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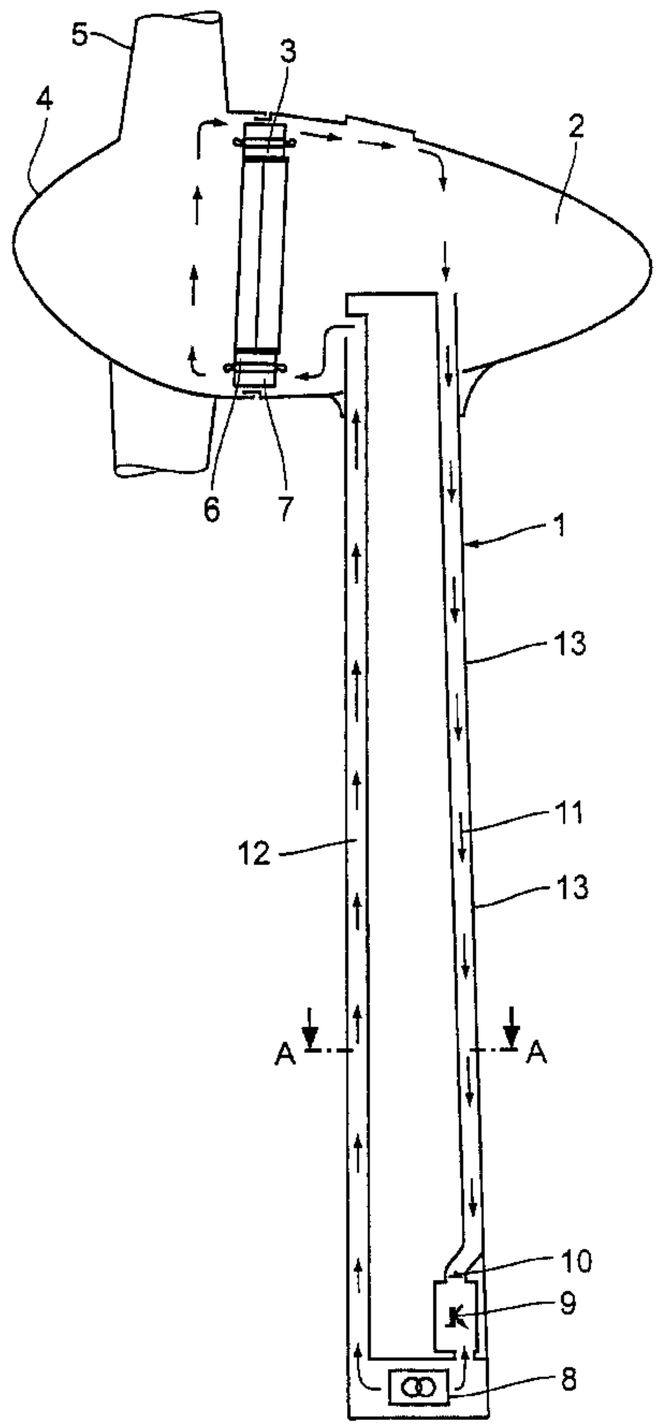

(57) Abrégé/Abstract:
The conversion of energy regularly results in losses in the form of heat. This applies both for the conversion of kinetic energy of wind into electrical energy in the generator of a wind energy facility, where these losses regularly occur in the main drive train of the wind energy facility, and also for the electrical feeding of energy generated by the wind energy facility into a medium voltage

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(57) Abrégé(suite)/Abstract(continued):
network. For this purpose, regular devices of power electronics, e.g., rectifiers, and/or transformers, are necessary. In the main drive train, which is mounted in the nacelle for a wind energy facility, the losses occur overwhelmingly in the gears, at the bearings, and in the generator or at other control units, such as, e.g., in the hydraulic systems or similar control and regulation units, which adjust the rotor blades or turn the wind energy facility into the wind. For gearless wind energy facilities, e.g., model E-66 of Enercon, the main losses occur at the main drive train in the generator, i.e., in the nacelle (head) of the wind energy facility. The task of the invention is to prevent the previously mentioned disadvantages and to provide a cooling device for a wind energy facility, which reduces the losses of the wind energy facility. Wind energy facility (1) with a completely closed or at least partially closed cooling circuit, with which the heat to be dissipated from the cooling circuit is dissipated by the tower (3) or the nacelle (2) of the wind energy facility (1).

Abstract

The conversion of energy regularly results in losses in the form of heat. This applies both for the conversion of kinetic energy of wind into electrical energy in the generator of a wind energy facility, where these losses regularly occur in the main drive train of the wind energy facility, and also for the electrical feeding of energy generated by the wind energy facility into a medium voltage network. For this purpose, regular devices of power electronics, e.g., rectifiers, and/or transformers, are necessary. In the main drive train, which is mounted in the nacelle for a wind energy facility, the losses occur overwhelmingly in the gears, at the bearings, and in the generator or at other control units, such as, e.g., in the hydraulic systems or similar control and regulation units, which adjust the rotor blades or turn the wind energy facility into the wind. For gearless wind energy facilities, e.g., model E-66 of Enercon, the main losses occur at the main drive train in the generator, i.e., in the nacelle (head) of the wind energy facility.

The task of the invention is to prevent the previously mentioned disadvantages and to provide a cooling device for a wind energy facility, which reduces the losses of the wind energy facility.

Wind energy facility (1) with a completely closed or at least partially closed cooling circuit, with which the heat to be dissipated from the cooling circuit is dissipated by the tower (3) or the nacelle (2) of the wind energy facility (1).

WIND ENERGY FACILITY WITH A CLOSED COOLING CIRCUIT

The conversion of energy regularly results in energy being lost in the form of heat. This applies to both the conversion of the kinetic energy of wind into electrical energy in the generator of a wind energy facility, where these losses regularly occur in the main drive train of the wind energy facility, and also for the electrical feeding of energy generated by the wind energy facility into a medium voltage network. For this purpose, regular devices of power electronics, e.g., rectifiers, and/or transformers, are necessary. In the main drive train, which is mounted in the nacelle for a wind energy facility, the losses occur overwhelmingly in the gears, at the bearings, and in the generator or at other control units, such as, e.g., in the hydraulic systems or similar control and regulation units, which adjust the rotor blades or turn the wind energy facility into the wind. For gearless wind energy facilities, e.g., model E-66 of Enercon, the main losses occur at the main drive train in the generator, i.e., in the nacelle (head) of the wind energy facility.

For the power supply, losses occur overwhelmingly at the power transformer and, if necessary, in the power electronics, e.g., in the rectifier.

For a 1.5 MW wind energy facility, the losses can be in the range of 60-100 kW. Up until now, these losses were dissipated into the environment by means of fans. In this way, cold air is suctioned in from the outside by the fans to cool the corresponding components, e.g., the generator. The heated air is then blown back outside.

Consideration has also already been given to cooling the generator with water and to then cooling the heated water back down with a heat exchanger. All of these known solutions have in common a large amount of air that is always needed from the outside. This is particularly disadvantageous if the outside air is humid or, particularly in coastal regions, if it has a high salt content, and the cooling elements

are then exposed to this humid and high salt content air. This problem is especially extreme with wind energy facilities that stand directly on the coast or, in offshore technology, directly in salt water.

The task of the invention is to prevent the previously mentioned disadvantages and to provide a cooling device for a wind energy facility which reduces its losses.

The task is solved with a wind energy facility with the feature according to Claim 1. Advantageous refinements are described in the subordinate claims.

The basic concept of the invention is to provide an essentially closed cooling circuit for a wind energy facility, so that no or practically no outside air has to be used for cooling. In this way, the cooling air circulates within the wind energy facility from its nacelle to the tower or to the base of the wind energy facility and the energy stored by the coolant, preferably air, during the cooling is dissipated by means of the tower of the wind energy facility. The tower of the wind energy facility is always exposed to the wind, so that the tower of the wind energy facility acts as a cooling element or a heat exchanger, which dissipates the stored energy to the wind enveloping the tower.

Another advantage of the concept according to the invention is that the tower is also heated from the inside out for very cold outside temperatures of approximately -20° to -30°C by its function as a heat exchanger and a load-bearing part of the wind energy facility. Due to this fact, the wind energy facility can remain in operation. According to the state of the art up until now, a special cold-resistant steel had to be used for very cold locations, such, e.g., northern Sweden, Norway, Finland, Canada, etc.

If desired, due to very low outside temperatures below the freezing point, it is also possible to combine the heating of the rotor blades with the cooling circuit, so that its own energy does not have to be used for heating the rotor blades.

The coolant is cooled by the tower due to the fact that at least one air channel is formed in the tower itself (inside or outside), and the heated air flows through this channel such that the air can dissipate its energy at least partially at the tower walls.

One air channel is preferably formed such that the tower is configured with double walls, so that one part of the cooling channel is formed through the load-bearing wall of the tower.

By using the tower of the wind energy facility, which is usually manufactured out of steel, as a cooling element or a heat exchanger, a component that is otherwise present and required by every wind energy facility is used for an advantageous function. Heated air flows in the steel tower at its outer wall. This outer wall has a very large surface area, e.g., for a 1.5 MW facility, approximately 500 m^2, and thus offers a very large heating/cooling surface. The wind enveloping the tower continuously cools this surface.

The possible cooling power of the wind increases with rising wind speed. This correlation is shown in Figure 1. With rising wind speed, the generator power also rises, and thus, also the power loss. The correlation between the generator power and the wind speed is shown in Figure 2. Thus, rising power losses can be dissipated relatively easily because the cooling power of the tower of the wind energy facility also rises with the increasing power loss.

Figure 3 shows an embodiment of the invention with reference to a wind energy facility according to model E-66 from Enercon, which provides a generator power of 1.5 MW. Figure 3 shows a cross section of a wind energy facility 1 in with a nacelle 2 at the end of the head, which is supported by a tower 3. This tower is anchored in the ground (not shown).

The nacelle houses the main drive train of the wind energy facility. This main drive train essentially comprises a rotor 4 with rotor blades 5 (only shown in outline), as well as a generator 3 connected to the rotor. This generator has a generator rotor 6 and a generator stator

7. If the rotor, and thus the generator rotor, turns, then electrical energy, e.g., as alternating current (direct current) is generated.

The wind energy facility further has a transformer 8, as well as a rectifier 9 connected in series before this transformer, wherein the rectifier supplies electrical energy in the form of alternating or three-phase current to the transformer. The transformer feeds the energy generated by the wind energy facility into a network, preferably a medium voltage network (not shown).

The tower is configured in sections with double walls, as can be seen in Figure 3, and in each double walled region, it forms a cooling channel. In this cooling channel, a fan 10 is formed (several fans can also be provided), which drives the air through the cooling channels.

Figure 4 shows a cross section of the tower walls cut along the line A-A from Figure 3. It can be seen here that in the illustrated example, two cooling channels 11, 12 are formed, and the tower is configured in a certain region with double walls. The air heated by the generator now flows through an air channel 12 out of the machines (nacelle) into the upper tower region. There, the heated air is directed to the inner side of the steel tower. As already mentioned, the steel tower is configured with double walls over a great length, e.g., approximately 50-80%, with an outer wall 13 and an inner wall 14, and there it forms the cooling channel 11. Here, the inner wall 14 in the cooling channel can be made of a simple material, e.g., plastic or cloth. The heated air from generator 3 must now flow along a large stretch on the inside of the steel tower 1. In this way, the tower or its steel is heated over a large surface area and the air is cooled. In the lower region of the tower there is the rectifier 9 and the medium voltage transformer 8 (and/or additional electrical devices). These components must also be cooled. The cooled generator air is now guided first through the rectifier. Here, the devices of the power electronics are actively cooled. The air output from the rectifier is now further guided to the transformer and also cools the transformer. Subsequently, the air

rises through the second cooling channel 12 back upwards to the machine house and to the generator.

The cooling circuit is thus closed and it is not necessary to introduce cooled air from the outside.

For cooling all components, particularly sensitive components, the wind energy facility always uses the same air.

If necessary, air filters and additional cooling devices (e.g., heat exchangers) can obviously also be mounted in the cooling channel, if desired.

The advantages of the invention consist in the fact that no high salt content or humid air comes into contact with the sensitive components, such as generators, rectifiers, and transformers. The risk of corrosion is thus drastically reduced within the machine housing and the tower. In the wind energy facility, particularly in its tower, there can be no build up of mold or fungi.

In total, for the cooling of the entire wind energy facility, considerably less energy is required than before because (secondary) cooling power is produced from the outside of the tower by the wind.

By forming cooling channels in the rotor blades and by connecting these cooling channels to the cooling circuit according to the invention, it is also possible to introduce the air heated by the generator first into the cooling channels of the rotor blades, so that during cold periods, particularly for temperatures around the freezing point, the rotor blades can be deiced. The formation of cooling channels in a rotor blade is also known, e.g., from DE 195 28 862.9.

The formation of the cooling channels in the machine housing is done through corresponding walls and air guiding devices, which direct the air such that it passes the elements, such as, e.g., the generator.

If the cooling power of the tower is not sufficient, e.g., on very warm days, it is also possible to use additional cooling elements, such as, e.g., conventional heat exchangers, in the cooling circuit.

Figure 5 shows an alternative embodiment of the cooling circuit according to Figure 3. Here, it can be seen that the wind energy facility has two separate and independent closed cooling circuits 15, 16, which each dissipate stored heat to the tower. However, the two cooling circuits 15, 16 are separated from each other, which is different than the configuration shown in Figure 3. Here, each of the individual cooling circuits 15, 16 has a passage or a cross channel within the tower 3 at the turning point, so that the air flowing into or out of the tower is directed to the opposite side of the tower and thus is further cooled for the unit to be cooled, which can be the generator or the power electronics.

Figure 6 shows an additional embodiment of a wind energy facility according to the invention. Here, an air channel, e.g., an exhaust tube 17, leads through the interior of the lower tower section. This can also be retrofitted very easily, e.g., to an existing wind energy facility and mounted (suspended) in the tower 3. Heated air originating from a power box 18, e.g., 600 kW power box is guided upwards from the tower base through this exhaust tube 17 and is output from the exhaust tube 17 into the tower. From there, the heated air flows back downwards after cooling at the tower walls and there it can be suctioned again by a ventilation device 20 (for supply air), which is coupled by means of an air hood 19 to the power box 18. The exhaust tube 17 can be connected directly at the air outlet of the power box 18 or there can be a second ventilation device 21, which suctions the heated air of the power box 18 and blows it into the exhaust tube 17, at the input of the exhaust tube 17. The exhaust tube is preferably made out of plastic and thus it is very easily realized and has a very small weight, which simplifies its attachment and retrofitting to a wind energy facility.

For improving the cooling effect of the nacelle 2, the nacelle can be completely or partially made out of metal, preferably aluminum, in order to also take advantage of the cooling effect of the nacelle, which is constantly enveloped by wind, and thus to increase the generator

cooling. Here it can also be advantageous to equip the nacelle on the inside with a surface area increasing structure, e.g., cooling ribs.

As first tests show, the configuration of a closed cooling circuit with the use of the air channel shown in Figure 6 is extremely effective and particularly cost effective, because the investment necessary for developing an air channel, particularly a plastic exhaust tube, is only very small in comparison with a heat exchanger and its constant maintenance costs. In addition, the cooling is extremely effective.

CLAIMS

1. A wind energy facility comprising:

a tower supporting a drive train driven by wind energy;

at least one cooling circuit, the cooling circuit comprising a cooling path containing a circulating coolant, the cooling path comprising a heat exchanger portion wherein heat from the circulating coolant heats an outer surface of the tower such that the heat from the circulating coolant is dissipated by the tower; and,

moving means for circulating the circulating coolant in said cooling path.

2. A wind energy facility according to claim 1, wherein the tower comprises at least one cooling channel adjacent an outer wall of the tower and the path extends through the cooling channel.

3. A wind energy facility according to claim 2, wherein the at least one cooling channel extends over at least 50% of a length of the tower.

4. A wind energy facility according to claim 2, wherein the at least one cooling channel extends over 50% to 80% of a length of the tower.

5. A wind energy facility according to any one of claims 1 to 4 wherein the coolant comprises air.

6. A wind energy facility according to claim 5 wherein the cooling circuit comprises at least one air line connected to transport air to the heat exchanger after the air has been heated by a heat-generating component of the wind energy facility which requires cooling, wherein the cooling path is defined at least in part by the air line.

7. A wind energy facility according to claim 6, wherein the air line comprises a tube connected to receive air heated by the heat-generating component of the wind energy facility which requires cooling.

8. A wind energy facility according to claim 7 wherein the heat-generating component comprises one or more of:

a generator;
a transformer;
the drive train; and,
a power electrical component.

9. A wind energy facility according to any one of claims 7 or 8 wherein an inlet end of the tube is connected to a ventilation device, by means of which air heated by the heat-generating component is blown into the tube.

10. A wind energy facility according to any one of claims 6 to 9, wherein the tube is at least ten metres long, and is located in a lower part of the tower such that heated air originating at an electrical energy-conversion device is blown through the tube, and the heated air is delivered to the heat exchanger at an outlet end of the tube.

11. A wind energy facility according to claim 10 wherein the tube is at least twenty five metres long.

12. A wind energy facility according to any one of claims 5 to 11 comprising at least one air filter disposed in the cooling circuit.

13. A wind energy facility according to any one of claims 1 to 12, wherein the tower has a longitudinal axis and is configured with double walls over at least one section along the longitudinal axis and wherein the heat exchanger comprises a portion of the cooling path that extends between the double walls such that heat from heated coolant introduced into the heat exchanger is dissipated to the outer surface of the tower.

14. A wind energy facility according to claim 13 wherein an inner one of the double walls comprises a material selected from the group consisting of cloth and plastic.

15. A wind energy facility according to claim 13 wherein the tower comprises two double-walled regions and the heat exchanger comprises portions of the cooling path which extend through each of the double-walled regions.

16. A wind energy facility according to any one of claims 1 to 15, wherein the coolant circulates essentially continuously in the cooling path to cool, both the drive train and at least one power electronic device.

17. A wind energy facility according to any one of claims 1 to 16 comprising a fan for circulating the coolant around the cooling circuit.

18. A wind energy facility according to any one of claims 1 to 17, wherein the cooling circuit heats the tower sufficiently that the wind energy facility can be kept in operation at outside temperatures in the range of approximately - 20° C to - 40° C.

19. A wind energy facility according to any one of claims 1 to 18 comprising one or more electrical devices for converting electrical energy wherein the cooling path extends past both: parts of the drive train; and parts of the electrical devices.

20. A wind energy facility according to any one of claims 1 to 18 comprising at least two cooling circuits, each of the cooling circuits being at least partly closed, wherein a first one of the cooling circuits cools the drive train of the wind energy facility, and a second one of the cooling circuits cools an electrical energy-conversion device.

21. A wind energy facility according to any one of claims 1 to 20 comprising a nacelle supported by the tower wherein the nacelle is completely or partially made out of a metal.

22. A wind energy facility according to claim 21 wherein the nacelle is completely or partially made of aluminum.

23. A wind energy facility according to any one of claims 21 or 22 wherein the nacelle is equipped completely or partially with cooling ribs.

24. A wind energy facility according to any one of claims 21 or 22 wherein the nacelle comprises means for increasing a surface area of the nacelle.

25. A wind energy facility according to any one of claims 1 to 24 wherein the outer surface of the tower comprises a metal wall.

26. A wind energy facility according to claim 25 wherein the metal wall is a steel wall.

27. A wind energy facility according to any one of claims 1 to 26 wherein a surface area of the outer surface of the tower exceeds 500 m^2.

28. A wind energy facility according to any one of claims 1 to 27 wherein the cooling circuit is connected to pass the circulating coolant through channels in rotor blades wherein the rotor blades are disposed to drive the drive train.

29. A wind energy facility according to any one of claims 1 to 27 wherein the cooling circuit is connected to cool one or more components at each of a base end of the tower and a top end of the tower.

30. A wind energy facility according to any one of claims 1 to 7 wherein the cooling path extends past the drive train so that the coolant carries heat from the drive train to the heat exchanger.

31. A method for cooling a heat-generating component in a wind energy facility comprising a tower supporting a wind-driven drive train, the method comprising:

carrying away heat from the heat-generating component by circulating a coolant past the heat-generating component;

cooling the coolant by passing a heat of the coolant to an outer wall of the tower; and,

recirculating the cooled coolant past the heat-generating component.

32. A method according to claim 31 wherein the coolant comprises air.

33. A method according to claim 31 or 32 wherein the heat exchanger comprises a double-walled portion of the tower and the method comprises circulating the coolant between inner and outer walls of the double-walled portion of the tower.

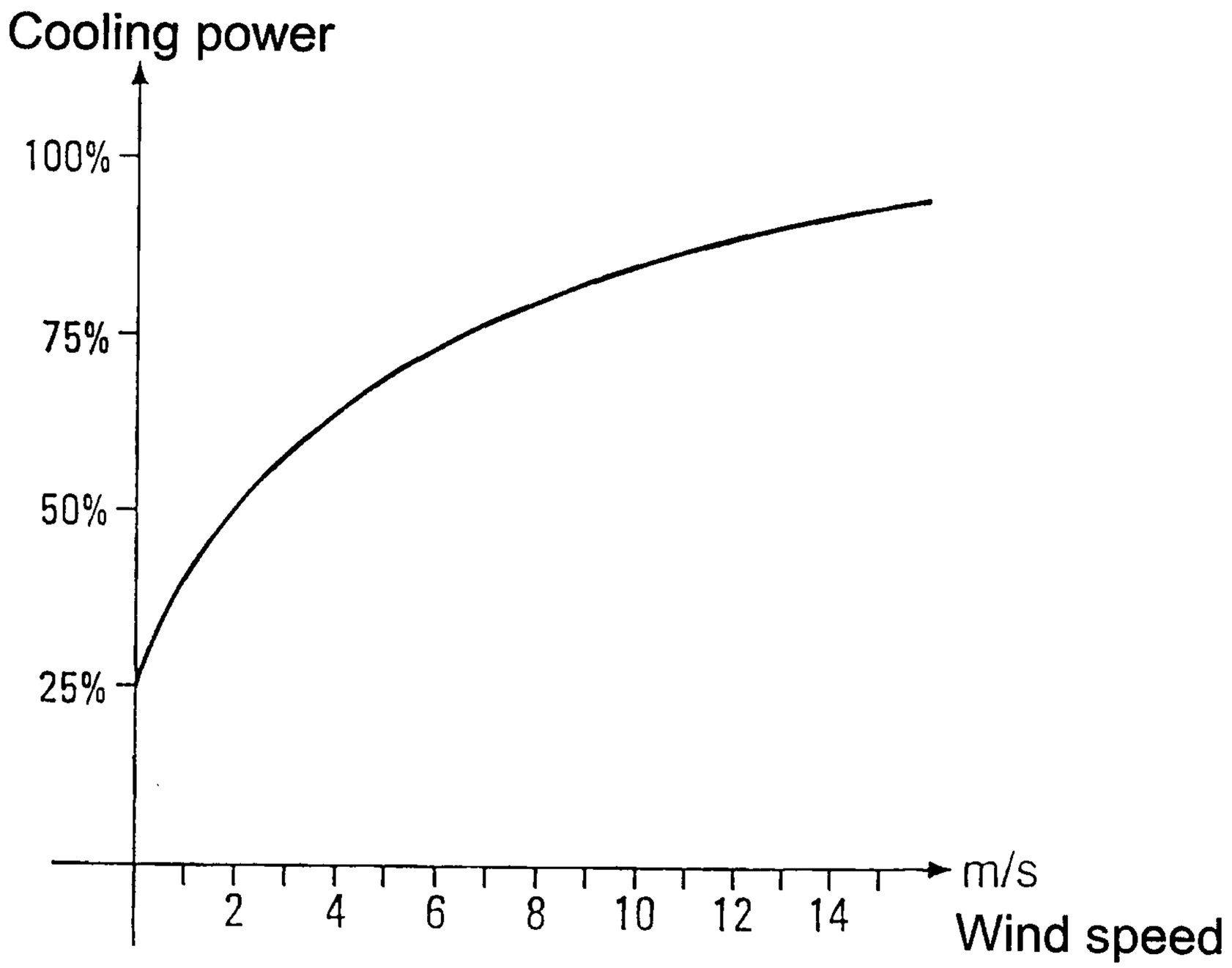


Fig. 1

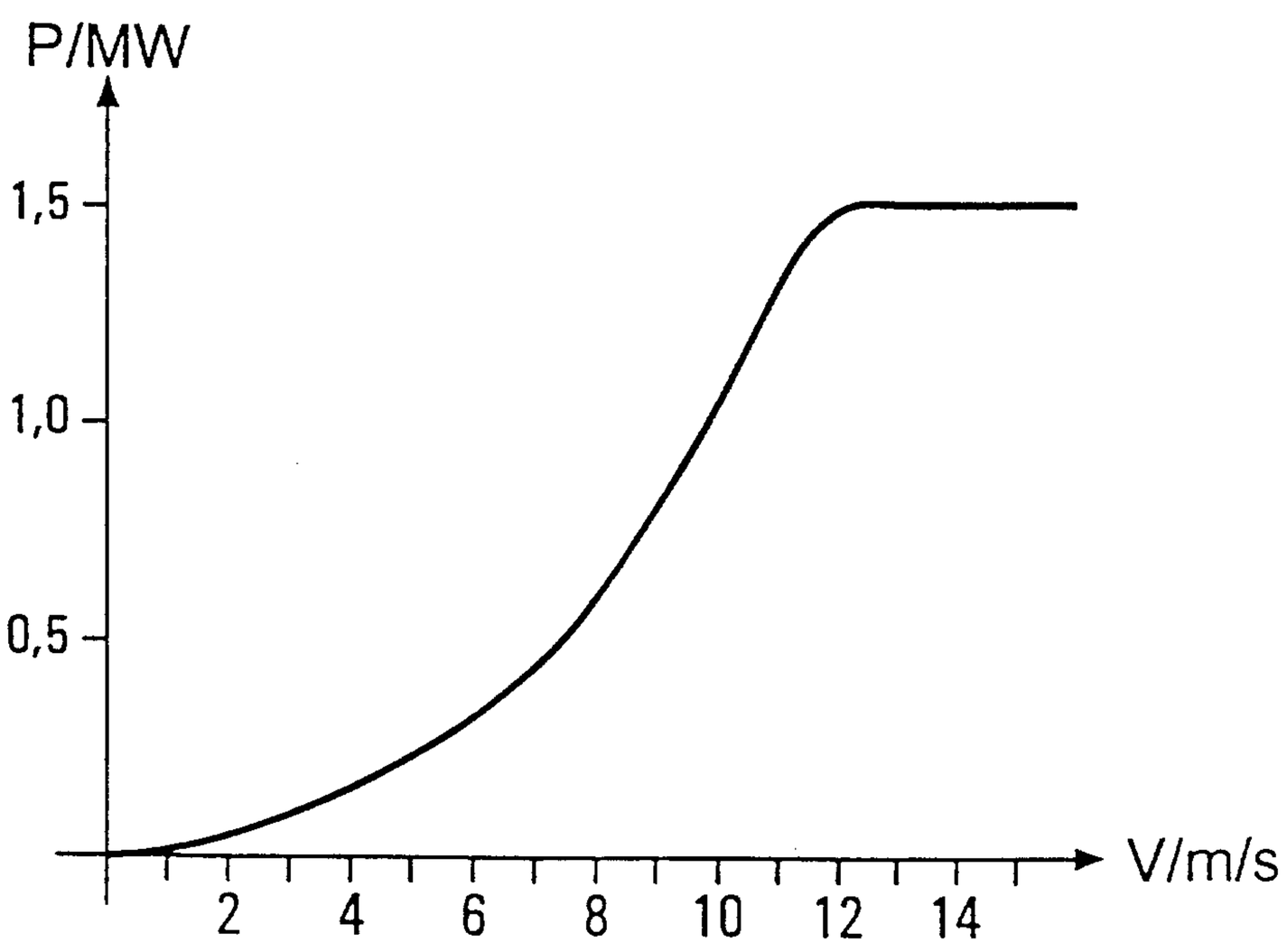


Fig. 2

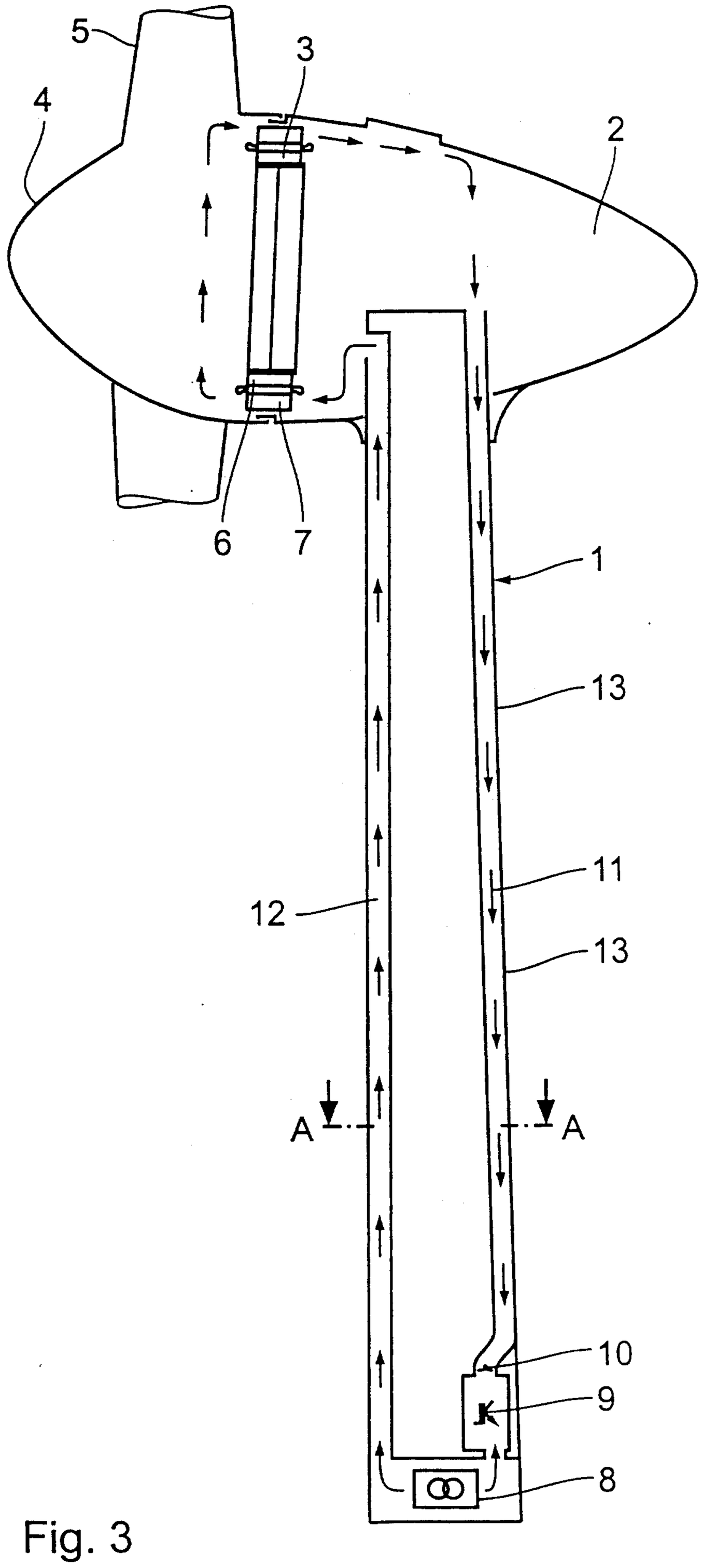


Fig. 3

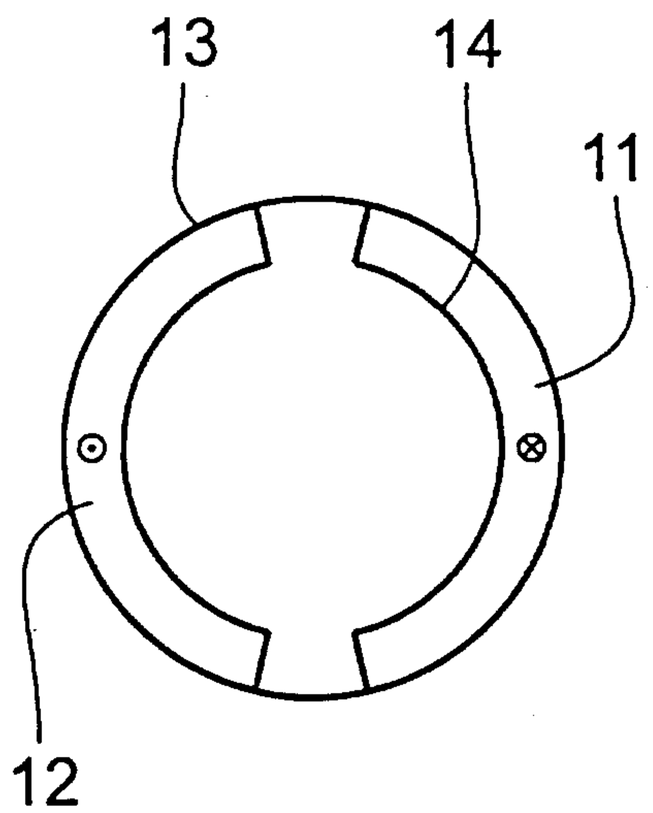


Fig. 4

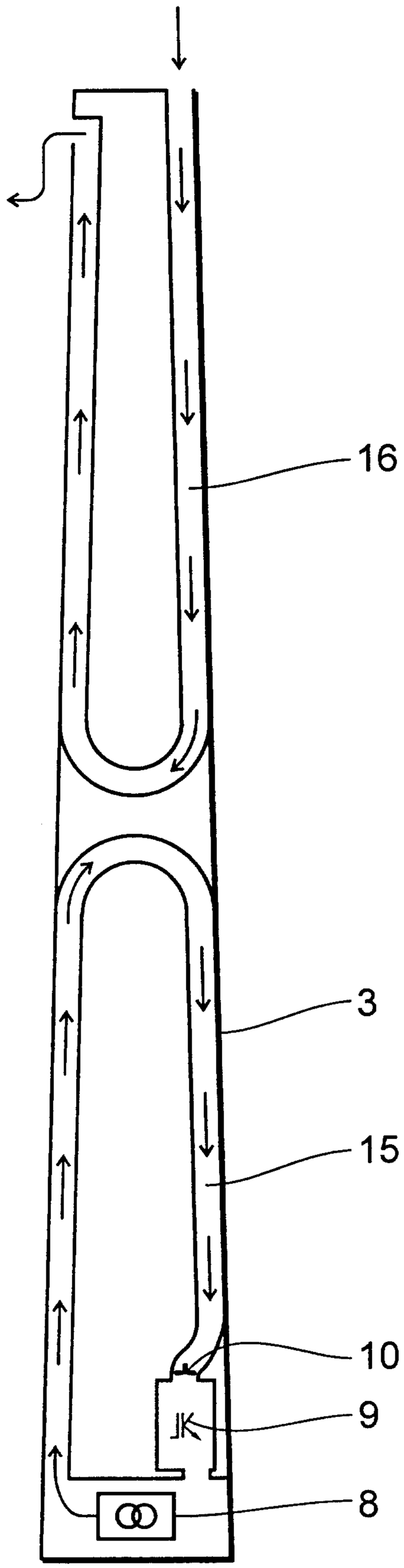


Fig. 5

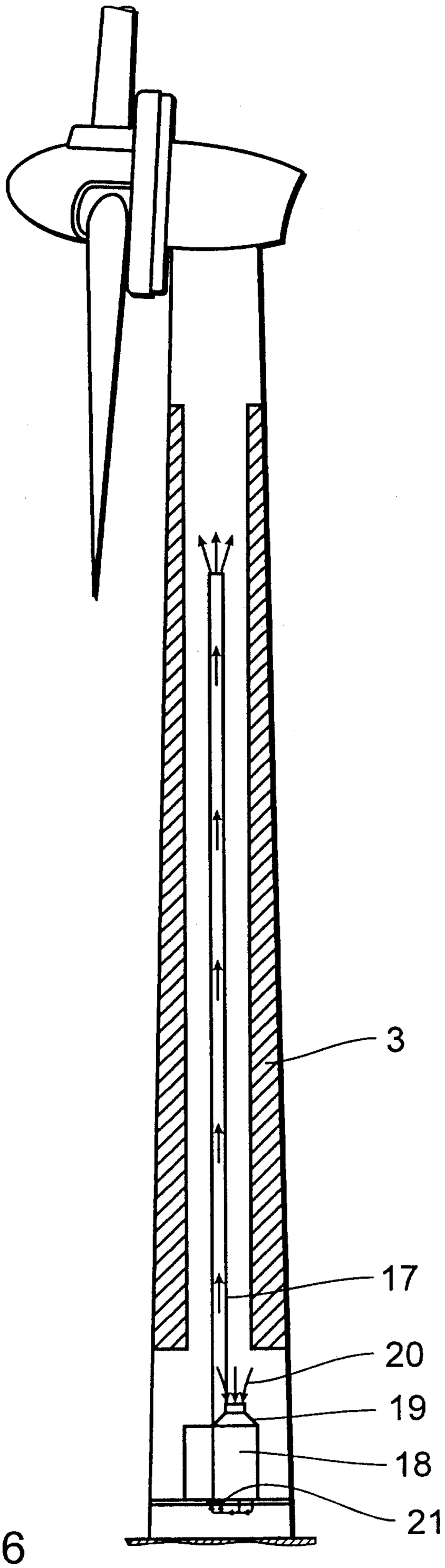
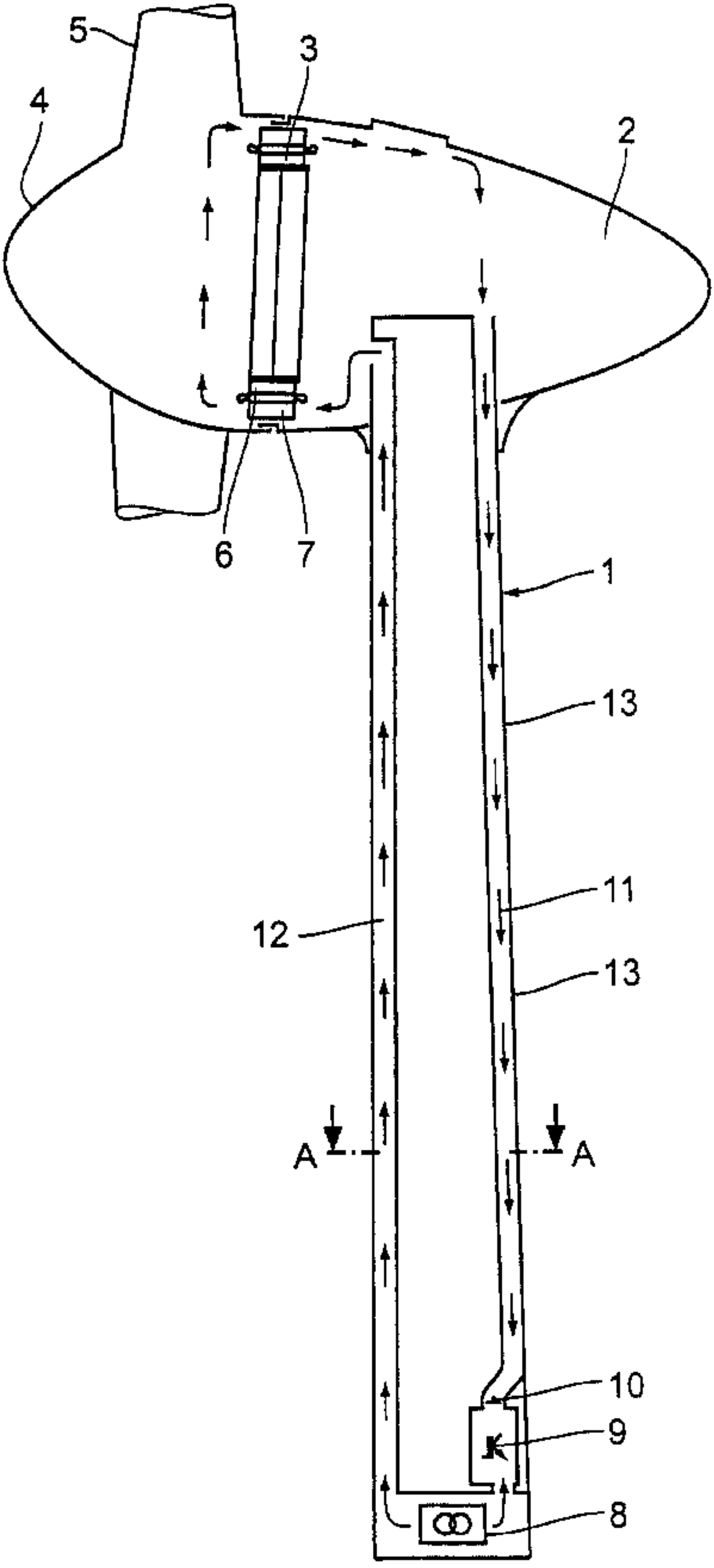


Fig. 6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