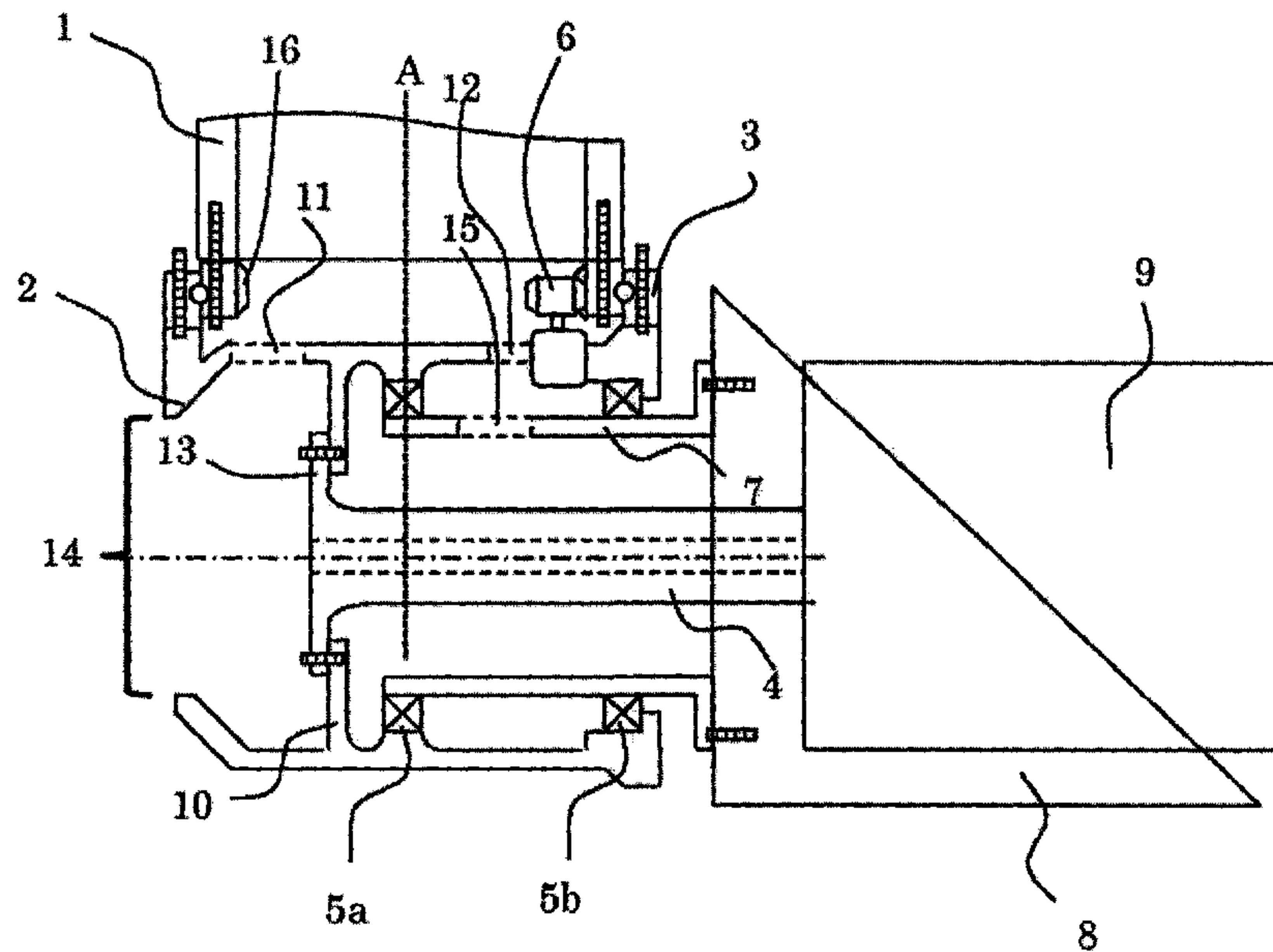




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 (72) **Inventeur/Inventor:**
 TOBINAGA, IKUO, JP
 (73) **Propriétaire/Owner:**
 HITACHI, LTD., JP
 (74) **Agent:** KIRBY EADES GALE BAKER

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(57) **Abrégé/Abstract:**

A wind turbine system includes blades which rotate by receiving wind, a nacelle which supports the blades and rotates with the blades, a main shaft for transmitting torque which is connected to the hub and is rotated by the rotation of the hub, and a generator which generates electricity using rotating energy of the main shaft, wherein the main shaft is connected to the hub inside the hub in the axial direction of the main shaft.

ABSTRACT

A wind turbine system includes blades which rotate by receiving wind, a nacelle which supports the blades and rotates with the blades, a main shaft for transmitting torque which is connected to the hub and is rotated by the rotation of the hub, and a generator which generates electricity using rotating energy of the main shaft, wherein the main shaft is connected to the hub inside the hub in the axial direction of the main shaft.

A HUB CONNECTION IN A WIND TURBINE

FIELD OF THE INVENTION

The present invention relates to a wind turbine system, an assembling method, an inspecting method, and an operation method of a wind turbine system and especially to a connecting way between a hub and a main shaft.

BACKGROUND ART

A wind turbine system has been introduced broadly as a main tool among renewable energy sources. In the wind turbine system, rotating energy is transmitted to the main shaft via rotation of the hub which supports blades, and a generator is also rotated by the rotation of the main shaft. Thus, electricity is generated in the generator.

In US 4757211, an example of a conventional wind turbine system is shown. In this literature, the following components are disposed in a nacelle, that is, a hub which supports blades and rotates with the blades, a main shaft connected to the hub and disposed in the inner diameter side of the hub, a gear box connected to the main shaft, and a generator which receives the rotating energy via the gear box and the rotating speed becomes higher through the gear box.

In the wind turbine system described in the US 4757211, the main shaft is connected to the hub at an outside portion of the hub, therefore the main shaft length in the axial direction becomes longer. If the main shaft length in the direction becomes longer, torsion is generated in the rotating direction when rotating the blades and the hub. The torsion can give rise to a reduction of transmission efficiency of rotating power, or a damage to the main shaft by being added of excess load to the main shaft. That is, reducing the efficiency of generating electricity or shortening the lifetime of the wind turbine system can be occurred.

SUMMARY OF THE INVENTION

In light of the forementioned problem, an object of the present invention is to provide a wind turbine system which can prevent reducing the efficiency of generating electricity or shortening the lifetime of the wind turbine system.

Another object of embodiments of the present invention is to provide an assembling method of a wind turbine system which can facilitate to assemble a wind turbine system.

A further object of embodiments of the present invention is to provide an inspecting method of a wind turbine system which can facilitate maintenance of a wind turbine system.

In order to solve the above problem or problems, the present invention of the wind turbine system comprises blades which rotate by receiving wind, a nacelle which supports the blades and rotates depending on wind direction, a main shaft for transmitting torque which is connected to the hub and is rotated by the rotation of the hub, and/or a generator which generates electricity using rotating energy of the main shaft, wherein the main shaft is connected to the hub inside the hub in the axial direction of the main shaft.

In order to solve the another problem, the present invention of the assembling method of a wind turbine system comprises blades which rotate by receiving wind, a nacelle which supports the blades and rotates depending on wind direction, a main shaft for transmitting torque which is connected to the hub and is rotated by the rotation of the hub, a generator which generates electricity using rotating energy of the main shaft, and/or a pitch drive which adjusts pitch angle of the blade. The hub has an opening on a side opposing the generator in the axial direction of the main shaft, wherein the pitch drive is carried into or out of inside the wind turbine system via the opening.

And in order to solve the further problem, the present invention of the inspecting method of a wind turbine system

comprises blades which rotate by receiving wind, a nacelle which supports the blades and rotates depending on wind direction, a main shaft for transmitting torque which is connected to the hub and is rotated by the rotation of the hub, a generator which generates electricity using rotating energy of the main shaft, a first gateway disposed farther from the generator with respect to the hub side flange in the axial direction of the main shaft in the hub, and/or a second gateway disposed closer to the generator than the first gateway. The hub has an opening at farther side from the generator in the axial direction of the main shaft. The opening, first gateway, and/or the second gateway are forming inspection pathways, and to allow an inspection of the inside of the wind turbine system.

In order to solve a further problem, the present invention of the operation method of a wind turbine system is comprising blades which rotate by receiving wind, a nacelle which supports the blades and rotates depending on wind direction, a main shaft for transmitting torque which is connected to the hub and is rotated by the rotation of the hub, a generator which generates electricity using rotating energy of the main shaft, a first gateway disposed farther from the generator with respect to the hub side flange in the

axial direction of the main shaft in the hub, and a second gateway disposed closer to the generator than the first gateway, and a pitch drive which adjusts pitch angle of the blade, and the hub has an opening at farther side from the generator in the axial direction of the main shaft, the hub has an opening at farther side from the generator in the axial direction of the main shaft, wherein the pitch drive is carried into or out of inside the wind turbine system via the opening, and wherein the opening, the first gateway, and the second gateway are forming inspection pathways to allow an inspection of the inside of the wind turbine system.

According to the invention, further, an entrance may be provided closer to the generator with respect to the bearing in the axial direction of the main shaft, and/or the size of the entrance is sufficient for inspection. Sufficient for inspection means allowing the inspection person to access the inside of the wind turbine.

According to the present invention of the wind turbine system, it is possible to prevent efficiency reduction when generating electricity or shortening the lifetime of the wind turbine system.

And according to the present invention of the assembling method of a wind turbine system, it is possible to facilitate assembly of a wind turbine system.

Further, according to the present invention of the inspecting method of a wind turbine system, it is possible to facilitate maintenance of the wind turbine system.

And according to the present invention of the operation method of a wind turbine system, it is possible to facilitate operation of a wind turbine system.

According to one embodiment of the present invention, there is provided a wind turbine system comprising: blades which rotate by receiving wind; a hub which supports the blades and rotates depending on wind direction; a main shaft for transmitting torque which is connected to the hub and is rotated by the rotation of the hub; a supporting main shaft which is disposed outwardly from the main shaft with a gap between the supporting main shaft and the main shaft; a generator which generates electricity using rotating energy of the main shaft; a pitch drive that adjusts a pitch angle of at least one of said blades; and a passage formed in the hub for movement of the pitch drive therethrough, wherein the main shaft is connected to the hub inside the hub in the axial direction of the main shaft, wherein the supporting main shaft is connected to the hub by at least two bearings that are located inside the hub, and wherein a rotation center of the blades is located between said at least two bearings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows an overall appearance of a wind turbine system.

Fig. 2 shows a connecting part between hub and main shaft in the embodiment 1.

Fig. 3 shows a connecting part between hub and main shaft in the embodiment 2.

Fig. 4 shows a connecting part between hub and main shaft in the embodiment 3.

DESCRIPTION OF EMBODIMENTS

Hereinafter, the appropriate examples to implement the present invention are explained with the drawings. Needless to say, those are just embodiments and therefore it doesn't mean that the present invention limits to the specified embodiments.

First Embodiment

The first embodiment is explained by fig. 1 and fig. 2. As shown in the fig. 1, a wind turbine system is roughly comprising blades 1 which rotate by receiving wind, a nacelle 20 which supports the blades 1 and receives the load of the blades 1, a tower 21 which supports the nacelle 20. The nacelle 20 is supported by the tower 21 in a substantially horizontal

plane and rotatable in the plane, and the nacelle is driven to rotate in the plane depending on wind direction.

Fig. 2 is to explain the connecting portion between a hub and a main shaft, and fig. 2 corresponds to a portion which is shown in Fig. 1 using dotted line. As shown in the fig. 2, the wind turbine system in this embodiment has blades 1, a hub 2 which supports the blades 1 and rotates with the blades 1, a pitch bearing 3 which adjusts the pitch angle of blades 1 by the drive, a main shaft 4 for transmitting torque which is connected to the hub 2 and is rotated by the rotation of hub 2, a speed-up gear 9 which is connected to the main shaft 4 and increases the rotating speed, a supporting main shaft 7 disposed outward from the main shaft 4 with a gap to the main shaft 4, and a main frame 8 which is connected to the tower 21 (not shown in fig. 2) and supports the supporting main shaft 7. The speed-up gear 9 is connected to a generator (not shown). The generator has a rotor with a certain gap to a stator and the rotor is rotated in the increased speed by the speed-up gear 9, and the generator generates electricity. The main shaft 4 is connected to the hub 2 inside the hub 2 in the axial direction of the main shaft 4. The main shaft 4 has a through-hole for plumbing or electrical cables for controlling electrical devices disposed in the hub 2.

The pitch bearings 3 have gears 16 each of which is fastened to both an inside of the hub 2 and the root portion

of the blade 1 which faces to the inside of the hub 2, and the pitch bearings 3 can adjust the pitch angle of blade 1 by the rotation of the gear 16 while the hub 2 rests. In the hub 2, a motor and a pitch drive 6 are configured and the pitch drive 6 has a pinion gear which is connected to the motor and rotated by the motor. The pinion gear of the pitch drive 6 contacts the gear 16 of the pitch bearing 3. By driving the motor of the pitch drive 6 and rotating the gear 16 via the pinion gear, the blade 1 can be adjusted to the desired pitch angle.

The supporting main shaft 7 differs from the main shaft 4, which is disposed inward of the supporting main shaft 7 with a gap to the supporting main shaft 7, that is to say, the supporting main shaft 7 isn't rotated with the blades 1 and the hub 2. The supporting main shaft 7 supports the weight of the blades 1 and the hub 2, and there are two bearings 5a, 5b disposed between the hub 2 and the supporting main shaft 7. The bearing 5a is disposed farther from the generator with respect to the rotation center (or the center of gravity) A of blades 1 in the axial direction of the main shaft 4 in the hub 2. In case a plurality of bearings are disposed (sometimes in line) in the long axial direction of the main shaft 4, if the bearing disposed farthest from the generator (the bearing 5a in this embodiment) is disposed closer to the generator with respect to the rotation center A, the load to the bearings becomes huge. To avoid this, the bearing disposed farthest from

the generator (the bearing 5a in this embodiment) is disposed farther from the generator with respect to the rotation center A in the axial direction of the main shaft 4. Further, by configuring the bearings between the hub 2 and the supporting main shaft 7, it is possible for the supporting main shaft 7 to support the load of the rotating blades 1 and the rotating hub 2 while the supporting main shaft 7 itself doesn't rotate with blades 1 or hub 2. The supporting main shaft 7 is fastened to the main frame 8.

The hub 2 has an opening 14 at farther side from the generator in the axial direction of the main shaft 4. The hub 2 has a hub side flange 10 which projects to inside of the hub 2. The main shaft 4 for transmitting torque has a main shaft side flange 13 at the opposite side from the generator in the axial direction of the main shaft 4, and the main shaft side flange 13 rotates with the main shaft 4. The main shaft side flange 13 is a large-diameter portion and the diameter of the flange 13 is larger than the diameter of the root portion in the main shaft (or which connects to the main shaft 4, in case the flange 13 is separated material from the main shaft 4). The root portion supports the load of the flange 13. Preferably, the diameter of the flange 13 (in the same direction with the inner diameter of the opening 14) is smaller than the inner diameter of the opening 14 because this enables the main shaft 4 to carry into the inside of the hub 2 through the opening

14. The flange 13 is connected to the hub side flange 10. Preferably, the hub side flange 10 is disposed farther from the entrance 11 (described later) with respect to the flange 13 in the axial direction of the main shaft 4. This displacement enables the entrance 11 to be kept large because the hub side flange 10 does not block the entrance 11.

In the hub 2, the entrance 11 is disposed farther from the generator with respect to the hub side flange 10 in the axial direction of the main shaft 4, and the entrance 11 is communicated with the opening 14. The entrance 11 and the opening 14 are formed larger than the pitch drive 6 so that the pitch drive 6 can pass and carry into or out of the inside of the hub 2 and blades 1. To assemble, inspect or operate the wind turbine system, even when the pitch drive 6 is carried into or out of the inside of the hub 2 and blades 1 under the condition of which the hub 2 and the main shaft 4 are connected, it is possible to carry it via the opening 14 and the entrance 11. Therefore, the assembling of the wind turbine system can be facilitated.

In the hub 2, a further entrance 12 is provided closer to the generator with respect to the bearing 5a which is the bearing disposed closer to the rotation center A in the axial direction, and also an entrance 15 is provided in the supporting main shaft 7 closer to the generator with respect to the bearing 5a. Those two entrances 12, 15 are communicated with each other.

Each of two entrances 12, 15 has a sufficient size to pass through for an inspecting person and allow to inspect or operate inside. The entrance 12 is disposed closer to the generator than the entrance 11.

This structure enables the inspecting person to get into or get out of the inside of the wind turbine system through the opening 14, the entrance 11, 12, 15 in order or vice versa, and to inspect the inside of the wind turbine system.

In the wind turbine system, the blades 1 rotate by receiving the wind, and the hub 2 connected to the blades 1 and the main shaft 4 for transmitting the torque are rotated by rotating the blades 1. By the rotating energy in which the rotating speed is increased via the speed-up gear 9, the rotor of the generator is driven and the generator generates electricity. During generating the electricity, torsion energy to the rotating direction is added.

In this embodiment, the main shaft 4 is connected to the hub 2 inside the hub 2 in the (longitudinal) axial direction of the main shaft 4. To compare with the case which the main shaft 4 is connected to the hub 2 outside the hub 2 in the axial direction of the main shaft 4, it becomes possible to shorten the axial length of the main shaft 4. Therefore, torsion of the main shaft 4 is less likely to be occurred when the blades are rotating, and the reduction of the efficiency for transmitting the torque or the excess load concentration to

the main shaft by the torsion can be prevented. As a result, shortening the lifetime of the wind turbine system can also be prevented.

In this embodiment, because the pitch drive 6 can be carried into or out of via the opening 14, even after assembling the hub, it is still possible to carry the pitch drive 6 into or out of the inside of the hub 2 easily. Therefore it is possible to improve assembling at the time of installation and at the time of replacement after some failure.

Further, in this embodiment, the entrance 11 which communicates with the opening 14 is provided, accordingly the space for carrying the pitch drive 6 can keep large. Therefore, it is further possible to improve assembling.

In this embodiment, the inspecting person can enter the inside of the wind turbine system through the opening 14, the entrance 11 as a first gateway, and the entrances 12, 15 as second gateways, and inspects the wind turbine system. Therefore, it can facilitate the maintenance, and additionally the space for the maintenance can keep large. So, the maintenance can be done much easily. Furthermore, the wind turbine system with the opening 14, the entrance 11 as the first gateway, and the entrances 12, 15 as the second gateways which are provided closer to the generator than the entrance 11 can work as the wind turbine system with high maintenance ability.

Second embodiment

The second embodiment is explained by fig. 3. The same structure and the same effect with the first embodiment are omitted. In the first embodiment, the main shaft side flange 13, which is a large-diameter portion, is formed integrally with the main shaft 4, but in this embodiment, a portion corresponding to the flange 13 is formed separately from the main shaft 24 for transmitting torque and the portion is made by a leaf spring (made from different material from the main shaft 24).

In the embodiment 1, the diameter of the flange 13 is formed smaller than the inner diameter of the opening 14, but in this embodiment, the diameter of the main shaft 24 and the leaf spring are not necessarily to be smaller than the inner diameter of the opening 14 because they are separated material and therefore it is possible to connect with each other in the hub 2 after carrying them into the hub 2.

Further, in case the power except for rotating power is added via the blades 1 and the hub 2, because a flexible member (in this embodiment, a leaf spring 23) is used between the hub 2 and the main shaft 24, it is possible to reduce the power (unnecessary load) transmitted to the main shaft 24 except for the rotating direction. Of course, other than a leaf spring, if it has flexibility, then the same effect can be obtained.

Third embodiment

The third embodiment is explained by fig. 4. The same structure and the same effect with the above embodiments are omitted.

In the first embodiment, the number of the bearings is two, but in this embodiment, the only one bearing 25 is used. The bearing 25 disposed at the rotation center (or the center of gravity) A of blades 1 in the axial direction of the main shaft 4 in the hub 2. In case the only one bearing is used, it is desirable to dispose at substantially rotation center in the axial direction of the main shaft for reducing the load which works on the bearing.

Incidentally, this embodiment is explained as an alternative of the first embodiment, but of course it is possible to use as an alternative of the second embodiment, that is, this embodiment's feature is also applicable for the case that the main shaft for transmitting torque and the main shaft side flange are separately formed.

In the above embodiments, the speed-up gear is used, but it's not always necessary, and it is possible to manufacture without the speed-up gear.

CLAIMS

1. A wind turbine system comprising:
 - blades which rotate by receiving wind;
 - a hub which supports the blades and rotates depending on wind direction;
 - a main shaft for transmitting torque which is connected to the hub and is rotated by the rotation of the hub;
 - a supporting main shaft which is disposed outwardly from the main shaft with a gap between the supporting main shaft and the main shaft;
 - a generator which generates electricity using rotating energy of the main shaft;
 - a pitch drive that adjusts a pitch angle of at least one of said blades; and
 - a passage formed in the hub for movement of the pitch drive therethrough,
 - wherein the main shaft is connected to the hub inside the hub in the axial direction of the main shaft,
 - wherein the supporting main shaft is connected to the hub by at least two bearings that are located inside the hub, and
 - wherein a rotation center of the blades is located between said at least two bearings.

2. A wind turbine system according to claim 1, wherein the hub has an opening at a side opposing the generator in the axial direction of the main shaft, and further comprising

a hub side flange which projects toward an inside surface of the hub;

a main shaft side flange connected to the hub side flange, and the main shaft side flange rotates with the main shaft;

wherein the passage is formed by (i) an entrance disposed distal to the generator and the hub side flange in the axial direction of the main shaft and (ii) said opening.

3. A wind turbine system according to claim 2, wherein the main shaft side flange is formed integrally with the main shaft, and the diameter of the main shaft side flange is larger than the diameter of a root portion of the main shaft side flange in the main shaft, and

wherein the diameter of the main shaft side flange is smaller than the inner diameter of the opening.

4. A wind turbine system according to claim 2, wherein the main shaft side flange is formed separately from the main shaft, and

wherein the hub side flange and the main shaft flange are connected via a flexible member.

5. A wind turbine system according to claim 2 or 3, wherein the hub side flange is disposed farther from the entrance than the main shaft side flange in the axial direction of the main shaft.

6. A wind turbine system according to any one of claims 2 to 5, wherein the supporting main shaft is disposed outward from the main shaft with a gap therebetween, wherein the at least two bearings are disposed between the supporting main shaft and the hub, and

wherein the location of a bearing disposed farthest from the generator is farther from the generator than the rotation center of the blades in the axial direction of the main shaft.

7. A wind turbine system according to claim 6, wherein a further entrance is provided closer to the generator than the location of a bearing of the at least two bearings that is most distal to the generator in the axial direction of the main shaft, and wherein the size of the entrance is sufficient for inspection.

8. The wind turbine system of claim 1, wherein the passage is formed by an opening in the hub at an opposing side from the generator in the axial direction of the main shaft,
wherein the pitch drive is moveable into or out of inside the wind turbine system via the opening.

9. The wind turbine system of claim 1 further comprising:

a first gateway disposed distal to the generator and the hub side flange in the axial direction of the main shaft in the hub; and

a second gateway disposed closer to the generator than the first gateway, and wherein

the hub has an opening at a farther side from the generator in the axial direction of the main shaft,

wherein the opening, the first gateway, and the second gateway form inspection pathways to allow an inspection of the inside of the wind turbine system.

10. The wind turbine system of claim 1 further comprising:

a first gateway disposed distal from the generator and the hub side flange in the axial direction of the main shaft in the hub; and

a second gateway disposed closer to the generator than the first gateway,

the hub has an opening at a farther side from the generator in the axial direction of the main shaft,

wherein the pitch drive is carried into or out of inside the wind turbine system via the opening and the first gateway, and

wherein the opening, the first gateway, and the second gateway form inspection pathways to allow an inspection of the inside of the wind turbine system.

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FIG. 1

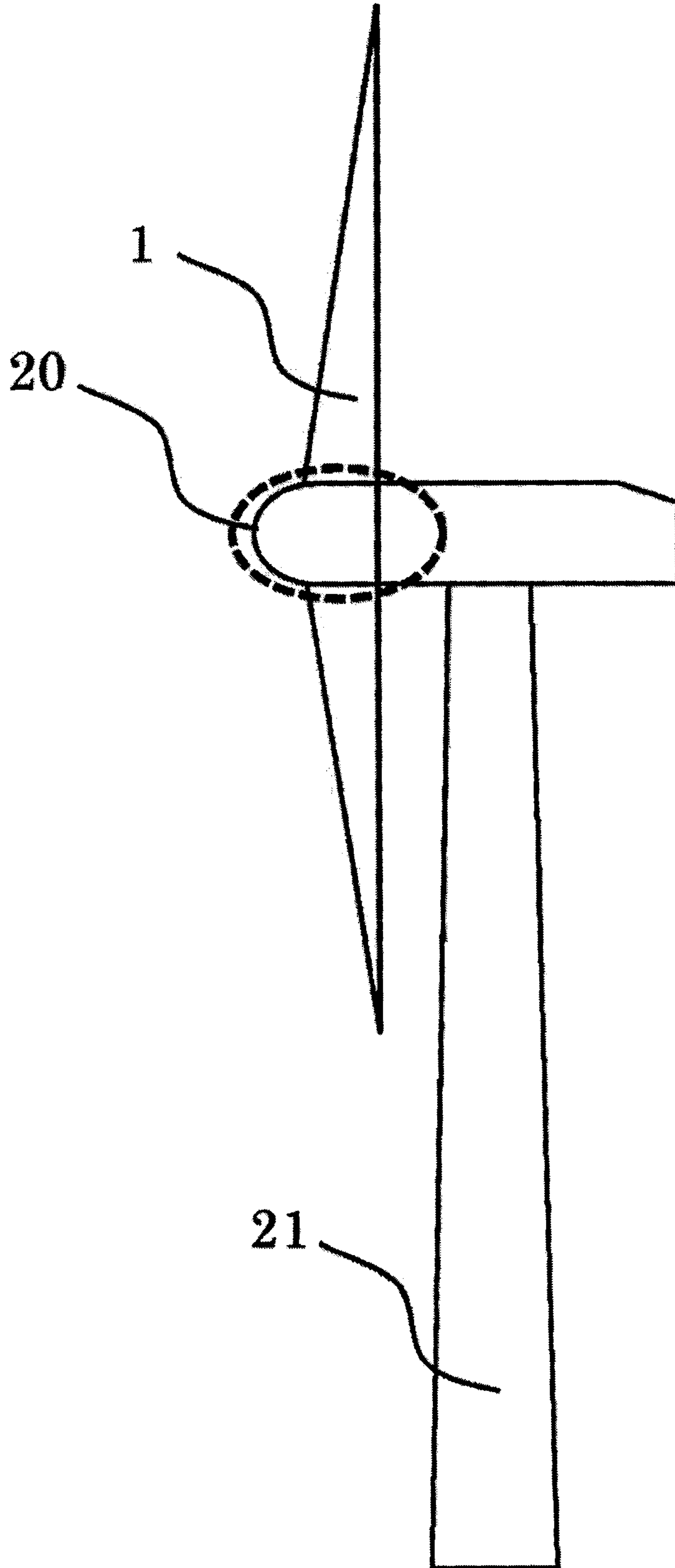


FIG. 2

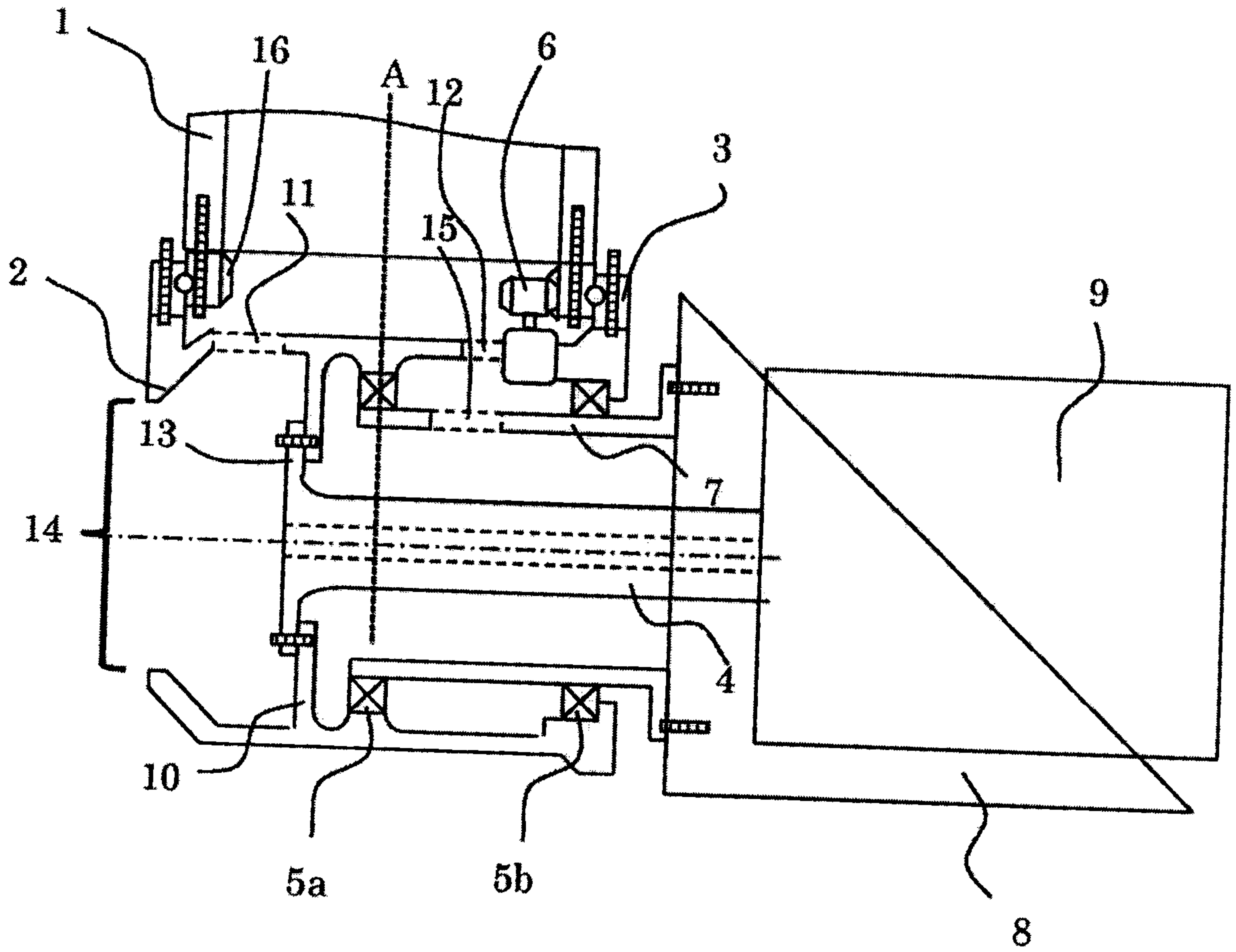


FIG. 4

