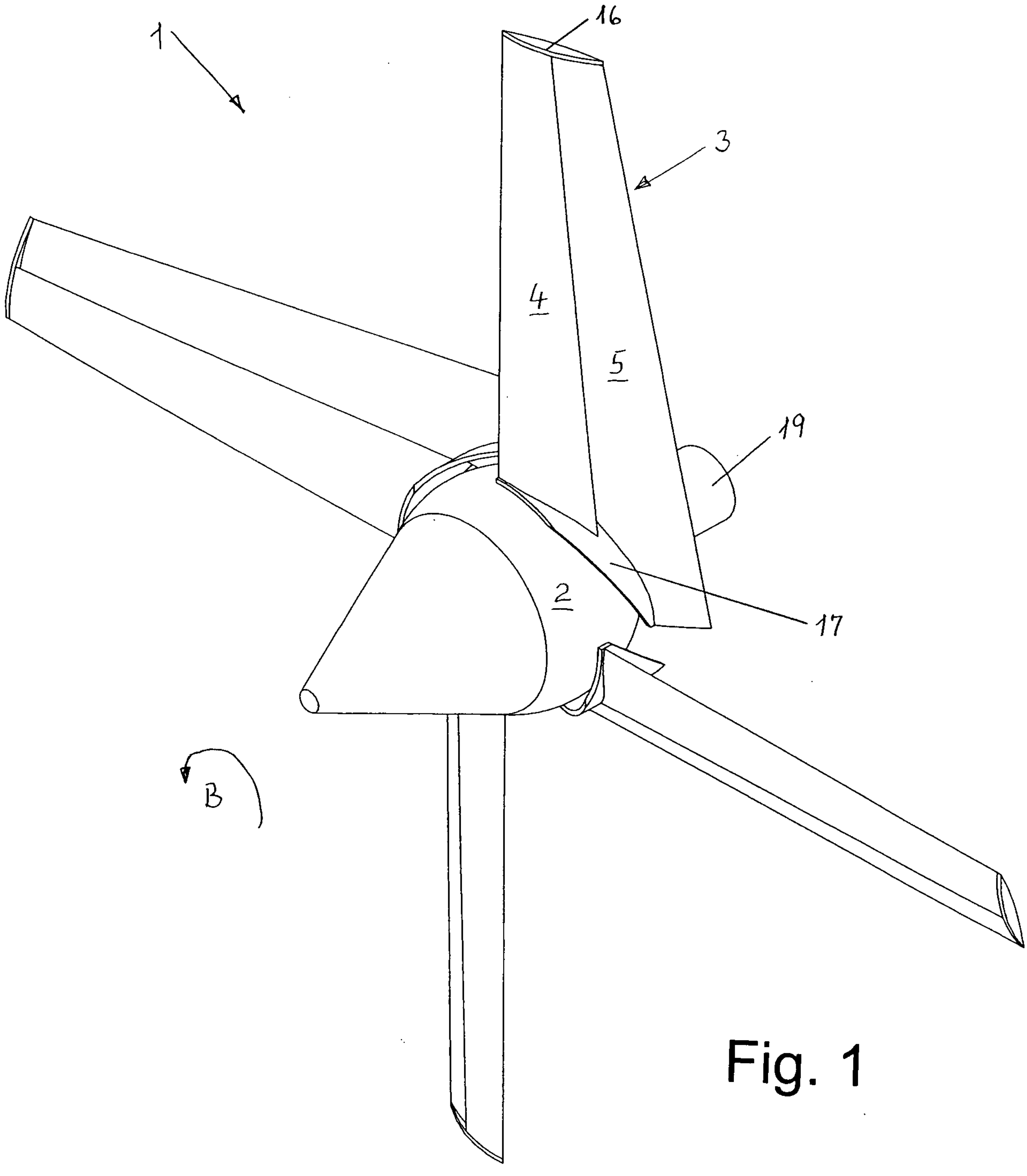



Fig. 1

Fig. 2

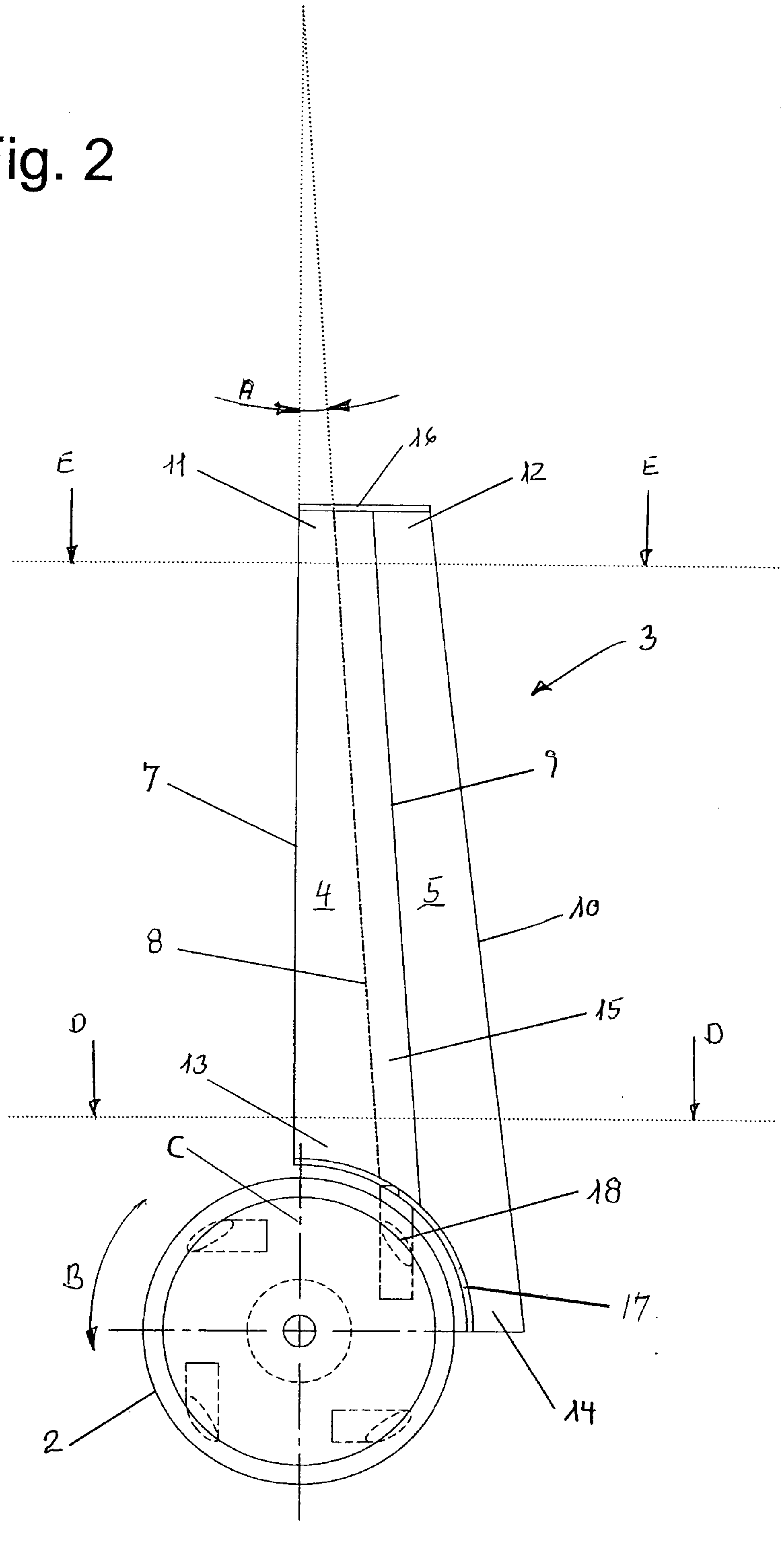
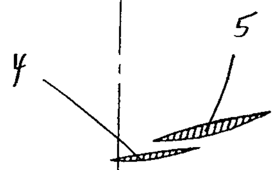


Fig. 4



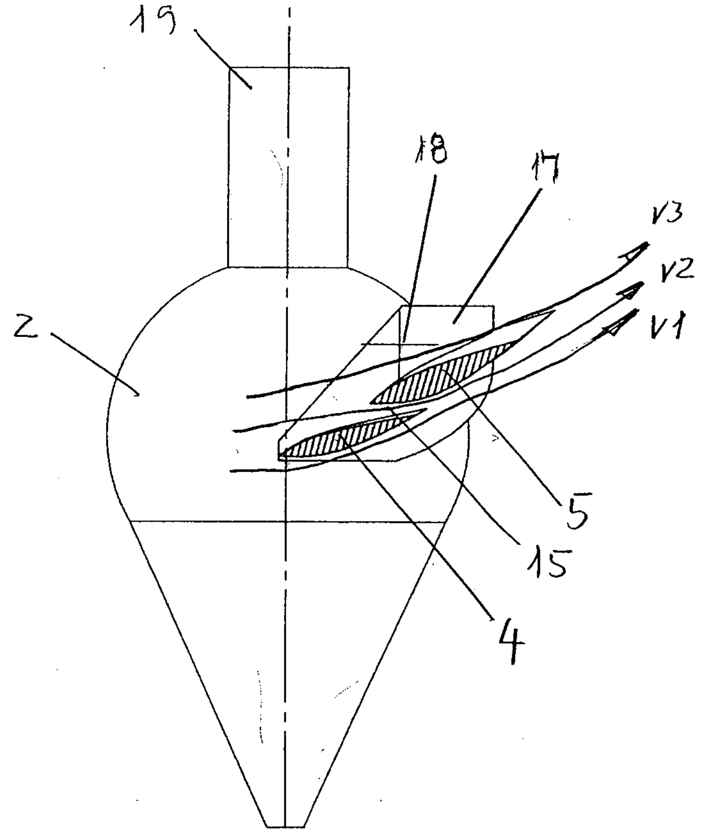




Fig. 3

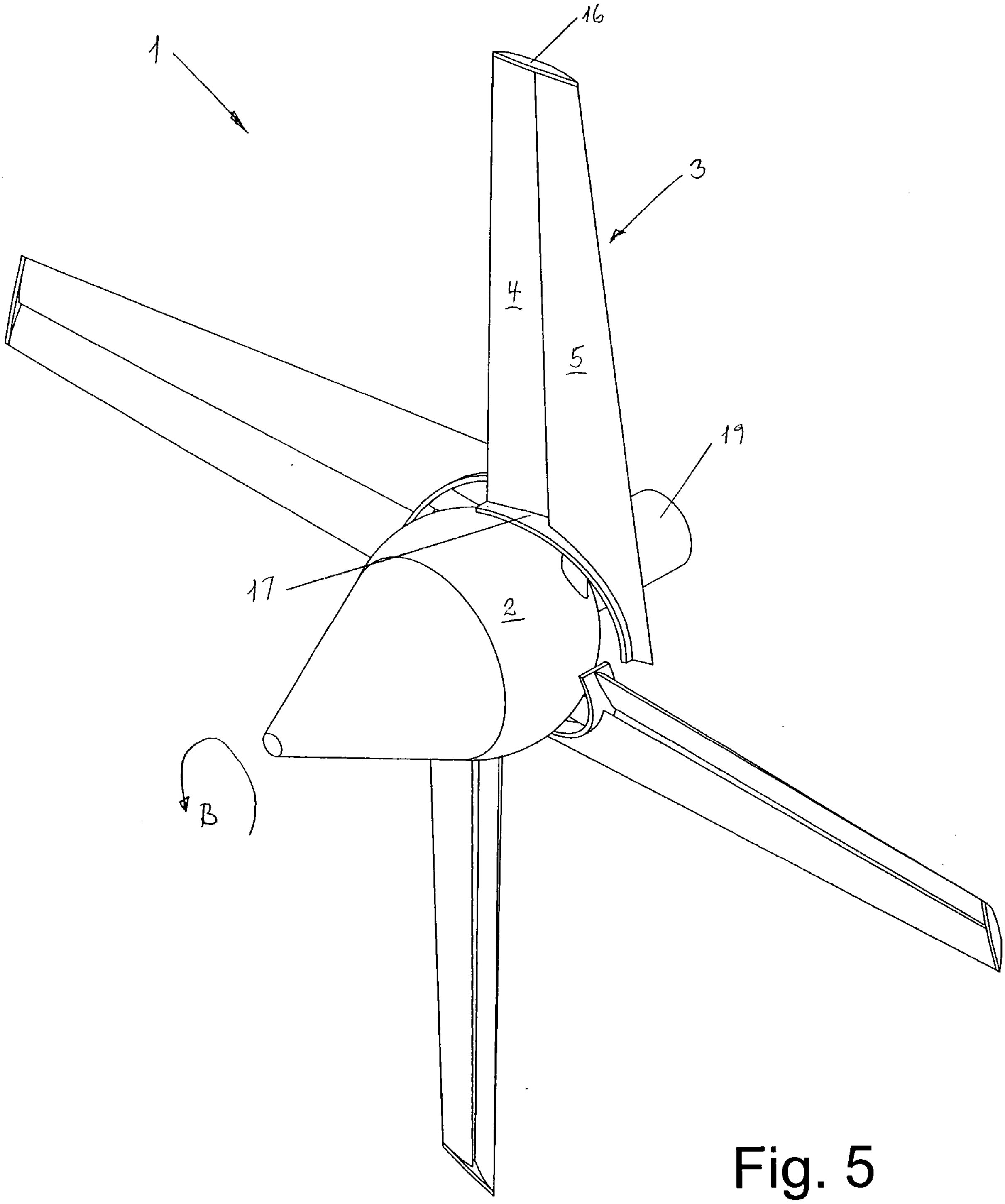
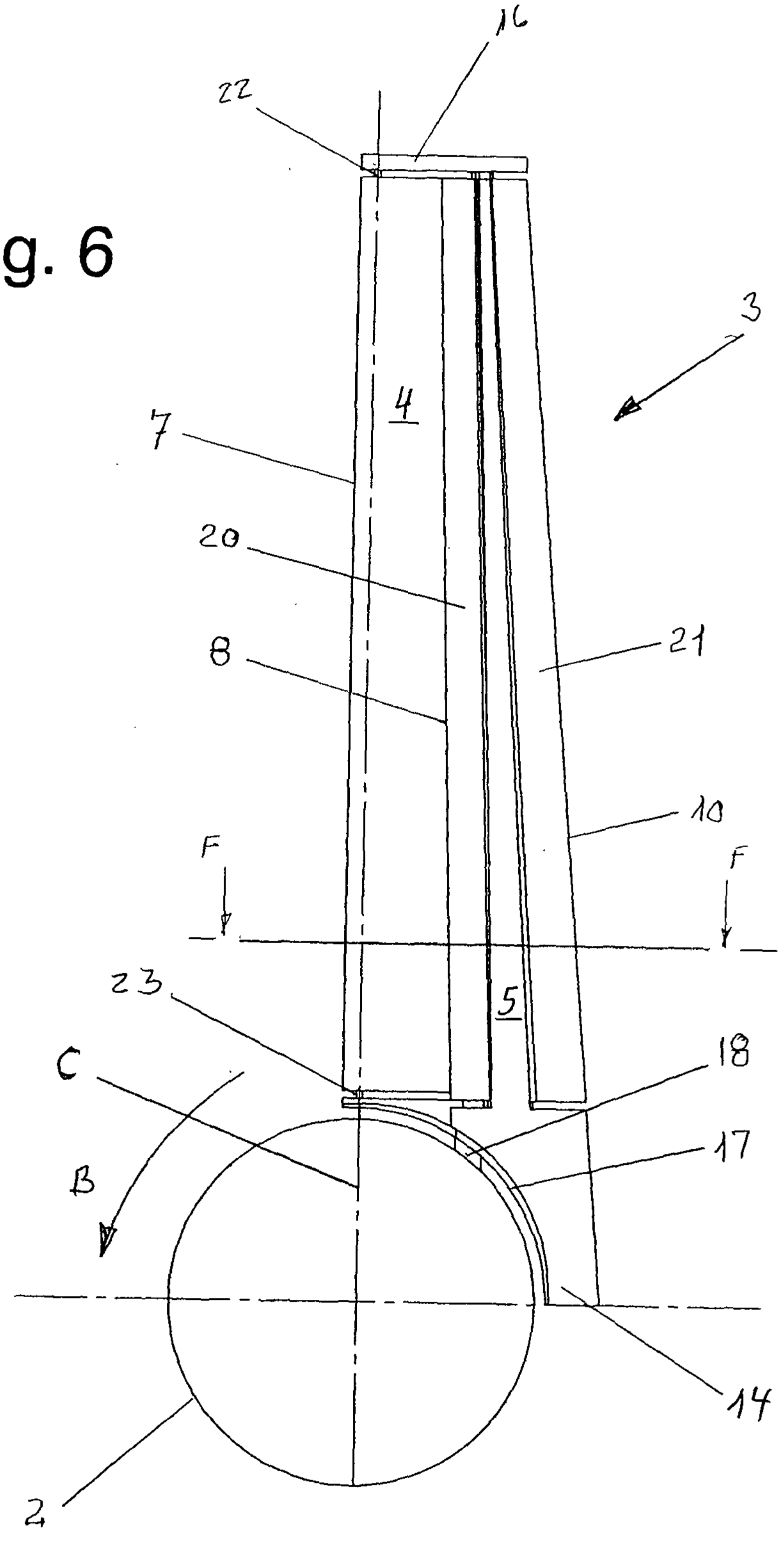



Fig. 5

Fig. 6



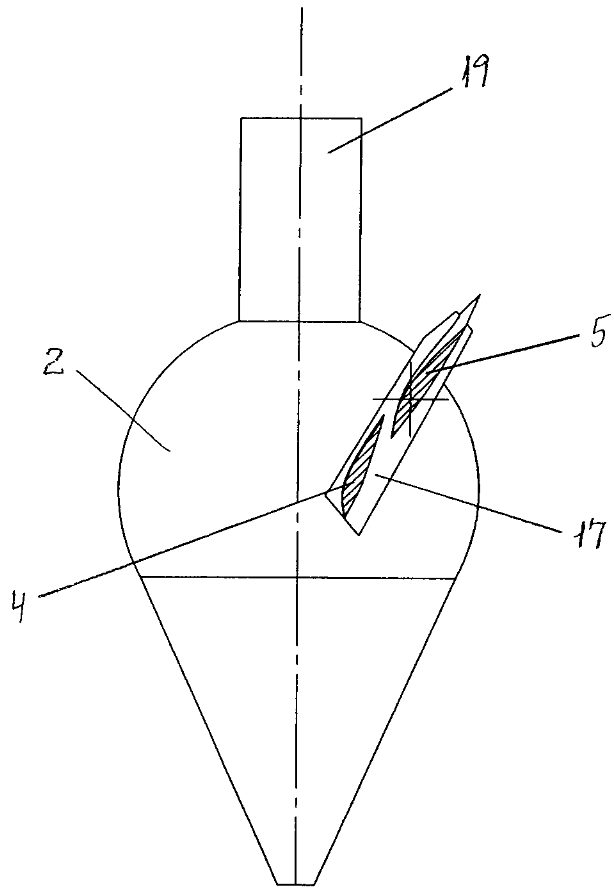



Fig. 7

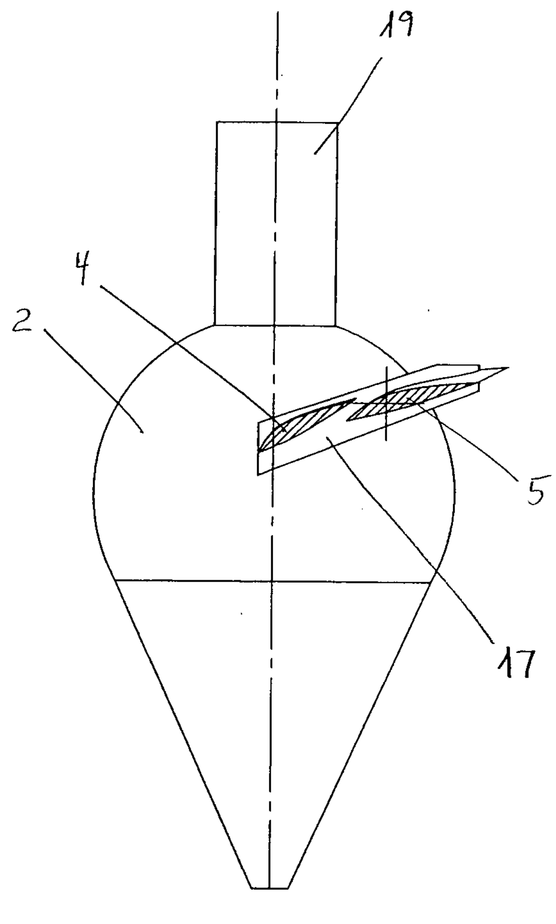



Fig. 8