



(22) Date de dépôt/Filing Date: 2015/04/21

(41) Mise à la disp. pub./Open to Public Insp.: 2015/10/23

(45) Date de délivrance/Issue Date: 2019/11/19

(30) Priorité/Priority: 2014/04/23 (DE10 2014 207 612.9)

(51) Cl.Int./Int.Cl. *F03D 17/00* (2016.01),
G01M 1/22 (2006.01), *G01M 13/045* (2019.01)

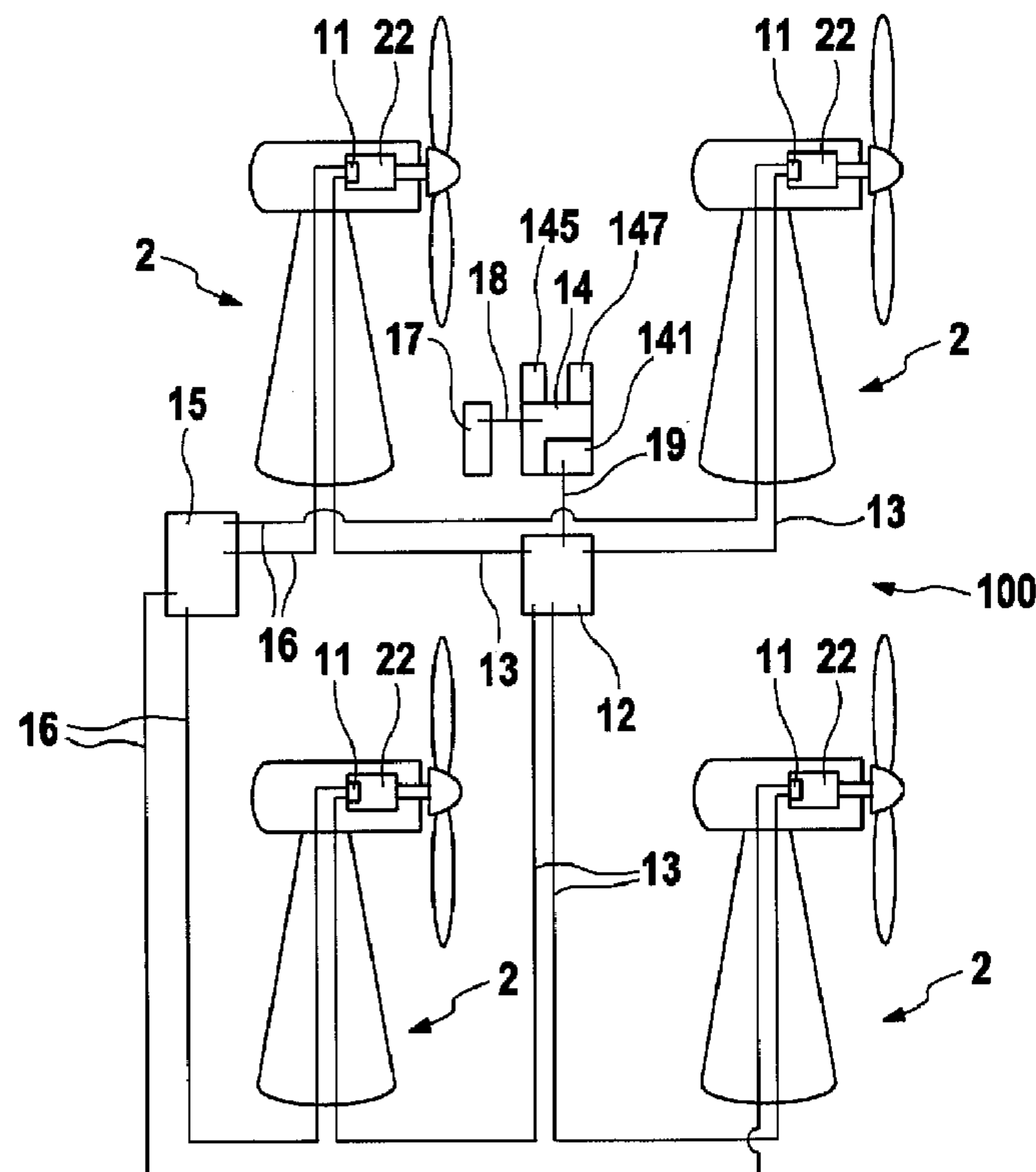
(72) Inventeurs/Inventors:
FALB, MARTIN, DE;
NIETMANN, LARS, DE

(73) Propriétaire/Owner:
SENVION SE, DE

(74) Agent: RIDOUT & MAYBEE LLP

(54) Titre : DISPOSITIF DE DIAGNOSTIC D'EOLIENNE POUR COMPOSANTES DE GENERATEUR

(54) Title: WIND TURBINE DIAGNOSTIC DEVICE FOR GENERATOR COMPONENTS



(57) Abrégé/Abstract:

The invention relates to a wind turbine diagnostic device (1) for diagnosing mechanical damage to generator components (221) of at least one wind turbine (2), comprising at least one speed sensor (11) for determining a variation over time of the rotational speed

(57) **Abrégé(suite)/Abstract(continued):**

of a generator (22) of a wind turbine (2), the speed sensor (11) having at least one speed signal output (111) for outputting the determined variation over time of the rotational speed, it being provided according to the invention that the wind turbine diagnostic device (1) has a frequency analysis module (12) with at least one speed signal input (121), which is connected to the speed signal output (111) by way of a speed signal line (13), and a frequency spectrum signal output (122) for outputting a frequency spectrum, the frequency analysis module (12) being designed for determining a frequency spectrum from the determined variation over time of the rotational speed; and, has a comparator element (14), which has a frequency spectrum signal input (142), which is connected to the frequency spectrum signal output (122) by way of a frequency spectrum signal line (19), the comparator element (14) being designed for comparing a frequency spectrum with a prescribed standard frequency spectrum and for diagnosing mechanical damage to generator components (221) on the basis of the comparison. This increases the possibility of predicting mechanical damage to generator components (221) caused by vibrations.

Abstract

The invention relates to a wind turbine diagnostic device (1) for diagnosing mechanical damage to generator components (221) of at least one wind turbine (2), comprising at least one speed sensor (11) for determining a variation over time of the rotational speed of a generator (22) of a wind turbine (2), the speed sensor (11) having at least one speed signal output (111) for outputting the determined variation over time of the rotational speed, it being provided according to the invention that the wind turbine diagnostic device (1) has a frequency analysis module (12) with at least one speed signal input (121), which is connected to the speed signal output (111) by way of a speed signal line (13), and a frequency spectrum signal output (122) for outputting a frequency spectrum, the frequency analysis module (12) being designed for determining a frequency spectrum from the determined variation over time of the rotational speed; and has a comparator element (14), which has a frequency spectrum signal input (142), which is connected to the frequency spectrum signal output (122) by way of a frequency spectrum signal line (19), the comparator element (14) being designed for comparing a frequency spectrum with a prescribed standard frequency spectrum and for diagnosing mechanical damage to generator components (221) on the basis of the comparison. This increases the possibility of predicting mechanical damage to generator components (221) caused by vibrations.

Wind turbine diagnostic device for generator components

The invention relates to a wind turbine diagnostic device for diagnosing mechanical damage to generator
5 components of a wind turbine.

The components of a generator of a wind turbine are subjected to strong mechanical loads, which can bring about damage to the generator components. If these
10 damaged generator components are not exchanged, consequential damage may occur, involving high costs to repair. It is therefore necessary to find out about damaged generator components as early as possible, in order to exchange them before sequential damage occurs.
15 The damaged generator components cause vibrations, which are manifested by fluctuations in the rotational speed of the generator. These vibrations can be sensed for example at the generator bearings.

20 Known wind turbine diagnostic devices comprise vibration sensors at the generator bearings. Owing to the restricted possibilities for positioning the vibration sensors on the generator bearings, these sensors primarily sense radial vibrations. Axial
25 vibrations are sensed only partially or not at all. Consequently, known vibration sensors only offer limited possibilities for diagnosis with respect to mechanical damage caused by axial vibrations.

30 The invention is based on the object of providing an improved wind turbine diagnostic device that increases the possibility of predicting mechanical damage to generator components caused by vibrations.

35 The way in which the invention achieves the object is to provide a wind turbine diagnostic device and a

method according to the independent claims.
Advantageous developments are the subject of the
dependent claims.

5 With respect to a wind turbine diagnostic device for
diagnosing mechanical damage to generator components of
at least one wind turbine, comprising at least one
speed sensor for determining a variation over time of
the rotational speed of a generator of a wind turbine,
10 the speed sensor having at least one speed signal
output for outputting the determined variation over
time of the rotational speed, it is provided according
to the invention that the wind turbine diagnostic
device has a frequency analysis module with at least
15 one speed signal input, which is connected to the speed
signal output by way of a speed signal line, and a
frequency spectrum signal output for outputting a
frequency spectrum, the frequency analysis module being
designed for determining a frequency spectrum from the
20 determined variation over time of the rotational speed;
and has a comparator element, which has a frequency
spectrum signal input, which is connected to the
frequency spectrum signal output by way of a frequency
spectrum signal line, the comparator element being
25 designed for comparing a frequency spectrum with a
prescribed standard frequency spectrum and for
diagnosing mechanical damage to generator components on
the basis of the comparison.

30 First of all, a number of terms should be explained in
more detail:

A signal line is understood as meaning a physical
signal line and a radio signal line. The physical
35 signal line may consequently consist for example of a
copper cable, a glass fiber cable or a metal rail. The

radio signal line may for example consist of a secure radio link.

5 A variation over time of the rotational speed is understood as meaning a multiplicity of continually determined speed values. The time interval between the individual values to be determined may in this case be chosen arbitrarily. Small time intervals bring about a higher temporal resolution, and consequently a more
10 accurate frequency analysis.

A frequency analysis module is understood as meaning a module that determines the underlying frequencies from a speed signal or a vibration signal. The frequency
15 analysis module may be for example a fast Fourier transform module, which carries out a Fourier transform on the vibration by means of fast algorithms.

The invention is based on the combination of two
20 findings, to be specific that on the one hand damaged generator components generate axial vibrations at the generator and on the other hand these axial vibrations lead to fluctuations in the rotational speed of the generator. The rotational speed is in this case
25 continually determined by speed sensors provided as standard in wind turbines, such as for example the incremental sensors of the converters. The frequencies underlying the fluctuations in the rotational speed can be determined by means of a frequency analysis of the
30 rotational speed determined during a specific time period. For this purpose, a variation over time of the rotational speed is transmitted from the speed sensor to the frequency analysis module. The frequency analysis module determines from the transmitted
35 variation over time of the rotational speed the frequencies underlying the fluctuations together with

their amplitudes. The frequency spectrum resulting from the frequency analysis comprises a great band width of multiples of the rotational speed with different amplitudes. The resulting frequency spectrum is
5 transmitted on to the comparator element. The comparator element has a standard frequency spectrum, which corresponds to a spectrum in which no vibrations caused by damaged generator components occur. By the comparison, the comparator element determines the
10 frequencies and the amplitudes of the vibrations that deviate from the standard frequency spectrum. The comparator element is designed for the purpose of making a diagnosis with respect to mechanically damaged generator components on the basis of these frequencies
15 and the amplitudes. Although only a rotational movement is in fact recorded by the frequency spectra formed from the rotational speed, surprisingly axial vibrations are also contained in said broad-band frequency spectrum. They can be sensed and classified
20 by comparison with the standard frequency spectrum.

In this way, the invention allows an earlier diagnosis of instances of mechanical damage to the generator components.

25 Furthermore, the vibrations occurring are independent of the rotational speed of the generator. The vibrations occur at low speeds and at high speeds. Consequently, the frequency analysis can be carried out
30 at any time, and the result thereof is invariant with respect to changes in rotational speed. Furthermore, this means that the result of the frequency analysis can be implemented even when there are highly variable wind conditions, which induce great changes in the
35 rotational speed.

The frequency analysis module is preferably designed as a fast Fourier transform module (FFT module), that is to say that the frequency analysis module carries out the frequency analysis by means of a fast Fourier transform. Using the FFT for the creation of the frequency spectra allows the Fourier transform of the rotational speed to be carried out very quickly. Consequently, the mechanical state of the generator components can be constantly monitored, and so an early check can be carried out when there is any anomalous vibrational behavior. This allows an exchange of damaged generator components that can be planned at an early time, before serious mechanical damage occurs. As a result, lengthy downtimes of the generator are avoided, and so the downtime costs are reduced.

The wind turbine diagnostic device expediently has a selector with at least one control signal output, which is designed for selecting a speed sensor from the speed sensors of multiple wind turbines and is designed for activating the speed sensor for outputting the data, the speed sensor being designed for outputting the determined variation over time of the rotational speed by way of the speed signal output in response to the activation by the selector. By means of the selector, a specifically selective diagnosis of a specific wind turbine from a multiplicity of wind turbines can be carried out. In this way, the diagnosis of an entire wind farm can be performed with only one frequency analysis module and one comparator element.

The comparator element advantageously comprises a difference module, which is designed for determining the difference between the frequency spectrum and the standard frequency spectrum. By means of the difference module, the determination of the deviations between the

frequency spectrum and the standard frequency spectrum can be carried out efficiently. This further speeds up the determination of instances of damage to the generator components.

5

The comparator element advantageously comprises a fault signal output, the comparator element being designed for outputting a fault signal by means of the fault signal output when the deviation between the frequency spectrum and the prescribed standard frequency spectrum exceeds a predetermined limit value, the fault signal comprising a reference to the generator components to be monitored. This enables the comparator element to pass on to an electronic data processing the damaged generator components to be monitored.

15

For this purpose, a fault module with a fault signal input may be expediently provided, the fault signal input being connected to the fault signal output by way of a fault signal line and the fault module being designed for reporting the generator components to be monitored on the basis of the diagnostic signal. The fault module may in this case advantageously comprise a screen, on which the generator components to be monitored can be marked or indicated.

20

25

Furthermore, the generator component is advantageously a slip ring of a generator. Instances of damage to the slip rings of the generators bring about very serious consequential damage, and so an exchange of damaged slip rings in good time brings about a great saving in costs.

30

It is also expedient if the comparator element comprises an imbalance module, which is designed for detecting imbalances in the generator components. The

35

early detection of imbalances allows the generator components to be monitored in a specifically selective manner, and so consequential damage, which may also comprise damage to the slip rings, is avoided.

5

The comparator element expediently has a harmonic module, which is designed for carrying out the comparison on the basis of the multiples of the rotational speed in the frequency spectrum and preferably comprises an input for ordering the harmonics to be monitored. It has been found that most instances of damage cause vibrations that are multiples of the rotational speed. Consequently, the comparison can be carried out even more quickly.

15

A vibration sensor for measuring vibrations at generator bearings with a vibration signal output is advantageously provided, the comparator element comprising a vibration signal input, which is connected to the vibration signal output by way of a vibration signal line, the comparator element being designed for taking the vibration signal into account in the diagnosis. Consequently, the comparator element and the vibration sensor interact in such a way that the primarily radial vibrations at the generator bearings can be brought together with the vibrations determined from the frequency spectrum in the diagnosis with respect to damaged generator components. In this way, the accuracy of the diagnosis is increased further.

30

The invention also relates to a generator for a wind turbine that has a wind turbine diagnostic device for diagnosing mechanical damage to generator components of a wind turbine, it being provided according to the invention with respect to the wind turbine diagnostic device comprising a speed sensor for determining a

35

variation over time of the rotational speed of a generator of a wind turbine, the speed sensor having at least one speed signal output for outputting the determined variation over time of the rotational speed, 5 that the wind turbine diagnostic device has a frequency analysis module with at least one speed signal input, which is connected to the speed signal output by way of a speed signal line, and a frequency spectrum signal output for outputting a frequency spectrum, the 10 frequency analysis module being designed for determining a frequency spectrum from the determined variation over time of the rotational speed; and has a comparator element, which has a frequency spectrum signal input, which is connected to the frequency spectrum signal output by way of a frequency spectrum 15 signal line, the comparator element being designed for comparing a frequency spectrum with a prescribed standard frequency spectrum and for diagnosing mechanical damage to generator components on the basis 20 of the comparison.

The wind turbine diagnostic device is in this case integrated in the generator. Consequently, the comparator element of the wind turbine diagnostic 25 device can be made to match the generator ex works, thereby allowing a diagnosis with great accuracy.

The invention also comprises a wind turbine that has a generator and a wind turbine diagnostic device for 30 diagnosing mechanical damage to generator components of a wind turbine, it being provided according to the invention with respect to the wind turbine diagnostic device comprising a speed sensor for determining a variation over time of the rotational speed of a 35 generator of a wind turbine, the speed sensor having at least one speed signal output for outputting the

determined variation over time of the rotational speed, that the wind turbine diagnostic device has a frequency analysis module with at least one speed signal input, which is connected to the speed signal output by way of
5 a speed signal line, and a frequency spectrum signal output for outputting a frequency spectrum, the frequency analysis module being designed for determining a frequency spectrum from the determined variation over time of the rotational speed; and has a
10 comparator element, which has a frequency spectrum signal input, which is connected to the frequency spectrum signal output by way of a frequency spectrum signal line, the comparator element being designed for comparing a frequency spectrum with a prescribed
15 standard frequency spectrum and for diagnosing mechanical damage to generator components on the basis of the comparison.

In this alternative of the invention, the wind turbine
20 diagnostic device is provided separately from the generator in the wind turbine. This allows the wind turbine diagnostic device to be retrofitted in an existing wind turbine.

25 With respect to the developments of the wind turbine diagnostic device on the generator according to the invention and the wind turbine according to the invention, reference is made to the statements made above.

30 The invention also relates to a method for diagnosing mechanical damage to generator components of a wind turbine, comprising the steps of: determining a time series of the rotational speed of the generator, the
35 following steps being provided according to the invention: determining a frequency spectrum of the

rotational speed; comparing the frequency spectrum with a prescribed standard frequency spectrum; and determining mechanical damage to generator components on the basis of the comparison.

5

The method can be advantageously carried out with a wind turbine diagnostic device described above.

10 The invention is explained in more detail on the basis of an exemplary embodiment, which is represented in the drawings, in which:

figure 1 shows a schematic representation of a wind turbine with a wind turbine diagnostic device;

15

figure 2 shows a schematic representation of a wind farm with a selector and a wind turbine diagnostic device;

20

figure 3 shows a schematic representation of a generator with a wind turbine diagnostic device;

25 figure 4 shows a schematic representation of a wind turbine diagnostic device;

figures 5a and b show a frequency spectrum of a damaged generator component (a) and a renewed generator component (b) of a first wind turbine; and

30

figures 6a and b show a frequency spectrum of a damaged generator component (a) and a renewed generator component (b) of a second wind turbine.

35

According to figure 1, a wind turbine is presented, denoted as a whole by the reference numeral 2 and having a tower 21, a nacelle 25, which is arranged on the tower, a rotor 23, which is rotatably mounted on one end face of the nacelle 25 and is connected to a generator 22 by way of a shaft 24, which may comprise a gear stage (not shown). The generator 22 may be designed as a synchronous or asynchronous generator.

The generator 22 comprises generator components 221, which are exposed to mechanical loads on account of the rotation of the shaft 24. In this exemplary embodiment, the generator component 221 is a slip ring. Also provided on the wind turbine 2 is a wind turbine diagnostic device, which is identified as a whole by the reference numeral 1. The wind turbine diagnostic device 1 comprises a speed sensor 11, which monitors the rotation of the shaft 24 of the generator 21.

The speed sensor 11 is designed to create and store a time series on the basis of the rotational speed. For storage, the speed sensor 11 comprises a memory component 113. The speed sensor also has a speed signal output 111. The wind turbine diagnostic device 1 also comprises a frequency analysis module 12, which comprises at least one speed signal input 121. The speed signal output 111 and the speed signal input 121 are connected to one another by way of a speed signal line 13. The time series determined by the speed sensor 11 on the basis of the rotational speed can be read out from the memory component 113 and transmitted to the frequency analysis module 12 by way of the speed signal output 111 by way of the speed signal line 13 and the speed signal input 121. The frequency analysis module 12 calculates from the time series on the basis of the

rotational speed a frequency spectrum in a way known per se by means of a fast Fourier transform.

The wind turbine diagnostic device 1 also has a
 5 comparator element 14. The calculated frequency spectrum is transmitted from the frequency analysis module 12 to the comparator element 14. For this purpose, the frequency analysis module 12 has a frequency spectrum signal output 122. The frequency
 10 spectrum signal output 122 is connected to a frequency spectrum signal input 142 of the comparator element 14 by way of a frequency spectrum signal line 19.

The comparator element 14 has a standard frequency
 15 spectrum, which corresponds to the frequency spectrum of an undamaged generator 22. The calculated frequency spectrum transmitted from the frequency analysis module 12 is compared with the standard frequency spectrum by the comparator element 14. Figure 5a shows a frequency
 20 spectrum of a generator 22, which has damaged generator components 221. The rotational speed of the generator 22 was at 1048 revolutions/min (rpm). The speed frequency is marked as a dashed vertical line on the extreme left in the frequency spectrum in figure 5a at
 25 $1048 \text{ rpm} / 60 = 17.47 \text{ rps (revolutions/s)} = 17.47 \text{ Hz}$. The further dashed vertical lines in the frequency spectrum to the right of the speed frequency are the multiples of the speed frequency.

30 Apart from at the speed frequency itself, the frequency spectrum shows clear amplitudes at the 2nd to 5th, 7th and 8th multiples of the speed frequency. These amplitudes indicate an instance of damage to a generator component 221, in particular the slip ring. A
 35 monitoring check on the slip ring led to the exchange of the slip ring.

After the exchange of the slip ring, a further diagnosis was carried out, yielding a frequency spectrum according to figure 5b. The diagnosis was
5 carried out at a generator speed of 748 revolutions/min. As in figure 5a, the speed frequency and the multiples of the speed frequency are depicted in the frequency spectrum as dashed vertical lines. There are clearly evident differences in the amplitudes
10 between the frequency spectrum according to figure 5a and the frequency spectrum according to figure 5b. There are no longer vibrations that cause great amplitudes at the multiples of the generator speed. All that is left is a small amplitude at the 3rd to 5th
15 multiples of the speed frequency. These amplitudes indicate imbalances in further generator components 221. In figures 6a and 6b, a further example of a frequency spectrum is presented, determined before (figure 6a) and after (figure 6b) the exchange of a
20 slip ring. Here, too, there are clearly evident differences between the frequency spectrum before the exchange and the frequency spectrum after the exchange. The remaining amplitudes in figure 6b once again indicate imbalances in further generator components
25 221.

To facilitate and speed up the comparison, the comparator element 14 has a difference module 141, which determines the difference between the calculated
30 frequency spectrum and the standard frequency spectrum. The comparator element 14 can quickly detect damaged generator components 221 by means of the difference between the calculated frequency spectrum and the standard frequency spectrum.

35

For the detection of imbalances, the comparator element 14 has an imbalance module 147. The imbalance module 147 is designed for determining imbalances in the generator components 221 from the frequency spectrum.

5

The comparator element 14 also has a harmonic module 145, which carries out the comparison on the basis of the multiples of the rotational speed of the generator. The harmonic module 145 has for this purpose an input 10 146 for the ordering of the harmonics to be monitored. By means of the input 146, the harmonic module 145 can be set for evaluating specific harmonics in the frequency spectrum. This allows a more accurate analysis.

15

The wind turbine diagnostic device 1 also comprises a fault module 17, which reports the damage to generator components 221. For this purpose, the fault module has a fault signal input 171, which is connected to a fault 20 signal output 143 of the comparator element 14 by way of a fault signal line 18. The comparator element 14 transmits to the fault module 17 by way of a fault signal line 18 a list of the generator components 221 that have an instance of damage according to the 25 diagnosis carried out. The fault module 17 marks the generator components 221 that have been reported as damaged by the comparator element 14. For this purpose, the fault module 17 has a monitor 172, which outputs a list of the damaged generator components 221. 30 Alternatively, the monitor 172 may depict a graphic representation of the generator components 221 and graphically mark the damaged generator components 221.

The wind turbine diagnostic device 1 also has a 35 vibration sensor 3, which picks up vibrations at the generator bearing. The vibration sensor 3 is positioned

radially from the axis of the generator 22. Consequently, the vibration sensor 3 principally picks up radial vibrations of the generator 22. The vibration sensor 3 comprises a vibration signal output 32, which
5 is connected to a vibration signal input 144 at the comparator element 14 by way of a vibration signal line 31. The vibration sensor 3 transmits the frequency and the amplitude of the radial vibrations to the comparator element 14 by way of the vibration signal
10 line 31. The comparator element 14 uses the data transmitted from the vibration sensor 3 with respect to the frequency and amplitude of the radial vibrations in order to increase the accuracy of the diagnosis with respect to the damaged generator components 221. Thus,
15 for example, when radial vibrations occur in the generator bearings, and at the same time anomalies in the frequency spectrum of the rotational speed, a slip ring defect can be dependably diagnosed.

20 The wind turbine diagnostic device 1 also has a selector 15, which comprises at least one control signal output 151. The control signal output 151 is connected to a control signal input 112 at the speed sensor 11 by way of a control signal line 16. The speed
25 sensor 11 is in this case designed in such a way that it outputs the determined time series on the basis of the rotational speed to the comparator element 14 when the selector 15 transmits a control signal. The selector 15 may in this case be connected to a
30 multiplicity of speed sensors 11 of different wind turbines 2, which are grouped together to form a wind farm 100. In this case, each speed sensor 11 has a control signal input 112, which is connected to one of the control signal outputs 151 of the selector 15 by
35 way of a separate control signal line 16. The selector 15 can consequently activate the speed sensors 11 of

different wind turbines 2 separately. Consequently, different wind turbines 2 can be subjected to a diagnosis at different points in time. In an embodiment that is an alternative to that described above, the frequency analysis module 12 also has multiple speed signal inputs 121. The speed signal inputs 121 are connected to the speed signal outputs 111 of the aforementioned speed sensors 11 of different wind turbines 2 of a wind farm 100. The frequency analysis module 12 thereby respectively receives a time series on the basis of the rotational speed of a specific wind turbine 2, the speed sensor 11 of which has been activated by the selector 15. Consequently, only one wind turbine diagnostic device 1 with multiple speed sensors 11 is required for multiple wind turbines 2. Only a single frequency analysis module 12, a single comparator element 14 and a single fault module 17 are necessary to check the entire wind farm 100.

The signal lines 13, 16, 18, 31 may also be designed as radio links. This avoids complex assembly work for the signal lines.

In a further alternative embodiment according to figure 3, the wind turbine diagnostic device 1 may be completely integrated in a generator 22. In this case, the speed sensor 11, the frequency analysis module 12, the comparator element 14 and the fault module 17 are integrated in the generator 23. A control element 15 may also be provided. Consequently, the generator 22 of a wind turbine 2 may comprise a complete wind turbine diagnostic device 1, the wind turbine diagnostic device 1 being used for the entire wind farm 100 in which the wind turbine 2 is positioned. By means of the inventive generator 22, a wind farm 100 can be equipped with a wind turbine diagnostic device 1 in an easy way.

The method according to the invention for diagnosing mechanical damage to generator components of a wind turbine is performed by the following steps:

- 5
- Firstly the rotational speed of the generator 22 is determined, in that for example an incremental sensor of a converter of a wind turbine 2 is read out. In this way, a time series on the basis of the rotational speed
- 10 is determined. In a further step, the frequency spectrum of the rotational speed is determined from the time series on the basis of the rotational speed. A fast Fourier transform may be used for this. Alternatively, recourse may be made to a conventional
- 15 Fourier transform. The determined frequency spectrum of the rotational speed is analyzed and compared with a prescribed standard frequency spectrum. The standard frequency spectrum is in this case a frequency spectrum of a wind turbine 2 that has no damaged generator
- 20 components 221. In a final step, damaged generator components 221 are determined on the basis of the comparison. In the comparison, the deviations between the calculated frequency spectrum and the standard frequency spectrum are determined and conclusions as to
- 25 the possible causes of the additional vibrations are reached on the basis of these deviations. Consequently, damage to the generator components 221 can be dependably diagnosed.
- 30 In a first preferred embodiment, the method may be carried out by means of the wind turbine diagnostic device 1 described above. Alternatively, however, the method may also be carried out without the wind turbine diagnostic device 1. For this purpose, the time series
- 35 on the basis of the rotational speed is read out

manually and a manual analysis of the frequency spectra is carried out on the basis of a Fourier transform.

WE CLAIM:

1. A wind turbine diagnostic device for diagnosing mechanical damage to generator components (221) of at least one wind turbine (2), comprising

at least one speed sensor (11) for determining a variation over time of the rotational speed of a generator (22) of a wind turbine (2), the speed sensor (11) having at least one speed signal output (111) for outputting the determined variation over time of the rotational speed,

wherein

the wind turbine diagnostic device (1) has a frequency analysis module (12) with at least one speed signal input (121), which is connected to the speed signal output (111) by way of a speed signal line (13), and a frequency spectrum signal output (122) for outputting a frequency spectrum, the frequency analysis module (12) being designed for determining a frequency spectrum from the determined variation over time of the rotational speed; and

has a comparator element (14), which comprises a frequency spectrum signal input (142), which is connected to the frequency spectrum signal output (122) by way of a frequency spectrum signal line (19), the comparator element (14) being designed for comparing a frequency spectrum of the rotational speed with a prescribed standard frequency spectrum and for diagnosing mechanical damage to generator components (221) on the basis of the comparison.

2. The wind turbine diagnostic device as claimed in claim 1,

wherein

the frequency analysis module (12) is designed for carrying out a frequency analysis by means of a fast Fourier transform.

3. The wind turbine diagnostic device as claimed in claim 1 or 2,

wherein

the wind turbine diagnostic device (1) has a selector (15) with at least one control signal output (151), which is designed for selecting a speed sensor (11) from the speed sensors (11) of multiple wind turbines (2) and is designed for activating the speed sensor (11) for outputting the data, the speed sensor (11) being designed for outputting the determined variation over time of the rotational speed by way of the speed signal output (111) in response to the activation by the selector (15).

4. The wind turbine diagnostic device as claimed in any one of claims 1 to 3,

wherein

the comparator element (14) has a difference module (141), which is designed for determining the difference between the frequency spectrum and the standard frequency spectrum.

5. The wind turbine diagnostic device as claimed in any one of claims 1 to 4,

wherein

the comparator element (14) has a fault signal output (143), the comparator element (14) being designed for outputting a fault signal by means of the fault signal output (143) when the deviation between the frequency spectrum and the prescribed standard frequency spectrum exceeds a predetermined limit value, the fault signal comprising a reference to the generator components (221) to be monitored.

6. The wind turbine diagnostic device as claimed in claim 5,

wherein

the wind turbine diagnostic device (1) has a fault module (17) with a fault signal input (171), the fault signal input (171) being connected to the fault signal output (143) by way of a fault signal line (18) and the fault module (17) being designed for reporting the generator components (221) to be monitored on the basis of the fault signal.

7. The wind turbine diagnostic device as claimed in any one of claims 1 to 6,

wherein

the generator component (221) is a slip ring of a generator (22).

8. The wind turbine diagnostic device as claimed in any one of claims 1 to 7,

wherein

the comparator element (14) comprises an imbalance module (147), which is designed for detecting imbalances in the generator components (221).

9. The wind turbine diagnostic device as claimed in any one of claims 1 to 8,

wherein

the comparator element (14) has a harmonic module (145), which is designed for carrying out the comparison on the basis of the multiples of the rotational speed in the frequency spectrum and preferably comprises an input (146) for ordering the harmonics to be monitored.

10. The wind turbine diagnostic device as claimed in any one of claims 1 to 9,

wherein

the wind turbine diagnostic device (1) has a vibration sensor (3) for measuring vibrations at generator bearings, the vibration sensor (3) having a vibration signal output (32), the comparator element (14) comprising a vibration signal input (144), which is connected to the vibration signal output (32) by way of a vibration signal line (31), the comparator element (14) being designed for classification of the vibration signal, for correlating evaluation of the rotational speed with respect to the classified vibration signal

and for taking the correlating evaluation into account in the diagnosis.

11. A generator for a wind turbine (2) that has a wind turbine diagnostic device (1) for diagnosing mechanical damage to generator components (221) of at least one wind turbine (2), the wind turbine diagnostic device (1)

comprising at least one speed sensor (11) for determining a variation over time of the rotational speed of a generator (22) of a wind turbine (2), the speed sensor (11) having at least one speed signal output (111) for outputting the determined variation over time of the rotational speed,

wherein

the wind turbine diagnostic device (1) has a frequency analysis module (12) with at least one speed signal input (121), which is connected to the speed signal output (111) by way of a speed signal line (13), and a frequency spectrum signal output (122) for outputting a frequency spectrum, the frequency analysis module (12) being designed for determining a frequency spectrum from the determined variation over time of the rotational speed; and

has a comparator element (14), which has a frequency spectrum signal input (142), which is connected to the frequency spectrum signal output (122) by way of a frequency spectrum signal line (19), the comparator element (14) being designed for comparing a frequency spectrum of the rotational speed with a prescribed standard frequency spectrum and for diagnosing

mechanical damage to generator components (221) on the basis of the comparison.

12. The generator as claimed in claim 11,

wherein

the wind turbine diagnostic device (1) is developed as claimed in one of claims 2 to 10.

13. A wind turbine comprising a generator (22) and a wind turbine diagnostic device (1) for diagnosing mechanical damage to generator components (221) of at least one wind turbine (2), the wind turbine diagnostic device (1)

comprising at least one speed sensor (11) for determining a variation over time of the rotational speed of a generator (22) of a wind turbine (2), the speed sensor (11) having at least one speed signal output (111) for outputting the determined variation over time of the rotational speed,

wherein

the wind turbine diagnostic device (1) has a frequency analysis module (12) with at least one speed signal input (121), which is connected to the speed signal output (111) by way of a speed signal line (13), and a frequency spectrum signal output (122) for outputting a frequency spectrum, the frequency analysis module (12) being designed for determining a frequency spectrum from the determined variation over time of the rotational speed; and

has a comparator element (14), which has a frequency spectrum signal input (142), which is connected to the frequency spectrum signal output (122) by way of a frequency spectrum signal line (19), the comparator element (14) being designed for comparing a frequency spectrum of the rotational speed with a prescribed standard frequency spectrum and for diagnosing mechanical damage to generator components (221) on the basis of the comparison.

14. The wind turbine as claimed in claim 13,

wherein

the wind turbine diagnostic device (1) is developed as claimed in one of claims 2 to 10.

15. A method for diagnosing mechanical damage to generator components (221) of a wind turbine (2), comprising the steps of:

- a. determining a time series of the rotational speed of a generator (22), involving
- b. determining a frequency spectrum of the rotational speed by means of a frequency analysis module (12) with at least one speed signal input (121), which is connected to a speed signal output (111) of a speed sensor (11) by way of a speed signal line (13), and a frequency spectrum signal output (122) for outputting a frequency spectrum;
- c. comparing the frequency spectrum with a prescribed standard frequency spectrum by means of a

comparator element (14) which comprises a frequency spectrum signal input (142), which is connected to the frequency spectrum signal output (122) by way of a frequency spectrum signal line (19), the comparator element (14) being designed for comparing a frequency spectrum with a prescribed standard frequency spectrum; and

- d. determining mechanical damage to generator components (221) on the basis of the comparison by means of the comparator element (14).

16. The method as claimed in claim 15,

wherein

the method is carried out with a wind turbine diagnostic device (1) as claimed in any one of claims 1 to 10.

1 / 4

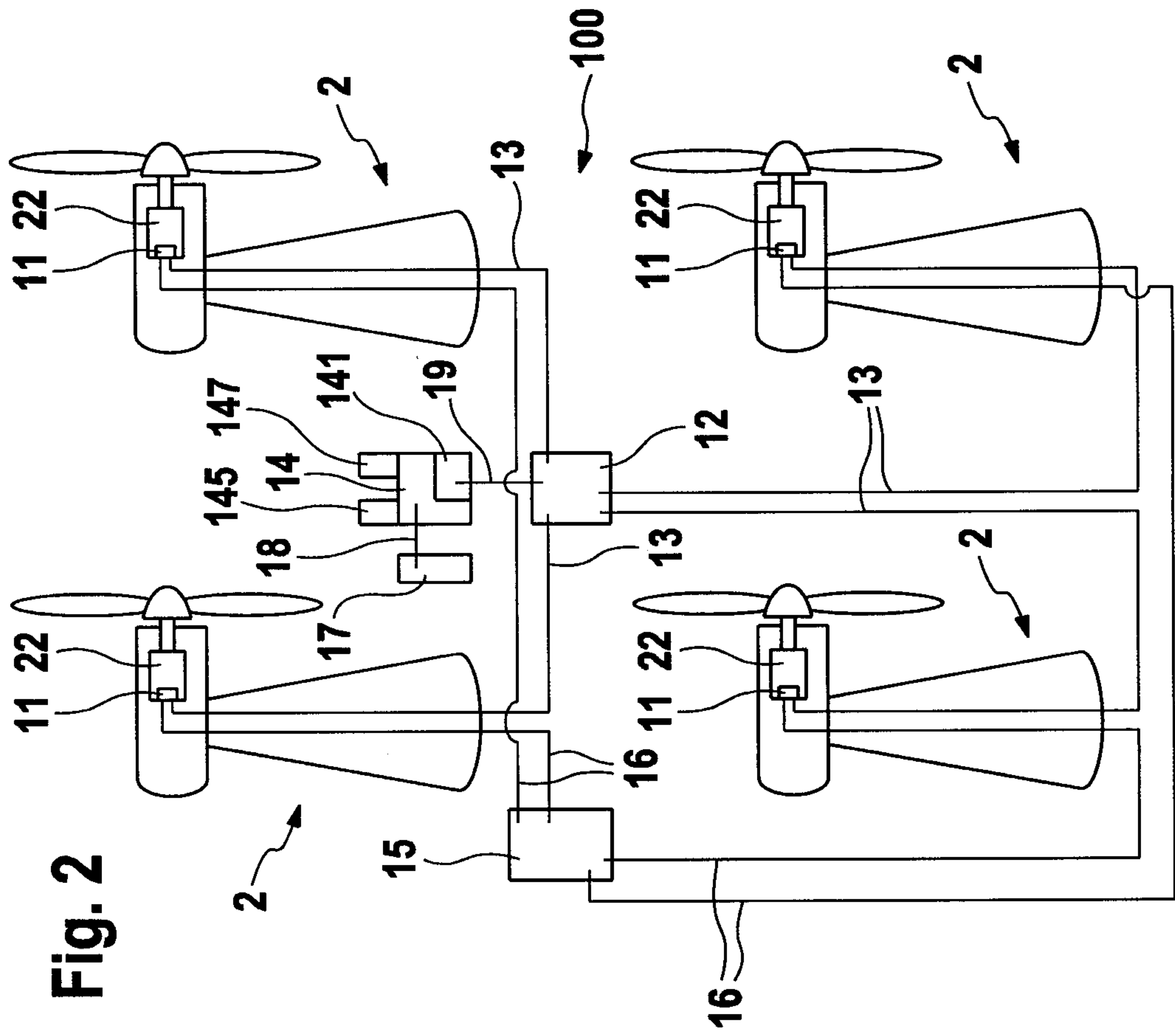


Fig. 2

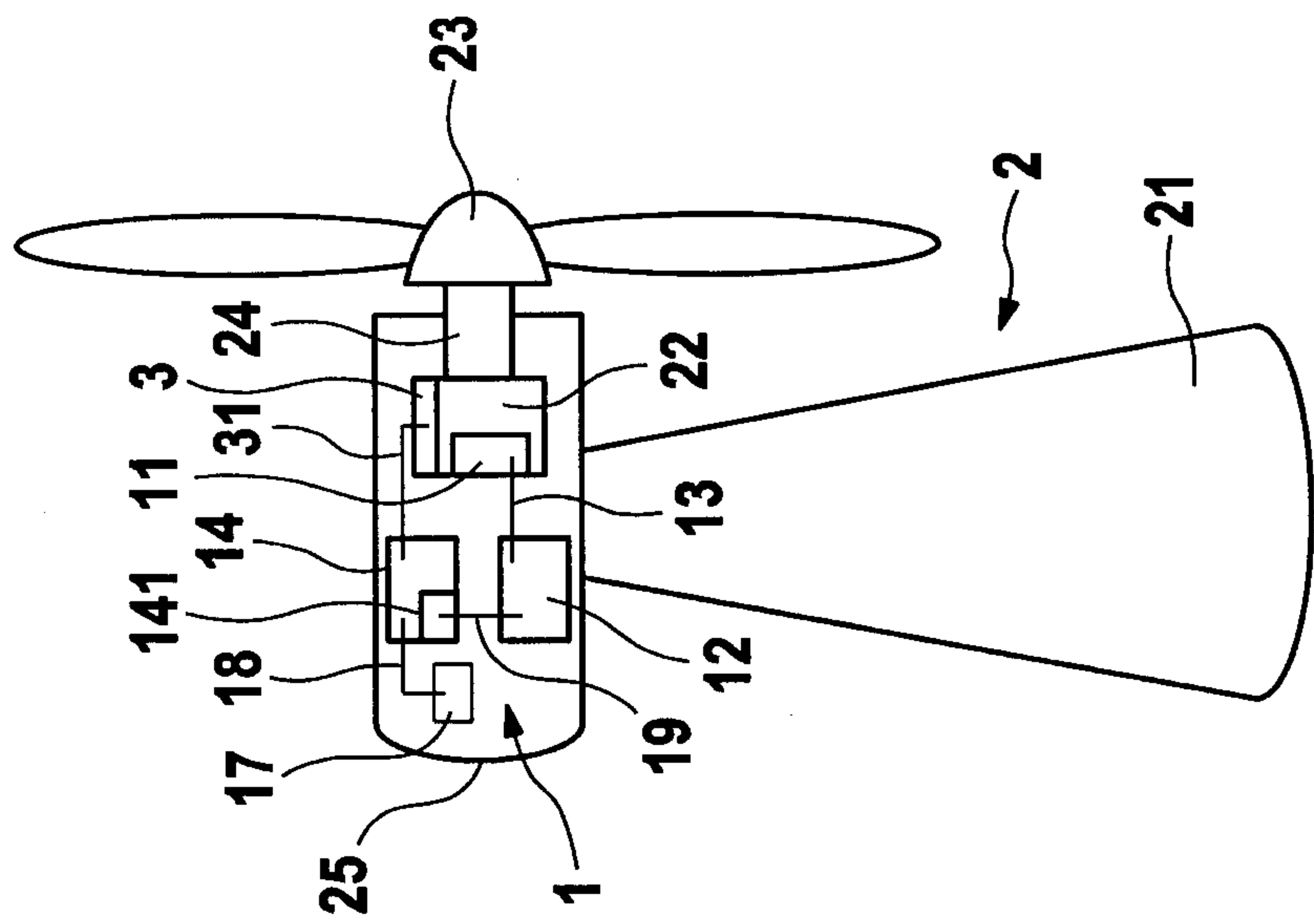


Fig. 1

