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(54) Benævnelse: **VINDTURBINEROTORBLAD MED ET GNISTGAB**

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Wind turbine rotor blade with a spark gap

The invention relates to a wind turbine rotor blade having a lightning receptor, a first electrical line and a potential equalization arrangement which has a first electrode, which is connected to the lightning receptor, and a second electrode, which is connected to the first electrical line, a spark gap being formed between the two electrodes.

It is known to use a lightning protection arrangement to protect wind turbine rotor blades against damage by lightning strike. For this purpose, a lightning receptor is generally arranged in the region of the blade tip. The current of lightning striking into the lightning receptor is then diverted, via a lightning conductor, toward the blade root, and from there, via the nacelle and the tower of the wind turbine, into the ground. If a plurality of electrically conductive elements are arranged, more or less in parallel, in the wind turbine rotor blade, electromagnetic induction in the case of a lightning strike causes large potential differences between the electrically conductive elements and said potential differences can lead to flashovers or even to the destruction of the wind turbine rotor blade. It is known to counteract flashovers of this kind using potential equalization elements.

Potential equalization of this kind is necessary, in particular, if one of the electrically conductive elements is an electrical heating device for de-icing the surface of the wind turbine rotor blade. These heating devices are provided with a power supply and have to be electrically isolated from the lightning protection system during operation. For this purpose, spark gaps may be provided in the interior of the rotor blade, between the heating device and the lightning protection arrangement, as shown in the publication WO 00/79128 A1. In the event of a lightning strike, these spark gaps are bridged and establish potential equalization between the heating device and the lightning protection arrangement.

The publication WO 2014/023734 A1 shows a wind turbine rotor blade having an electrical heating device and a lightning conductor. The heating device and the lightning conductor are connected to one another at several points over the length of the rotor blade, via spark gaps. The spark gaps are arranged in the interior of the rotor blade, in combination with the lightning receptors.

In order to ensure the operational reliability of the lightning protection arrangement, the functional performance of the spark gaps must be checked

regularly. In this case, in particular, spark gaps which are arranged in the blade tip region are accessible only with a great deal of difficulty.

From the document WO 2012/055418 A1 a wind turbine rotor blade with the features of the preamble of claim 1 has become known. In the known wind turbine rotor blade, a metallic vortex generator strip forms an additional lightning receptor, wherein an electrical connection of the additional lightning receptor and a lightning conductor comprises an exterior spark gap.

Proceeding from the above, the object of the invention is to provide a wind turbine rotor blade having a potential equalization arrangement which can more easily be kept in an operationally reliable state.

This object is achieved by the wind turbine rotor blade having the features of claim 1. Advantageous refinements are specified in the subsequent dependent claims.

The wind turbine rotor blade has a lightning receptor, a first electrical line and a potential equalization arrangement which has a first electrode, which is connected to the lightning receptor, and a second electrode, which is connected to the first electrical line, a spark gap being formed between the two electrodes and the two electrodes being arranged on an outer side of the wind turbine rotor blade and being exposed to the surrounding air flow.

The lightning receptor can be arranged, in particular, at or close to a blade tip of the wind turbine rotor blade, but also at a greater distance therefrom, even in combination with one or more further lightning receptors. The lightning receptor is generally composed of metal, for example of copper or aluminum, and offers an exposed surface on the outer side of the wind turbine rotor blade, into which lightning can strike.

The first electrical line may be a lightning conductor or another electrical line, for example a supply line, by means of which electrical energy can be supplied to an electric load which is arranged in or on the wind turbine rotor blade, or a signal line, via which electrical signals can be transmitted, for example, from a sensor which is arranged in or on the wind turbine rotor blade. The first electrical line may be dimensioned such that, in the event of a lightning strike in which potential equalization is effected by means of the spark gap, it can wholly or partially carry a lightning current, in particular as far as a blade root. In this sense, the first electrical line may be a lightning conductor, even if the first electrical line fulfills a different function during normal operation of the wind turbine rotor blade. The first

electrical line is electrically isolated from the lightning receptor. Potential equalization is effected by means of the spark gap only in the event of a lightning strike.

The connection of the first electrode to the lightning receptor and/or the connection of the second electrode to the first electrical line may be an indirect or direct connection. For example, this connection may include a rigid electrical conductor, a more or less flexible cable and/or a screwed connection.

The two electrodes are preferably solid metal parts, in particular composed of copper. The two electrodes are arranged at a distance from one another, said distance being dimensioned such that, in the case of the high potential differences that occur in the event of a lightning strike, a flashover occurs, the distance simultaneously ensuring sufficient electrical insulation for the potential differences which occur during normal operation of the wind turbine rotor blade. Typically, the distance between the two electrodes may be in the order of magnitude of approximately one or several centimeters.

In the case of the invention, the two electrodes are arranged on an outer side of the wind turbine rotor blade and are exposed to the surrounding air flow. An important advantage of this external arrangement of the electrodes is that they are readily accessible from the outside for servicing and repair work. Furthermore, the air flow can reach, in particular, the free space between the two electrodes and prevent moisture or particles accumulating.

In the case of the invention, the wind turbine rotor blade has a busbar which forms a current path from a pressure side of the wind turbine rotor blade to a suction side of the wind turbine rotor blade, the two electrodes being integrated into said current path and said current path being interrupted by the spark gap. Busbars as potential equalization elements are known. They are distinguished by a robust design and a high current-carrying capacity. If the busbar is intended to establish potential equalization between conductors which are arranged on different sides of the wind turbine rotor blade (pressure side/suction side), the busbar can be arranged, in particular, on the outer side of the wind turbine rotor blade. This allows the busbar to be mounted after the rotor blade is largely complete, in particular after two half-shells are joined together, it being possible for the two conductors which are to be connected to one another by means of the busbar to be integrated into said two half-shells. In the case of the invention, the spark gap is integrated into the busbar, this allowing a particularly compact arrangement.

In one refinement, the busbar is arranged substantially in the direction of an air flow which flows around the wind turbine rotor blade during operation. This is advantageous in respect of aerodynamics.

In one refinement, the busbar is routed around a profile trailing edge of the wind turbine rotor blade. As a result, undesirable interactions between the busbar and an electrical heating device which is arranged substantially in the region of the profile leading edge can be avoided.

In one refinement, the busbar has a first section with a first end which forms the first electrode and with a second end which is connected to the lightning receptor, and has a second section with a first end which forms the second electrode and with a second end which is connected to the first electrical line. The spark gap is arranged between the two electrodes. The two second ends can be routed directly as far as the conductors between which the busbar is intended to allow potential equalization and can be connected to said conductors, or can end at a distance from said conductors and can be connected to said conductors indirectly, for example by means of cables.

In one refinement, the first section or the second section has an elongate hole with the aid of which said section is fastened to the wind turbine rotor blade and which allows the distance between the two electrodes to be adjusted. The length of the spark gap can be adjusted in a targeted manner in this way. The electrical connection of the first section or of the second section at its second end can be established, in particular, with the aid of a threaded bolt which is inserted into the elongate hole, so that the elongate hole simultaneously allows simple fastening to the wind turbine rotor blade and reliable electrical connection.

In one refinement, the first section or the second section is routed around the profile trailing edge of the wind turbine rotor blade. In this way, the busbar allows potential equalization between the pressure side and suction side.

In one refinement, the first end of the first section tapers to a point in the direction of the first end of the second section and/or vice versa. The term “and/or vice versa” means that, as an alternative or in addition, the first end of the second section can taper to a point in the direction of the first end of the first section. Therefore, saying that the end in question tapers to a point means that, in particular, its width narrows in said direction, wherein the tip can be rounded to a greater or lesser extent. A geometry of this kind of one or both of the electrodes leads to the formation of the spark gap in a clearly defined region.

In one refinement, a surface region on the outer side of the wind turbine rotor blade in which the two electrodes are arranged is provided with a heat-resistant coating. When the spark gap is ignited, the coating serves as a protective layer for the material of the rotor blade shell (for example a glass fiber laminate) and can be composed of ceramic or Teflon for example.

In one refinement, the wind turbine rotor blade has an electrical heating device, and the first electrical line is a supply line via which the electrical heating device can be supplied with a heating current. In this case, the electrical isolation between the first electrical line and the lightning receptor which is generally connected to ground by means of a lightning conductor allows current to be supplied to the heating device in a reliable manner. At the same time, damage to the supply line or to the electrical heating device is prevented by the potential equalization which occurs in the event of a lightning strike.

In one refinement, the wind turbine rotor blade has a lightning conductor which is connected to the lightning receptor and leads to a blade root. The lightning conductor is a second electrical line and, like the first electrical line too, may optionally fulfill an additional function, for example as a supply or signal line. To this end, the lightning conductor can be electrically isolated from ground potential as necessary, for example using a further spark gap or another surge arrestor.

The invention is explained in greater detail below on the basis of exemplary embodiments which are illustrated in figures, in which:

figure 1 shows a simplified, perspective illustration of a rotor blade which is known from the prior art,

figure 2 shows a perspective illustration of a detail of a busbar for a wind turbine rotor blade according to the invention, and

figure 3 likewise shows a perspective illustration of a further detail of another busbar for a wind turbine rotor blade according to the invention.

All figures are schematic illustrations and use the same reference symbols for mutually corresponding elements.

Figure 1 shows a wind turbine rotor blade 10 which is known from the prior art and has an electrical heating device 30. The wind turbine rotor blade 10 has a blade

root 12 and a blade tip 14. In figure 1, the view is directed substantially toward the pressure side 16. The wind turbine rotor blade 10 has a suction side 18 on the side facing away from the viewer.

The wind turbine rotor blade 10 has a profile trailing edge 20 and a profile leading edge 22. A lightning receptor 24 is arranged in the region of the blade tip 14, said lightning receptor 24 being electrically conductively connected to a lightning conductor 26 which is indicated by a dashed line. The current of a lightning strike into the lightning receptor 24 can be diverted in the direction of the blade root 12 via the lightning conductor 26.

The wind turbine rotor blade 10 has an electric heating device 30, through which current flows in the longitudinal direction and which, at the blade root end of said rotor blade and at the blade tip end of said rotor blade, is in each case connected to a power supply cable 28, 29. Potential equalization connections 32, which each have an interposed spark gap 34, are located between the heating device 30 and the lightning conductor 26, and between the power supply cables 28, 29 and the lightning conductor 26. A potential equalization device according to the invention which is situated on the surface of the rotor blade and which is in the form of a busbar 36 with two electrodes, between which a spark gap is located, is arranged in the region of the rotor blade tip. During normal operation, the heating device 30 and the lightning conductor 26 are electrically isolated from one another, in order to prevent the heating current from flowing away via the lightning conductor 26. In the event of a lightning strike, the spark gaps 34 are ignited by the lightning current, and potential equalization is effected between the parallel conductors.

Figure 2 illustrates a busbar 36 in a position in which it is fastened to a wind turbine rotor blade 10 according to the invention. The wind turbine rotor blade 10 itself is omitted from figure 2.

The busbar 36 has a first section 38, the first end 40 of said first section forming the first electrode. A second end 42 of the first section 38 is connected to a lightning receptor 24, not illustrated in figure 2, specifically by means of the cable 44. A lightning conductor 46, which leads to the blade root 12, is likewise connected to the first section 38 of the busbar 36.

The busbar 36 also has a second section 48 which has a first end 50 which forms the second electrode, and has a second end 52 which is connected to a first electrical conductor 54, specifically by means of a bolt 56 which is routed through the rotor blade shell, not illustrated, and indicated by a dash-and-dot line.

During normal operation of the wind turbine rotor blade, the first electrical conductor 54 fulfills a function as a supply line for an electrical heating device 30, not illustrated in figure 2. In the event of a lightning strike, the first electrical conductor 54 additionally acts as a lightning conductor and can divert some of the lightning current to the blade root 12.

The first end 40 of the first section 38 of the busbar 36 tapers to a point in the direction of the first end 50 of the second section 48 of the busbar 36. The first end 50 of the second section 48 of the busbar 36 likewise tapers to a point in the direction of the first end 40 of the first section 38 of the busbar 36, so that a region of a smallest distance between the two electrodes which are formed by the two first ends 40, 50 is spatially precisely defined.

Figure 3 shows a further exemplary embodiment of a busbar 36, which is divided into two, for a wind turbine rotor blade 10 according to the invention. Said figure shows only the first section 38 and the second section 48 of the busbar 36. Said figure clearly shows an elongate hole 58 which is formed in the first section 38 and runs in the longitudinal direction of the first section 38 of the busbar 36 and allows the first section 38 to be fastened to the wind turbine rotor blade 10 in a different position, so that the length of the spark gap between the two sections 38, 48 of the busbar 36 can be adjusted in a targeted manner, as illustrated by the arrow 60.

A surface region 62 of the wind turbine rotor blade 10, not illustrated, in which a heat-resistant coating is applied to the wind turbine rotor blade is indicated using dashed lines. The two electrodes are located in the surface region 62.

List of reference symbols used:

10	Wind turbine rotor blade
12	Blade root
14	Blade tip
16	Pressure side
18	Suction side
20	Profile trailing edge
22	Profile leading edge
24	Lightning receptor
26	Lightning conductor
28	Power supply cable
29	Power supply cable
30	Heating device
32	Potential equalization connection
34	Spark gap
36	Busbar
38	First section of the busbar 36
40	First end of the first section 38
42	Second end of the first section 38
44	Cable
46	Lightning conductor
48	Second section of the busbar 36
50	First end of the second section 48
52	Second end of the second section 48
54	First electrical line
56	Bolt
58	Elongate hole
60	Arrow
62	Surface region with coating

Patentkrav

1. Vindturbinerotorblad (10) med en lynaflederreceptor (24), en første elektrisk ledning (54) og en potentialeudligningsindretning som har en første elektrode, der er forbundet til lynaflederreceptoren (24), og en anden elektrode der er forbundet med den første elektriske ledning (54), hvor der er dannet et gnistgab mellem de to elektroder, hvilke to elektroder er anbragt på en ydre side af vindturbinerotorbladet (10) og er udsat for den omgivende luftstrøm,
kendetegnet ved en strømskinne (36) der danner en strømbane fra en trykside (16) af vindturbinerotorbladet (10) til en sugside (18) af vindturbinerotorbladet (10), i hvilken de to elektroder er integreret og hvilken er afbrudt af gnistgabet.

2. Vindturbinerotorbladet (10) ifølge krav 1, **kendetegnet ved, at** strømskinnen (36) er anbragt i det væsentlige i strømningsretningen af en luftstrøm, som strømmer rundt om vindturbinerotorbladet (10) under drift.

3. Vindturbinerotorblad (10) ifølge et af kravene 1 eller 2, **kendetegnet ved, at** strømskinnen (36) er ført omkring en profilbagkant (20) af vindturbinerotorbladet (10).

4. Vindturbinerotorblad (10) ifølge et af kravene 1 til 3, **kendetegnet ved, at** strømskinnen (36) omfatter: en første sektion (38) med en første ende (40) som danner den første elektrode, og med en anden ende (42) som er forbundet til lynaflederreceptor (24), og en anden sektion (48) med en første ende (50) der danner den anden elektrode, og med en anden ende (52) som er forbundet til den første elektriske ledning (54).

5. Vindturbinerotorbladet (10) ifølge krav 4, **kendetegnet ved, at** den første sektion (38) eller den anden sektion (48) har et aflangt hul (58) ved hjælp af hvilket den nævnte sektion er fastgjort til vindturbinerotorbladet (10) og som gør det muligt at justere afstanden mellem de to elektroder.

6. Vindturbinerotorblad (10) ifølge krav 4 eller 5, **kendetegnet ved, at** den første sektion (38) eller den anden sektion (48) er ført omkring profilbagkanten

(20) af vindturbinerotorbladet (10).

7. Vindturbinerotorblad (10) ifølge et af kravene 4 til 6, **kendetegnet ved, at** den første ende (40) af den første sektion (38) løber til et punkt i retning af den første ende (50) af den anden sektion (38) og/eller omvendt.

8. Vindturbinerotorblad (10) ifølge et af kravene 1 til 7, **kendetegnet ved, at** et overfladeområde (62) på den ydre side af vindturbinerotorbladet (10), hvori de to elektroder er anbragt, er forsynet med en varmeresistent belægning.

9. Vindturbinerotorblad (10) ifølge et af kravene 1 til 8, **kendetegnet ved, at** vindturbinerotorbladet (10) omfatter en elektrisk opvarmningsindretning (30), og den første elektriske ledning (54) er en forsyningsledning, over hvilken den elektriske opvarmningsindretning (30) kan forsynes med en opvarmningsstrøm.

10. Vindturbinerotorblad (10) ifølge et af kravene 1 til 9, **kendetegnet ved, at** vindturbinerotorbladet (10) omfatter en lynafleder (46), der er forbundet til lynafl ederreceptoren(26) og fører til en bladrod (12).

Fig. 1

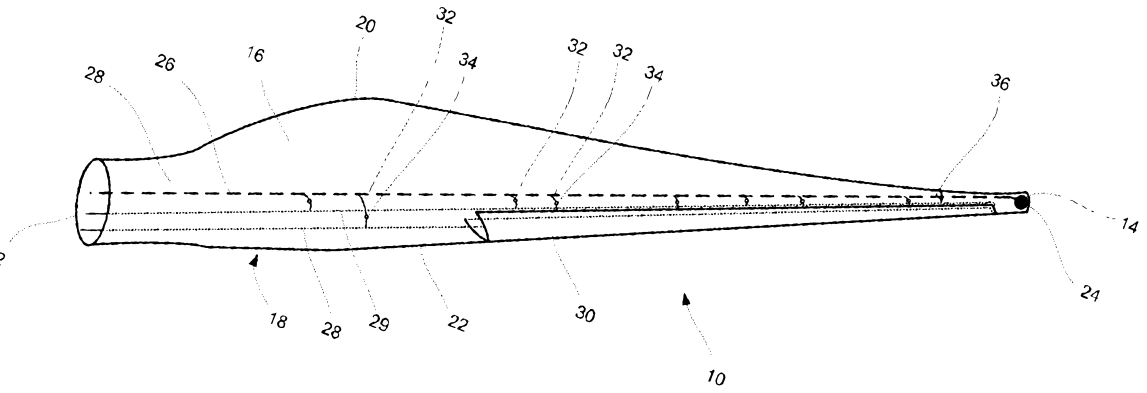

Fig. 2

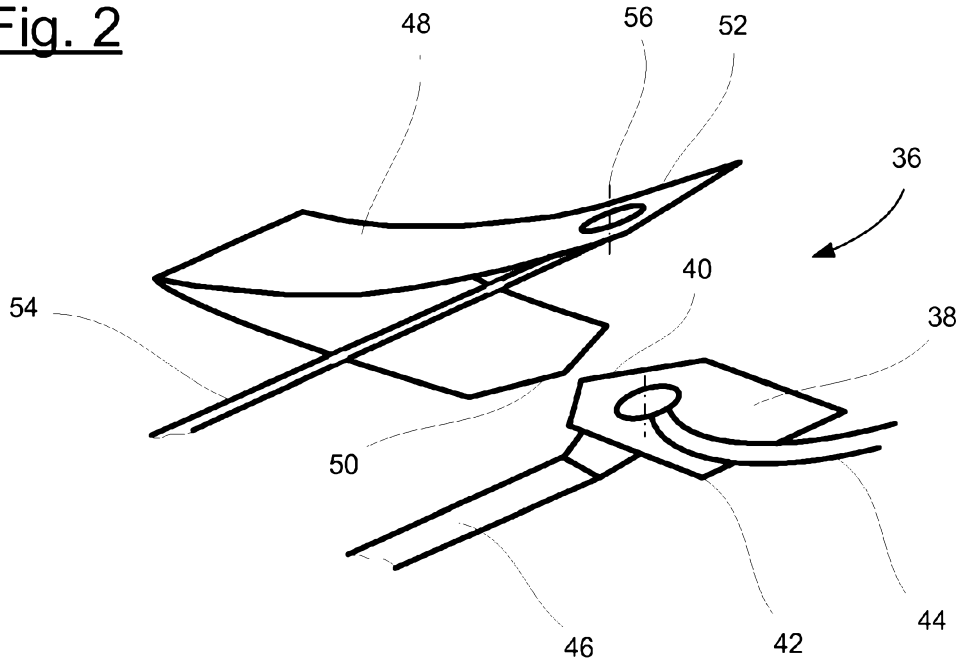

Fig. 3