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Description

Prior art

5 During operation, considerable forces act on large rolling-element bearings, such as used for example in wind turbines. It is therefore desirable to be able to carry out load measurements on the rolling-element bearing.

10 For this purpose, it is known for example from EP 0 637 734 B1, by means of strain gages which are arranged in a bore hole in a rolling element, to measure the deformations of the rolling element, the forces acting on the rolling-element bearing, that is to say the loads, being able to be extrapolated from the

15 deformations of the rolling element. In order to supply energy to the strain gages and an amplifier which is connected thereto as well as a transmitter, a first coil is further arranged in the rolling element, which coil is supplied with energy inductively by a second coil which is arranged on a non-rotatable

20 bearing ring of the rolling-element bearing.

To supply energy to the second coil, complex wiring which disrupts operation is required. Furthermore, the strain gages and the respective attachments thereof, generally bondings, are susceptible to wear, in particular since said gages generally come

25 into contact with grease and/or other lubricants in the rolling-element bearings and must therefore be replaced regularly. Therefore, such a load measurement is possible only under laboratory conditions.

30

Furthermore, it is known from EP 1 849 013 B1 to arrange sensors on a cage which fixes the rolling elements in the positions thereof relative to one another, the sensors measuring eddy currents which are induced in the rolling elements by coils. The

35 prevailing loads can then be extrapolated from the eddy current measurements. In this case as well, energy is supplied inductively by an energy transmission coil arranged in the outer ring. This again results in the disadvantages already discussed.

DE 698 28 236 T2 discloses a rolling-element bearing having a rotary system, which rolling-element bearing comprises at least one row of rolling elements and a rolling-element cage, wherein
5 the rotary system comprises an energy-consuming member and an electrical energy supply device, which generates electrical energy from mechanical energy. The electrical energy supply device is connected to a rolling element and is coupled elastically to a member situated outside the rolling element, for example to
10 the rolling-element cage.

DE 10 2007 009 093 A1 describes a rolling element having an RFID tag and having a generator as an energy source, which generator is configured to generate electrical energy from changes in the
15 movement state of the rolling element relative to the running surfaces, i.e. from acceleration processes.

DE 11 2013 007 416 T5 discloses a rolling element having a generator which has a generator shaft. At the shaft end of the
20 generator shaft, there is provided a permanent magnet which interacts with a magnet provided on the cage. The forms of magnetization of the two magnets are identical, wherein a relative rotation is possible if a magnetic force generating an angular momentum is overcome. The angular momentum restores the
25 relative orientation of the magnets with respect to the rest of the configuration with minimum magnetic field energy, in which the directions of magnetization of the two magnets are opposite one another.

30 DE 11 2013 007 412 T5 describes a sensor roller having the features according to the preamble of Claim 1. The sensor roller is arranged in a cage between an inner ring and an outer ring and is provided with a bore hole, which bore hole accommodates a sensor unit and a first section of a generator assembly. A
35 second section of the generator assembly is provided by the cage, wherein at least one magnetic circuit of the generator assembly is opened and closed by the second section as a function of a relative rotation between cage and sensor roller. There are

limitations due to the maximum degree of miniaturization for the generator assembly to be accommodated in the bore hole of the roller, and also to the amount of power that is to be generated at a certain rotational speed.

5

A further device for load measurement in a rolling-element bearing is known from US 4 174 430 A.

Alternatively, EP 1 795 869 A1 discloses a rolling element,
10 comprising a bore hole in which two boards are arranged parallel to and at a distance from one another, an electrode being attached to the boards opposite in each case, which electrodes capacitively measure the distance of the boards from one another. This distance is variable, since the boards bend as a
15 result of the load-induced deformation of the rolling element. This measurement is restricted to a region of the rolling element and is likewise susceptible to wear as a result of the bending of the circuit boards. An external energy supply is also disclosed again, which is disadvantageous, since it necessitates
20 wiring of the rolling-element bearing. In addition, the boards can shift relative to one another, which leads to measurement inaccuracies.

Disclosure of the invention

25

The problem addressed by the present invention is thus that of providing a rolling-element bearing, by means of which reliable and continuous load measurement is possible even during ongoing operation, in particular without wiring of the rolling-element
30 bearing being necessary.

This problem is solved by a rolling element for use in a rolling-element bearing, comprising an outer casing and a bore hole, the bore hole being provided along a centerline of the rolling element,
35 the rolling element having at least one sensor arranged in the bore hole for load measurement and a radio module for transmitting the data measured by the sensor, wherein the rolling element has a micro-generator, the micro-generator being

provided to provide the energy required for operation of the sensor and/or of the radio module. Preferably, the outer casing is provided at least in part as a running surface on which bearing rings, in particular an outer ring and an inner ring, of the rolling-element bearing roll. In this case, one of the bearing rings, in particular the outer ring, is preferably provided in a rotationally fixed manner, whereas the other bearing ring is provided concentrically therewith and so as to be rotatable. Preferably, the rolling element is cylindrical, barrel-shaped, toroidal and/or conical. In this case, the rolling element has a main extension direction, the centerline being arranged parallel to the main extension direction. Particularly preferably, the rolling element is provided substantially rotationally symmetrically around the centerline, in particular in the region between the bore wall and the outer casing. The outer casing corresponds in particular to an outer lateral surface of the rolling element. For example, the rolling element is in the form of a cylinder having a length of 104 mm and a diameter of 65 mm. In this case, the bore hole preferably has a diameter of 20 mm. Preferably, the radio module and/or the micro-generator are also arranged at least in part in the bore hole. In the context of this application, a micro-generator is in particular a device having small dimensions which obtains energy from the environment and thus represents an autonomous energy source. Particularly preferably, the micro-generator is used at least for a process of what is known as energy harvesting. The micro-generator is provided to obtain energy from the rolling or rotational movement of the rolling element, which energy said micro-generator then provides for the operation of the sensor and/or of the radio module.

The rolling element according to the invention has the advantage over the prior art that the rolling element has an integrated and autonomous energy supply and transmits the data wirelessly by means of the radio module so that no wiring of the rolling element or of one of the bearing rings and thus of the rolling-element bearing is necessary. Furthermore, the rolling element according to the invention provides precise load measurements

and allows this in particular even during the ongoing operation of a rolling-element bearing equipped with the rolling element according to the invention.

- 5 Advantageous configurations and developments of the invention can be found in the dependent claims and the description with reference to the drawings.

According to one preferred embodiment of the present invention,
10 it is provided that the sensor is a capacitive sensor, the sensor being provided to measure a distance between the sensor and the bore wall. The rolling element is deformed according to the forces acting on the rolling-element bearing and thus on the rolling element, and this can be measured on the basis of a
15 change in the cross section of the bore hole. Particularly preferably, the sensor is configured to transmit the measured data to the radio module, the radio module being configured to transmit the measured data, for example to a suitable receiver terminal. Very particularly preferably, the capacitive sensor has
20 a dielectric medium. Even more preferably, the bore wall has an at least partially electrically conductive material at least in part. For example, the rolling element is produced from an electrically conductive material and/or has an electrically conductive coating on the bore wall. As an electrically conductive
25 material, in particular a metal material is considered. As a result, in an advantageous manner, a precise and simple load measurement is made possible.

According to another preferred embodiment, it is provided that,
30 in the bore hole, at least two sensors which are at a distance from one another along the centerline are arranged. As a result, in an advantageous manner, it is made possible to also measure a tipping of the rolling element in addition to the forces by evaluating, in particular comparing, the measured data of the
35 sensors.

According to another preferred embodiment, it is provided that, in the axial direction, at the level of the sensor, particularly

preferably opposite said sensor with respect to the centerline, a means for producing a defined distance from the bore wall is provided, the means having in particular a magnet and/or a spring means. Very particularly preferably, the means is a rolling
5 contact block, the rolling contact block comprising a magnet, by which said block is pulled onto the bore wall, in particular in such a way that the rolling contact block lies against the bore wall at least in part. As a result, in an advantageous manner, the precision of the load measurement is further in-
10 creased, since it is ensured that the sensor can measure the entire deformation of the rolling element as a distance. Preferably, the distance between the sensor and the bore wall is at least 50 μm and at most 150 μm . Particularly preferably, the distance between the sensor and the bore wall in a load-free
15 state is 100 μm when the means lies against the bore wall. Preferably, the capacitive sensor is electrically coupled to the means by a resonant circuit. The resonant circuit is produced by coils arranged on a circular path between the bore hole and the outer casing. The coils can in this case be at a uniform
20 distance. As a result, it is advantageously made possible for a frequency at which the system oscillates to be measured, which frequency in turn is related to the amount of the deformation and thus the load. A resonant circuit system of this type is advantageously insensitive to disruptions.

25 According to another preferred embodiment, it is provided that, in the bore hole, a circuit board is arranged, the radio module, the micro-generator, the capacitive sensor and/or the means being attached to the circuit board. Particularly preferably, the
30 circuit board has a thickness of from 1 mm to 2 mm, in particular 1.6 mm. As a result, in an advantageous manner, a simple installation of the individual components in the rolling element is made possible.

35 According to another preferred embodiment, it is provided that the rolling element further has an energy accumulator, the energy accumulator being provided to store the energy generated

by the micro-generator. Particularly preferably, the energy accumulator is provided on the circuit board. Very particularly preferably, the energy accumulator is a storage battery and/or a capacitor, in particular a high-capacitance capacitor, e.g. what is known as a green-cap capacitor.

According to another preferred embodiment, it is provided that the radio module is provided to transmit the measured data in a frequency range of from 100 MHz to 6 GHz, preferably from 300 MHz to 2 GHz, particularly preferably from 700 MHz to 1 GHz, in particular at a frequency of 833 MHz. As a result, in an advantageous manner, a wireless data transmission is made possible, which is also not disrupted by optionally metal components of the rolling element or of the rolling-element bearing and comprises a sufficiently large transmission range.

According to another preferred embodiment, it is provided that the bore hole comprises a diameter of from 5 mm to 50 mm, preferably from 10 mm to 30 mm, in particular a diameter of 20 mm, and/or that the rolling element is preferably cylindrical and particularly preferably comprises a length of from 90 mm to 110 mm, in particular 104 mm, and very particularly preferably a diameter of from 60 mm to 70 mm, in particular 65 mm. As a result, firstly, a sufficiently large bore hole for accommodating all the components is provided, secondly, in the case of a bore hole having the above-mentioned dimensions, the deformation clearance which is available is large enough for a precise measurement, in particular without impairing the structural stability of the rolling element.

According to another preferred embodiment, it is provided that, on the bore wall, in particular in the radial direction, a strain gage is arranged in an at least partially circumferential manner. As a result, it is advantageously possible, in addition to the precise capacitive measurement, to implement a redundant and proven measuring method with little complexity.

It is provided that the micro-generator is an inductive generator. The inductive generator cooperates with magnets which are arranged on a cage of a rolling-element bearing. As a result, in a particularly advantageous manner, it is possible to provide an autonomous energy supply, which in particular also provides energy only when it is required, namely during a rotation of the rolling element. In combination with magnets, in this case, advantageously no wiring of the rolling-element bearing is necessary.

According to another preferred embodiment, it is provided that the rolling element has a means for determining position. Particularly preferably, the means is at least one magnet, in particular a diametral magnet. Said magnet very particularly preferably cooperates with a detection means for determining the position of the rolling element, the rolling element having the detection means, in particular the inner ring, the outer ring and/or the cage. As a result, in a particularly advantageous manner, it is possible to determine the absolute and/or relative position of the rolling element in the rolling-element bearing.

The present invention further relates to a rolling-element bearing, in particular a large rolling-element bearing, comprising a first bearing ring and a second bearing ring which is rotatable about an axis of rotation and in particular is arranged concentrically with the first bearing ring, and a plurality of rolling elements arranged between the first bearing ring and the second bearing ring, wherein at least one rolling element is a rolling element according to the invention. Preferably, the first bearing ring is an outer ring, and/or the second bearing ring is an inner ring. As a result, it is advantageously possible to provide a rolling-element bearing which, without additional installation complexity, allows an, in particular continuous, wireless load measurement.

According to a preferred embodiment, it is provided that the rolling-element bearing has a detection means for determining the position of the rolling element. Particularly preferably,

the detection means cooperates with a means for determining the position of the rolling element, the rolling element having the means for determining position. Very particularly preferably, it is provided that the inner ring, the outer ring and/or the cage comprise the detection means. As a result, in a particularly advantageous manner, it is possible to determine the absolute and/or relative position of the rolling element in the rolling-element bearing.

Further details, features and advantages of the invention can be found in the drawings and in the following description of preferred embodiments with reference to the drawings. In this case, the drawings illustrate merely exemplary embodiments of the invention which do not limit the essential inventive concepts.

Brief description of the drawings

Fig. 1 is a schematic perspective view of a rolling element according to an exemplary embodiment of the present invention.

Fig. 2 is another schematic perspective view of a rolling element according to an exemplary embodiment of the present invention.

Fig. 3 is a schematic sectional view perpendicular to the centerline of a rolling element according to an exemplary embodiment of the present invention comprising a cage of a rolling-element bearing.

Fig. 4 is a schematic sectional view parallel to the centerline of a rolling element according to an exemplary embodiment of the present invention.

Fig. 5 is a schematic equivalent circuit diagram of the coils from Fig. 3 and 4 according to an exemplary embodiment of the present invention.

Fig. 6 is a schematic cross section of a bore hole of a rolling element according to an exemplary embodiment of the present invention.

Fig. 7 shows a circuit board of a rolling element according to an exemplary embodiment of the present invention.

Fig. 8 is a schematic perspective view of a rolling element according to an exemplary embodiment of the present invention.

Fig. 9 is a schematic perspective view of a circuit board of a rolling element according to an exemplary embodiment of the present invention.

Fig. 10 is a perspective view of a rolling-element bearing according to an exemplary embodiment of the present invention.

Fig. 11 is a perspective detailed view of a rolling-element bearing according to an exemplary embodiment of the present invention.

Embodiments of the invention

In the different drawings, like parts are always provided with the same reference signs and therefore are generally also named or mentioned only once in each case.

Fig. 1 is a schematic perspective view of a rolling element 1 according to an exemplary embodiment of the present invention. A rolling element 1 of this type is used in rolling-element bearings and is used to movably guide a first bearing ring 11 and a second bearing ring 12 relative to one another, in particular an inner ring 12 arranged in an outer ring 11 which is arranged in a rotationally fixed manner. In this case, a plurality of rolling elements are conventionally provided between

the outer ring 11 and the inner ring 12, which elements roll on running surfaces of the outer ring 11 and the inner ring 12. The present case relates to what is known as a measuring roller, that is to say a rolling element 1, which is provided and designed for measuring loads in the rolling-element bearing.

In this case, the rolling element 1 comprises a cylindrical or substantially conical body having an outer casing 2 which is used as a running surface and on which the outer ring 11 and the inner ring 12 roll. The rolling element 1 has a bore hole 3 in the center thereof which is formed concentrically around the centerline of the rolling element 1. A plurality of coils 10, which in this case are arranged on a circular path between the bore hole 3 and the outer casing 2, can additionally be seen.

In this case, there are fourteen coils 10, which are each arranged so as to be offset by approx. 25° , a magnetic field which is directed in the opposite direction in each case being generated by applying a current or a voltage. A resonant circuit is produced by applying an alternating voltage. Said circuit will be described in greater detail in connection with the following drawings.

Furthermore, the rolling element 1 comprises a means for determining position 16, in this case a diametral magnet, which cooperates with a detection means to determine the absolute and/or relative position of the rolling element 1 in the rolling-element bearing. In this case, for example, the cage 13 comprises the detection means. In this case, the relative position is the position of the rolling element 1 relative to the cage 13, in particular relative to a reference point.

Fig. 2 is another schematic perspective view of a rolling element 1 according to an exemplary embodiment of the present invention. In this case, the embodiment shown substantially corresponds to the embodiment shown in Fig. 1, and therefore reference is made generally to the comments in this regard. It can clearly be seen here that the rolling element 1 is substantially cylindrical.

In the bore hole 3, a measuring arrangement which is to be explained in greater detail in the following is provided.

Fig. 3 is a schematic sectional view perpendicular to the centerline of a rolling element 1 according to an exemplary embodiment of the present invention comprising a cage 13 of a rolling-element bearing. In this case, the embodiment shown substantially corresponds to the embodiments shown in the previous drawings, and therefore reference is made generally to the comments in this regard. In the bore hole, a sensor 5, in this case a capacitive sensor 5, a radio module 6 and a micro-generator 4 are provided. In this case, the micro-generator is an inductive micro-generator. So that the rolling elements of a rolling-element bearing remain at a regular distance for a uniform load distribution, a cage 13 is arranged between the outer ring 11 and the inner ring 12, which cage comprises the rolling elements. This means that the rolling elements are rotatable but are mounted in fixed positions with respect to the cage 13. At the point of the rolling element 1, the cage 13 has magnets 15, in this case four magnets 15. Said magnets 15 make it possible to induce a current in the micro-generator 4 and thus provide an energy supply for the sensor 5 and the radio module 6 as well as the coils 10. Alternatively or additionally, and in the context of the present invention preferably, the micro-generator is provided in such a way that said micro-generator generates energy solely from the movement, i.e. the rolling, of the rolling element.

The sensor 5 is arranged on a circuit board 8 (not shown here). On the other side of the circuit board 8, i.e. opposite the sensor 5 with respect to the centerline, a means 7 is arranged for producing a defined distance from the bore wall. In this case, said means 7 is a rolling contact block having a magnet 14 arranged therein. The magnet ensures that the rolling contact block comes into contact with the bore wall, since it is attracted alternately by the magnetic fields of the coils 10. As a result, the means 7 comprising the circuit board 8 and thus also the sensor 5 performs an oscillation, the frequency of

which depends firstly on the coils 10 and secondly on the distance between the means 7 and the bore wall or the distance between the sensor 5 and the bore wall, and of course on the properties of the rolling contact block, e.g. the mass thereof and the strength of the magnet 14. The capacitive sensor 5 thus measures a frequency that corresponds to a distance from the bore wall. If the rolling element 1 is then deformed by forces, i.e. loads, acting on the rolling element 1, then the bore hole 3 deforms as well. The distance between the capacitive sensor 5 and the bore wall thus changes, and the measured frequency also changes together therewith. The measured frequency is transmitted to the radio module 6, which transmits said frequency wirelessly from the rolling element. It is also conceivable for a deformation or load to be determined from the measured data beforehand, which deformation or load is then transmitted.

Fig. 4 is a schematic sectional view parallel to the centerline of a rolling element 1 according to an exemplary embodiment of the present invention. In this case, the embodiment shown substantially corresponds to the embodiment shown in Fig. 3, and therefore reference is made generally to the comments in this regard. In particular the bore hole 3 can be seen here, and the micro-generator 4 and the radio module 6 are shown schematically.

Fig. 5 is a schematic equivalent circuit diagram of the coils 10 from Fig. 3 and 4 according to an exemplary embodiment of the present invention. In this case, the coils 10 represent resistors which are connected in series. According to the drawings described previously, fourteen coils 10, accordingly fourteen resistors, are provided in this case.

Fig. 6 is a schematic cross section of a bore hole 3 of a rolling element 1 according to an exemplary embodiment of the present invention. The circuit board 8 can be seen clearly here, the capacitive sensor 5 being arranged on one side of the circuit board 8, and the means 7 comprising the magnet 14 being arranged

on the other side. In addition, various deformations or distances d are drawn in. In the embodiment shown, the distance d_0 between the capacitive sensor 5 and the bore wall in a load-free state is approx. 100 μm , the magnet 14 of the means 7 having brought the rolling contact block into contact with the bore wall. Depending on whether the bore hole is distorted or compressed, the distance, that is to say the deformation, changes between a minimum value $d_{\min}$ of 50 μm and a maximum value $d_{\max}$ of 150 μm . On the left-hand side of the drawing, a resonant circuit is shown schematically. In this regard, reference is made to the comments regarding Fig. 4. In this case, the capacitive sensor 5 and the rolling contact block have, at least in part, an outer contour which follows the contour of the bore wall in a load-free state, that is to say which is concentric with the bore wall.

Fig. 7 shows a circuit board 8 of a rolling element 1 according to an exemplary embodiment of the present invention. For reasons of clarity, not all the elements are shown in this case. In the center, the point which is provided for attaching the micro-generator 4 is visible. On both sides of said point and on both edges of the circuit board 8, attachment points can be seen, which are used to attach two capacitive sensors 5, 5'. These two sensors 5, 5' which are at a distance from one another along the centerline allow a measurement relative to one another and thus, in addition to a pure force measurement along three axes, also allow the measurement of a tipping of the rolling element 1, that is to say a deformation of the rolling element 1 which has different strengths along the centerline. Furthermore, a radio module 6 is shown merely by way of example. The circuit board 8 is dimensioned in such a way that it fits into the bore hole 3 and preferably comprises a small lateral tolerance.

Fig. 8 is a schematic perspective view of a rolling element 1 according to an exemplary embodiment of the present invention. In this case, the embodiment shown substantially corresponds to the embodiments shown in the previous drawings, and therefore reference is made generally to the comments in this regard. In

particular, the circuit board 8 inserted in the bore hole 3 comprising the sensor 5 and the means 7 can be seen well here.

5 **Fig. 9** is a schematic perspective view of a circuit board 8 of a rolling element 1 according to an exemplary embodiment of the present invention. In this case, the embodiment shown substantially corresponds to the embodiment shown in Fig. 7, and therefore reference is made generally to the comments in this regard. Two capacitive sensors 5, 5' and accordingly two means 7, 7' in
10 the form of rolling contact blocks are also provided here. In addition, it can clearly be seen where the magnet 14 is inserted in the means 7, this being merely an example of an attachment option.

15 **Fig. 10** is a perspective view of a rolling-element bearing according to an exemplary embodiment of the present invention. In this case, said rolling-element bearing is a large rolling-element bearing comprising an outer ring 11, an inner ring 12 (not shown here for reasons of clarity) and a cage 13 which is
20 arranged therebetween which has a plurality of rolling elements and keeps said elements at a uniform distance from one another. At least one rolling element in this case is a rolling element 1 within the meaning of this application, that is to say a measuring roller.

25 **Fig. 11** is a perspective detailed view of a rolling-element bearing according to an exemplary embodiment of the present invention. In particular, a rolling element 1 according to the invention is shown here, in addition to two conventional rolling
30 elements. As can be seen from the drawing, the rolling element 1 has no wiring, said element functions autonomously and transmits the measured data wirelessly, and therefore the rolling-element bearing can be surrounded for example by a housing, and a load measurement is still possible. As a result, the large
35 rolling-element bearing can be installed for example in a wind turbine and transmit load measurement data to a control unit so that a need for maintenance can be detected in good time and without complex interventions in the rolling-element bearing.

List of reference numerals

	1	rolling element
	2	outer casing
5	3	bore hole
	4	micro-generator
	5, 5'	sensor
	6	radio module
	7, 7'	means for producing a defined distance from the bore
10	wall	
	8	circuit board
	9	strain gage
	10	coils
	11	outer ring
15	12	inner ring
	13	cage
	14	magnet
	15	cage magnets
	16	means for determining position
20	d	deformation

Patentkrav

1. Valselegeme (1) til anvendelse i et valseleje med en
udvendig kappe (2) og en boring (3), idet boringen (3) er til-
5 vejebragt langs med en midterakse på valselegemet (1), idet
valselegemet (1) omfatter i det mindste en i boringen (3)
placeret sensor (5) til belastningsmåling og et radiomodul (6)
til overførsel af de af sensoren (5) målte data, idet valsele-
gemet omfatter en mikrogenerator (4), der er indrettet til at
10 tilvejebringe den til drift af sensoren (5) og/eller af radio-
modulet (6) fornødne energi, idet mikrogeneratoren (4) er en
induktiv generator, som er udformet til at virke sammen med
magneter, som er placeret i et bur i et valseleje, kendetegnet
ved, at et stort antal spoler (10) er placeret i en cirkelbane
15 mellem boringen (3) og den udvendige kappe (2).

2. Valselegeme (1) ifølge krav 1, kendetegnet ved, at sensoren
(5) er en kapacitiv sensor, idet sensoren (5) er indrettet til
at måle en afstand mellem sensoren og boringsvæggen.

20

3. Valselegeme (1) ifølge et af de foregående krav, kendeteg-
net ved, at der i boringen (3) er placeret i det mindste to
sensorer (5, 5'), som er placeret med indbyrdes afstand langs
med midteraksen.

25

4. Valselegeme (1) ifølge et af de foregående krav, kendeteg-
net ved, at der i aksial retning på højde med sensoren (5),
fortrinsvis liggende over for denne i forhold til midteraksen,
er tilvejebragt et middel (7) til at skabe en defineret afstand
30 til boringsvæggen, idet midlet (7) navnlig omfatter en magnet
(14).

5. Valselegeme (1) ifølge et af de foregående krav, kendeteg-
net ved, at der i boringen (3) er placeret en platine (8), idet
35 radiomodulet (6), mikrogeneratoren (4), den kapacitive sensor
(5) og/eller midlet (7) er fastgjort på platinen (8).

6. Valselegeme (1) ifølge et af de foregående krav, kendetegnet ved, at radiomodulet (6) er indrettet til at overføre de målte data i et frekvensområde fra 100 MHz til 6 GHz, fortrinsvis fra 300 MHz til 2 GHz, særligt foretrukket fra 700 MHz til 1 GHz, navnlig med en frekvens på 833 MHz.

7. Valselegeme (1) ifølge et af de foregående krav, kendetegnet ved, at boringen (3) har en diameter på 5 mm til 50 mm, fortrinsvis på 10 mm til 30 mm, navnlig en diameter på 20 mm, og/eller idet valselegemet fortrinsvis er udformet cylinderformet og særligt foretrukket har en længde på 90 mm til 110 mm, navnlig 104 mm, samt ganske særligt foretrukket har en diameter på 60 mm til 70 mm, navnlig 65 mm.

8. Valselegeme (1) ifølge et af de foregående krav, kendetegnet ved, at der på boringsvæggen, navnlig i radial retning i det mindste delvist omløbende, er placeret en udvidelsesmålestrimmel (9).

9. Valselegeme (1) ifølge et af de foregående krav, kendetegnet ved, at valselegemet (1) omfatter et middel til positionsbestemmelse.

10. Valseleje, navnlig stort valseleje, med en første lejering og en omkring en drejeaksel drejelig og navnlig koncentrisk i forhold til den første lejering (11) placeret anden lejering (12) samt et stort antal mellem den første lejering (11) og den anden lejering (12) placerede valselegemer, kendetegnet ved, at i det mindste et valselegeme er et valselegeme (1) ifølge et af de foregående krav.

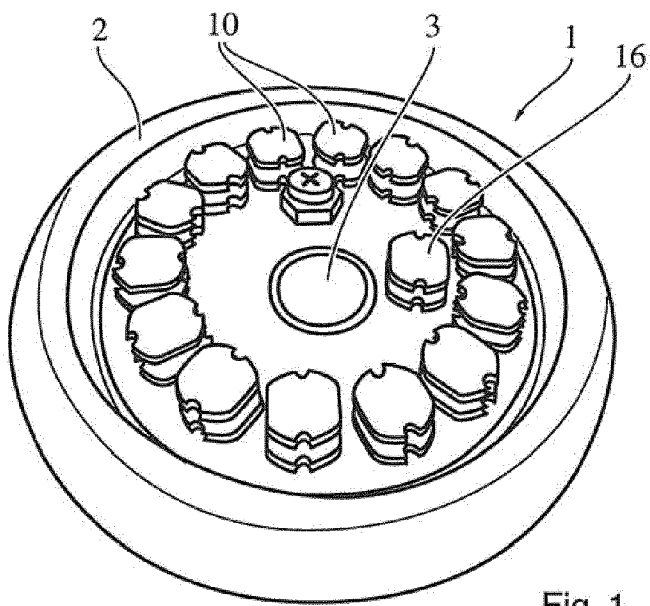
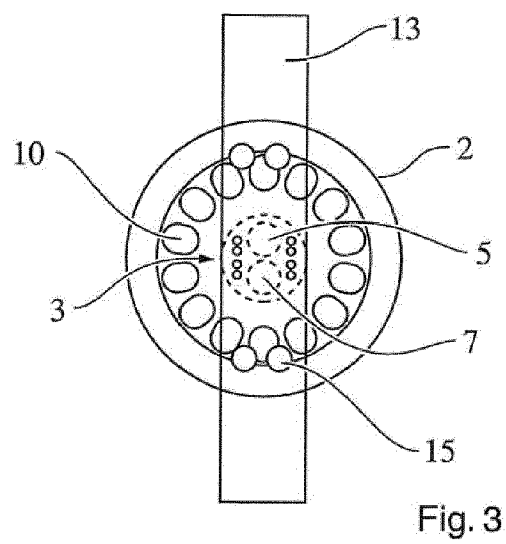
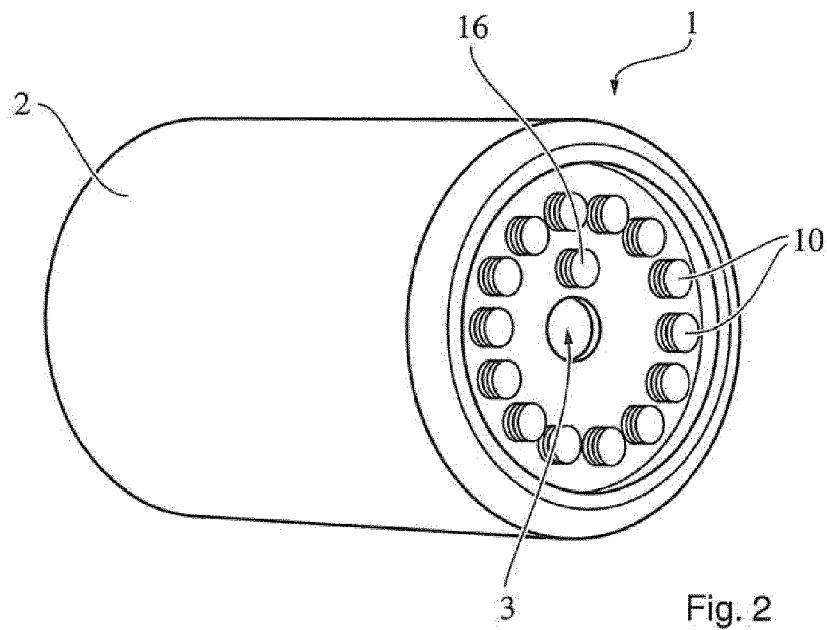
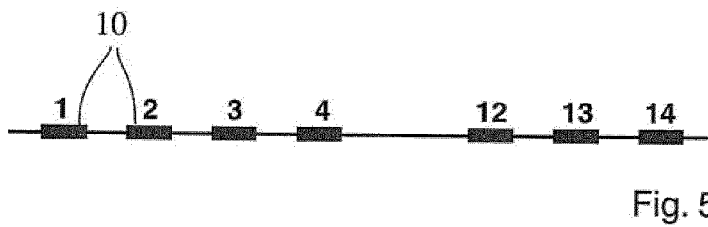
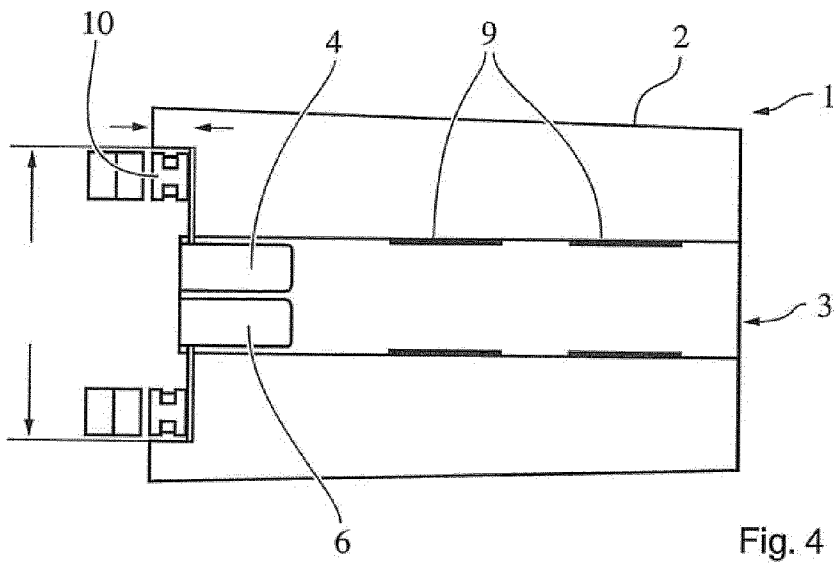


Fig. 1





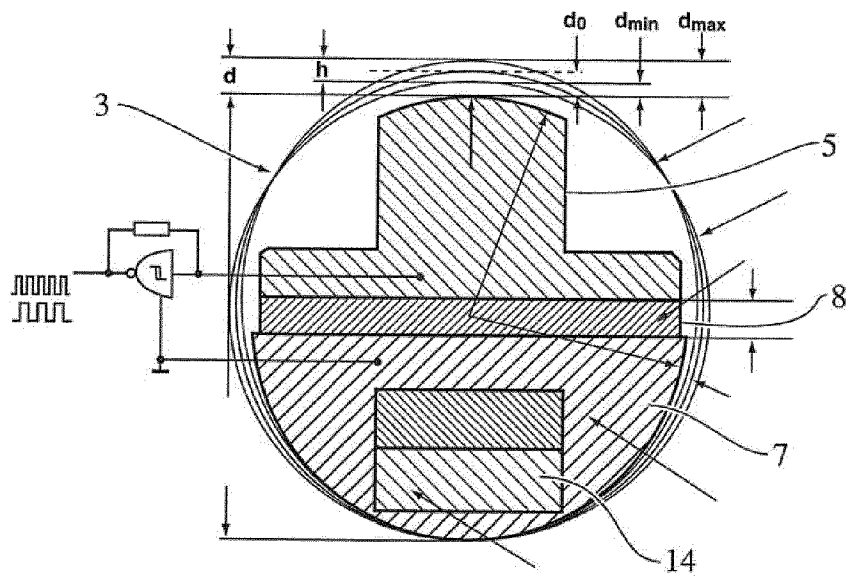


Fig. 6

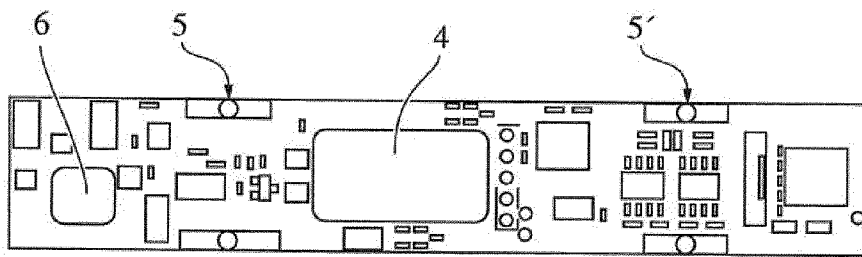


Fig. 7

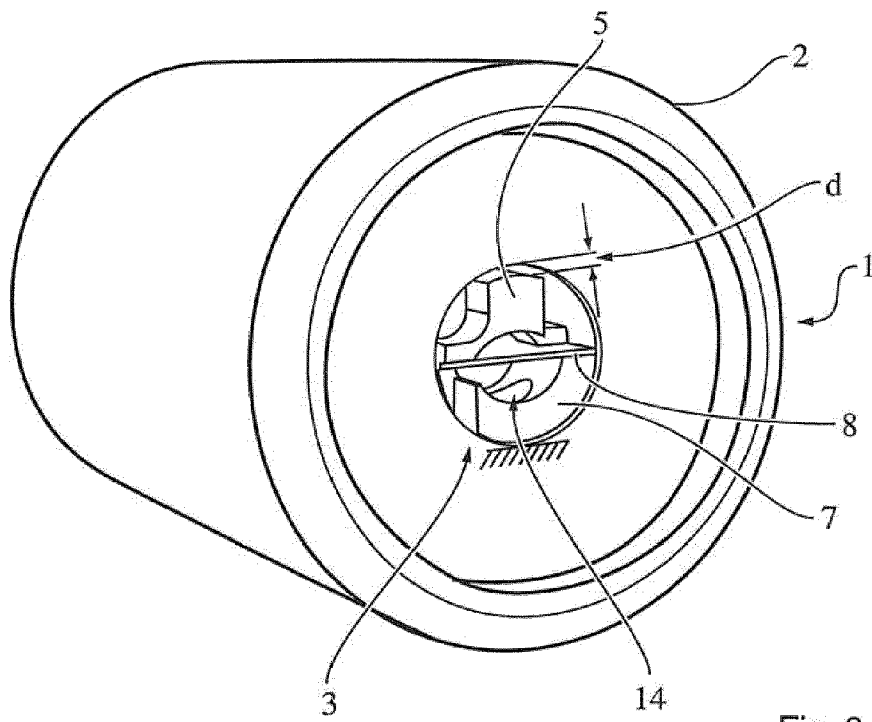


Fig. 8

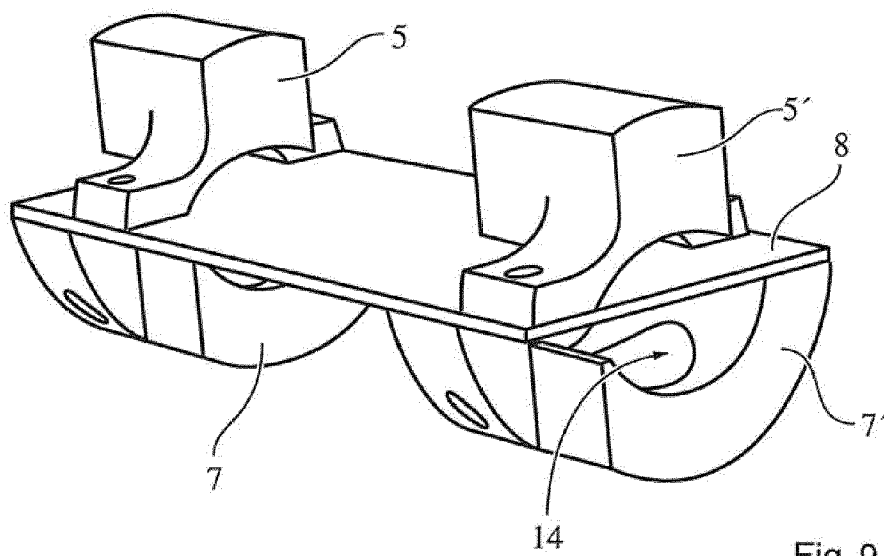


Fig. 9

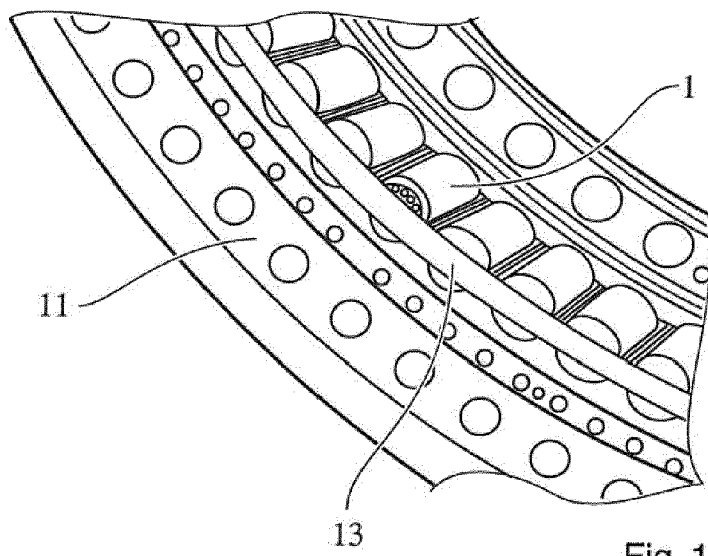


Fig. 10

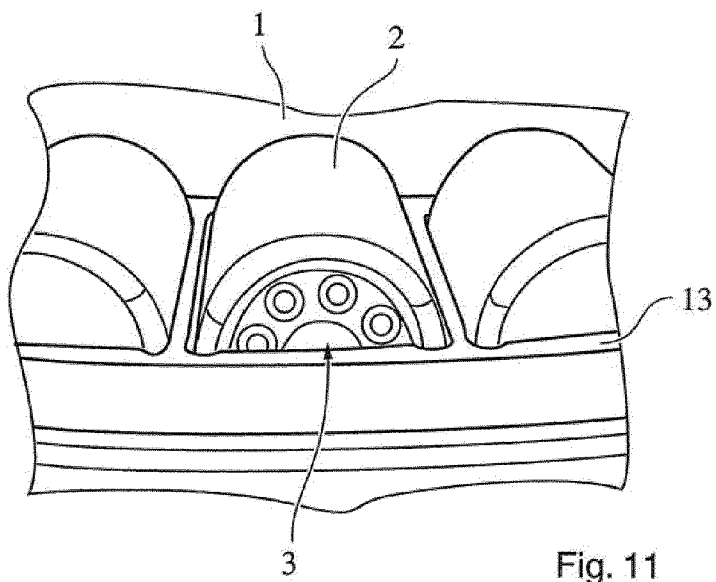


Fig. 11