(19) DANMARK

(10) **DK/EP 3047144 T3**

Patent- og Varemærkestyrelsen

(12) # Oversættelse af europæisk patentskrift

(51) Int.Cl.: ***F 03 D 17/00 (2016.01)*** ***F 16 B 37/14 (2006.01)*** ***G 01 M 5/00 (2006.01)***

(45) Oversættelsen bekendtgjort den: **2019-08-12**

(80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2019-05-01**

(86) Europæisk ansøgning nr.: **14758299.3**

(86) Europæisk indleveringsdag: **2014-09-01**

(87) Den europæiske ansøgnings publiceringsdag: **2016-07-27**

(86) International ansøgning nr.: **EP2014002360**

(87) Internationalt publikationsnr.: **WO2015039727**

(30) Prioritet: **2013-09-19 DE 102013218845**

(84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**

(73) Patenthaver: **Senvion GmbH, Überseering 10, 22297 Hamburg, Tyskland**

(72) Opfinder: **HÖR, Oliver, Lehmkuhle 42, 24796 Bredenbek, Tyskland**
RIESBERG, André, Falkenring 5, 49134 Wallenhorst, Tyskland

(74) Fuldmægtig i Danmark: **RWS Group, Europa House, Chiltern Park, Chiltern Hill, Chalfont St Peter, Bucks SL9 9FG, Storbritannien**

(54) Benævnelse: **ENHED, SYSTEM OG METODE TIL OVERVÅGNING AF EN FLANGEFORBINDELSE AF ET VINDKRAFTVÆG**

(56) Fremdragne publikationer:
WO-A1-2013/053758
WO-A2-2010/092426
US-A- 4 484 132

Description

The invention concerns a device, a system and a method for monitoring a flange connection of a wind turbine, in particular a flange connection subject to high dynamic loads. The invention also concerns a wind turbine.

Wind turbines are highly dynamically loaded machines with 10^9 load cycles, which are otherwise very rare in mechanical engineering. This dynamic leads to very strong material fatigue. For logistical reasons, however, the main components of a wind turbine can only be assembled on site. This means that the complete loads from the wind rotor must be transmitted via detachable connections, usually flange connections with screw bolts. The highly loaded flange connections include the tower flanges, the tower head bearing, the shaft and gear bearings, the rotor shaft to rotor hub connection, as well as the connection of the rotor blades via the blade bearings with the rotor hub. These flange connections show unavoidable weak points in the form of bolt holes.

For example, rotor blade bearings represent the blade root-side attachments of the rotor blades to the rotor hub. These components are highly stressed in the operation of the wind turbine and in the event of damage can lead to serious problems up to the dropping of a rotor blade.

A typical design of rotor blade bearings has two bearing rings rotatably connected to each other via rolling elements, each of which is provided with drilled holes to accommodate connecting bolts or rotor blade connecting bolts. These boreholes are also weak points of the rotor blade bearings.

The inspection of rotor blade bearings is particularly time-consuming and only possible to a limited extent due to their lack of accessibility. Cracks in the rotor blade bearing are therefore difficult, if at all, to detect before they lead to a failure of the rotor blade bearing. The same applies to other flange connections of wind turbines.

US 4,484,132 A reveals a crack and fracture detection system with an electrically insulating substrate in which small electrically conductive particles are embedded that are in electrical contact with each other. As long as the substrate is an elastomer, it is applied to an object to be monitored and then cures and is then capable of breaking or tearing if the object being monitored becomes deformed. In the event of a crack or rupture, the conductive paths of the electrically conductive particles are interrupted. WO 2013/053758 A1 reveals a nut cap with a sensor.

Therefore, the present invention is based on the task of simplifying the monitoring of a flange connection, in particular a rotor blade bearing, of a wind turbine, which is in particular subject to high dynamic loads, whereby the monitoring should be carried out cost-effectively and during operation.

The task on which the invention is based is solved by a device according to claim 1.

A basic idea of this inventive concept is to use cracked bolt nuts or bolt heads as indicators for cracks in the flange connection or in the bearing. A crack in the rotor blade bearing leads, for example, to the rotor blade bolt and the nut screwed onto it being subjected to disproportionately high loads in the event of a bearing crack, and this therefore leads to a crack in the blade nut or a bolt head if necessary. It can also happen that the blade nut is stripped by the rotor bolt. The same also applies to other failing flange connections of wind turbines.

In the context of the invention, bolts, bolt heads and the corresponding nuts are therefore understood to be synonymous with rotor blade bolts or rotor blade bearing bolts and their heads or nuts, as well as bolts, bolt heads and bolt nuts of other flange connections of wind turbines.

The bolt head or the bolt nut are monitored as an indicator for cracks in the bearing in the flange connection or, as invented, by a type of "nut cap", so that it is possible, for example, to initiate an automatic system shutdown if a critical bearing crack occurs, which in the worst case could lead to blade dropping in the case of the rotor blade bearing.

This "cap" is designed as a monitoring body that can be mounted on the bolt head or bolt nut. In the simplest case, the monitoring body is attached to the bolt. A sensor monitors or determines the structural integrity of the monitoring body. If the monitored nut or bolt head tears, the monitoring body is also destroyed. This destruction is detected by the sensor and serves to signal damage to the flange connection, especially the bearing. The blade nut tears if it is stripped from the bolt in the event of bearing failure. This event leads to damage of the monitoring body.

The system thus offers an automatic, simple, robust, cost-effective and easily retrofittable possibility to monitor the bolt nuts or bolt heads, and thus also the bearing and the flange connection, for damage, in particular cracks.

The monitoring body is preferably designed as a plastic moulded part. It is advantageous for the monitoring body to have predetermined breaking points at one or more corners of the central receptacle and/or at one or more edges of the central receptacle, which in particular are designed as areas with reduced material thickness. A suitable material for this is, for example, polyamide PA 2200 fine powder, which makes it possible to manufacture the monitoring body in a laser sintering process. This makes it possible to manufacture the monitoring bodies in a very short time. Larger quantities are preferably produced cost-effectively using the widespread injection moulding process.

The predetermined breaking points ensure that the monitoring body breaks reliably and cleanly if the component on which the monitoring body is mounted breaks. The material should exhibit a mixture of sufficient elasticity for damage-free assembly on the component to be monitored and sufficient brittleness to ensure damage in the event of damage to the component to be monitored. Many plastics are suitable for this purpose.

The monitoring body has an advantageous hexagonal opening for the normally hexagonal nuts and hexagonal bolt heads and can be pushed over the nut or bolt head. The opening can be slightly larger than the actual nut. The material and the opening should be selected so that the gap is sufficiently large over the entire temperature range of operation of the wind turbine and there is no cracking of the monitoring body due to different expansion coefficients of steel and plastic.

In order to obtain a defined crack behavior of the monitoring body, for example, the six corners of the hexagonal opening can be provided with a recess and thus form fractures. Alternatively or additionally, the six edges can also be provided with predetermined breaking points. In order to reduce the risk of the predetermined breaking points tearing during assembly or due to vibrations, for example, a collar or web can be provided for stabilization in the lower area. This collar or web can also serve as a support surface for the monitoring body on the flange, e.g. rotor blade bearing.

The height of the monitoring body recess may be the total height of a nut, but it may also be less than the height of the nut to be monitored.

The monitoring body preferably has a fixing device for, in particular detachable, axial fixing on a bolt head or a bolt nut, wherein in particular the fixing device has at least one fixing element which is designed for engagement in an external thread of a bolt and is resilient and/or can be fixed by means of a fixing means, in particular a snap ring or a cable tie. By means of the fixing device, the monitoring body is centered on the bolt and fixed axially thereon. In this way it is ensured that the monitoring body does not slip from the bolt part to be monitored, i.e. the bolt head or the bolt nut. This fixing element also offers a further possibility to monitor the removal of the nut from the bolt, as the fixing is destroyed. The sensor can therefore preferably also monitor the fixing element.

The sensor preferably has at least one electrical conductor which at least substantially once or several times surrounds the central receptacle, and which is designed in particular as a wire, as an electrically conductive fibre or as an electrically conductive coating on the monitoring body. This means that the sensor has an electrical conductor which, in the event of damage to the monitored component, tears together with the monitoring body. This interrupts the electrical conductivity of the electrical conductor. This interruption allows it, immediately detect damage to the monitored component, such as the bolt nut. Alternatively or additionally, the sensor can also be designed as an optical, inductive, capacitive or structure-borne sound sensor within the scope of the invention, which detects a crack in the monitoring body.

A particularly simple version of the electrical conductor is a track made of conductive paint, as used on computer boards. Thin strands or electrically conductive fibres, such as carbon fibres, are also suitable. However, the coating with conductive lacquer is particularly cost-effective.

If a paint track is used as an electrical conductor, it can be applied in a design form as a spiral to the outside of the monitoring body. It can also preferably be applied to the underside or the top of a web. The circumference of the central mount should preferably be at least approximately 360°. A spiral paint track can either be continuously ascending or offset at one point. In this case, contact points for attaching the cable are preferably located between two predetermined breaking points.

Furthermore, a coating for protection against simple mechanical influences, e.g. during transport, is preferably applied outside the paint track. The basic body of the monitoring body as well as the paint and protective layers should be thermally matched to each other so that no detachment or cracking occurs over the entire operating temperature range.

The transition from the paint track or the electrical conductor to the plug or cable for an external connection must also be safe over the entire temperature range and also in the event of thrust or vibration. A strain relief can be provided so that the contact point is not stressed when the individual devices are connected to each other.

It should be possible to install each monitoring body of each device individually. They should preferably have a plug and a socket for this purpose. Separate connecting bodies are provided between the individual monitoring bodies or each monitoring body is provided on one side with a sufficiently long cable.

Plugs and/or cables are preferably arranged at the side of the monitoring body to ensure that the permissible or the available total height is not exceeded.

For contacting the sensor, preferably at least one connecting plug is comprised which is electrically conductively connected to the ends of the at least one electrical conductor and/or an RFID chip which is designed for wireless signal transmission and/or for wireless operation and/or for wireless power supply of the sensor and has a unique identifier.

When RFID chips are used, cabling is no longer necessary in every case, especially if the RFID chip is inductively supplied with power and is designed to transmit measurement signals or a result of a conductivity test. As a result of a conductivity test, a simple distinction between "signal" and "no signal" is sufficient in the context of this invention.

If no signal identification is provided, an optical trip indicator, in particular a low-current LED, is preferred. Thus, when the wind turbine is at a standstill, the LEDs on the devices can be used to quickly locate the affected nut or bolt head.

The task underlying the invention is also solved by a system for monitoring a flange connection of a wind turbine, in particular a flange connection subject to high dynamic loads, with a plurality of devices according to the invention described above and an evaluation device which is connected wirelessly or wired to the plurality of devices and is designed to receive signals from the sensors of the devices.

Thus, the inventive system has the same characteristics, advantages and properties as the devices contained therein.

Preferably, the majority of the devices are connected in series or in parallel, or several sensors are connected in series, and each individual sensor or subgroup of the sensors connected in series has a trip indicator. When forming subgroups, certain areas can be monitored collectively. In the case of the rotor blade bearing, for example, the area of several degrees around the trailing edge of the blade has proven to be a particularly critical area. For example, a crack in this area can be considered more severe than an incipient crack in another area that is less stressed. This can be taken into account when deciding about the control or shut down of the wind turbine. Likewise, it is preferably possible to equip bolt nuts or heads with the monitoring devices in accordance with the invention only in an area of the flange connection known to be critical, whereby the costs for the system can be reduced to a fraction of the complete equipment of all bolts of a flange connection with approximately the same safety. Thus, preferably only an area of critical bolts in the area of a rotor blade trailing edge is monitored if it is known, in particular from mathematical analyses or field experience, that cracks only occur in this area.

For sensors which require an external power supply and/or for signal transmission, an inductive connection or a connection via a slip ring or a cable connection from the sensors to an external power source and/or evaluation unit, protected in particular by a drag chain, is preferably included. If RFID chips are used, the power can be supplied either by local batteries on the respective device or inductively.

The task underlying the invention is also performed by a wind turbine with a system described above for Monitoring of a flange connection, in particular a rotor blade bearing, which is subject to high dynamic loads, is solved.

Finally, the task on which the invention is based is solved by a method for monitoring a flange connection, in particular a rotor blade bearing, of a wind turbine, which is subject to high dynamic loading, in particular, by the characteristics of the claim 12.

In the context of the invention, signaling means a display on an operating console, e.g. for remote maintenance, as well as direct feedback to an automatic control unit of the wind turbine. Preferably, the wind turbine is shut down if damage to the flange connection is signaled.

In a preferred variant, several sensors of several devices are operated in series or grouped together. A switch-on reduces the technical effort, while the grouping of sensors connected in series enables a localisation with likewise reduced technical effort.

Monitoring is preferably carried out continuously or at discrete time intervals. With continuous monitoring, damage to the rotor blade bearing that affects a bolt or the bolt nut or bolt head can be detected immediately. In the case of inductively operated RFID chips, for example, discontinuous monitoring at regular intervals is also possible.

In order to signal a damage, it is preferably intended that a sensor emits a signal if a monitoring body is damaged or destroyed, or alternatively that a damage is detected if a continuously present signal is interrupted (so-called "fail safe") or if a sensor is not detected due to an interruption of its electrical conductor during monitoring. This latter case is, for example, the case with wireless monitoring in which, for example, RFID chips are inductively energized and, in the case of a structurally intact surveillance body, send a response that will be centrally received. If a monitoring body is structurally no longer intact due to damage to the monitored component and the electrical conductor is thus interrupted, this sensor and RFID chip can no longer send a response.

An invention-based system for monitoring rotor blades, for example, is intended in particular for retrofitting to existing wind turbines. A wireless version with RFID signal transmission is particularly suitable for this, because no complex signal transmission via two rotating axes from the moving blade bearing ring to the nacelle via slip rings and/or drag chain is required. Only the monitoring bodies have to be attached to the blade bolts and an RFID transmitter and receiver unit installed in the rotating rotor hub or the nacelle near the blade bearings. In the simplest case, the transmitting and receiving unit uses an existing, preferably digital, input into the control system of the wind turbine to transmit a signal for a Damage. The alternative installation of a drag chain in the restricted space conditions at the blade bearings requires a considerable constructional effort. The advantage of this system, however, is its high reliability in signal transmission.

This invention is used in particular for monitoring rolling bearings designed as flange connections, in particular blade bearings or azimuth bearings. In comparison to conventional systems for monitoring rolling bearings, the invention-based system and the the device has the advantage of simplicity. This is based on the knowledge that the vast majority of cases of total failure of a blade or azimuth bearing, for example, initially lead to cracking through a bolt hole in one of the bearing rings, which leads to the bolt nut/bolt head bursting open with little delay. This is certainly recognized by the invention. The time between the failure of the bolt nut or bolt head and the total failure of the rolling bearing is sufficiently long to allow the wind turbine to shut down safely after damage has been detected. In order to protect the damaged components, it is particularly preferred to shut down the turbine at a reduced shutdown speed compared to an emergency stop.

Further features of the invention can be seen from the description of the invention's design forms together with the claims and the attached drawings. Invented embodiments may fulfil individual features or a combination of several features.

The invention is described below without limitation of the general idea of invention by means of examples of execution with reference to the drawings, whereby explicit reference is made to the drawings with regard to all details of the invention which are not explained in detail in the text. Show it:

Fig. 1 a schematic representation of a nacelle of a wind turbine,

Fig. 2a) to c) a first example of a device according to invention,

Fig. 3a) to c) Detailed views of the device from Fig. 2,

Fig. 4a, b) schematic representation of a second example of a device according to the invention,

Fig. 5a) to c) schematic representation of a third example of a device according to invention,

Fig. 6a) to d) schematic representation of a fourth example of a device according to invention,

Fig. 7a), b) Excerpts of a system according to invention.

In the drawings, identical or similar elements and/or parts are each provided with the same reference numbers, so that there is no need for a new presentation in each case.

In Fig. 1 a nacelle 1 or a tower head of a wind turbine is shown schematically from the side. To the nacelle 1 is connected a rotor hub 2 with three rotor blade connections with rotor blade bearings 3 for rotor blades 4. A rotor blade 4 is also shown with its root end. The rotor blade connections each have flanges for connecting a rotor blade 4 and blade angle adjustment devices for adjusting and locking the rotor blade angle. A rotor blade bearing mounted on the flange and covered with a fairing is provided with the reference symbol 5. For bolting a rotor blade 4 to the rotor blade bearing 3, the rotor blade bearings 3 have a large number of 3' bores around the circumference to accommodate screw bolts or rotor blade bolts.

Inside nacelle 1, rotor hub 2 is followed by bearing 6 of a slow rotor shaft, which is directly connected to rotor hub 2. The slow shaft is connected to a gear 7, which increases the speed of the slow rotor shaft and transfers it to a fast shaft. The fast shaft, which is connected to the gear 7, leads to a generator 8, which is arranged at the rear end of nacelle 1. Also shown is an electronic control device 9 with an inverter that adapts the electrical current generated by the generator 8 so that it can be fed into a private or public power grid.

The lower part of nacelle 1 shows a machine carrier with a main carrier 10 and a rear carrier 11. The main carrier 10 supports the bearing 6 of the slow shaft as well as the rotor hub 2 and the gearbox 7. The rear carrier 11 carries electrical components such as the generator 8, control and switch cabinets as well as a transformer and the inverter if necessary.

For azimuthal rotation, i.e. for the rotation of nacelle 1 on the longitudinal axis of tower 15, several azimuthal drives 12, usually between four and sixteen, are arranged on main carrier 10, which rotate nacelle 1 on tower 15 via a gear wheel and gear rim gear. In addition, adjacent azimuth brakes 13 are designed to relieve the azimuth drives 12. They hold the nacelle 1 in a fixed azimuthal position as soon as an azimuth target position is reached. During an azimuth adjustment, they are moved to a fixed azimuth position with a residual pressure to decouple the azimuth drives 12 from external influences.

The rear end of nacelle 1 is also equipped with wind sensors, e.g. an anemometer 16, and lightning protection 14. A further lightning protection not shown is usually arranged in the area of the transition between nacelle 1 and rotor hub 2 in order to divert lightning strikes from rotor blade 4 into tower 15.

In the following figures, the invention is explained using a rotor blade bearing designed as a flange connection. These designs can easily be transferred to a very advantageous monitoring of an azimuth bearing arranged between the tower head and the nacelle, which is very similar in function and design to a blade bearing.

Fig. 2a) shows a bolt nut 20 which is damaged due to damage to a rotor blade bearing 3 and has a crack 21. The volume or circumference of the bolt nut 20 has increased as a result.

Fig. 2b) shows a first example of a monitoring body 30 according to the invention, which can be mounted on a structurally intact nut 20. The monitoring body 30 has a lower part, namely a nut holder 31', as well as an upper bolt holder 32, which has a central bolt holder 33 as opening. An electrical conductor in the form of a spiral-shaped electrically conductive coating is attached to the circumference of the nut attachment 31. This is contacted at both ends by means of contact pins 34, 35, which in turn can be connected to an evaluation device or other sensors.

In Fig. 2c) a cross-sectional representation is shown schematically by a corresponding monitoring body 30, in which the hexagonal nut holder 31' is recognisable. This is adapted to the shape of the nut to be monitored or the bolt head to be monitored and designed in such a way that normal thermal size changes of the monitored component do not lead to damage of the monitoring body 30. In the nut attachment 31 on 2 sides there is a cavity 37 for the insertion of the contact pins 35, 35 from Fig. 2b), which additionally act as predetermined breaking points. The contact pins 34, 35 are conductively connected to the coating, i.e. the electrical conductor 36. On the underside a web 39 is arranged circumferentially for stabilisation and support on the rotor blade bearing 3.

Fig. 3 shows schematic diagrams of the monitoring body 30 from Fig. 2. Fig. 3a) shows a side view in which the spiral arrangement of the electrical conductor 36 is shown. Fig. 3b) shows a view from below, from which the hexagonal shape of the nut holder 31' can be seen. H" indicates a detail which is magnified in Fig. 3c). It can be seen that by means of a groove in the corner between two walls the material thickness is further diluted so that a predetermined breaking point 38 is created. In order to avoid a crack during assembly or normal vibrations, this area is fully reinforced by a web 39.

Fig. 4 shows a second example of a device according to the invention, in Fig. 4a) from a perspective upper view and in Fig. 4 from a perspective upper view. Fig. 4b) perspective diagonally from below.

A bolt nut 20 sits on a bolt 22. A monitoring body 50 is pushed onto the bolt nut 20, the nut attachment 51 of which partially accommodates the bolt nut 20. The nut attachment 51 has several windows or openings and is only solid at the corners of the hexagonal form. A circumferential web 59 closes the nut attachment 51 at the bottom. The wall thickness of the web 59 is weakened by a notch in the centre of each side face of the nut 20, so that a total of six predetermined breaking points 58 are achieved there. The windows serve to save material and weaken the structure of the monitoring body 50.

The nut attachment 51 continues upwards at bolt 20 and has elements there which engage in the thread structure of bolt 22.

A bolt fastening part 52 is placed on this upper part, which exerts pressure on the upper part of the nut attachment 51, so that the nut attachment 51 is fixed axially on the bolt nut 20. The bolt mounting part 52 has spring elements 55 for this purpose.

For use in monitoring a blade bearing, it is particularly advantageous if the monitoring body has a releasable axial fixing device in order, on the one hand, to provide absolutely secure fixing during movements about the tower, rotor and blade axis and, on the other hand, to enable rapid disassembly if, for safety reasons, it is necessary to check the bolt preload or tightening torques.

The nut attachment 51 also has a mounting 54 on one side for a contact and for a circuit board as well as a plug 53 for connection to external devices.

On the underside of bar 59 shown in Fig. 4b), there is a rotating electrical conductor 56 in the form of an electrically conductive coating. Only in the area of one corner of the bolt nut 20 does the electrical conductor 56 not enclose the hexagonal opening continuously. Nevertheless, the electrical conductor 56 essentially encloses the opening, since destruction of the monitoring body 50 in any case leads to a break in the area of a predetermined breaking point 58, so that an interruption of the electrical conductor 56 is ensured.

The application of the conductive lacquer from below shown in Fig. 4 is technically easier than a lateral application according to Fig. 2 and Fig. 3.

Fig. 5 shows another example of an inventive monitoring body 70. Fig. 5a) shows a schematic top view, Fig. 5b) a schematic perspective bottom view. This is designed in one piece and, like the monitoring body 50 from Fig. 4, has windows on the sides of the mounting for the bolt nut 20. The monitoring body 70 also has a lower circumferential web 79 with predetermined breaking points 78 at the side centres of the bolt nut 20. The lower nut attachment 71 merges into an upper bolt receiving part 72, which is held together by a 73' cable tie. Slits are provided to form resilient elements which can be inserted into the Engage bolt thread. They also serve to cut through the 73' cable tie again.

A wiring and a 79' connector plug are also shown, which can be coupled with corresponding components of other devices.

Fig. 5b) shows the conductive lacquer or electrical conductor 76 applied at the bottom. The wiring is shown incompletely. The central circuit board has an LED 99a that does not have a reference sign. This LED lights up in case of damage. RFIDs can also be used instead of wired sensors.

Fig. 5c) shows the monitoring body 70 in detail. The lower web 79 with the predetermined breaking points 78 and the holder for contacting the board 74 is clearly visible. An upper ring carries the bolt receiving part 72 with resilient element 73 with a nose for fixing in an external thread of a bolt 22. Furthermore there are retaining lugs for a cable tie or a snap ring on the outside.

Fig. 6 a) to d) shows another example of a device according to invention. Fig. 6a) and 6b) show upper and lower schematic perspective representations of a nut attachment 91 of a monitoring body 90. In the lower area, these correspond to those shown in Fig. 5 with a circumferential web and predetermined breaking points 98 on the web. In the upper area, the bolt mounting 92, a locking element 93 with an inward facing nose and outward facing retaining structures 95 for a snap ring. This nut attachment 91 also has a mounting 94 for contacting and circuit board. A similar coating of an electrical conductor 96 is shown on the underside of the bar, as in Fig. 5.

Fig. 6c) and 6d) show the monitoring body 90 on pin 22 and with snap ring 97. Also shown are a
The connector plug 99' and a circuit board with a low-current LED 99a and a cabling 99.

The LED 99a is used to locate damaged bolt nuts 20.

Fig. 7a) shows three devices according to invention with monitoring body 90 and sensor, still without complete wiring, while in Fig. 7b) the left and the middle sensor are wired together in series, so that a series connection 100 of the sensors is realized is. The third sensor is either connected in series again or is connected to a group of other sensors that are not displayed in the same way Series connection grouped.

In the context of the invention, characteristics identified by "in particular" or "preferably" are to be understood as optional characteristics.

List of reference marks

1	nacelle
2	rotor hub
3	rotor blade bearing
3'	Bore
4	rotor blade
5	Flange
6	Bearing of the slow rotor shaft
7	Gearbox
8	generator
9	Control electronics with inverter
10	main carrier
11	rear carrier
12	azimuth drive
13	yaw brake
14	lightning protection
15	tower
16	anemometer
20	bolt nut
21	rip
22	bolts
30	monitoring body
31	nut attachment
31'	Nut mounting
32	bolt retainer
33	Central bolt mounting
34, 35	contact pins
36	electrical conductor
37	hollow
38	predetermined breaking point
39	web
50	monitoring body
51	nut attachment
52	bolt fastener
53	plug
54	Holder for contacting and circuit board
55	spring element

56	electrical conductor
58	predetermined breaking point
59	web
70	monitoring body
71	nut attachment
72	bolt retainer
73	resilient element
73'	cable tie
74	Holder for contacting and circuit board
76	electrical conductor
78	predetermined breaking point
79	web
79'	Wiring and connectors
90	monitoring body
91	nut attachment
92	bolt retainer
93	locking element
94	Holder for contacting and circuit board
95	retaining structure
96	electrical conductor
97	snap ring
98	predetermined breaking point
99	wiring
99a	LED
99'	Connector plug
100	series connection

PATENTKRAV

1. Enhed til overvågning af en, især dynamisk stærkt belastet, flangeforbindelse af et vindkraftanlæg med en positiv og / eller ikke-positiv kontakt med et bolthoved eller en boltmøtrik (20) af en bolt (22), der kan monteres som et møtrikhætte dannet overvågningslegeme (30, 50, 70, 90) med en central beholder (33) til bolthovedet eller boltmøtrikken (20), hvor overvågningslegemet (30, 50, 70, 90) er dannet, i tilfælde af skade eller ødelæggelse af et bolthovede eller i det centrale beholder (33) Boltmøtrik (20), der skal beskadiges, og på et overvågningslegeme (30, 50, 70, 90) arrangeret sensor, der er designet til at bestemme en strukturel integritet af overvågningslegemet (30, 50, 70, 90), hvor overvågningskroppen til en eller et antal hjørner af den centrale beholder og / eller ved en eller flere kanter af den centrale beholder forudbestemte brudpunkter (38, 58, 78, 98) og / eller sensoren har mindst en elektrisk leder (36, 56, 76, 96), der omgiver den centrale beholder mindst i det væsentlige en eller flere gange.

2. Apparat ifølge krav 1, **kendetegnet ved**, at overvågningslegemet (30, 50, 70, 90) er dannet som en plaststøbning **med** de forudbestemte brudpunkter (38, 58, 78, 98), der er udformet især som punkter med reduceret materialetykkelse.

3. Apparat ifølge krav 1 eller 2, **kendetegnet ved**, at overvågningslegemet (30, 50, 70, 90) har en fastgørelsesindretning til især frigørbar aksial fastgørelse på et bolthoved eller en boltmøtrik (20), hvor især fastgørelsen af mindst en til indgreb har en hantråd i en bolt (22) dannet fastgørelseselement, der er elastisk og / eller ved hjælp af et detekteringsorgan, især en snapring (97) eller et kabelbånd, kan bestemmes.

4. Indretning ifølge et af kravene 1 til 3, **kendetegnet ved**, at sensoren har den mindst ene centrale, der mindst modtager i det væsentlige en eller flere gange omkretsende elektriske ledere (36, 56, 76, 96), hvor den elektriske leder som en ledning, som elektrisk ledende fiber eller som en elektrisk ledende belægning på overvågningslegemet (30, 50, 70, 90) dannes.

5. Apparat ifølge krav 4, **kendetegnet ved**, at mindst et forbindelsesprop til kontakt med sensoren er inkluderet, som er elektrisk ledende forbundet til enderne af den mindst ene elektriske leder (36, 56, 76, 96) og / eller en trådløs signaloverførsel og / eller eller til den trådløse betjening og / eller den trådløse strømforsyning til den sensorformede RFID-chip er inkluderet i en unik identifikator.

6. Indretning ifølge et af kravene 1 til 5, **kendetegnet ved, at** en optisk frigørelsesindikator , især en lavstrøms-LED (99a) er inkluderet.

7. System til overvågning af en, især dynamisk stærkt belastet, flangeforbindelse af en vindmølle med en flerhed af anordninger ifølge et af kravene 1 til 6 og en evalueringsindretning, der er trådløst eller kabelforbundet til flerheden af indretninger og er indrettet til at modtage signaler fra sensorer på indretningerne ,

8. System ifølge krav 7, **kendetegnet ved**, at flerheden af enheder er forbundet i serie eller parallelt, eller at et antal sensorer er forbundet i serie hinanden bag hinanden, og hver enkelt eller undergruppe af sensorer, der er forbundet i serie, hver har en trippeanvisning.

9. System ifølge krav 7 eller 8, **kendetegnet ved, at** boltmøtrikker (20) eller hoveder kun er udstyret med anordningerne i et område af flangeforbindelsen, der vides at være kritisk.

10. System ifølge et af kravene 7 til 9, **kendetegnet ved, at** for sensorer, der kræver en ekstern strømforsyning og / eller signaloverførsel, en induktiv forbindelse eller en forbindelse via en glidering eller især ved hjælp af en trækædet beskyttet kabelforbindelse af sensorer til en ekstern Strømkilde og /

eller evaluering er inkluderet.

11. Vindenergianlæg med et system til overvågning af en, især dynamisk stærkt belastet, flangeforbindelse ifølge et af kravene 7 til 10.

12. Fremgangsmåde til overvågning af en, især dynamisk stærkt belastet, flangeforbindelse af en vindmølle, hvor et eller flere overvågningslegemer (30, 50, 70, 90), hvilke eller hvilke i positiv og / eller ikke-positiv indgreb med et bolthoved eller en boltmøtrik (20) af en bolt (22) monterbar og formet med et centralt stik (33) til bolthovedet eller boltmøtrikken (20) på en sådan måde, at det forhindrer skader på eller ødelæggelse af et bolthoved eller boltmøtrik (33) placeret i den centrale beholder (33). 20) enheder, der omfatter en sensor (30, 50, 70, 90) anbragt på overvågningskroppen, som er designet til at bestemme en strukturel integritet af overvågningskroppen (30, 50, 70, 90) og fortrinsvis efter en 7. krav 1 til 6 er dannet, monteret på en eller flere bolte (22) i det mindste en flange af en vindmølle og den strukturelle integritet af overvågningsorganerne (30, 50, 70, 90) overvåges ved hjælp af sensorer på overvågningsorganerne (30, 50, 70, 90), hvorved i tilfælde af skade eller ødelæggelse af et eller flere overvågningsorganer (30, 50, 70, 90) 90) en skade på flangeforbindelsen (3) signaliseres.

13. Fremgangsmåde ifølge krav 12, **kendetegnet ved, at** når man signalerer en skade på flangeforbindelsen, stoppes vindmøllen.

14. Fremgangsmåde ifølge krav 12 eller 13, **kendetegnet ved, at en** flerhed af sensorer for en flerhed af anordningerne drives i serie eller grupperes i grupper.

15. Fremgangsmåde ifølge et af kravene 11 til 14, **kendetegnet ved,** at sensoren i et overvågningsorgan (30, 50, 70, 90) i tilfælde af beskadigelse eller ødelæggelse af overvågningslegemet (30, 50, 70, 90) udsender et signal eller at der opdages en skade, hvis sensoren i et overvågningsorgan

(30, 50, 70, 90), hvilken sensor har mindst en elektrisk leder (36, 56, 76, 96), der omgiver den centrale beholder mindst i det væsentlige en eller flere gange, hvilken elektrisk leder, især som en ledning, er dannet som en elektrisk ledende fiber eller som en elektrisk ledende belægning på overvågningskroppen, på grund af en afbrydelse af dens elektriske leder (36, 56, 76, 96) detekteres ikke i en overvågning, eller et kontinuerligt afventende signal afbrydes.

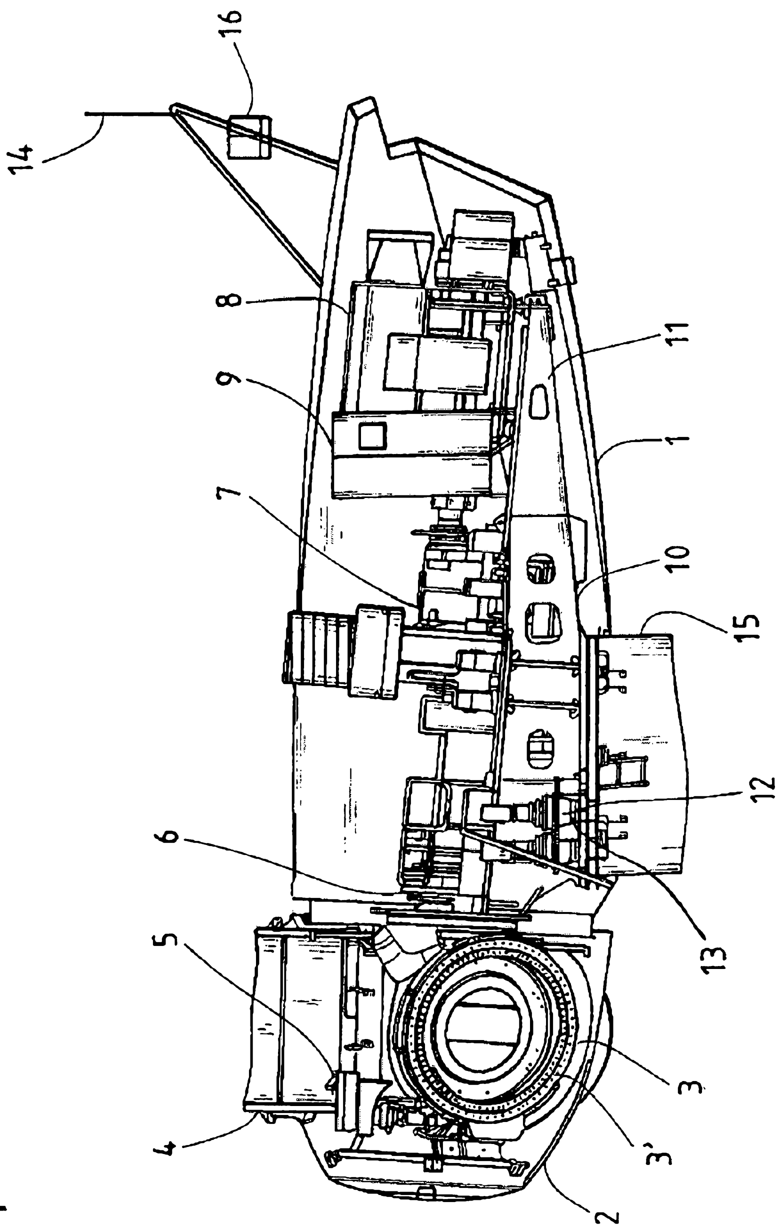


Fig. 1

Fig. 2

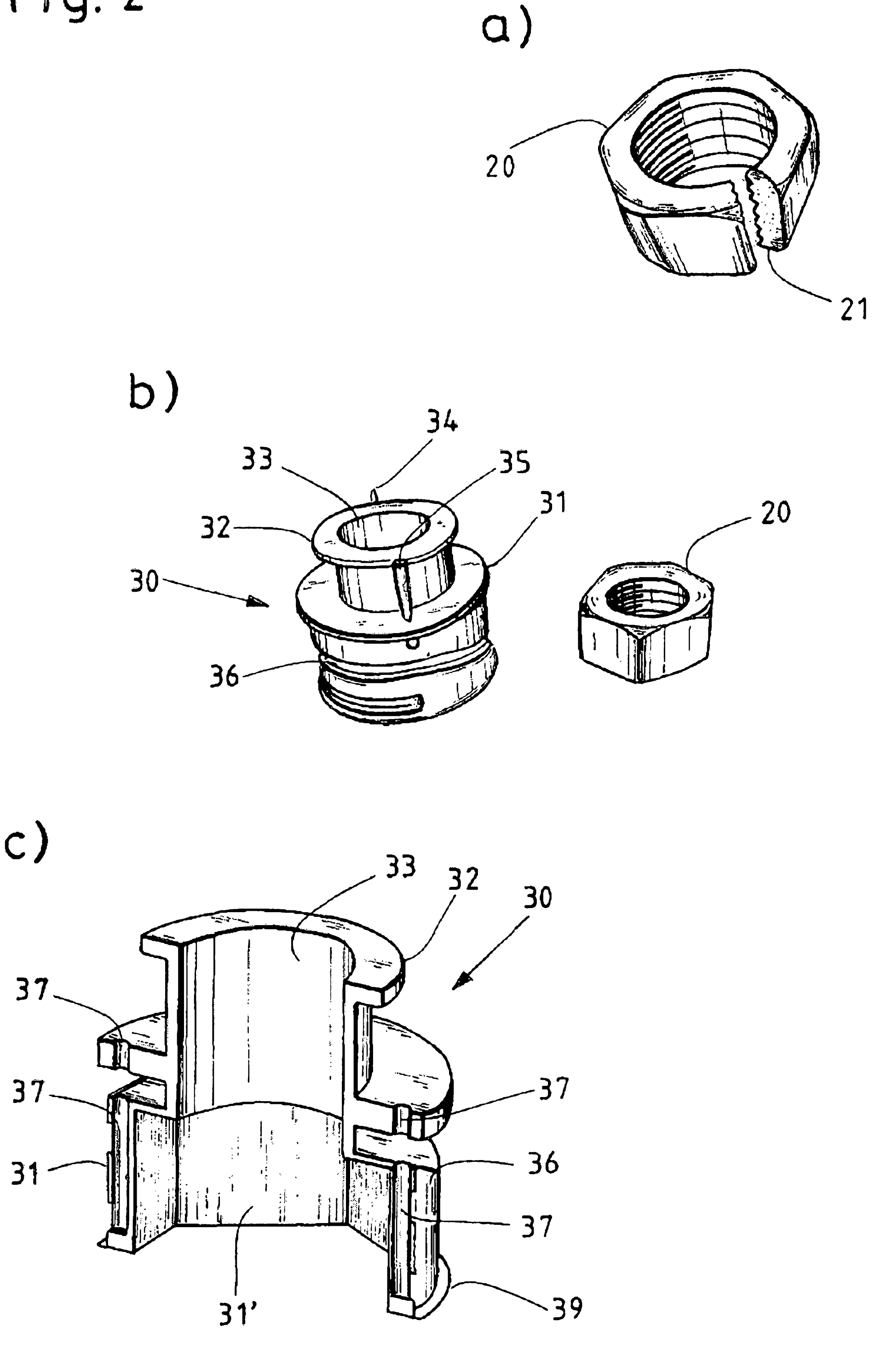
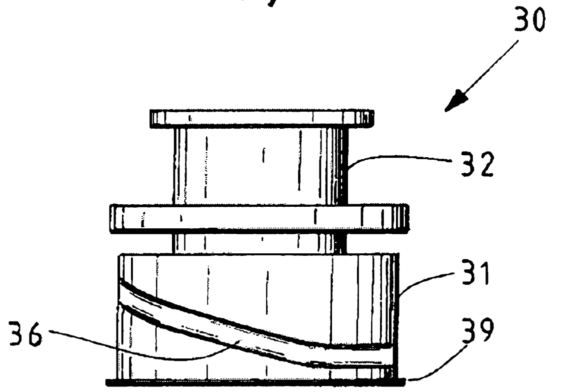
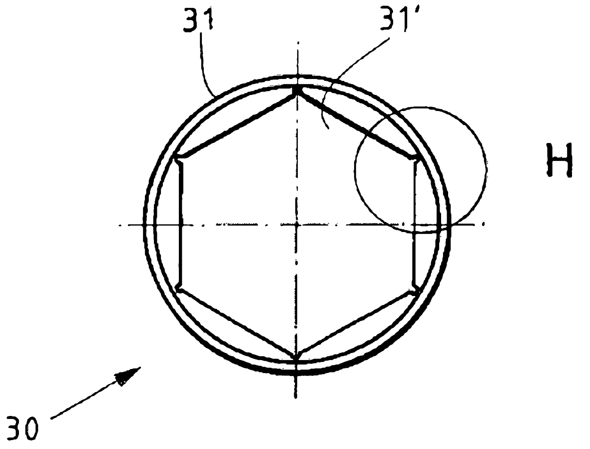


Fig. 3

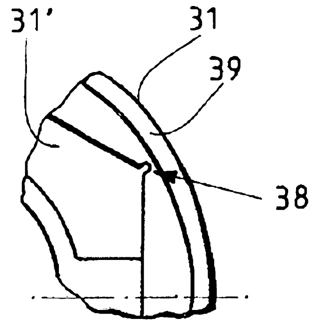
a)



b)



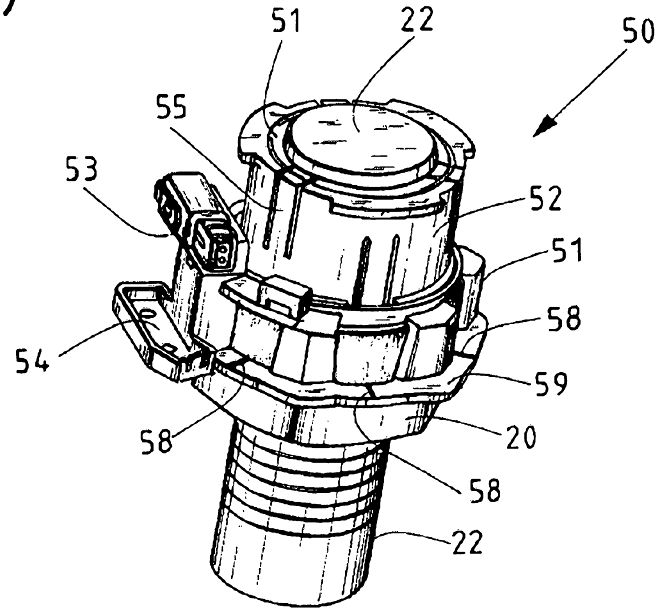
c)



H

Fig. 4

a)


51
22
50
55
53
52
51
58
54
59
58
20
58
22

b)

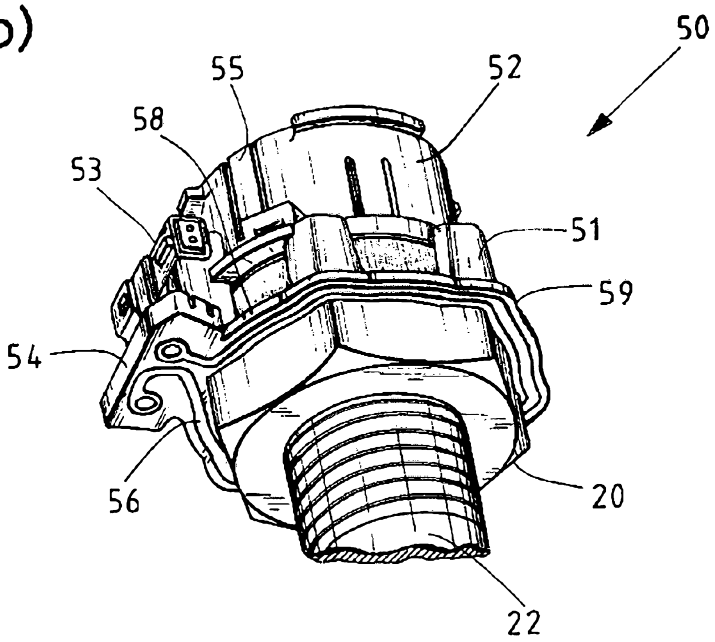
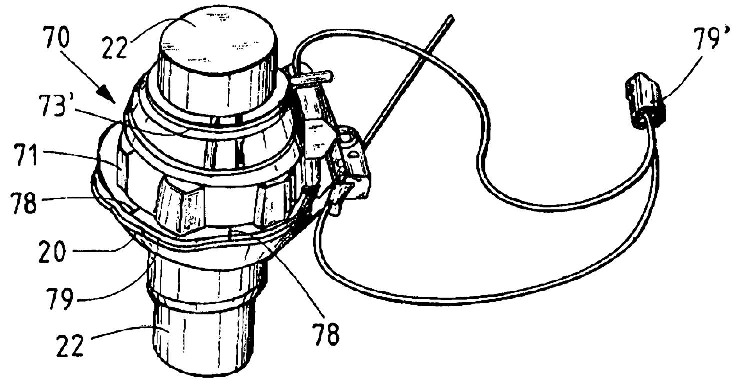
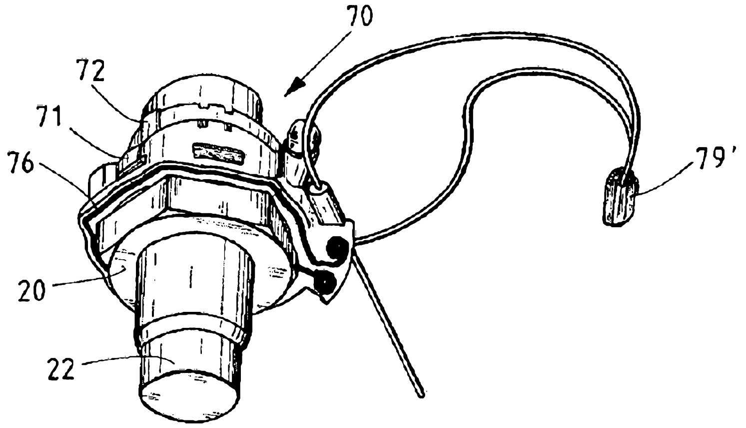

50
55
52
58
53
51
59
54
56
20
22

Fig. 5

a)



b)



c)

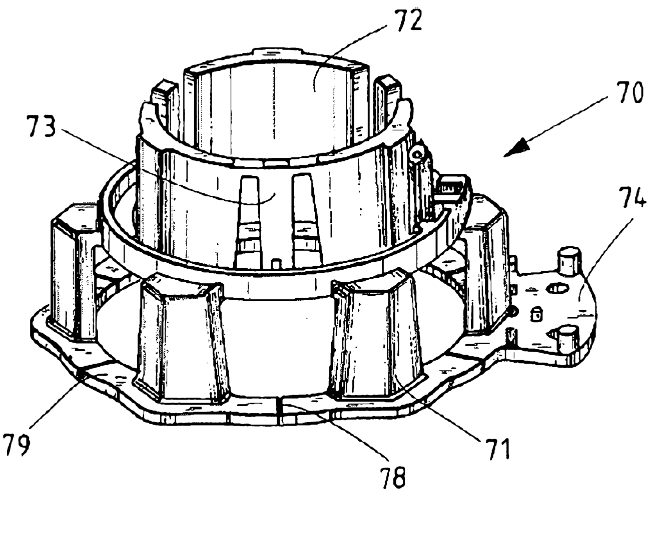


Fig. 6

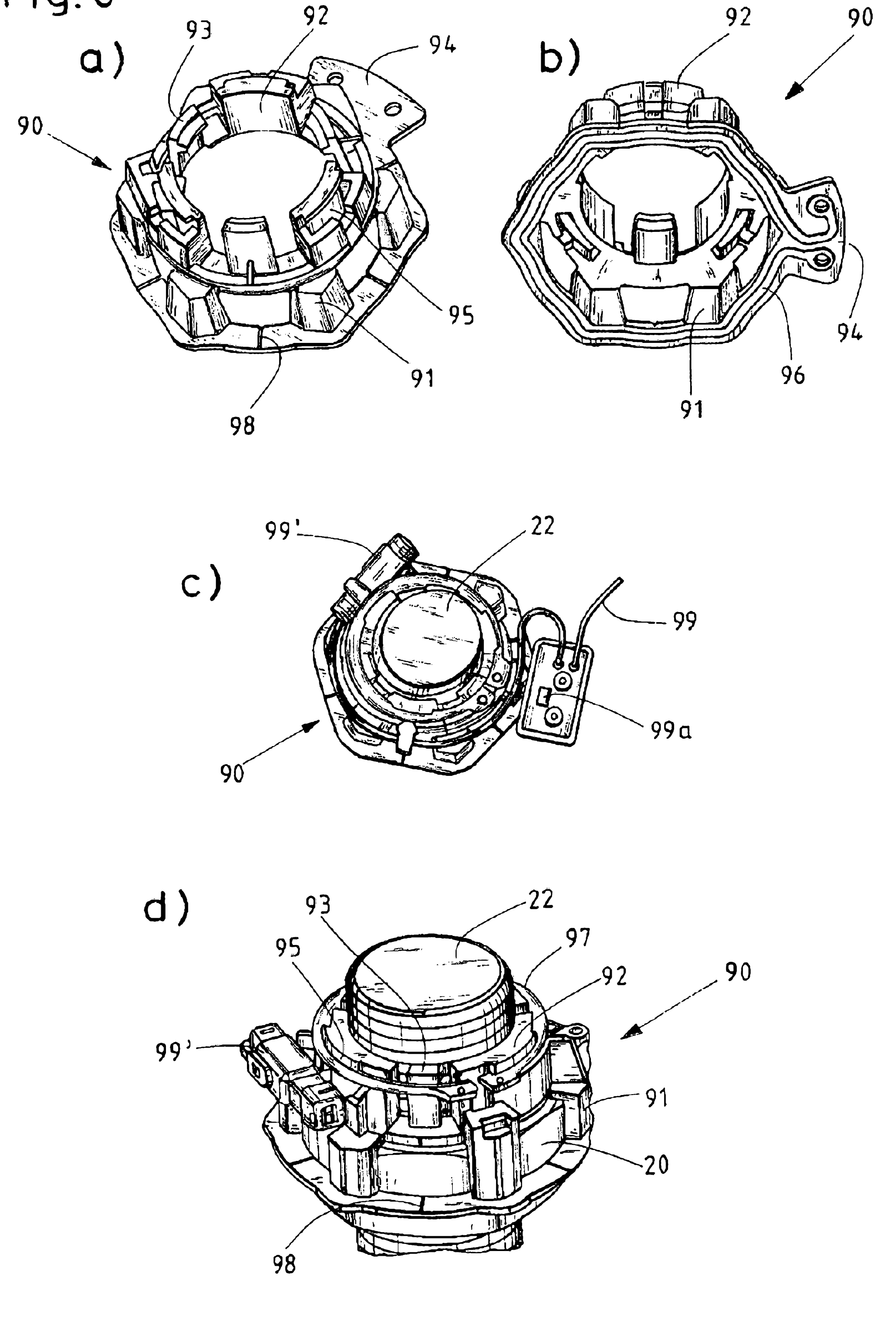
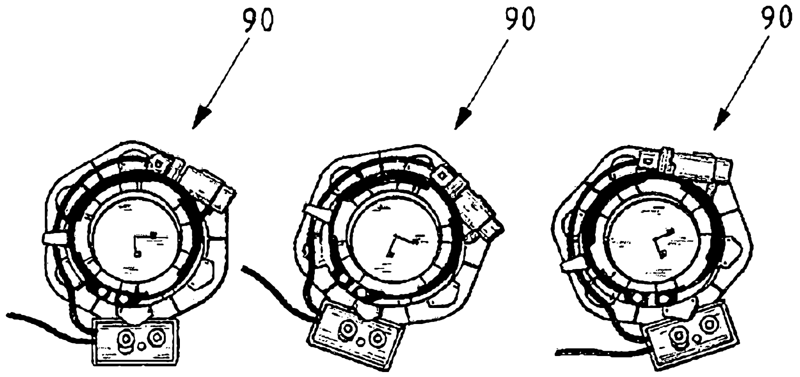

a)
93
92
94
90
95
91
98
b)
92
90
94
96
91
c)
99'
22
99
99a
90
d)
93
22
97
95
92
90
99'
91
20
98

Fig. 7

a)



b)