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(54) Benævnelse: **Fremgangsmåde til drift af et vindenergianlæg og vindenergianlæg til udøvelse af fremgangsmåden**

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"OPTICAL DETECTION OF ICE ON A HELICOPTER ROTOR", NTIS TECH NOTES, US DEPARTMENT OF COMMERCE. SPRINGFIELD, VA, US, 1. August 1992 (1992-08-01), Seite 616, XP000325353, ISSN: 0889-8464

The invention relates to a method for operating a wind turbine in which an icing hazard is determined, as well as a wind turbine with a light source, a light detector and a controller connected to the light detector.

At a few wind turbine locations, components of the wind turbine, in particular rotor blades, repeatedly ice over due to high humidity or precipitation at temperatures around the freezing point. Such icing can impair the operation of the wind turbine, in particular reduce the aerodynamic performance of the rotor blades. Beyond the corresponding loss of revenue, aerodynamic imbalance can result which can reduce the life of components.

Correspondingly, effective deicing can increase the life and efficiency of a wind turbine at locations where icing occurs. Active and passive deicing systems can be used, in particular for deicing rotor blades. Active deicing systems have in particular an electrically operated heating device. Such a heating device is for example knowing from WO 98/53200 A1.

In order to be able to use active deicing systems in a targeted manner and without excessive energy consumption, it is very important to recognize incipient ice formation or an icing hazard. In this regard, US 2011/0089692 A1 discloses measuring the meteorological data of temperature, relative humidity and sunlight in the environment of a wind turbine and thereby determining a probability of icing. In the known method, there is also monitoring of whether the wind turbine reaches an expected performance value at the respective wind speed. Depending on deviations in performance and the identified icing hazard, the wind turbine can be shut off.

Viktor Carlsson: “Measuring routines of ice accretion for Wind Turbine applications", Master Thesis, Master of Science Programme in Engineering Physics, 180 hp, Umeå Universitet, Skellefteå Kraft, discloses recognizing icing that has already occurred in the proximity of the wind turbine based on a comparison of the measurements of a heated and unheated anemometer. The thesis also describes the problem of rotor blade icing within clouds and, in this context, the possibility of determining the cloud height (cloud base height) founded on a runtime measurement of the light of a laser backscattered by the cloud cover. This type of cloud height measurement is also known by the abbreviation of LIDAR (*light detection and ranging*).

The document WO 2011/048024 discloses measuring the distance of the rotor blades using optical sensors in wind turbines in order to identify asymmetrical rotor blade loads and to correspondingly correct the azimuth position of the wind turbine, and/or the pitch angle of individual rotor blades.

A method is known from the document US 2012/0207589 A1 for identifying ice on a surface of a wind turbine rotor blade. In the known method, the intensities of light reflected diffusely from the surface and mirrored light is evaluated. The difference between diffuse reflection and mirroring is differentiated with the assistance of a polarization filter.

Against this background, it is the object of the invention to provide a method for operating a wind turbine by means of which an icing hazard can be easily and precisely determined.

This object is achieved by a method for operating a wind turbine which has a rotor with at least one rotor blade passing over a rotor area, with the steps indicated in claim 1. Advantageous embodiments of the method are cited in the dependent claims.

The method includes the following steps:

- directing a lighting beam toward the rotor area,
- detecting light intensities of returned shares of the lighting beam, wherein a first light intensity comprises light reflected back by the at least one rotor blade, and a second light intensity comprises none of the light reflected back by the at least one rotor blade,
- determining an icing hazard based on the detected light intensities.

The lighting beam is emitted by a light source. The fact that it is directed toward the rotor area means that the light of the lighting beam illuminates a region which lies at least partially within the rotor area. The illuminated region can be more or less in the form of a dot, but it can also be relatively extensive. In particular, the illuminated region can be dimensioned such that it lies completely within the projection of a rotor blade on the rotor area at the time at which a rotor blade is located at the position of the illuminated region during its rotation. In this case, there are points in time at which the entire lighting beam, or at least a share of the lighting beam contacting the rotor area, entirely contacts a rotor blade.

The light intensities are for example detected using a light detector. That the returned parts of the light beam are detected means that it is not the intensity of the lighting beam itself which is detected, but rather only those parts that have previously contacted objects or particles, in particular on a rotor blade, which are located within the lighting beam, water droplets and/or snowflakes, and are reflected by them in particular in the direction substantially opposite that of the lighting beam. The physical process underlying the return can in particular be diffusion, or reflection, or a mixture thereof.

In the method according to the invention, light intensities are used which correspond to different situations. The first light intensity corresponds to the situation in which the lighting beam completely or partially contacts a rotor blade, and at least a part of the lighting beam is returned by the rotor blade. This is contained in the first light intensity to the extent that it is not attenuated on the “return path” from the rotor blade to the location of detection. To this are added the shares of the lighting beam which are returned before contacting the rotor blade, i.e., from being scattered by water droplets.

The second light intensity corresponds to the situation in which the rotor blade is not in the region contacted by the lighting beam, and/or in a region toward which a light detector is oriented that is used for detection. In this situation, only those portions of the lighting beam are detected which are returned by particles, droplets, or other structures different from the rotor blade. This returning can take place both in front of or behind the rotor area. It arises from a clouding of the air, in particular from water droplets and/or snowfall.

Accordingly, the first light intensity is influenced by the rotor blade, and the second light intensity is not. The second light intensity is generally less than the first light intensity. Under certain conditions, both intensities can be approximately equal, for example during strong snowfall.

The first and second intensity can be detected at the same points in time, or at different points in time. In particular, a single lighting beam and a single light detector can be used. In this case, the two light intensities must be detected sequentially. The movement of the rotor blade through the illuminated region causes a continuous alteration of the lighting situation.

Alternatively, the two light intensities can be detected for spatially different regions of the rotor area. This can optionally occur simultaneously. For example, regions of the rotor area can be illuminated in which a rotor blade is located at a specific time, and a region of the rotor area which differs therefrom in which there is no rotor blade. The regions can be at a distance from each other, for example when using two lighting beams. They can also form a contiguous area within the rotor area which extends beyond the dimensions of a rotor blade arranged therein. Likewise and possibly in combination therewith, the detector regions of one or more light detectors can also be focused or limited such that both light intensities can be detected for spatially different, separate regions of the rotor area.

In these cases, simultaneous detection of the first and second light intensities is readily feasible.

An icing hazard is determined with the invention. The icing hazard is a measure of whether icing of the wind turbine can be anticipated. The icing hazard can be simple yes/no information, or a quantitative variable which corresponds to the probability of icing. In the latter case, steps associated with the determination of the icing hazard such as the starting of a heater can be linked to the exceeding of a specific probability value.

The invention offers a particularly simple way of determining the icing hazard. Included in the evaluation is how the returned shares of the light intensity behave “with and without” the rotor blade. In particular, the share of light intensity returned independent of the rotor blade, i.e., the second light intensity, is decisively influenced by the weather conditions, in particular by the haziness of the air such as by water droplets, snowflakes, etc. By additionally taking into account the first light intensity, the analysis is easily related to the situation in a rotor blade environment. The obtained measured values are particularly meaningful due to this direct spatial reference to the location of the rotor.

In contrast to the known LIDAR methods, the method of the invention can be executed with relatively simple measuring devices. This is assisted by the fact that only light intensities and not runtimes have to be evaluated.

In one embodiment, the lighting beam is directed toward a region of the rotor area that is arranged less than a quarter of the rotor diameter below a highest point of the rotor area. The region can also be arranged at a vertical distance of less than one-eighth of the rotor diameter, or less than 5 m, or less than 1 m below the highest point. An icing hazard from “in-cloud icing” can thereby be discerned early because a lowering of the cloud cover to the highest region of the rotor area can be reliably detected and distinguished from cloud covers that lie only slightly higher and are therefore less critical.

In one embodiment, the lighting beam only emits light within a spectral range at a bandwidth of 200 nm or less, and/or at wavelengths outside of the visible range, and/or only light intensities are detected within a spectral range at a bandwidth of 200 nm or less, and/or at wavelengths outside of the visible range. The bandwidth can also only be 100 nm or less, or 50 nm. Emission and detection preferably occur within the same spectral range. The spectral range outside of the visible range can for example lie within the UV range, or within the IR range, in particular in the so-called eye-safe range of approximately 1.5 µm to 2 µm. A plurality of spectral ranges can also be used simultaneously, both for emitting as well as for detecting the light. For transmitting the light, light sources can be used in particular whose emission is restricted to the respective spectral range. To detect the returned light, filters can be used such as bandpass, notch or edge filters in addition to light detectors with a corresponding spectral sensitivity. By means of these measures, disturbing influences from other light sources can be reduced. Likewise, a disturbance of the environment can be avoided; for example, people are not blinded.

In one embodiment, the lighting beam is conical. The cone can have an opening angle of for example 10° or less, 5° or less, 1° or less or 0.1° or less. This allows the light from any desired light source, in particular a laser, to be modified with a beam-forming lens system, in particular spread or focused. This generates a specific illuminated region. It is also possible to use a lens system or collimator to detect the returned light which concentrates the detection region of a light detector basically on the illuminated region. For example, restricting the opening angle of the detection range to 10° or less, 5° or less, 1° or less, or 0.1° or less can be recommendable.

In one embodiment, the first light intensity is caused by diffuse backscatter and/or reflection of the light of the lighting beam at a surface of the at least one rotor blade, wherein the surface of the adjacent surfaces of the at least one rotor blade has deviating optical properties. This makes it possible to configure the measuring procedure to be more reliable/robust since the first light intensity can be optimized within specific limits for the measuring method and is independent of the general optical properties of the surface of the rotor blade. For example, the first light intensity can be significantly increased by a mirror. A Fresnel lens system, a retroreflector or an optical grid can also be arranged or integrated on or in the surface. Moreover, the different optical properties can be achieved by locally changing the surface composition or color of the rotor blade, wherein the aerodynamic properties of the rotor blade can remain substantially unchanged. It is also possible to roughen the surface or modify the geometry of the rotor blade surface in the region of the surface with the special optical properties.

In one embodiment, the light reflected back by the at least one rotor blade is caused by diffuse backscatter of the lighting beam at a surface of the at least one rotor blade. The surface can be one that does not differ from the adjacent rotor blade surfaces. In this case, no changes are necessary on the sides of the rotor blades in comparison to a conventional wind turbine. Alternatively, the surface can be modified, in particular roughened, to achieve stronger backscatter. In any case, a restriction to diffuse backscatter from the rotor blade avoids difficulties in the alignment of the surface with respect to the light source and the light detector.

In one embodiment, the light intensities are detected continuously and divided into a constant share and periodic share over time for evaluation. This allows the obtained signal to be evaluated with simple means and supplied to a controller.

In one embodiment, a rotor speed and/or a rotor angle of rotation are taken into consideration in the division into the constant share and the periodic share over time. The periodic share can thereby be effectively filtered out in particular in a lock-in method, even when the signals are very noisy. The frequency to be filtered out can in particular correspond to the current rotor speed multiplied by the number of rotor blades of the rotor. If alternatively or additionally the rotor angle of rotation is taken into account, the signals can be filtered out which have the “correct” phasing.

In one embodiment, the icing hazard is determined based on the relationship between the amplitude of the periodic share and the amount of the constant share over time. This evaluation of the signal enables an extra determination of an icing hazard. The smaller the ratio, the more light is returned independent of the rotor blade, i.e., the greater is the haziness of the air, in particular from water droplets or snow.

In one embodiment, an outside air temperature, a local surface temperature of a component of the wind turbine, a temperature within the at least one rotor blade, a temperature in a nacelle of the wind turbine, a temperature in a hub of the wind turbine, a temperature in a tower of the wind turbine, an air humidity, a dew point, a frost point, a range of vision, a cloud height and/or an air pressure are taken into consideration in determining the icing hazard of the at least one part of the wind turbine. The overall comparison of these additional variables in the method according to the invention makes it possible to more precisely determine an icing hazard. A temperature that is considered in determining the icing hazard can also in principle be measured around the wind turbine, for example in a weather station on the ground, or on a nacelle of the wind turbine. Measuring a local temperature in the proximity of the component whose icing hazard is to be determined can, however, lead to more precise results, in particular because local changes in temperature are taken into account for operating the wind turbine. For example, the icing hazard of components close to a machine cabin of the wind turbine can be decreased by the development of heat from the generator or gearing. In contrast generally due to the low pressure that arises from the flow around the rotor blades, much lower temperatures occur in particular in the region of the rotor blades than at a greater distance from the rotor blades. A measurement of this local temperature takes into account such effects. Other meteorological data that is taken into consideration such as an absolute or relative humidity or the visibility can preferably be detected at a central location. The surface temperature can for example be detected with a temperature sensor which is in direct thermal contact with the surface. In certain situations, the local surface temperature may deviate from the air temperature even directly adjacent to the surface, for example in strong sunlight. The surface temperature is definitive for an ice build-up on the surface so that the icing hazard can be determined very precisely by measuring it.

In one embodiment, a heating device for a component of the wind turbine is activated if the determined icing hazard exceeds a set extent. This counteracts icing. The heating device can for example be a rotor blade heater. The heating device can in particular be electrically operated. Another option for reacting to the icing hazard is to shut off the wind turbine. This simple measure causes a loss of revenue, but damage to the system from icing or endangerment of persons close to the wind turbine from falling ice can be prevented. This solution is recommendable in particular for locations at which an icing hazard only occurs very rarely.

The object specified above is also achieved by the wind turbine with the features of claim 12. Advantageous embodiments are specified in the subsequent dependent claims.

The wind turbine has a rotor that has at least one rotor blade passing across a rotor area, and a device for determining an icing hazard that has the following:

- a light source that is arranged such that it directs a lighting beam toward the rotor area,
- a light detector that is arranged such that it detects the reflected components of the lighting beam, and
- a controller which is connected to the light detector and is designed to determine an icing hazard based on the detected light intensities and in so doing takes into account at least one first light intensity and at least one second light intensity, wherein the first light intensity comprises light reflected back by the at least one rotor blade, and the second light intensity comprises none of the light reflected back by the at least one rotor blade.

In explaining the features and advantages of the wind turbine, reference will be made to the above explanations of the method according to the invention which correspondingly apply. The wind turbine is in particular provided for executing the method according to the invention. By detecting the light intensities and using corresponding signals in a controller to determine the icing hazard, the precision can be easily improved when determining the icing hazard. The light detector can for example be a semiconductor detector such as a CCD (charge coupled device), or a photocell. The light source and light detector are generally arranged on the same side of the rotor surface.

In one embodiment, the light source is a laser light source. Laser light is suitable for a robust measuring system since background noise can be easily suppressed. Only one wavelength, i.e., that of the laser must be detected by the light detector. Other frequencies can be suppressed/not detected, or filtered out.

In one embodiment, the light source and/or the light detector is arranged in the region of a nacelle of the wind turbine. This makes it particularly easy to install and service the measuring arrangement or retrofit an existing wind turbine.

In one embodiment, the wind turbine is designed to execute the method in one or more of the above-described embodiments. This means that the respective component of the wind turbine, in particular the rotor blade, light source, light detector and/or controller is designed as explained in conjunction with the corresponding method steps. For example, the light source can be arranged such that the lighting beam is directed toward the aforementioned special region of the rotor area, or the light source and/or the light detector can have one of the spectral ranges noted above, and/or a surface section of the at least one rotor blade which the lighting beam contacts can be provided with the above-explained special optical properties. In another embodiment, the controller can be configured to execute the above-explained evaluation steps, etc.

The invention is explained in greater detail below with reference to an exemplary embodiment shown in the figures. In the following:

Fig. 1 shows a schematic representation of a wind turbine according to the invention,

Fig. 2 shows details of the light source and light detector from Fig. 1 in a schematic representation,

Fig. 3 shows two diagrams of detected light intensities, i.e., one in which the backscatter in the atmosphere is relatively slight (a), and one in which the backscatter in the atmosphere is relatively strong (b).

Fig. 1 shows a schematically simplified wind turbine 10 according to the invention which has a tower 12, a nacelle 20 and a rotor 14 with an essentially horizontal axis, three rotor blades 16 and a rotor hub 18.

In addition, the wind turbine 10 has a device for determining an icing hazard with a light source 30, light detector 32 and a controller 22. The light source 30 and light detector 32 are connected to the controller 22. The controller 22 can be an independent electronic controller, or part of a central operation management system of the wind turbine. The light source 30 and light detector 32 are arranged on the nacelle 20; in the depicted example, in the rear third of the nacelle 20.

The three rotor blades 16 pass over a circular rotor area (not shown) when rotating about the rotor axis. The light source 30 is arranged such that a lighting beam 34 that it emits illuminates a region 38 within the rotor area. In the example, this is located about 1 m to 10 m below a highest point 40 of the rotor area. The light detector 32 is arranged such that its detection range is at least partially arranged within the illuminated region 38, or ideally corresponds substantially therewith in terms of shape and size.

If one of the rotor blades 16 is within the illuminated region 38, a part of the lighting beam 34 is returned at the surface of this rotor blade 16 toward the light detector 32. Independent of the position of the rotor 14, another part of the lighting beam 34 is returned by particles in the air, in particular in the form of water droplets or snow. If a rotor blade 16 is in the illuminated region 38, these two returned parts of the lighting beam jointly form the returned share 36. The light detector then detects a first light intensity I_1 (see Fig. 3).

If there is no rotor blade 16 in the illuminated region 38, the part of the lighting beam returned by the rotor blade 16 is missing, and the returned share 36 merely originates from the backscatter in the air. The light detector 32 correspondingly detects a second light intensity I_2 (see Fig. 3).

Fig. 2 shows the light source 30 and light detector 32 enlarged. The light source 30 is an eye-safe IR laser such as a solid-state laser or a laser diode. The light detector 32 can be a semiconductor detector such as a CCD sensor or a photocell. Through a light-tight housing 24 and an arrangement of collimator lenses 26 with a specific opening angle, it detects light emitted by the light source 30 which was then returned.

To suppress daylight and/or other sources of disturbance such as the light from a hazard beacon, a notch filter 28 is arranged between the two collimator lenses 26. The notch filter 28 only lets light wavelengths pass through on the basis of which the light intensity is to be detected by the light detector 32, and is tuned to the light emitted by the light source 30.

Fig. 3 a) and 3 b) show for example the characteristics of the light intensities detected with the light detector over time. Fig. 3 a) shows two strong signal peaks at a first light intensity I_1. These signal peaks recur after a period 46 and are generated while the individual rotor blades 16 pass through the illuminated region 38 when a maximum share of the lighting beam 34 is returned. Between the signal peaks, none of the rotor blades 16 are located in the illuminated region 38, and the almost constant second light intensity I_2 is detected. The figure also reveals a division of the light intensities into a temporally constant share 44 that corresponds to the second light intensity I_2 and a periodic share with an amplitude 42 that corresponds to the difference between the first light intensity I_1 and the second light intensity I_2. It can be seen that the light intensity I_1 is many times larger than the light intensity I_2. This means that the intensity of the share of the lighting beam 34 returned by the air, or respectively the particles contained in the air, is significantly less than the intensity of the share returned by the rotor blade 16. It can therefore be concluded that even in the top region of the rotor area there is no appreciable cloud or snowfall density, and the icing hazard is correspondingly low.

In Fig. 3 b), the ratio of the second light intensity I_2 and first light intensity I_1 is lower; the signal peaks are significantly less pronounced. The amplitude 42 of the periodic share of the light intensities is only about one-tenth of the amount of the temporally constant share 44. The distance between the two light intensities I_2 and I_1 is less than the situation in Fig. 3 a). The situation is typical for a high cloud or snowfall density in the region between the rotor blade and the measuring arrangement consisting of the light source 30 and the light detector 32. In this case, a majority of the lighting beam 34 is returned before reaching the rotor area which produces a relatively large second light intensity I_2. The light intensity I_2 is generally larger than the situation depicted in Fig. 3 a). In addition, the lighting beam 34 already weakened by the backscatter on the path from the light source 30 to the rotor area is further weakened along the return path to the light detector 32 after being returned or reflected by the rotor blade 16. Under corresponding temperature conditions, the icing hazard is elevated due to the high cloud or snowfall density.

List of reference numbers

10	Wind turbine
12	Tower
14	Rotor
16	Rotor blade
18	Rotor hub
20	Nacelle
22	Controller
24	Housing
26	Collimator
28	Notch filter
30	Light source
32	Light detector
34	Lighting beam
36	Returned light
38	Illuminated region
40	Highest point of the rotor area
42	Periodic share

44 Temporally constant share

46 Period

I_1 First light intensity

I_2 Second light intensity

Patentkrav

1. Fremgangsmåde til drift af et vindenergianlæg (10), som har en rotor (14) med mindst et rotorblad (16), som stryger hen over en rotorflade, med følgende trin:

- rette en belysningsstråle mod rotorfladen,
- registrere lysintensiteter fra tilbagekastede andele (36) af belysningsstrålen (34), hvorved en første lysintensitet (I_1) omfatter lys, som tilbagekastes fra det mindst ene rotorblad (16) og en anden lysintensitet (I_2), som ikke omfatter lys, der kastes tilbage fra det mindst ene rotorblad (16), men fremkaldes af belysningsstrålens (14) bagud spredning af belysningsstrålen (34) i luften,
- registrering af en overisningsfare på grundlag af de registrerede lysintensiteter.

2. Fremgangsmåde ifølge krav 1, **kendetegnet ved,** at belysningsstrålen (34) er rettet imod et område (38) af rotorfladen, som er anbragt mindre end en fjerdedel af rotordiameteren under et højeste punkt (40) på rotorfladen.

3. Fremgangsmåde ifølge krav 1 eller 2, **kendetegnet ved,** at belysningsstrålen (34) kun udstråler lys i et spektralområde med en båndbredde på fra 200 nm eller mindre og/eller med bølgelængder uden for det synlige område og/eller at kun lysintensiteter i et spektralområde med en båndbredde på fra 200 nm eller mindre og/eller en bølgelængde uden for det synlige område registreres.

4. Fremgangsmåde ifølge et af kravene 1 til 3, **kendetegnet ved,** at belysningsstrålen (34) er kegleformet.

5. Fremgangsmåde ifølge et af kravene 1 til 4, **kendetegnet ved**, at den første lysintensitet (I_1) fremkaldes ved diffus bagudspredning og/eller refleksion af belysningsstrålens (34) lys på en overflade på det mindst ene rotorblad (16), hvorved overfladen har optiske egenskaber, som afviger fra de nærliggende overflader på det mindst ene rotorblad (16).

6. Fremgangsmåde ifølge et af kravene 1 til 5, **kendetegnet ved,** at lyset (36), som tilbagekastes fra det mindst ene rotorblad (16), fremkaldes ved diffus bagudspredning af belysningsstrålen (34) på et rotorblad henholdsvis det mindst ene rotorblads (16) overflade.

7. Fremgangsmåde ifølge et af kravene 1 til 6, **kendetegnet ved,** at lysintensiteterne registreres og opdeles til udnyttelsen i en tidsmæssig konstant andel (44) og en periodisk andel (42).

8. Fremgangsmåde ifølge krav 7, **kendetegnet ved,** at ved opdelingen i en tidsmæssig konstant andel (44) og den periodiske andel tages der hensyn til et rotoromdrejningstal og/eller en rotordrejevinkel.

9. Fremgangsmåde ifølge et af kravene 7 eller 8, **kendetegnet ved,** at overisningsfaren bestemmes på grundlag af en difference eller et forhold imellem bidraget fra den periodiske andels amplitude (42) og bidraget fra den tidsmæssige konstante andel (44).

10. Fremgangsmåde ifølge et af kravene 1 til 9, **kendetegnet ved,** at der tages hensyn til en udelufttemperatur, en lokal overfladetemperatur på en komponent i vindenergianlægget (10), en temperatur inden i det mindst ene rotorblad (16), en temperatur i en gondol (20) på vindenergianlægget (10), en temperatur i et nav (18) på vindenergianlægget (10), en temperatur i et tårn (12) på vindenergianlægget (10), en luftfugtighed, et dugpunkt, et frysepunkt, en synsvidde, en skyhøjde og/eller et lufttryk ved beregningen af overisningsfaren.

11. Fremgangsmåde ifølge et af kravene 1 til 10, **kendetegnet ved** det yderligere trin:

- aktivering af en varmeindretning til en komponent i vindenergianlægget (10), såfremt den konstaterede overisningsfare overskrider et forudbestemt mål.

12. Vindenergianlæg (10) med en rotor (14), som omfatter mindst et rotorblad (16), der overstryger en rotorflade, og en indretning til registreringen af en overisningsfare, og som omfatter følgende:

- en lyskilde (30), som er således anbragt, at den retter en belysningsstråle (34) mod rotorfladen,
- en lysdetektor (32), som er således placeret, at den registrerer tilbagekastede andele af belysningsstrålen (34), og
- en styreindretning (22), som er forbundet med lysdetektoren (32), **kendetegnet ved**, at
- styreindretningen er indrettet til på grundlag af de registrerede lysintensiteter at bestemme en overisningsfare og derved tage hensyn til mindst en første lysintensitet (I_1) og mindst en anden lysintensitet (I_2), hvorved den første lysintensitet (I_1) omfatter lys (36), som kastes tilbage fra mindst et rotorblad (169, og den anden lysintensitet (I_2) omfatter lys, som ikke kastes tilbage fra det mindst ene rotorblad (16), men fremkaldes af badudspredningen af belysningsstrålen (34) i luften.

13. Vindenergianlæg (10) ifølge krav 12, **kendetegnet ved,** at lyskilden (30) er en laserlyskilde.

14. Vindenergianlæg (10) ifølge krav 12 eller 13, **kendetegnet ved,** at lyskilden (30) og/eller lysdetektoren (32) er anbragt i området af en gondol (20) på vindenergianlægget (10).

15. Vindenergianlæg (10) ifølge et af kravene 12 til 14, **kendetegnet ved,** at vindenergianlægget (10) er indrettet til udøvelse af fremgangsmåden ifølge et af kravene 1 til 11.

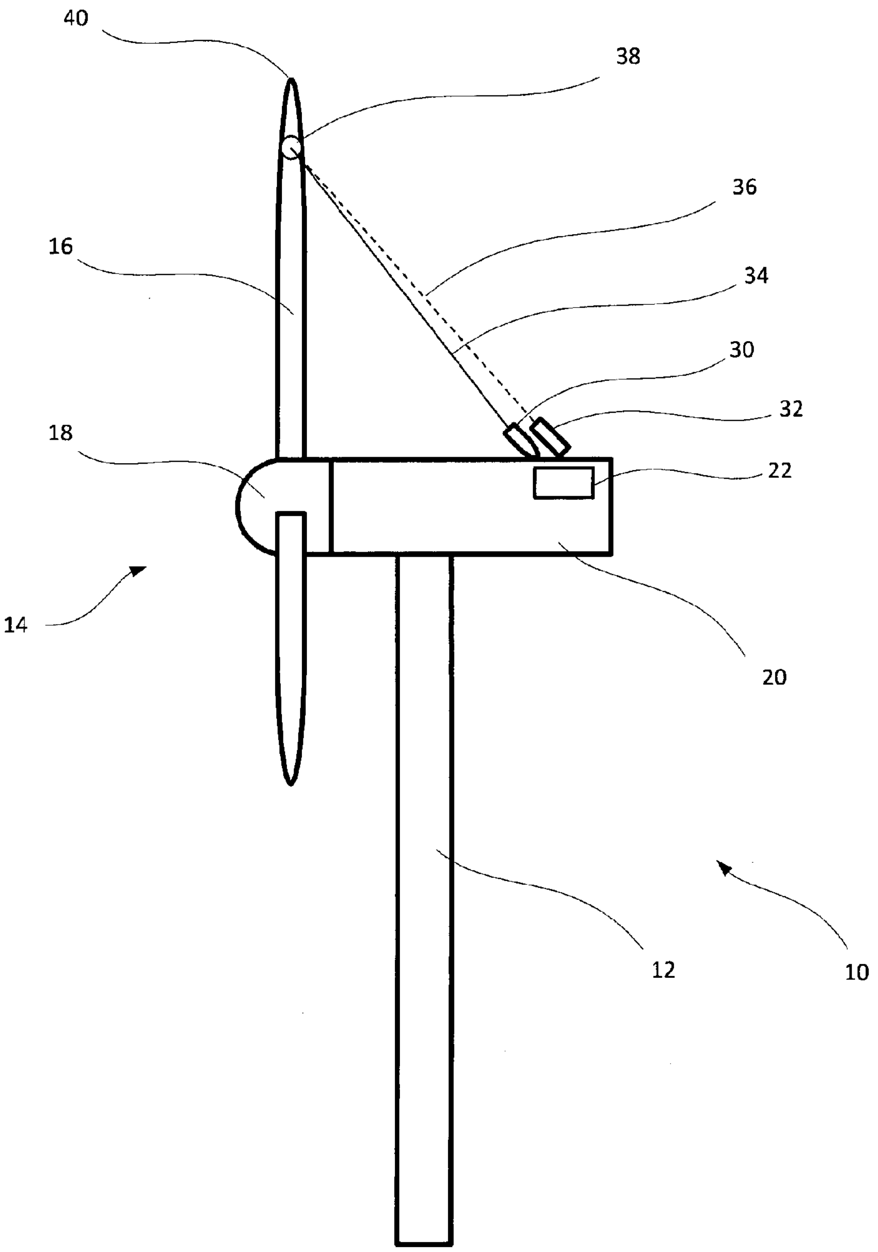

Fig. 1

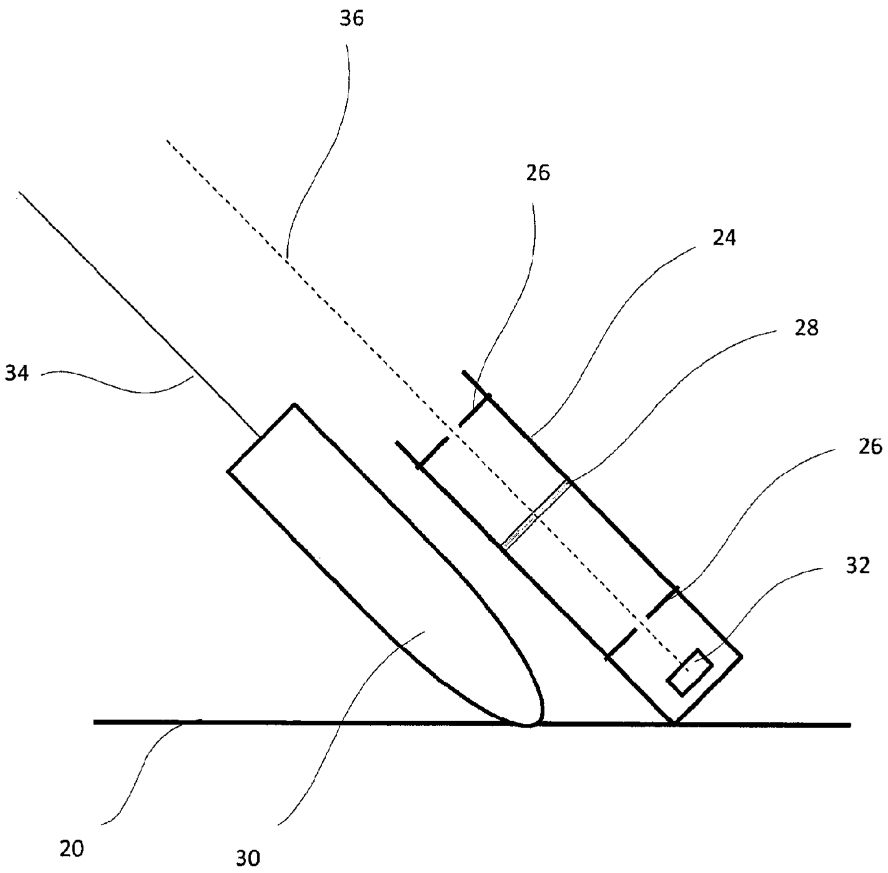

Fig. 2

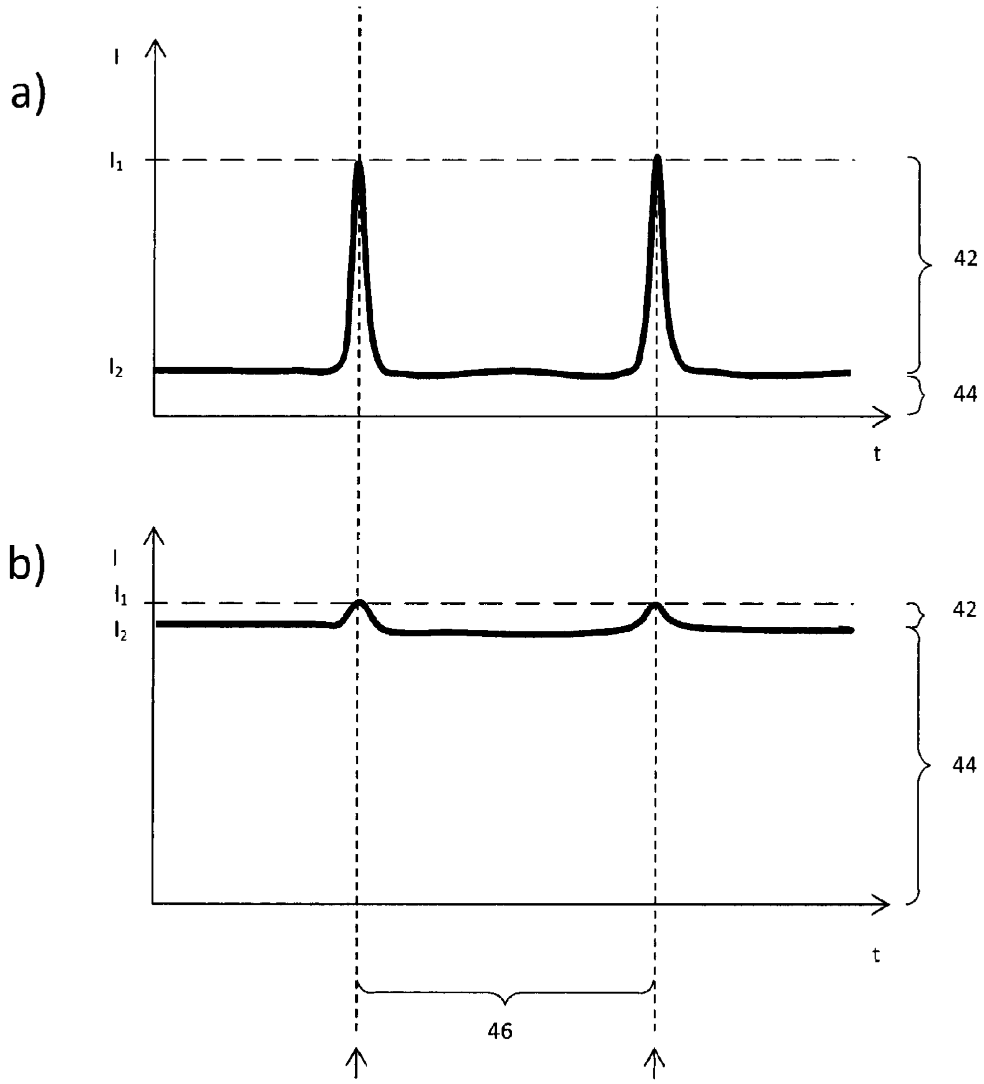

Fig. 3