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(71) **Applicant**: **WINDVECTOR AB** [SE/SE]; Sisjö Kullegata 7, S-421 32 Västra Frölunda (SE).

(72) **Inventor**: **WICKSTRÖM, Stellan**; Mellanängsgatan 8, S-431 44 Mölndal (SE).

(74) **Agent**: **FRITSCHE, Daniel**; Awapatent AB, Södra Hamngatan 37-41, Box 11394, S-404 28 Göteborg (SE).

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(54) **Title**: METHOD AND DEVICE FOR DETECTING ACCUMULATION OF ICE AND/OR SNOW ON A BLADE OF A WIND TURBINE

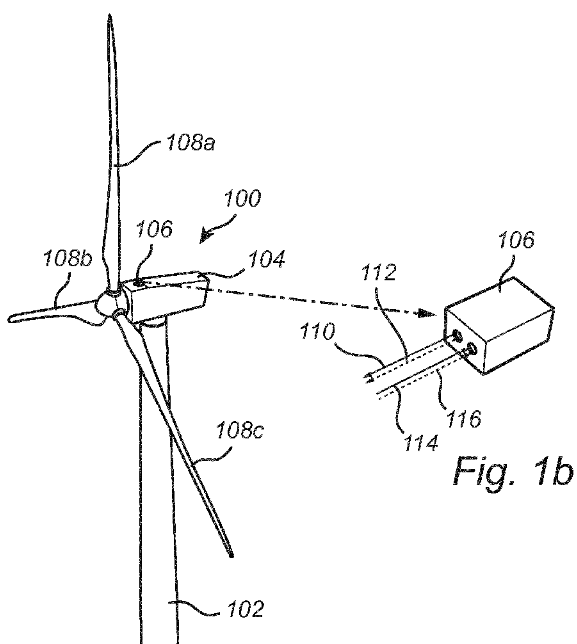

Fig. 1b

Fig. 1a

(57) **Abstract**: The present invention relates to a method for detecting accumulation of ice and/or snow on a blade (108a, 108b, 108c) of a wind turbine (100), said method comprising the steps of: transmitting (S1) a first light beam (110) having a first wavelength and a second light beam (112) having a second wavelength in a direction towards said blade (108a, 108b, 108c) of said wind turbine (100), wherein light of said first wavelength is absorbed by ice and/or snow to a higher degree than light of said second wavelength; detecting (S2) a first intensity of reflected light (114) from said blade (108a, 108b, 108c) having said first wavelength; detecting (S2) a second intensity of reflected light (116) from said blade (108a, 108b, 108c) having said second wavelength; comparing (S3) said first intensity of reflected light (114) with said second intensity of reflected light (116); and determining (S4) a presence of accumulated ice and/or snow on said blade (108a, 108b, 108c) based on a relation between said first intensity of reflected light (114) and said second intensity of reflected light (116).

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METHOD AND DEVICE FOR DETECTING ACCUMULATION OF ICE AND/OR SNOW ON A BLADE OF A WIND TURBINE

Technical field

The present invention relates to the field of wind turbines, and more specifically to a device for instantaneously detecting accumulation of ice and/or snow on a blade of a wind turbine. The invention also relates to a corresponding method for detecting accumulation of ice and/or snow on the blade.

Background

In the field of wind turbines, a number of parameters are important for optimizing energy efficiency. This can, for example, be the positioning of the wind turbines, size of the blades, height of the wind turbine nacelle above ground, knowledge of wind condition, etc. Furthermore, it is also beneficial to supervise the condition of the blades of the wind turbine such that the wind turbine is able to work at an approximately optimal efficiency. It is hence advantageous to continuously control the blades such that they are intact and free from accumulated material, such as for instance ice or snow.

When the blades are accumulated with material, such as ice, the wind turbine can be subjected to serious unintended loads which can cause overloads and stresses to the blades as well as to the entire drive train of the wind turbine. Also, if one blade is accumulated with more material than another blade, the wind turbine may be subjected to an unbalanced situation, which may reduce the energy efficiency as well as damage interior parts of the wind turbine. In addition, accumulation of ice on the wind turbine blades increases the risk for e.g. persons being close to the wind turbine, since there is a risk that ice is thrown from the blades during rotation thereof.

The field of wind power is an increasingly growing market and development has been made in an attempt to efficiently and reliably control the wind turbine in terms of e.g. detecting accumulation of material on the blades of the wind turbine.

WO2011/009 459 A2 discloses a device for detecting surface conditions such as accumulation of material on the blades of a wind turbine. The blades of the wind turbine are being subjected to light from a radiation emitter; the amounts of diffuse and specular reflected radiation reflected from the blade are thereafter evaluated in order to determine if accumulated material is present on the blade.

Although apparently providing for detection of accumulation of material that requires the wind turbine to be stopped for maintenance, the method described in WO2011/009 459 A2 would be likely to indicate accumulation of material also in cases when there is no actual need for maintenance. It thus appears that unnecessary stops could occur, which would then result in a reduction in the amount of produced energy as well as an increase in operational costs.

Summary of the invention

In view of the above mentioned and other drawbacks of the prior art, an object of the present invention is thus to provide an improved method and device for detecting accumulation of ice and/or snow on the blade of a wind turbine. To detect accumulation of ice and/or snow on the blade of the wind turbine is advantageous since it can provide e.g. a signal to an operator of the wind turbine indicating a need for maintenance. Hereby, the risk of, for example, ice being thrown from the blades is reduced which thereby provides for an increased safety for people being occupied close to the wind turbine. Also, detection of accumulation of ice and/or snow on the blade is beneficial in a durability aspect, since the wind turbine may be prevented from being exposed to overloads and fatigue.

According to a first aspect of the present invention there is provided a method for detecting accumulation of ice and/or snow on a blade of a wind turbine, the method comprising the steps of: transmitting a first light beam having a first wavelength and a second light beam having a second wavelength in a direction towards the blade of the wind turbine, wherein light of the first wavelength is absorbed by ice and/or snow to a higher degree than light of the second wavelength; detecting a first intensity of reflected light from the blade having the first wavelength; detecting a second intensity of reflected light from the blade having the second wavelength; comparing the first intensity of reflected light with the second intensity of reflected light; and determining a presence of accumulated ice and/or snow on the blade based on a relation between the first intensity of reflected light and the second intensity of reflected light.

The present invention is based on the realization that the blades of the wind turbine during operation will cover the light beams, which are transmitted from an optical device preferably arranged on the wind turbine nacelle, every time they pass the light beams, and hence reflected light beams will be provided to the optical device. By providing light beams having different ice and/or snow absorbing properties, the reflected light beams provided to the optical device will hence have different intensity if there is accumulation of ice and/or snow present on the blade of the wind turbine.

Advantages of the present invention include, for example, that smaller amount of accumulation of ice and/or snow may be detected on the blades, i.e. the method may detect the presence of ice and/or snow on the blade of the wind turbine at an early stage of ice and/or snow growth. Furthermore, the intensity of the reflected light from the first light beam will decrease in relation to the thickness of ice and/or snow onto which the first light beam is transmitted. Hereby, the relation between the intensity of reflected light of the first light beam and the second light beam will provide an indication of the thickness of accumulated ice and/or snow on the blade. This may be beneficial since a smaller amount of ice and/or snow may be acceptable and an operator of the wind turbine may thus determine, based on the intensity relation between the reflected light from the first and second light beams, when to provide maintenance on the blades. Hereby, the amount of maintenance may be reduced and the operator can decide to turn off the wind turbine when the accumulation of ice and/or snow has exceeded an acceptable level. The wind turbine may thus be able to produce energy to an essentially optimal level.

According to an example embodiment of the present invention, the step of transmitting may comprise the step of alternatingly providing pulses of light having the first and the second wavelength.

The wording “alternatingly” should in the following and throughout the entire description be interpreted such that the light beams having the first and the second wavelength are sequentially transmitted towards the blade of the wind turbine. The light beams having the first wavelength may thus be transmitted a predetermined number of times, followed by transmitting light having the second wavelength a predetermined number of times and thereafter again followed by transmitting light having the first wavelength, etc. The predetermined number of time which the light beams are transmitted may be determined based on, for example, the width of the blade, the rotational speed of the blade, etc. The predetermined number of times which the light beams are transmitted may be chosen such that an acceptable comparison can be made for the reflected light having the first and the second wavelength. For example, the optical device may every second time detect reflected light having the first wavelength and every other second time detect reflected light having the second wavelength. An advantage is that the optical device may, when receiving light having alternatingly different intensity, in a convenient manner compare the detected reflected light beam having e.g. the first wavelength with the previously detected light beam having e.g. the second wavelength, and so on. Hereby, a more or less instantaneous determination of the presence of accumulated ice and/or snow on the blade may be provided.

According to an example embodiment of the present invention, the pulses may be transmitted with a pulse repetition frequency such that at least 100 pulses of each wavelength are transmitted during one passage of the blade.

An advantage is, at least, that by providing such a minimum frequency of pulses, a surface line over the width of the blade may be sufficiently scanned for accumulation of ice and/or snow. Also, a pattern of accumulated ice and/or snow on the blade may be provided.

According to an example embodiment of the present invention, the method may further comprise the steps of acquiring a signal indicative of a rotational speed of the blade of the wind turbine, and determining a measure indicative of an accumulation of ice and/or snow on the blade based on the rotational speed of the blade and the reflected light having the second wavelength.

Hereby, it may be possible to detect accumulated ice and/or snow on the blade width. The signal indicative of the rotational speed of the blades in conjunction with the detection of reflected light having the second wavelength may provide for a determination of the present width of the blade. The present detected width of the blade may thereafter be compared to e.g. a stored width of the blade without accumulation of ice and/or snow.

According to an example embodiment of the present invention, the method may further comprise the steps of determining a measure indicative of an accumulation of ice and/or snow on the blade; saving the measure indicative of an accumulation of ice and/or snow on blade; and providing a parameter indicative of a development over time of the accumulation of ice and/or snow on the blade based on the saved measure.

Hereby, an operator of the wind turbine may be able to make predictions of the development of ice and/or snow on the blade.

According to an example embodiment, the method further comprises the step of determining a growth of ice and/or snow on the blade based on the parameter indicative of a development over time of the accumulation of ice and/or snow.

An advantage is, at least, that the growth of ice and/or snow may be determined. Hereby, an operator of the wind turbine may determine if the growth rate of ice and/or snow is of such a level that it is necessary or not to provide maintenance on the blades. The risk of providing “unnecessary” maintenance on the blades is hence reduced.

According to a second aspect of the present invention there is provided an ice detection device for detecting accumulation of ice and/or snow on a blade of a wind turbine, the device comprising: an optical transmitter configured to transmit a first light beam having a first wavelength and a second light beam having a second wavelength, wherein light of the first wavelength is absorbed by ice and/or snow to a higher degree than light of the second wavelength, an optical receiver configured to detect a first intensity of reflected light having the first wavelength and a second intensity of reflected light having the second wavelength, and processing circuitry connected to the optical receiver and configured to determine a presence of accumulation of ice and/or snow on the blades based on a relation between the first intensity of reflected light and the second intensity of reflected light.

According to an example embodiment of the present invention, the processing circuitry may be configured to control the optical transmitter to alternatingly provide pulses of light having the first and the second wavelength.

According to an example embodiment, the processing circuitry may be further configured control the optical transmitter to transmit the pulses with a pulse repetition frequency such that at least 100 pulses of each wavelength is transmitted during one passage of the blade.

According to an example embodiment of the present invention, the processing circuitry may comprise input for acquiring a signal indicative of a rotational speed of the blade of the wind turbine.

According to an example embodiment of the present invention, the processing circuitry may be further configured to provide the determined presence of accumulated ice and/or snow to a storage device.

According to an example embodiment of the present invention, the storage device may be configured to provide a parameter indicative of a development over time of the accumulation of ice and/or snow on the blade.

Moreover, according to an example embodiment, the storage device may be configured provide a parameter indicative of growth of ice and/or snow on the blade based on the parameter indicative of a development over time of accumulation of ice and/or snow.

Effects and features of this second aspect are largely analogous to those described in relation to the above mentioned first aspect of the present invention.

Furthermore, a wind turbine may be arranged, comprising a nacelle and wind turbine blades and is configured to be mounted on top of a supporting structure, wherein the wind turbine further comprises the above described ice detection device positioned on the nacelle and arranged to transmit light beams towards the blades of the wind turbine.

Brief description of the drawings

These and other aspects of the present invention will now be described in more detail, with reference to the appended drawings showing example embodiments of the invention, wherein:

Fig. 1a is a perspective view illustrating a wind turbine provided with an ice detection device for detecting accumulation of ice and/or snow according to an embodiment of the present invention;

Fig. 1b is an enlarged view of the ice detection device of Fig. 1a according to an embodiment of the present invention;

Fig. 2 is a schematic block diagram illustrating an embodiment of the ice detection device in Fig. 1b;

Fig. 3 is a wavelength spectrum for the reflectance of ice and snow;

Fig. 4 is a diagram schematically illustrating the intensity variation of reflected light from the blade; and

Fig.5 is a flow chart schematically illustrating an embodiment of a method for detecting accumulation of ice and/or snow on the blade of the wind turbine.

Detailed description of example embodiments of the present invention

In the following description, the present invention is described with reference to a device and corresponding method for detecting accumulation of ice and/or snow on a blade of a wind turbine, by using a laser beam transmitting device which is positioned behind the blades in an upwind direction.

It should be noted that this by no means limits the scope of the present invention, which is equally applicable with other light transmission means than a laser beam transmitting device. Furthermore, the ice detecting device is equally applicable for detecting accumulation of snow on the blades of the wind turbine and the use of the wording “ice detection device” is merely for simplicity of description.

Fig. 1a is a perspective view illustrating a wind turbine 100. The wind turbine 100 comprises a nacelle 104 and three turbine blades 108a – c, hereinafter just referred to as blades. The nacelle 104 is mounted on top of a supporting structure, here in the form of a frame 102, of the wind turbine 100. On top of the nacelle 104, behind the blades 108a – c, is mounted an ice detection device 106 for detecting accumulation of ice and/or snow on the blades 108a – c of the wind turbine 100 during operation.

As is illustrated in Fig. 1b, showing an enlarged view of the ice detection device in Fig. 1a, the ice detection device 106 is configured to transmit two light beams 110, 112 having two different wavelengths in a direction towards the blade of the wind turbine. Moreover, the ice detection device 106 is further configured to detect reflected light beams 114, 116 from the blades. The reflected light beams 114, 116 naturally also have the different wavelengths as described above. The different wavelengths will be described further below.

In order to describe the ice detection device 106 illustrated in Figs. 1a and 1b in more detail, reference is made to Fig. 2 illustrating a schematic block diagram of the ice detection device 106. The functionality and method for detecting accumulation of ice and/or snow will be described in detail below with reference to Figs. 4 and 5.

The ice detection device 106 comprises processing circuitry 402, a storage device 404, an optical transmitter 406 and an optical receiver 408. The processing circuitry 402 is configured to control the optical transmitter 406 to alternatingly provide pulses of light 110, 112 having the first and the second wavelength towards the blade 108a of the wind turbine 100. The optical receiver 408 is configured to detect reflected light from the blade. More specifically, the optical receiver 408 is configured to detect a first intensity of reflected light 114 having the first wavelength and a second intensity of reflected light 116 having the second wavelength. The processing circuitry 402 is further configured to receive the detected intensity of reflected light from the optical receiver 408 and to determine a presence of accumulated ice and/or snow on the blade 108a. Moreover, the processing circuitry is, in the example embodiment, also arranged to provide the determined presence of accumulated ice and/or snow to the storage device 404, for example by providing a signal to the storage device 404 indicating the present accumulation of ice and/or snow on the blade. The storage device 404 is configured to store and evaluate the determined presence of ice and/or snow so that, for example, the growth of accumulated ice and/or snow over time can be provided to the processing circuitry 404. For example, if the processing circuitry 402 detects a 2 millimeter accumulation of ice on the blade, the storage device 404 receives the detected amount of ice from the processing circuitry 402 and stores it in e.g. a memory. When the processing circuitry 402 thereafter provides another value of accumulated ice and/or snow on the blade, the storage device can determine, based on the stored values and the recently received value, if accumulation of ice and/or snow on the blade is increasing or decreasing, and at which rate. The storage device can, for example, be a hard drive storage device, a memory unit, etc.

Furthermore, the processing circuitry 402 may further comprise an input 410 for e.g. acquiring a rotational speed of the blade 108a. In such a case, the processing circuitry 402 may provide a signal to the optical transmitter 406 to only transmit light beams 112 having the second wavelength. The optical receiver 408 receives reflected light beams 416 having the second wavelength and the processing circuitry 402 may thereafter determine the presence of accumulated ice and/or snow on the blade 108a based on a detected width of the blade 108a which is compared to a stored width of the blade 108a without the presence of accumulated ice and/or snow.

Turning to Fig. 3, a schematic wavelength spectrum for the reflectance of ice and snow is provided. As can be seen, different wavelengths of light is reflected by ice and snow to various degrees. Light 110 having the first wavelength is reflected less by ice and snow in comparison to light 112 having the second wavelength. Accordingly, light 110 having the first wavelength is absorbed by ice and snow to a higher degree than light 112 of the second wavelength. The depicted example of the first and the second wavelength is only for illustrative purposes and the wavelengths may of course be others having more or less reflectance to ice and snow. The first and second wavelengths can be chosen from a plurality of wavelengths; the important aspect is that there is a difference in absorption properties to ice and snow between the first and the second wavelength. Accordingly, the skilled person realizes that the he can turn to known measuring data when choosing the different wavelengths. According to one example, the first wavelength may be 1.5 μm and the second wavelength may be 0.9 μm. Other wavelengths are of course conceivable

Now, reference is made to Fig. 4 in order to describe an example of detecting accumulation of ice and/or snow on the blade 108a of the wind turbine 100. As described above in relation to Fig. 2, the optical receiver 408 is configured to detect a first intensity of reflected light 114 having the first wavelength and a second intensity of reflected light 116 having the second wavelength, and as described in relation to Fig. 3, ice and snow absorbs light having the first wavelength to a higher degree than light having the second wavelength. In Fig. 4, the presence of accumulated ice and/or snow on a blade during operation is illustrated. The reflected light beams 114 having the first wavelength are depicted as continuous lines, while the reflected light beams 116 having the second wavelength are depicted as dashed lines. The entire width of the blade 108a, 108b, 108c covered by the light beams 110, 112 is denoted by 206. As is depicted in Fig. 4, the intensity of the reflected light 116 having the second wavelength is at the substantially same intensity level across the entire width 206 of the blade, while the reflected light 114 having the first wavelength has a varying intensity level over the width 206 of the blade. Accordingly, the portions of the blade 108 having a presence of accumulated ice and/or snow has a lower intensity of reflected light 114 of the first wavelength compared to the intensity of reflected light 116 of the second wavelength. Furthermore, by alternatingly transmitting pulses of light beams 110, 112 having the first and second wavelength and thereby alternatingly detecting reflected light 114 having the first wavelength and reflected light 116 having the second wavelength, accumulated ice and/or snow on the blade 108a may be more or less instantaneously detected. Also, the intensity of reflected light 114 having the first wavelength will vary depending on the specific amount of accumulated ice and/or snow on the blade, i.e. increased accumulated ice and/or snow on the blade 108a will provide a reduced intensity of the detected reflected light 114 having the first wavelength, and vice versa. Accordingly, in the example illustrated in Fig. 4, there is more accumulation of ice and/or snow on the portions of the blade where the difference in intensity between the reflected light 114 having the first wavelength and the reflected light 116 having the second wavelength is greatest. Furthermore, in a case where there is a large amount of ice and/or snow on the blades, the ice detection device may not necessarily detect reflected light having the first wavelength since it may have been entirely absorbed by the ice and/or snow present on the blade 108a.

Finally, in order to describe the method for detecting accumulated ice and/or snow on the blade 108a of the wind turbine, reference is made to Fig. 5. As described above in relation to Fig. 2, the processing circuitry 402 is configured to control the optical transmitter 406 to alternatingly transmit S1 light 110 having the first wavelength and light 112 having the second wavelength in a direction towards the blade 108a of the wind turbine 100. When the transmitted light 110, 112 hits the blade it is reflected and the optical receiver 408 is configured to detect S2 reflected light 414 having the first wavelength and reflected light 416 having the second wavelength. More specifically, as also described above, the optical receiver is configured to detect a first intensity of reflected light 414 having the first wavelength and a second intensity of reflected light 416 having the second wavelength. The detected intensity of reflected light is thereafter provided to the processing circuitry 402. The processing circuitry is configured to compare S3 the first intensity of reflected light 414 having the first wavelength with the second intensity of reflected light 416 having the second wavelength. Based on a difference between the first intensity of reflected light and the second intensity of reflected light, the processing circuitry 402 is further configured to determine S4 a presence of accumulated ice and/or snow on the blade 108a of the wind turbine.

Furthermore, the determined presence of accumulated ice and/or snow on the blade 108a of the wind turbine 100 can be provided to the storage device 404 as also described above. The storage device 404 can thereafter continuously be provided with input from the processing circuitry 402 so that the storage device 404 can provide the processing circuitry 402 with parameters indicating, for example, a development over time of accumulated ice and/or snow on the blade 108a of the wind turbine 100.

In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage.

CLAIMS

1. A method for detecting accumulation of ice and/or snow on a blade (108a, 108b, 108c) of a wind turbine (100), said method comprising the steps of:

- transmitting (S1) a first light beam (110) having a first wavelength and a second light beam (112) having a second wavelength in a direction towards said blade (108a, 108b, 108c) of said wind turbine (100), wherein light of said first wavelength is absorbed by ice and/or snow to a higher degree than light of said second wavelength;
- detecting (S2) a first intensity of reflected light (114) from said blade (108a, 108b, 108c) having said first wavelength;
- detecting (S2) a second intensity of reflected light (116) from said blade (108a, 108b, 108c) having said second wavelength;
- comparing (S3) said first intensity of reflected light (114) with said second intensity of reflected light (116); and
- determining (S4) a presence of accumulated ice and/or snow on said blade (108a, 108b, 108c) based on a relation between said first intensity of reflected light (114) and said second intensity of reflected light (116).

2. The method according to claim 1, wherein said step of transmitting comprises the step of:

- alternatingly providing pulses of light having said first and said second wavelength.

3. The method according to claim 2, wherein the pulses are transmitted with a pulse repetition frequency such that at least 100 pulses of each wavelength is transmitted during one passage of the blade (108a, 108b, 108c).

4. The method according to any one of the preceding claims, further comprising the steps of:

- acquiring a signal indicative of a rotational speed of said blade (108a, 108b, 108c) of said wind turbine (100); and
- determining a measure indicative of an accumulation of ice and/or snow on said blade (108a, 108b, 108c) based on said rotational speed of said

blade (108a, 108b, 108c) and said reflected light (116) having said second wavelength.

5. The method according to any one of the preceding claims, further comprising the steps of:

- determining a measure indicative of an accumulation of ice and/or snow on said blade (108a, 108b, 108c);

- saving said measure indicative of an accumulation of ice and/or snow on said blade (108a, 108b, 108c); and

- providing a parameter indicative of a development over time of said accumulation of ice and/or snow on said blade (108a, 108b, 108c) based on said saved measure.

6. The method according to claim 5, further comprising the step of:

- determining a growth of ice and/or snow on said blade (108a, 108b, 108c) based on said parameter indicative of a development over time of said accumulation of ice and/or snow.

7. An ice detection device (106) for detecting accumulation of ice and/or snow on a blade (108a, 108b, 108c) of a wind turbine (100), said ice detection device (106) comprising:

- an optical transmitter (406) configured to transmit a first light beam (110) having a first wavelength and a second light beam (112) having a second wavelength, wherein light of said first wavelength is absorbed by ice and/or snow to a higher degree than light of said second wavelength,

- an optical receiver (408) configured to detect a first intensity of reflected light (114) having said first wavelength and a second intensity of reflected light (116) having said second wavelength, and

- processing circuitry (402) connected to said optical receiver (408) and configured to determine a presence of accumulated ice and/or snow on said blade (108a, 108b, 108c) based on a relation between said first intensity of reflected light (114) and said second intensity of reflected light (116).

8. The ice detection device according claim 7, wherein said processing circuitry (402) is configured to control said optical transmitter (406) to alternatingly provide pulses of light having said first and said second wavelength.

9. The ice detection device according to claim 8, wherein said processing circuitry (402) is configured to control said optical transmitter (408) to transmit said pulses with a pulse repetition frequency such that at least 100 pulses of each wavelength is transmitted during one passage of the blade.

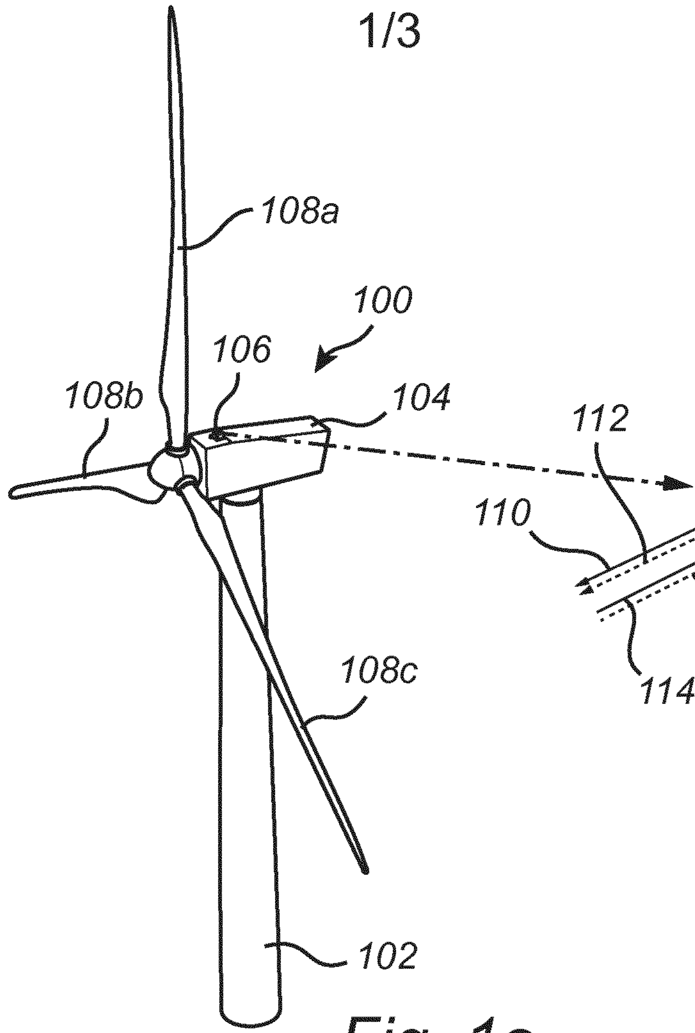
10. The ice detection device according to any one of claims 7 to 9, wherein said processing circuitry (402) comprises input for acquiring a signal indicative of a rotational speed of said blade (108a, 108b, 108c) of said wind turbine (100).

11. The ice detection device according to any one of claims 7 to 10, wherein said processing circuitry (402) is further configured to provide said determined presence of accumulated ice and/or snow to a storage device (404).

12. The ice detection device according to claim 11, wherein said storage device (404) is configured to provide a parameter indicative of a development over time of said accumulation of ice and/or snow on said blade (108a, 108b, 108c).

13. The ice detection device according to claim 12, wherein said storage device (404) is configured to provide a parameter indicative of growth of ice and/or snow on said blade (108a, 108b, 108c) based on said parameter indicative of a development over time of accumulation of ice and/or snow.

14. A wind turbine (100), comprising a nacelle (104) and wind turbine blades (108a, 108b, 108c) and is configured to be mounted on top of a supporting structure, wherein the wind turbine (100) further comprises an ice detection device according to any one of claims 7 to 13 positioned on the nacelle (104) and arranged to transmit light beams towards the blades (108a, 108b, 108c) of the wind turbine (100).



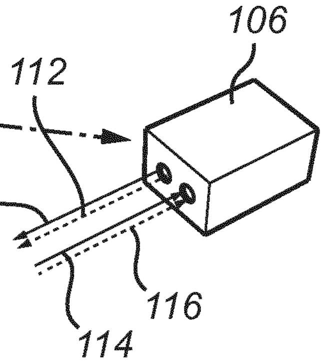


Fig. 1b

Fig. 1a

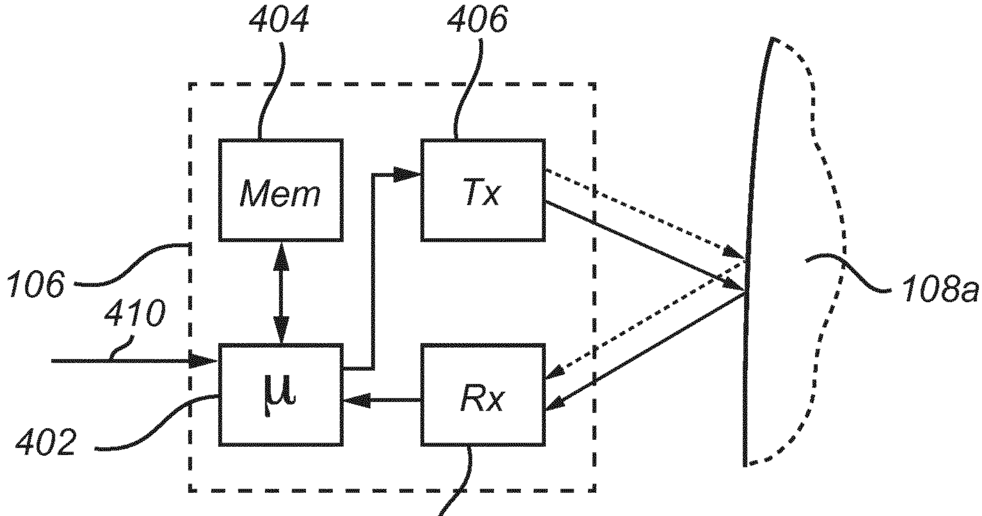


Fig. 2

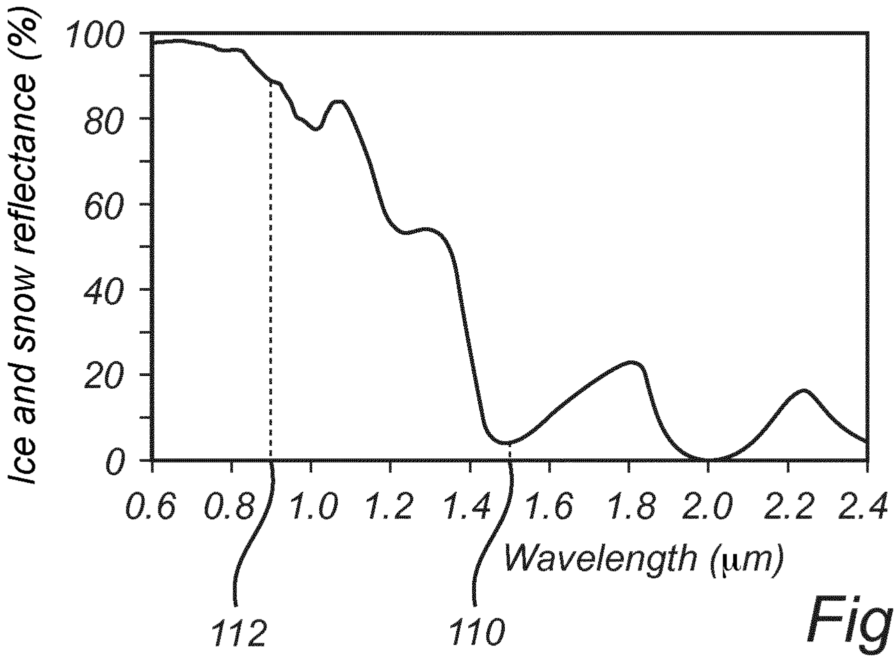

Ice and snow reflectance (%)
100
80
60
40
20
0
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
Wavelength (μm)
112
110

Fig. 3

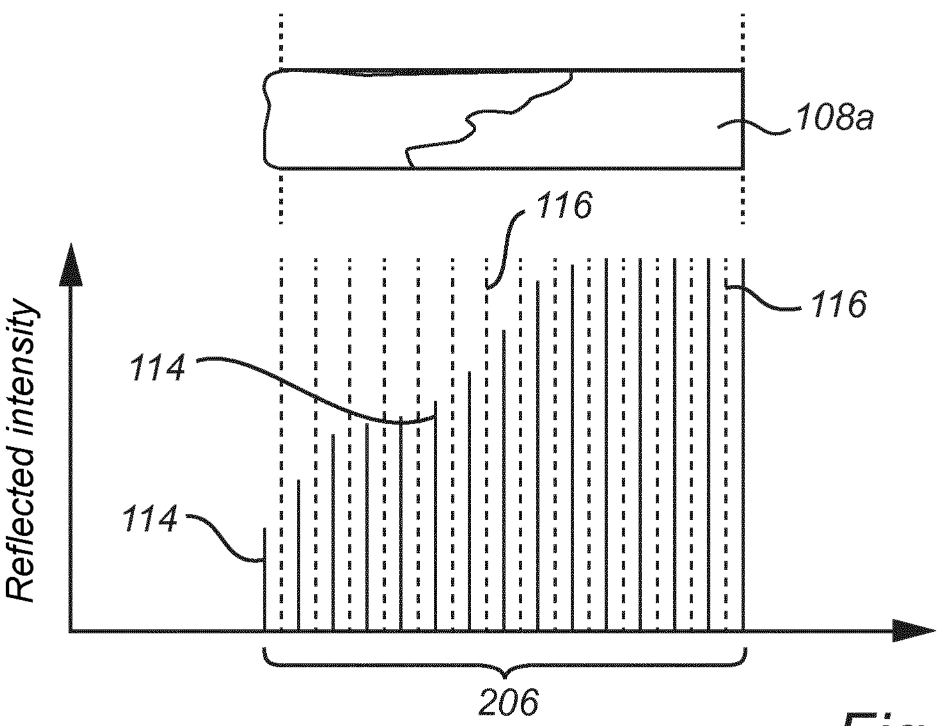

108a
116
116
114
114
Reflected intensity
206

Fig. 4

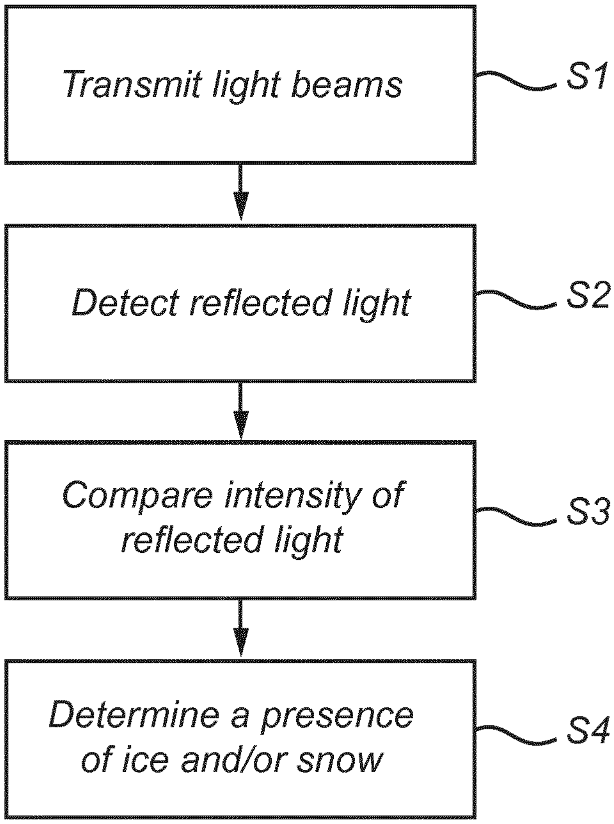

Transmit light beams
S1
Detect reflected light
S2
Compare intensity of reflected light
S3
Determine a presence of ice and/or snow
S4

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/055461

A. CLASSIFICATION OF SUBJECT MATTER
INV. F03D11/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 478 600 A (VESTAS WIND SYS AS [DK]) 14 September 2011 (2011-09-14) page 2, line 20 - line 32 page 3, line 13 - line 17 page 5, line 21 - line 28 -----	1,4-7, 10-14
X	WO 2011/009459 A2 (LIWAS APS [DK]; FRIDTHJOF JACK [DK]) 27 January 2011 (2011-01-27) cited in the application page 7, line 19 - line 21 page 27, line 25 - page 28, line 15 figure 3 -----	1,7,11, 14
A	DE 10 2006 032387 A1 (REPOWER SYSTEMS AG [DE]) 24 January 2008 (2008-01-24) paragraphs [0009], [0019], [0025] -----	1,5-7, 11-14

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 May 2013	07/06/2013

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Angelucci, Stefano

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Form PCT/ISA/210 (second sheet) (April 2005)

International application No
PCT/EP2013/055461

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011/042950 A1 (MIZOUE TAKETO [JP] ET AL) 24 February 2011 (2011-02-24) paragraphs [0041] - [0044] -----	1,4,7,14

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Information on patent family members

International application No
PCT/EP2013/055461

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