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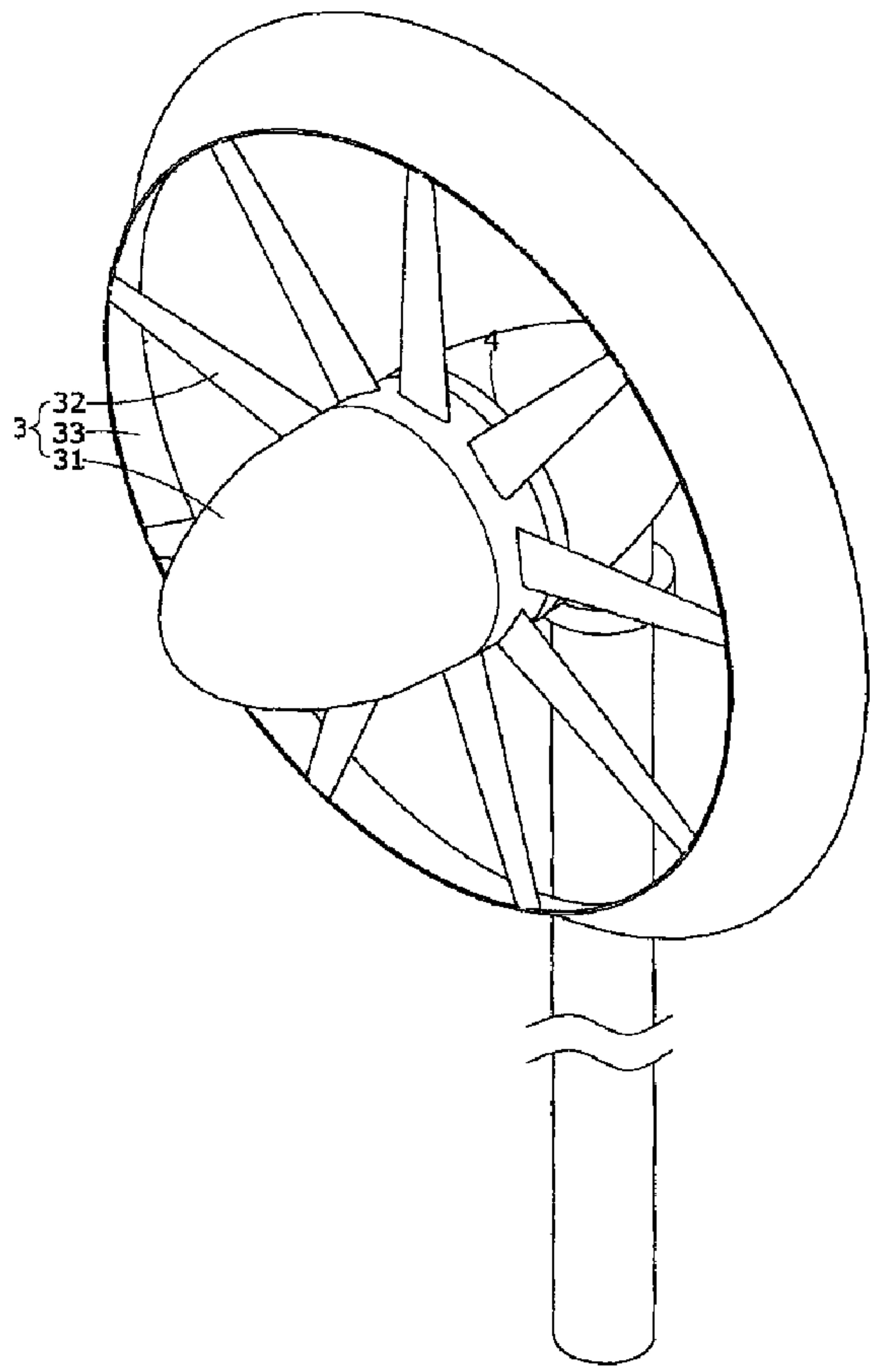
(54) Titre : STRUCTURE ROTORIQUE D'EOLIENNE
(54) Title: ROTOR STRUCTURE OF WIND TURBINE



(57) Abrégé/Abstract:
A rotor structure is provided for a wind turbine and includes a central hub from which a plurality of blades radially extends. The blades have distal free ends that are surrounded by and coupled to a circumferentially arranged hood for rotation therewith. As

(57) Abrégé(suite)/Abstract(continued):
such, with the rotor mounted to a generator of the wind turbine, when air flows caused by winds get into wind facing surfaces of the blades, the air flows are accelerated by either a divergent configuration, a convergent configuration, or a convergent-divergent configuration of the hood to remarkably enhance the performance of wind power generation and reduce the overall size of the rotor of the wind turbine.

ABSTRACT OF THE DISCLOSURE

A rotor structure is provided for a wind turbine and includes a central hub from which a plurality of blades radially extends. The blades have distal free ends that are surrounded by and coupled to a circumferentially arranged hood for rotation therewith. As such, with the rotor mounted to a generator of the wind turbine, when air flows caused by winds get into wind facing surfaces of the blades, the air flows are accelerated by either a divergent configuration, a convergent configuration, or a convergent-divergent configuration of the hood to remarkably enhance the performance of wind power generation and reduce the overall size of the rotor of the wind turbine.

TITLE: ROTOR STRUCTURE OF WIND TURBINE

(a) Technical Field of the Invention

The present invention generally relates to wind power generation techniques, and particularly to a rotor for application in wind turbines.

(b) Description of the Prior Art

Recently, with the increased price fluctuation of fossil fuels, a crisis of energy rises. Scientists of all the countries of the world are seeking for energy substitutes (green energy), such as solar energy, wind energy, tidal energy, and even bio-energy, in order to meet the needs of energy consumption of human beings by generation of electrical power with theses sustainable energy provided by the Nature and to achieve the goal of carbon reduction and energy saving. Taking wind energy as an example, the development of the wind energy based power generation has started since the first wind turbine built up by Danish meteorologist Poul La Cour in the 19th century. The wind energy is a non-exhaustible, non-polluting, and self-generated energy and has a wide distribution over the whole world so that it can be various local needs of power supply, reduces power loss due to long distance transmission, and lowers down the costs of power supplying.

Wind power generation uses wind energy to drive the rotation of a rotor for conversion the wind energy into electrical power. Thus, aerodynamic performance (such as shape and number of blades) is critical to the output efficiency of the wind power generation. There are lots of inventions related to the wind power generation, such as US Patent No. 7, 094,018 B2, Taiwan Utility Model Publication No. M279736, Design No. D119380, and US Patent No. 4,075,500.

As shown in FIG. 1 of the attached drawings, a conventional rotor 1 comprises a central hub 11 from which a plurality of blades 12 radially extends. The rotor illustrated in the drawing is of a type having nine blades 12. The central hub 11 is coupled to a drive shaft of a generator 2. However, as shown in FIG. 2, when this type of known rotor 1 is put in operation, air flows caused by winds to move through the rotor 1 are broken by ends of the blades 12, leading to generation of noise and turbulences. The turbulences may cause expansion of the air flows, decelerating the air flow and thus reducing the rotational speed of the rotor 1 and eventually affecting the performance of wind power generation.

SUMMARY OF THE INVENTION

Thus, an objective of an aspect of the present invention is to provide a rotor structure of a wind turbine, which increases the speed of the air flow passing the rotor so as to improve performance of power generation.

Another objective of an aspect of the present invention is to provide a rotor structure of a wind turbine that reduces noise.

A further objective of an aspect of the present invention is to provide a rotor structure of a wind turbine that offers greater flexibility of design.

A rotor structure of a wind turbine in accordance with the present invention comprises: a central hub; a connection ring being concentrically arranged outside the central hub, a first plurality of blades being set between the central hub and the connection ring, first ends of the first plurality of blades being attached to the central hub, second ends of the first plurality of blades being attached to the connection ring; and a hood having a first circumferential edge portion and a second circumferential edge portion, an extension section being formed and extending between the first circumferential edge portion and the second circumferential edge portion, the first circumferential edge portion having a diameter that is less than a diameter of the second circumferential edge portion, a second plurality of blades being set between the connection ring and the hood, first ends of the second plurality of blades being attached to the connection ring, second ends of the second plurality of blades being attached to the first circumferential edge portion, when the rotor being mounted to the wind turbine for operation, the hood and the connection ring rotate with the first or the second plurality of blades. This causes the air flows effect acceleration to thereby improve performance of wind power generation.

When the first plurality of blades, the connection ring and the second of plurality blades rotate with the hood, due to the existence of the hood, noise caused by breaking air flows may not occur. Further, the central hub of the rotor may be provided with a concentrically arranged connection ring to offer flexible increase of the number of blades between the central hub and the hood so as to increase the rotational torque of the rotor and also provide the effect of accelerating the rotation of the rotor. Comparison between the rotor of the present invention and the conventional rotor that is done by coupling theses rotors to generators that are of identical performance of power generation reveals that the size and the area of wind facing surface of the rotor of the present invention are far less than those of the conventional rotors. Thus, the present invention also offers the advantage of reducing the size of rotor.

The foregoing objective and summary provide only a brief introduction to the present invention. To fully appreciate these and other objects of the present invention as well as the invention itself, all of which will become apparent to those skilled in the art, the following detailed description of the invention and the claims should be read in conjunction with the accompanying drawings. Throughout the specification and drawings identical reference numerals refer to identical or similar parts.

Many other advantages and features of the present invention will become manifest to those versed in the art upon making reference to the detailed description and the accompanying sheets of drawings in which a preferred structural embodiment incorporating the principles of the present invention is shown by way of illustrative example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a conventional rotor.

FIG. 2 is a cross-sectional view illustrating the operation of the conventional rotor.

FIG. 3A is a perspective view of a divergent configuration rotor of a wind turbine without a connection ring, the divergent configuration rotor comprising a hood attached to a plurality of blades.

FIG. 3B is a cross-sectional view of the divergent configuration rotor of the wind turbine without the connection ring, the divergent configuration rotor comprising the hood attached to a plurality of blades.

FIG. 3C is a cross-sectional view showing another type of the divergent configuration rotor of the wind turbine without a the connection ring, the divergent configuration rotor comprising the hood attached to the plurality of blades.

FIG. 4 schematically illustrates the principle of the flow of fluid.

FIG. 5A is a perspective view of a convergent configuration rotor of a wind turbine without a connection ring, the convergent configuration rotor comprising a hood attached to a plurality of blades.

FIG. 5B is a cross-sectional view of the convergent configuration rotor of the wind turbine without the connection ring, the convergent configuration rotor comprising the hood attached to the plurality of blades.

FIG. 5C is a cross-sectional view showing another type of the convergent configuration rotor of the wind turbine without the connection ring, the convergent configuration rotor comprising the hood attached to the plurality of blades.

FIG. 6A is a perspective view of a rotor embodiment of the present invention.

FIG. 6B is a cross-sectional view of the rotor embodiment of the present invention.

FIG. 7 shows torque-rotational speed curves for various rotors.

FIG. 8 shows performance-rotational speed curves for various rotors.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following descriptions are exemplary embodiments only, and are not intended to limit the scope, applicability or configuration of the invention in any way. Rather, the following description provides a convenient illustration for implementing exemplary embodiments of the invention. Various changes to the described embodiments may be made in the function and arrangement of the elements described without departing from the scope of the invention as set forth in the appended claims.

With reference to FIGS. 3A-3C and FIG. 4, a rotor constructed in accordance with the present invention generally designated with reference numeral 3 comprises a central hub 31 from which a plurality of blades 32 radially extends. The blades 32 have distal free ends that are surrounded by and coupled to a circumferentially arranged horn-like hood 33. The hood 33 has a first circumferential edge portion 331 and a second circumferential edge portion 332 and an extension section 333 formed and extending between the first circumferential edge portion 331 and the second circumferential edge portion 332. The first circumferential edge portion 331 has a diameter that is smaller than a diameter of the second circumferential edge portion 332 so that the extension section 333 of the hood 33 exhibits a divergent configuration. The distal end of each blade 32 is connected to an inner surface of the first circumferential edge portion 331 and each blade 32 has a wind facing surface that is in a direction opposite to the extension section 333 of the hood 33. Further, the extension section 333 of the hood 33 can be of an outward-deflected curved configuration (as shown in FIGS. 3A and 3B) or a straight configuration that inclines outward (as shown in FIG. 3C).

The central hub 31 of the rotor 3 is fit to a drive shaft of a generator 4, and when winds cause air flows to enter through the wind facing surfaces of the blade 32, making the blade 32 rotating, the power generated by the generator 4 can be calculated with the following equation:

$$P = \frac{1}{2}\rho A V^3$$

where P is the power generated, ρ indicates air density, A represents a cross-sectional area of the rotor, and V is the speed of the air flow. It is apparent from the equation that since the air density can be considered fixed and is regarded as a constant, to change the power generated, a feasible way is to change the cross-sectional area of the rotor, or to change the speed of air flow, between which changing the speed of the airflow is of more remarkable results.

Also referring to FIG. 4, a circular opening 51 is formed in a bottom of a container 5 that is full of liquid. The circular opening 51 has a cross-sectional area of A_1 and the speed of the liquid flow in the circular opening 51 is V_1. By adding a horn-like hood 52 that diverges outwards under the circular opening 51, with the cross-sectional area of the horn-like hood 52 being A_2 and the speed that the liquid flows outward being V_2, in accordance with fluid dynamics, $A_1V_1=A_2V_2$, it is evident that when the liquid flows through the outward-divergent horn-like hood 52, expansion of the liquid is induced (namely, $A_2>A_1$). Although the speed of outward flow V_2 is reduced (namely V_1 being greater than V_2), yet acceleration of the liquid results when the liquid enters the hood 52. Based on the same principle, the hood 52 in accordance with the present invention is designed on the basis of the effect of expansion to accelerate the speed of air flow and thus improve the performance of power generation. For example, increasing the flow speed to 1.1 times make an increase of power generated by 1.1^3 times, namely .133 times of power generated.

On the other hand, the power generation performance is conventionally increased by increasing area, which makes the original size increased to 1.33 times to provide the same power generation performance. This makes the conventional techniques facing problems associated with machining precision in the manufacturing thereof, as well as drawbacks associated with wastes in the respects of manufacturing and material costs. In addition, in use, due to the increase of the size of the rotor 3, additional limitation is imposed to the installation thereof, making it difficult to get popular. Taking a generator 4 having the same power generation capacity as an example, since the speed of the incoming air flow can be made higher (see FIG. 3B), when compared to the conventional rotor 1 (see FIG. 1) having a fixed air flow speed, the cross-sectional area (in other words, reducing the overall size) can be reduced. Further, when the hood 33 is put in rotation, since no breaking of air flow occurs, the noise induced by the operation thereof can be reduced.

As shown in FIGS. 5A, 5B and 5C, in another embodiment, the distal ends of the blades 62 that are mounted to the central hub 61 of the rotor 6 are similarly surrounded by and coupled to a horn-like hood 63 and the hood 63 has a first circumferential edge portion 631 and a second circumferential edge portion 632 with an extension section 633 similarly formed and extending between the first circumferential edge portion 631 and the second circumferential edge portion 632. The first circumferential edge portion 631 has a diameter that is greater than that of the second circumferential edge portion 632 so that the extension section 633 exhibits a convergent configuration. The distal end of each blade 62 is connected to an inner surface of the second circumferential edge portion 632 and each blade 62 has a wind facing surface that is in the same direction as the extension section of the hood 63. Further, the extension section 633 of the hood 63 is of an outward-deflected curved configuration (as shown in FIGS. 5A and 5B) or a straight configuration that inclines outward (as shown in FIG. 5C).

As shown in FIGS. 5B and 5C, when winds cause air flows to enter through the wind facing side of the rotor 6, the air flows first contact the convergent configuration of the curved or straight hood 63 (namely the side corresponding to the first circumferential edge portion 631), making the air flows moving toward the side corresponding to the second circumferential edge portion 632 and thus concentrated centrally with increased flow speed, whereby the force that acts on and drives the blades is increased and the power generation performance is improved.

As objectives and advantages noted above, a perspective view and a cross section view of an embodiment of the present invention are shown in FIGS. 6A and 6B. The present invention discloses a rotor of a wind turbine, comprising : a central hub 81; a connection ring 83; a hood 84 and a plurality of blades 82, and the plurality of blades 82 comprise a first plurality of blades 820 and a second plurality of blades 822. The connection ring 83 is concentrically arranged outside the central hub 81. Further, the first plurality of blades 820 are set between the central hub 81 and the connection ring 83, first ends of the first plurality of blades 820 are attached to the central hub 81, and second ends of the first plurality of blades 820 are attached to the connection ring 83. The hood 84 has a first circumferential edge portion 841 and a second circumferential edge portion 842; an extension section 843 is formed and extending between the first circumferential edge portion 841and the second circumferential edge portion 842; the first circumferential edge portion 841 having a diameter that is less than a diameter of the second circumferential edge portion 842, the second plurality of blades 822 are set between the connection ring 83 and the hood 84, first ends of the second plurality of blades 822 are attached to the connection ring 83, second ends of the second plurality of blades 822 are attached to the first circumferential edge portion 841, when the rotor 8 is mounted to the wind turbine for operation, the hood 84 and the connection ring 83 rotate with the first or the second plurality of blades 820, 822. The first plurality of blades 820 has a number less than a number the second plurality of blades 822. The second plurality of blades 822 between the connection ring 83 and the hood 84 are used to increase the rotational torque of rotor 8 without affecting incoming air flow rate (or also referred to as thickness) so as to increase the rotational speed of the rotor 8 and improve power generation performance. Further, the configuration of the hood 84 can be any one of the hoods 33, 63, such as the divergent hood 33, the convenient hood 63, and the hood 84 is attached to the seconds of the second plurality of blades 82 to also effect increase of air flow speed and improvement of power generation performance.

Furthermore, the extension section 843 of the hood 84 could be an outward-deflected curved configuration or an outward-inclined straight configuration. When winds cause air flows to enter through the wind facing side of the rotor 8, the air flows first contact the convergent configuration of the curved or straight hood 84 (namely the side corresponding to the first circumferential edge portion 841), making the air flows moving toward the side corresponding to the second circumferential edge portion 842 and thus concentrated centrally with increased flow speed, whereby the force that acts on and drives the plurality of blades 82 is increased and the power generation performance is improved.

Also referring to FIGS. 7 and 8, the present inventor has taken records of the operations of the conventional rotor, the divergent rotor, and the present invention multi-stage-blade rotor and comparison is made for the torque-rotational speed relationship and the performance-rotational speed relationship to evidence the difference between the present invention and the conventional techniques and the improved performance realized by the present invention.

As shown in FIG 7, L_1 indicates the torque-rotational speed curve of the conventional rotor, L_2 is the torque-rotational speed curve of the divergent rotor, and L_3 is the torque-rotational speed curve of the multi-stage-blade rotor, for there is a corresponding relationship between the torque and the angular momentum that drives the rotation of the rotor. When the rotational speed is zero (0), the torque generated is referred to as the brake torque (the higher the better). Comparison of theses curves indicates that the curve having a peak showing up earliest is Curve L_3 (the earlier the better), and then sequentially Curve L_2 and Curve L_1. It can be seen that the peak torque value of the present invention appears in a lower rotational speed and thus, a good angular momentum can be obtained early at a low rotational speed, resulting in excellent power generation performance.

Further, as shown in FIG 8, L_4 indicates a performance-rotational speed curve of the conventional rotor, L_5 is the performance-rotational speed curve of the divergent rotor, and L_6 is the performance-rotational speed curve of the multi-stage-blade rotor. The performance (CP) is calculated with the following equation:

$$CP = \frac{\tau \cdot \omega}{\frac{1}{2}\rho A V^3}$$

where τ indicates torque, ω is angular speed, P is power, ρ is air density, A is cross-sectional area of rotor, and V is speed of air flow.

In accordance with the above equation, the performance curve of each rotor can be calculated. The maximum performance of the conventional rotor for conversion of wind power into mechanical power is 0.593, which is set by Betz limit and the performance can be calculated by multiplying it with a power coefficient. As shown in the drawing, the performance provided by the present invention is higher than that of the conventional techniques. In other words, using the present invention to generate power has a higher performance.

To conclude, the present invention offers the following advantages:

(1) As shown in FIGS. 3A-3C, the divergent hood consisting in the present invention applies the effect of air flow expansion to increase the air flow speed at the wind facing surfaces of the blades to thereby improve the performance of power generation.

(2) As shown in FIGS. 5A, 5B and 5C, the convergent hood consisting in the present invention centrally concentrates the air flows so as to increase the air flow speed at the wind facing surface of the blades to thereby improve the performance of power generation.

(3) Further, a the various configurations of the hoods offered by the present invention rotate in synchronization with the blades so that breaking air flow does not occur and the noise induced in the operation can be reduced.

(4) Furthermore, the multi-stage-blade rotor of the present invention comprises at least one internally set connection ring and plurality blades are respectively between the connection ring and the hood and between the connection ring and the central hub, whereby without affecting incoming flow rate, the rotational torque of the rotor can be increased to effect acceleration of the rotation of the rotor, which also leads to improvement of the performance of power generation. Thus, as compared to the known techniques, the present invention is useful in meeting various needs for different applications and offers flexibility in design practice.

While certain novel features of this invention have been shown and described and are pointed out in the annexed claim, it is not intended to be limited to the details above, since it will be understood that various omissions, modifications, substitutions and changes in the forms and details of the device illustrated and in its operation can be made by those skilled in the art without departing in any way from the spirit of the present invention.

What is claimed is:

1. A rotor of a wind turbine comprising:

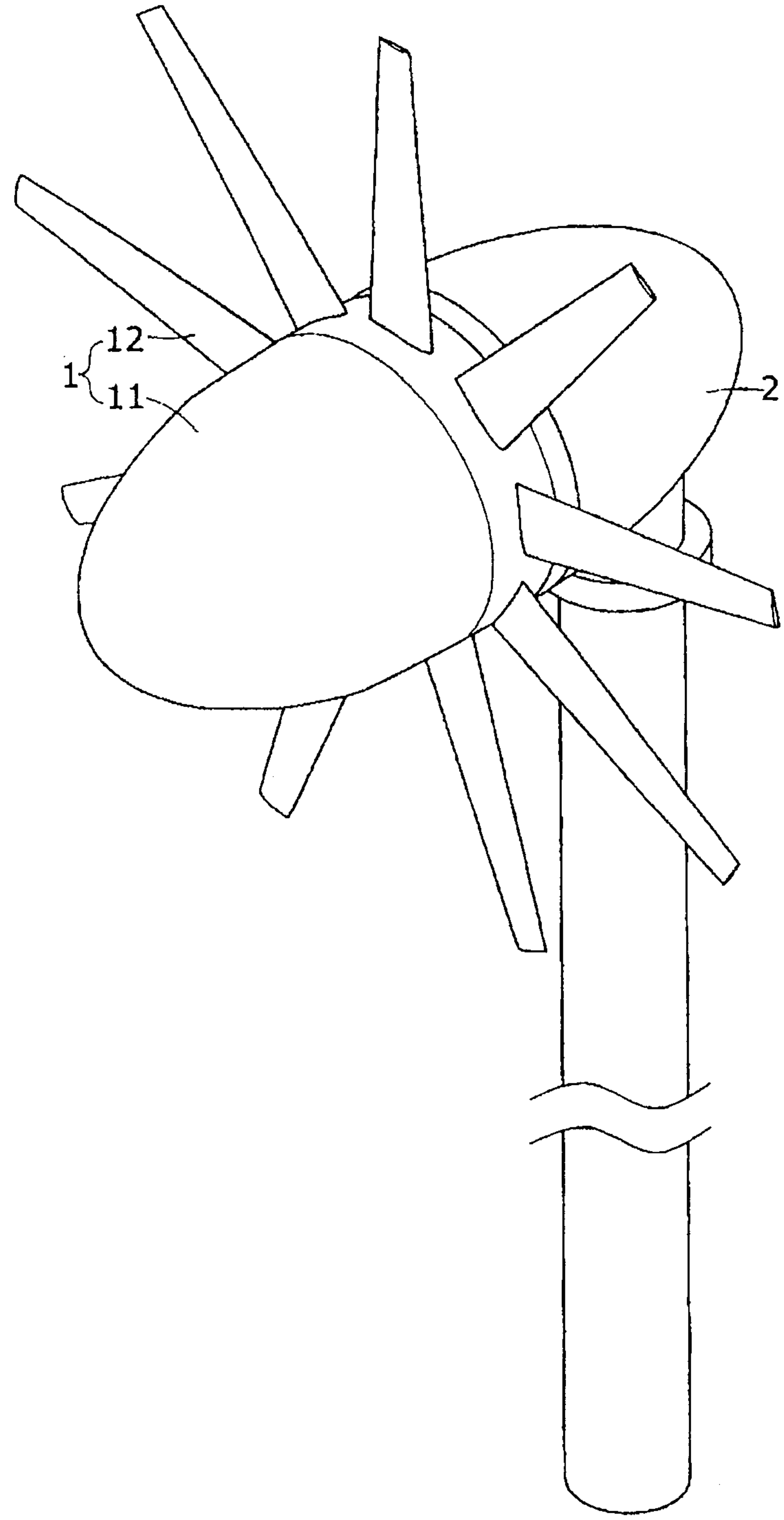
a central hub;

a connection ring being concentrically arranged outside the central hub, a first plurality of blades being set between the central hub and the connection ring, first ends of the first plurality of blades being attached to the central hub, second ends of the first plurality of blades being attached to the connection ring; and

a hood having a first circumferential edge portion and a second circumferential edge portion, an extension section being formed and extending between the first circumferential edge portion and the second circumferential edge portion, the first circumferential edge portion having a diameter that is less than a diameter of the second circumferential edge portion, a second plurality of blades being set between the connection ring and the hood, first ends of the second plurality of blades being attached to the connection ring, second ends of the second plurality of blades being attached to the first circumferential edge portion, when the rotor being mounted to the wind turbine for operation, the hood and the connection ring rotate with the first or the second plurality of blades.

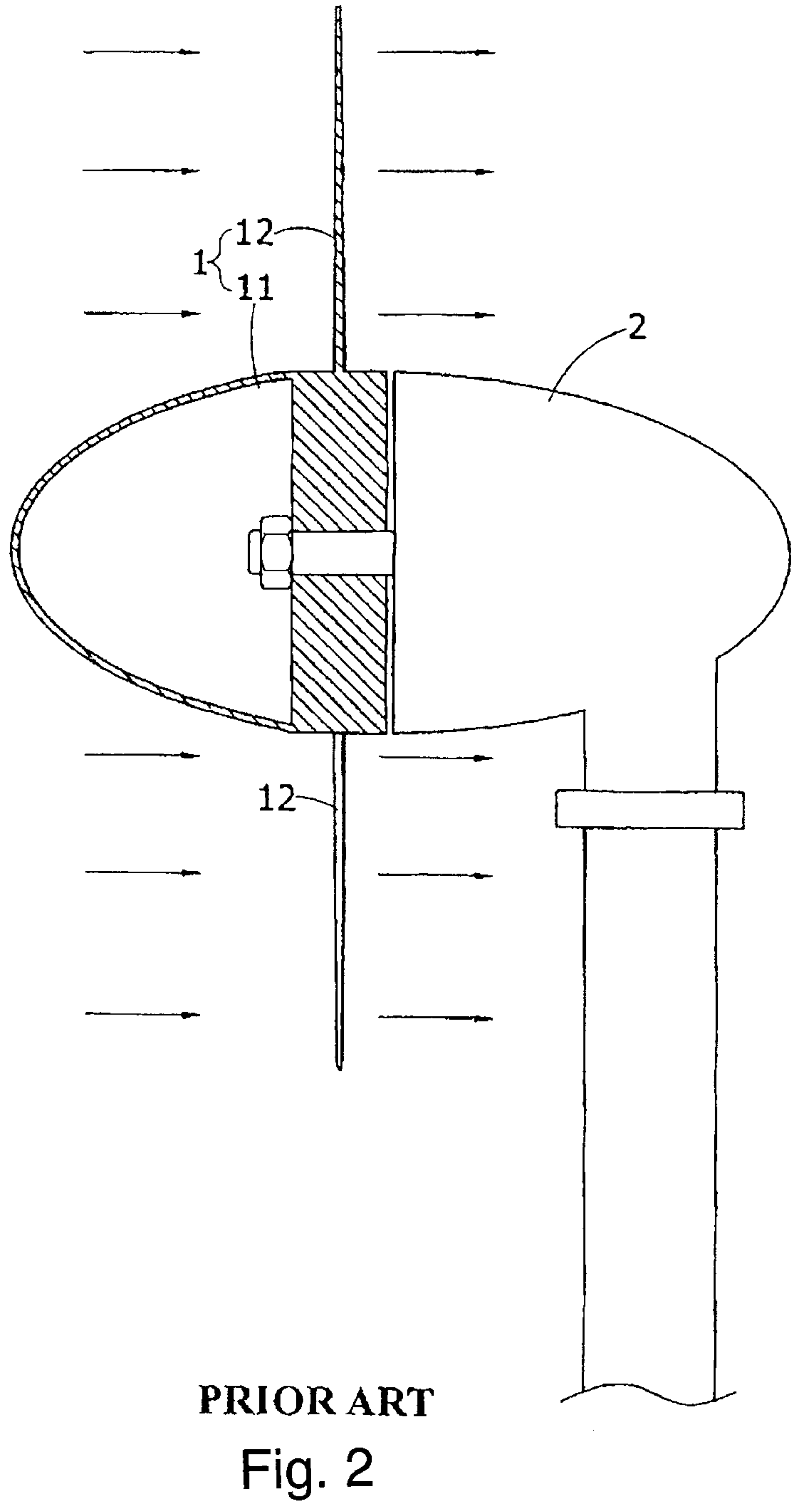
2. The rotor according to claim 1, wherein the first plurality of blades has a number less than a number of the second plurality of blades.

3. The rotor according to claim 2, wherein a transverse section of the extension section is of an outward-deflected curved or outward-inclined straight configuration.



PRIOR ART

Fig. 1



PRIOR ART

Fig. 2

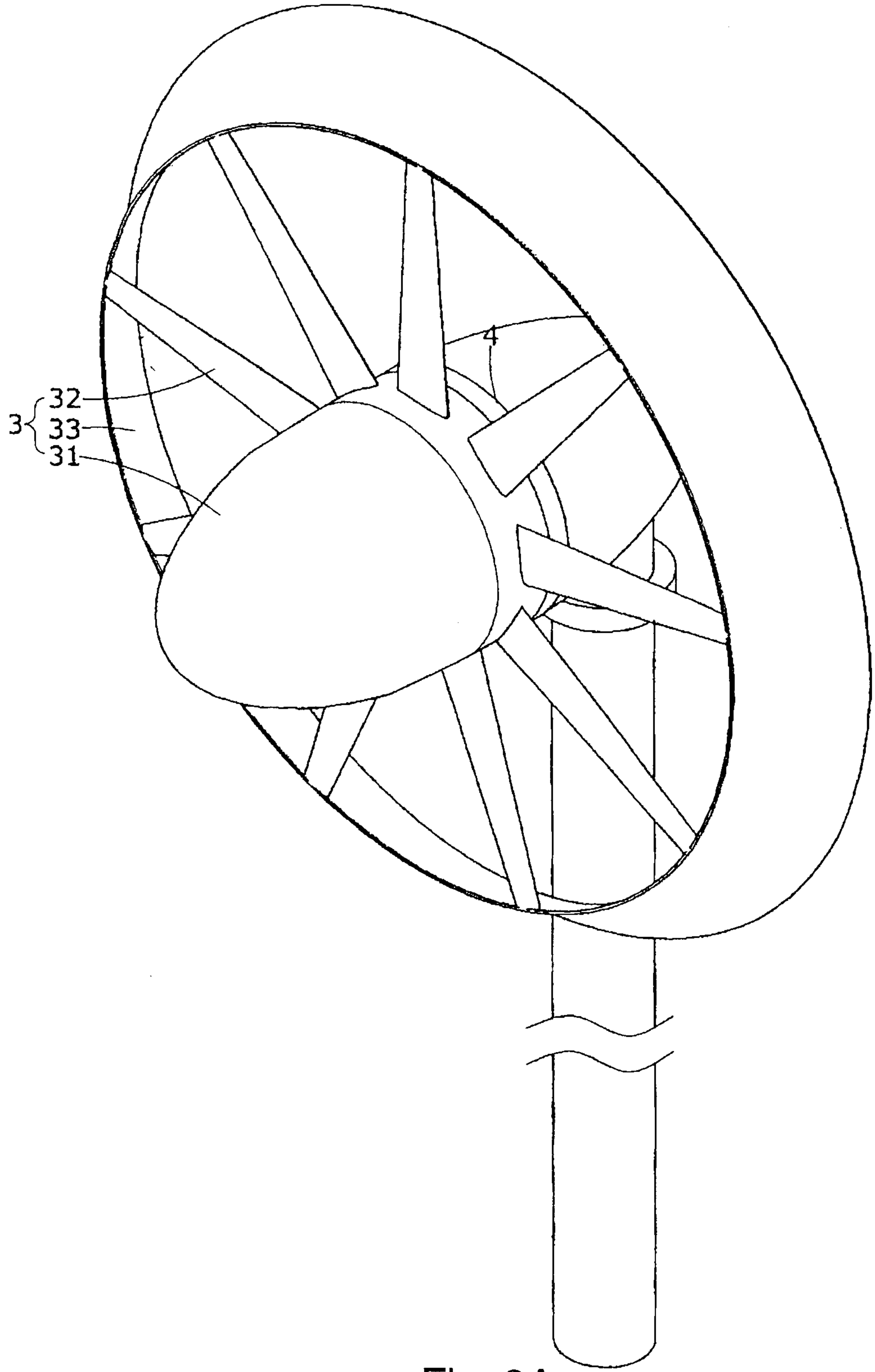


Fig. 3A

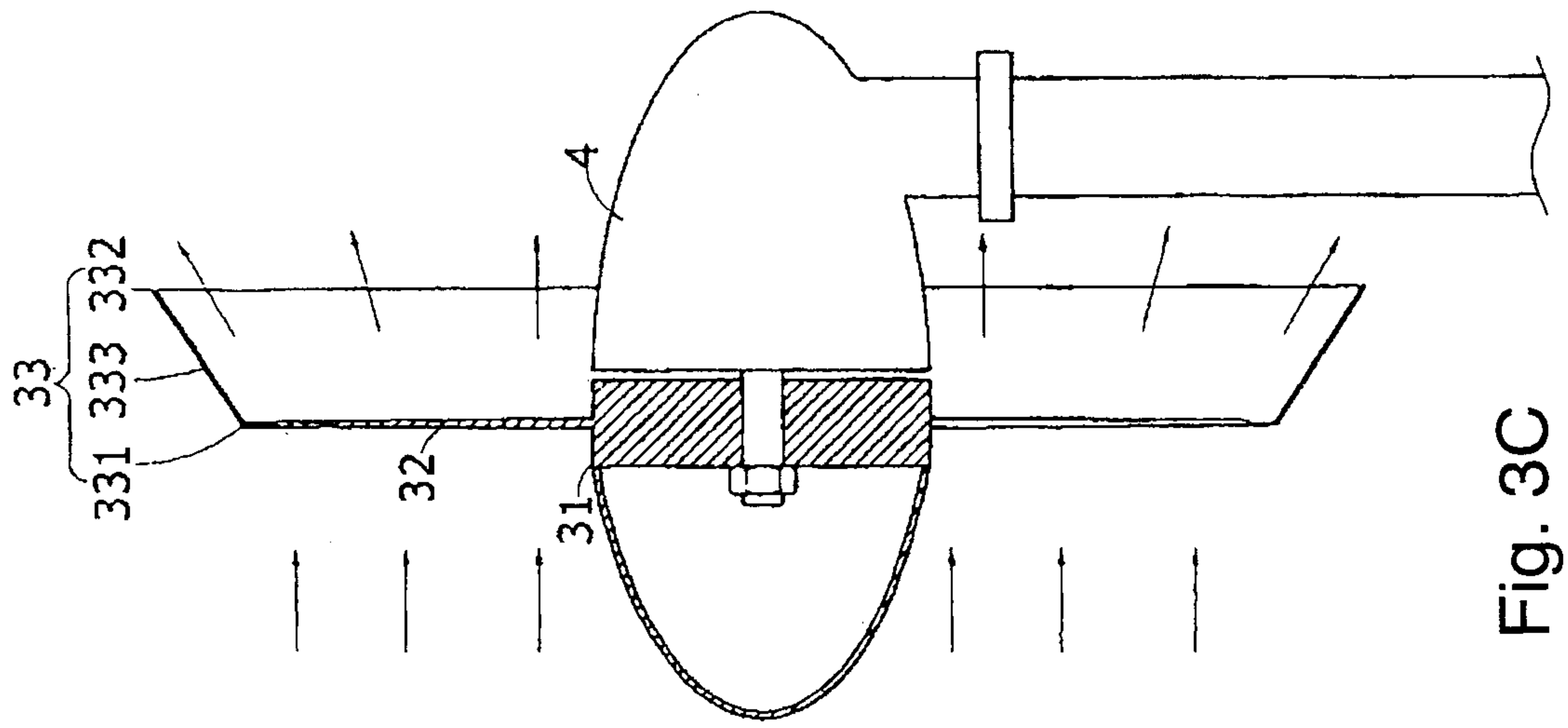


Fig. 3C

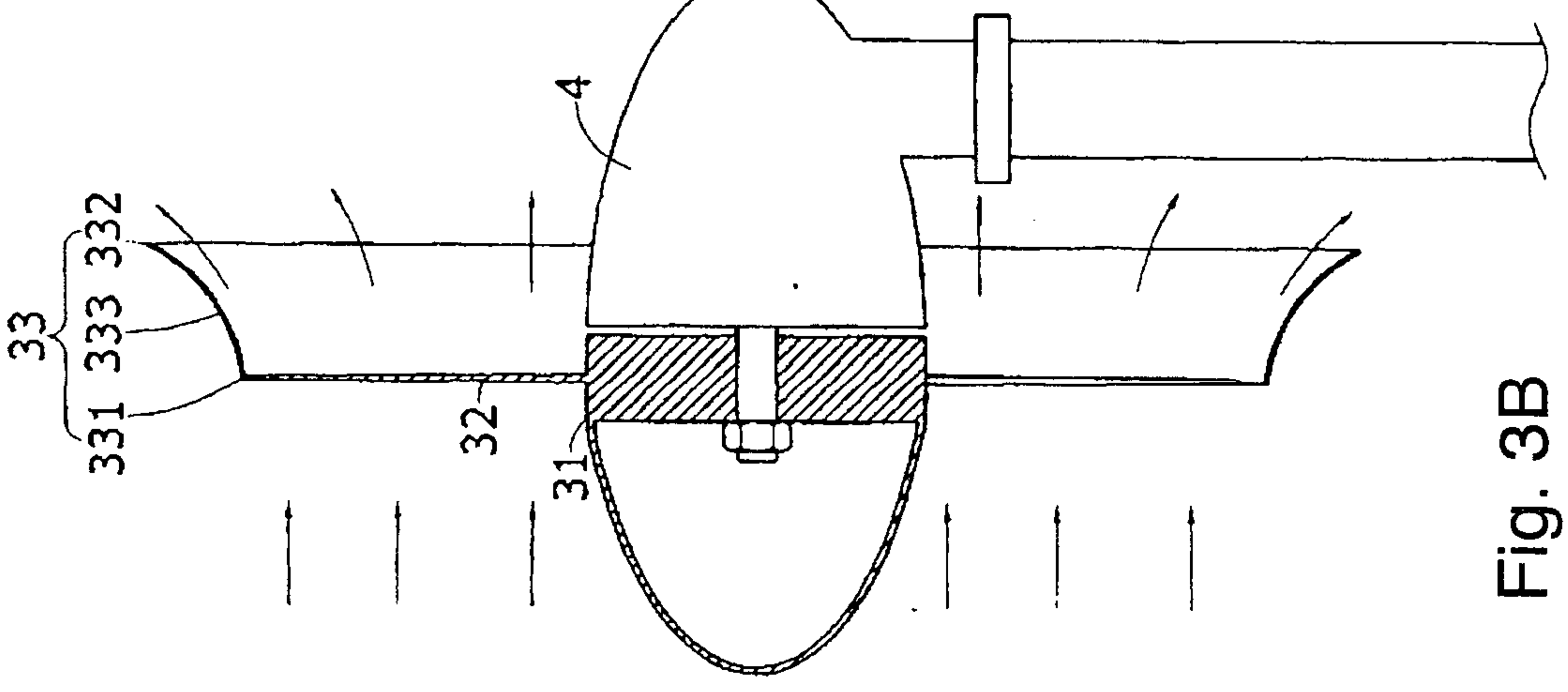


Fig. 3B

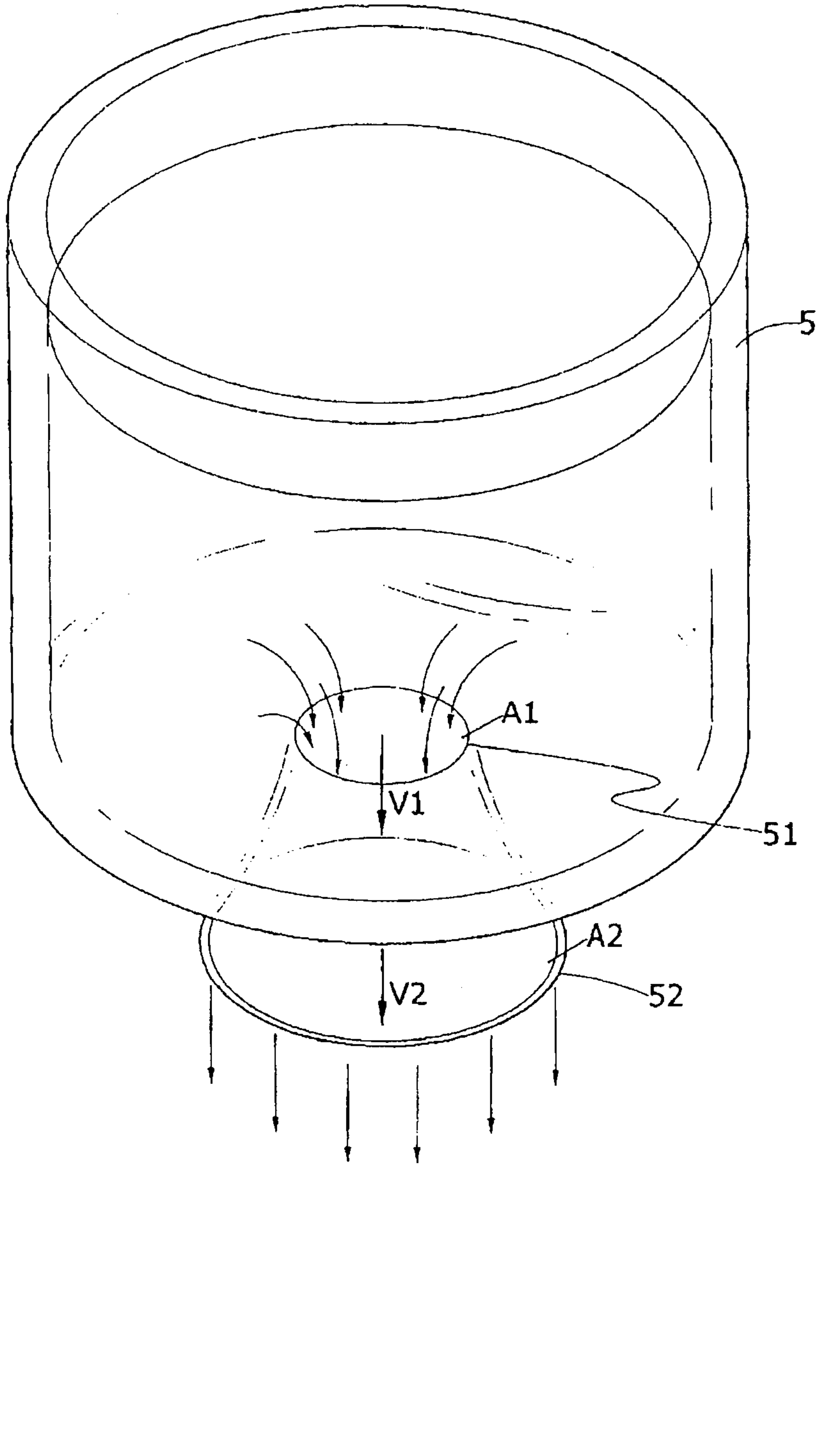


Fig. 4

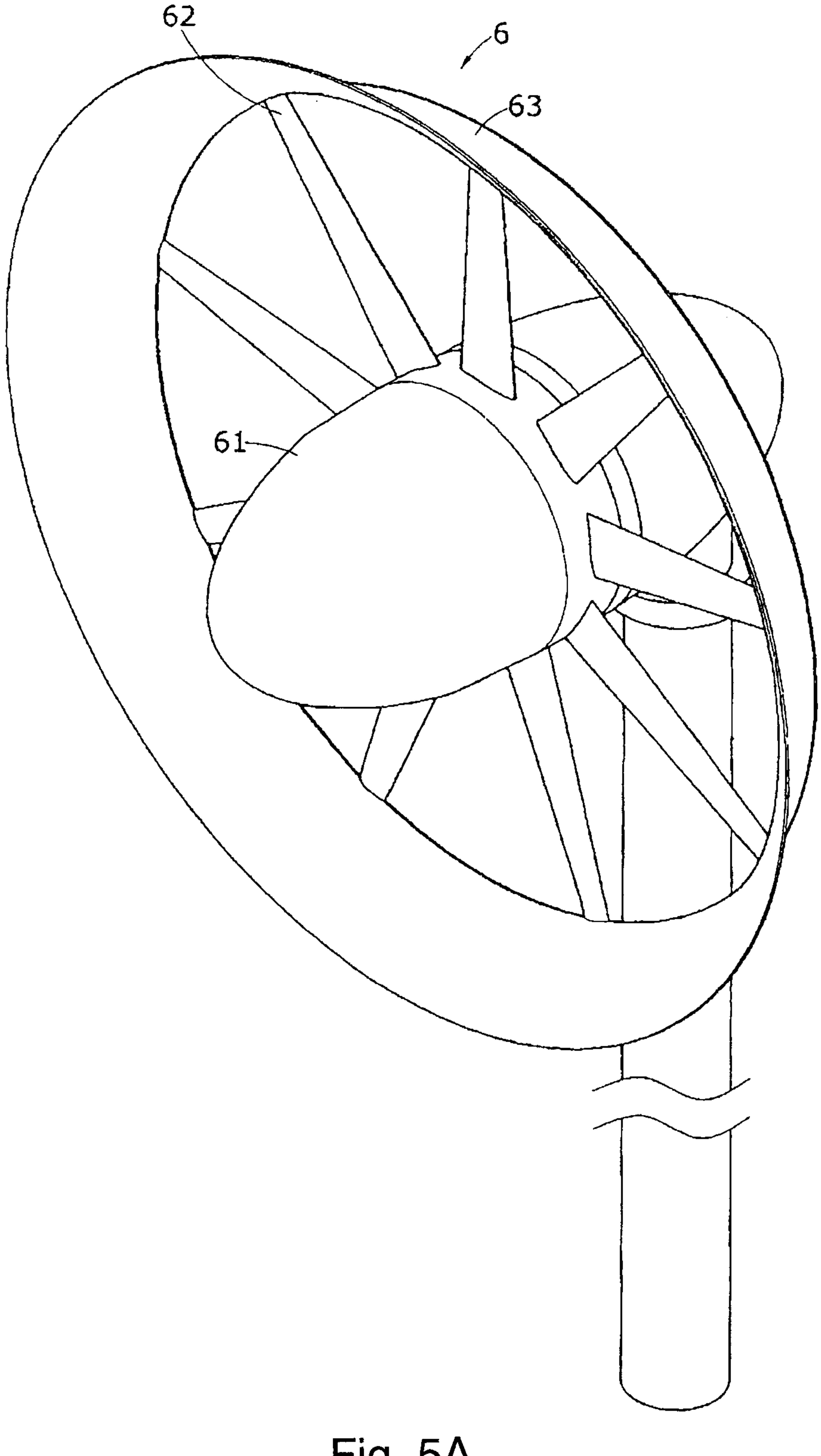


Fig. 5A

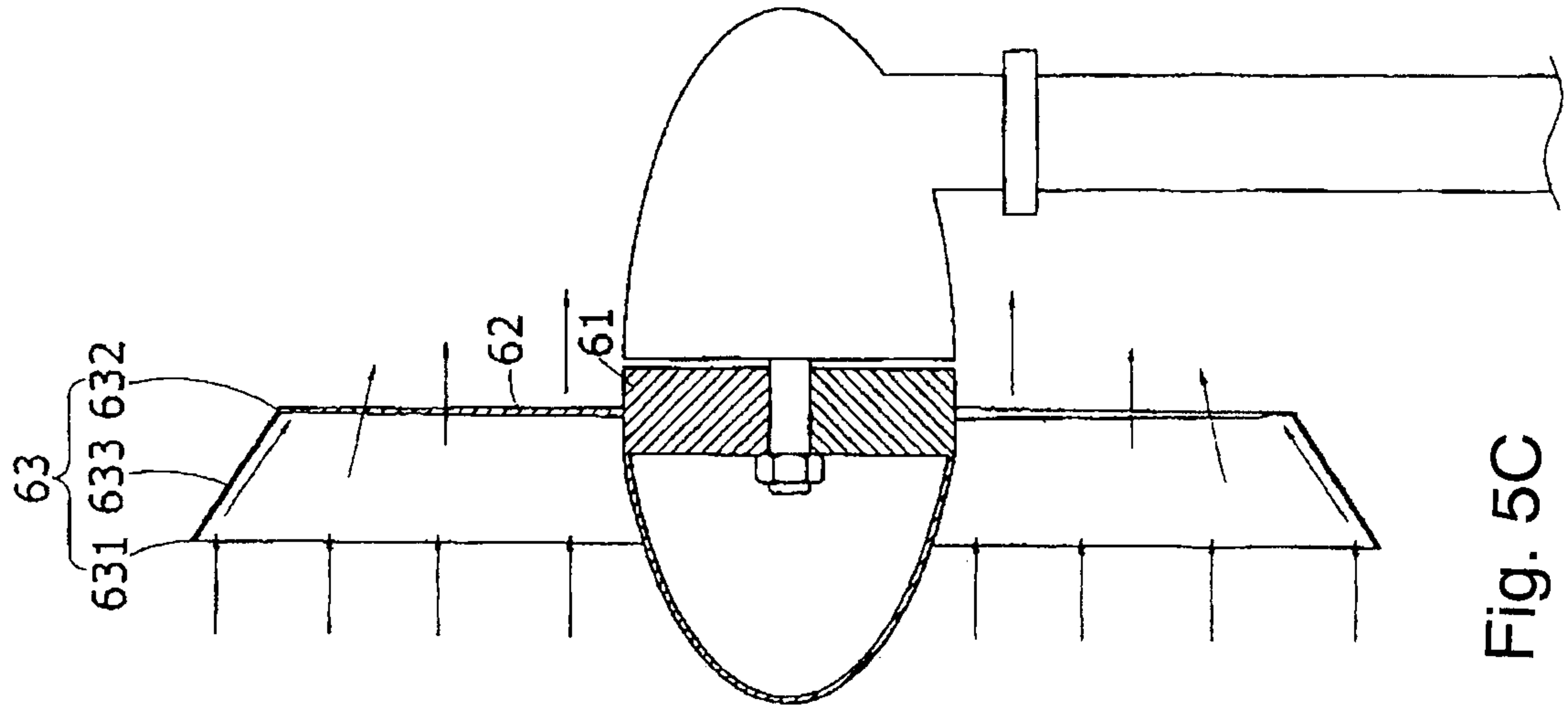


Fig. 5C

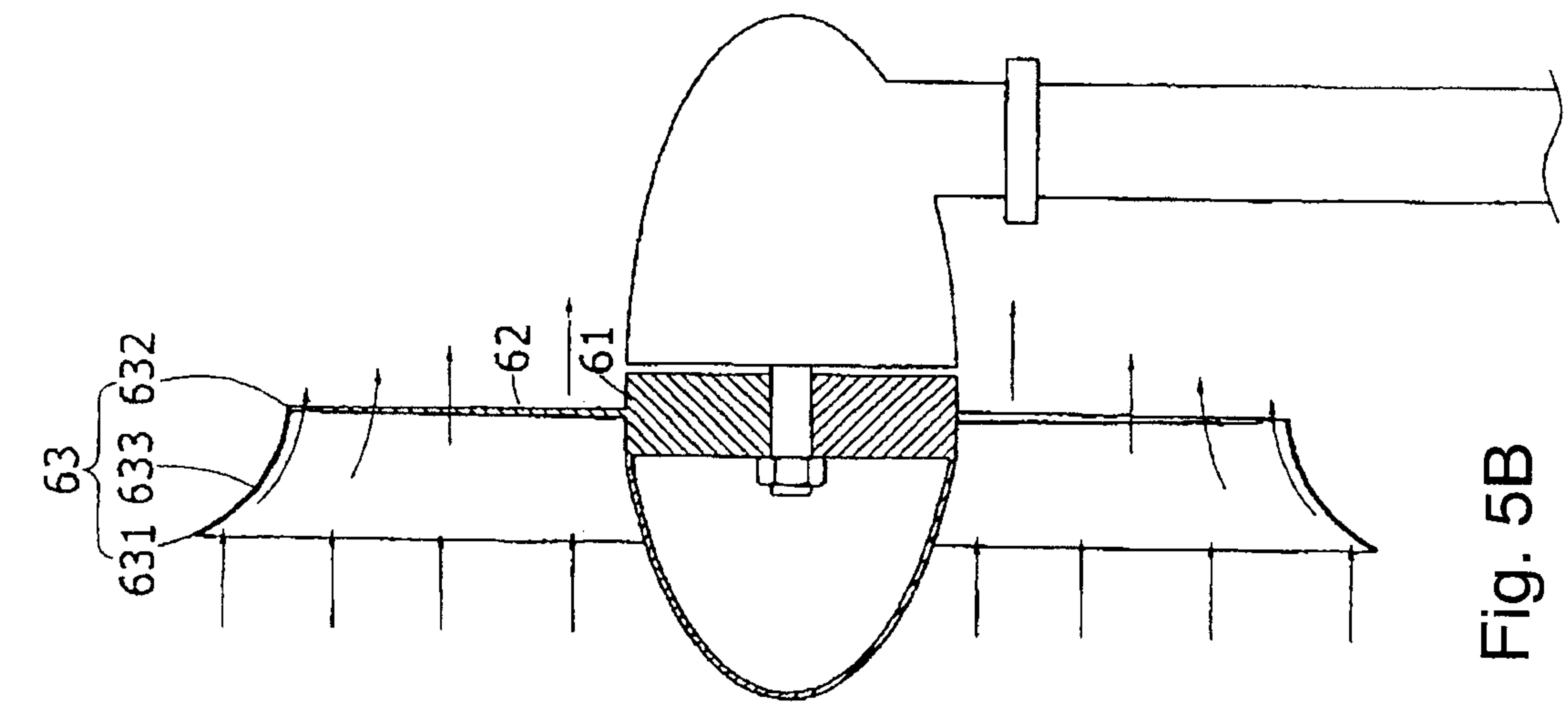


Fig. 5B

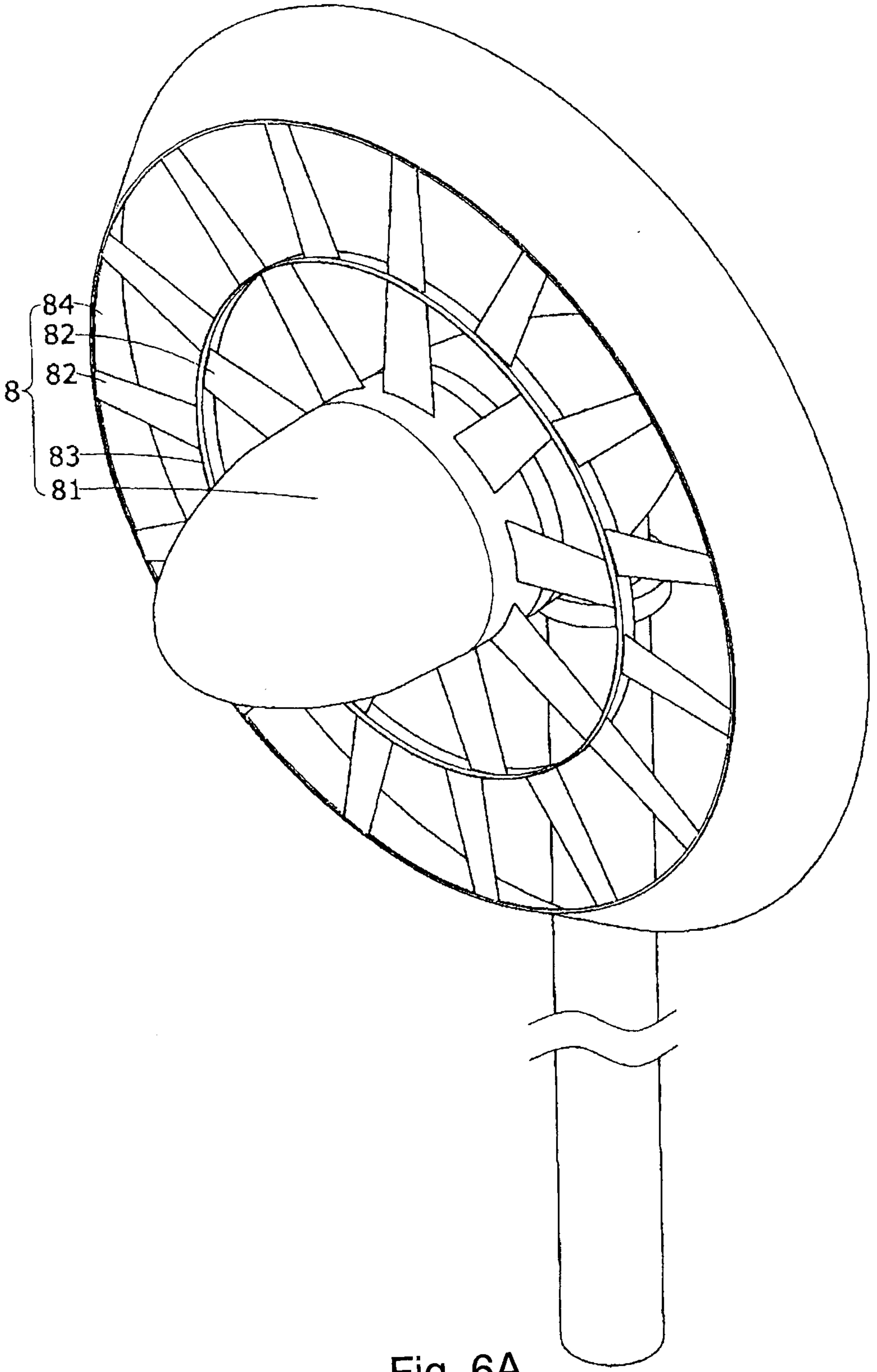


Fig. 6A

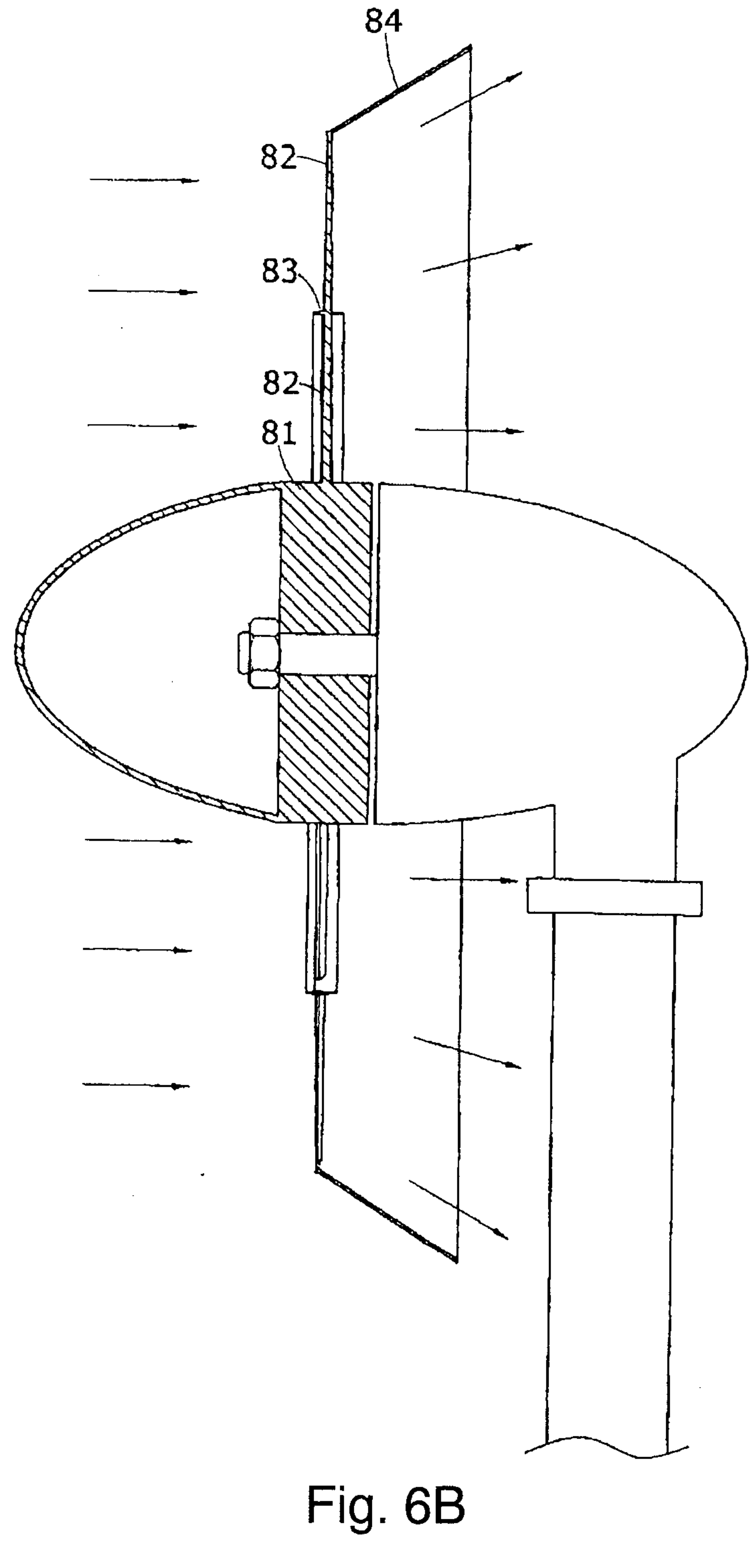


Fig. 6B

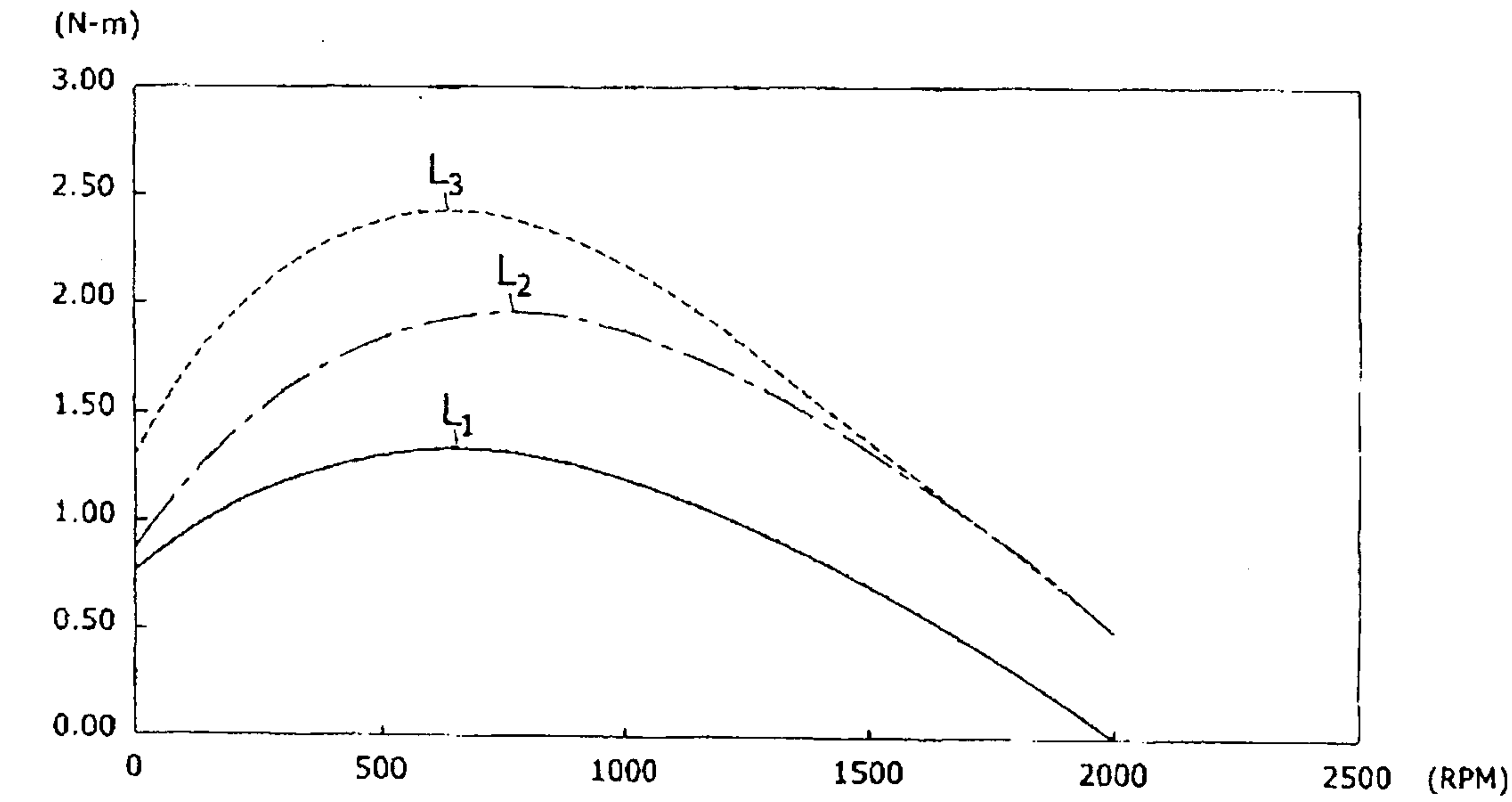

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Fig. 7

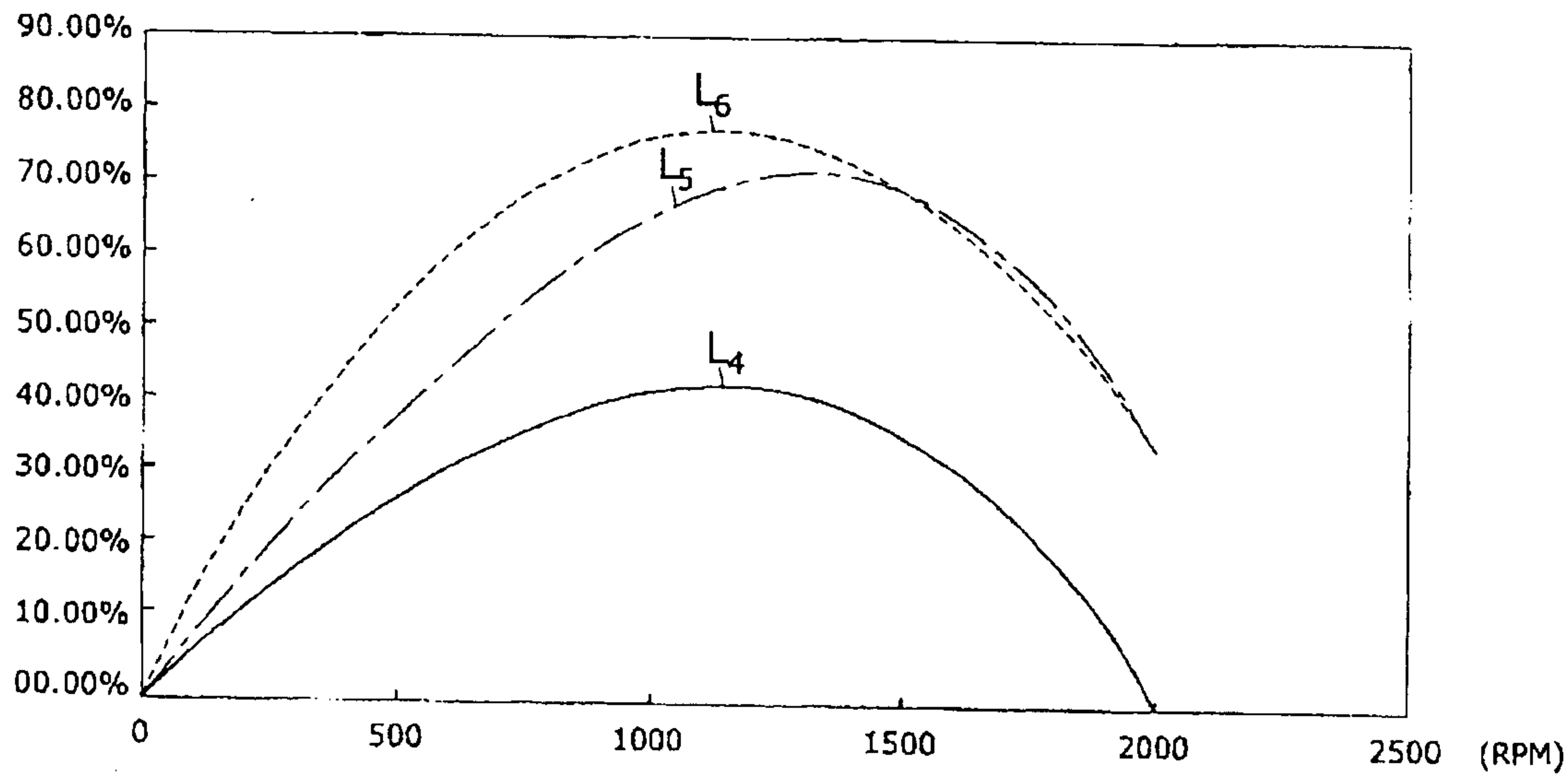
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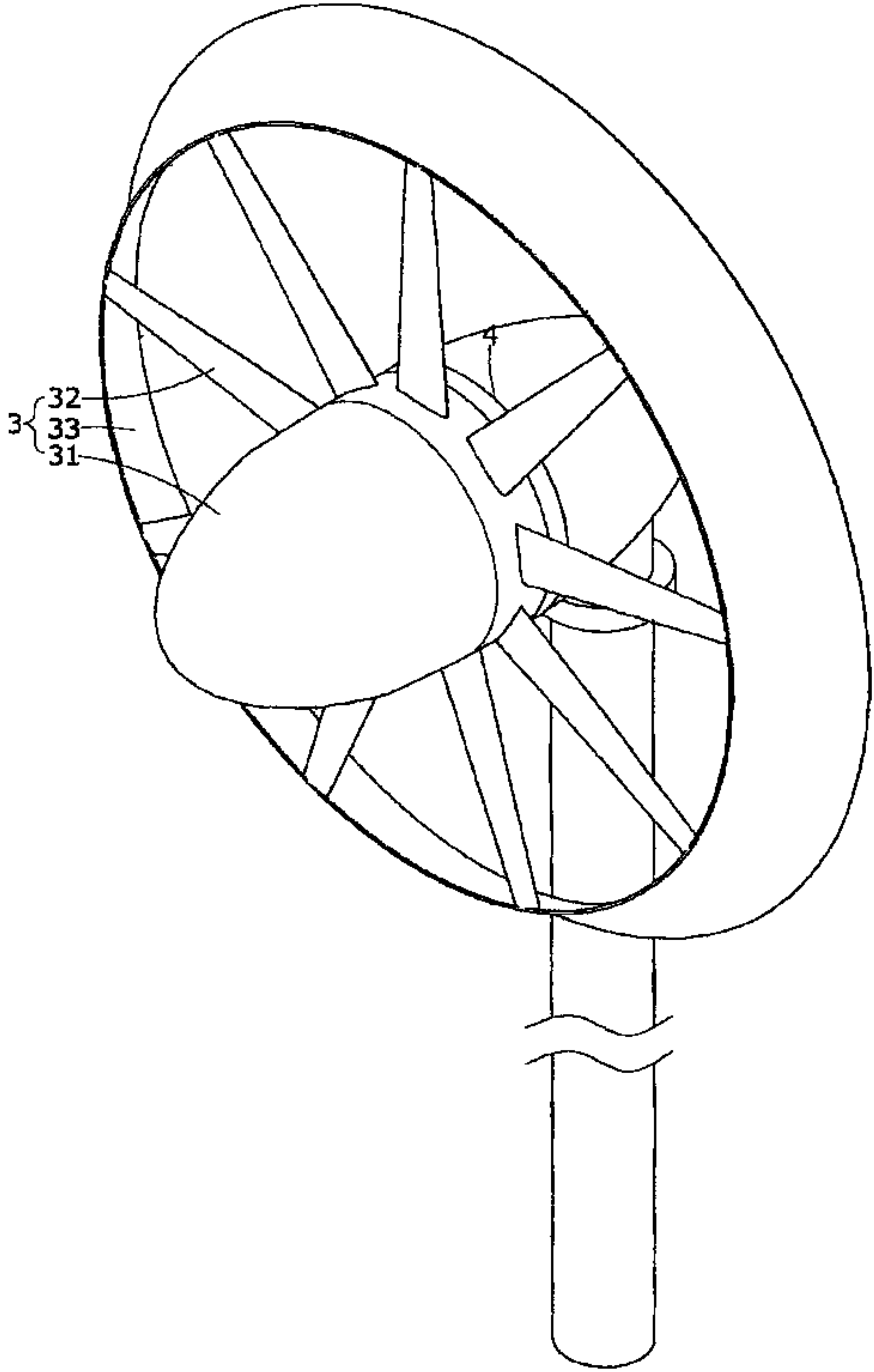
Fig. 8



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