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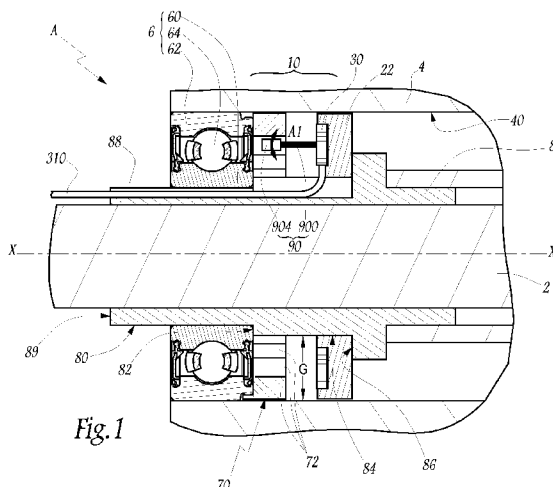
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(54) Title: SENSOR UNIT FOR SENSING THE ROTATION SPEED OF A ROTATABLE ELEMENT WITH RESPECT TO A FIXED ELEMENT AND BEARING ASSEMBLY COMPRISING SUCH A SENSOR UNIT



(57) Abstract: This sensor device (10) for sensing the rotation speed of a rotatable element (4) with respect to a fixed element (2) comprises a coder element (70), fast in rotation with the rotatable element (4), formed by a magnetized multipole ring (70) for producing an alternating magnetic field while rotating, and a sensing element (90) adapted to detect the magnetic field variations. The sensing element (90) includes a piezoelectric sensor (900) having one end fast with the fixed element (2) and having, on its other end, a magnet (904) radially facing the magnetized ring (70).

**SENSOR UNIT FOR SENSING THE ROTATION SPEED OF A ROTATABLE ELEMENT
WITH RESPECT TO A FIXED ELEMENT AND BEARING ASSEMBLY COMPRISING
SUCH A SENSOR UNIT**

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a sensor unit for sensing the rotation speed of a rotatable element with respect to a fixed element. The invention also relates to a bearing, in particular of the rolling type, comprising such a sensor unit.

BACKGROUND OF THE INVENTION

Automotive vehicles are generally equipped with rotation speed sensors in order to determine their moving speed. Such sensors are mounted in the wheel assemblies so as to sense the rotation speed of the wheels.

Sensor devices for sensing the angular position of a rotating element often use, as known from US-5 309 094, induction sensors involving a coder element, adapted to create magnetic field variations, and a sensing element adapted to determine, on the basis of the magnetic field variations, the angular position of the rotating element.

In general, the coder element is a magnetic ring formed by several magnets having alternated polarities along the circumference of the ring. The sensing element is generally an annular coil in which a magnetic core is mounted, and which faces the whole of the circumference of the coder element.

This type of sensors needs a relatively high mounting space which provokes issues when it must be integrated in some automotive vehicles, such as motorcycles, where the mounting space available is reduced.

SUMMARY OF THE INVENTION

The aim of the invention is to provide a new sensor unit for sensing the rotation speed of a rotatable element with respect to a fixed element, which is more compact than the sensor devices of the prior art.

To this end, the invention concerns a sensor unit for sensing the rotation speed of a rotatable element with respect to a fixed element, comprising a coder element, which is fast in rotation with the rotatable element, formed by a magnetized multipole ring for producing an alternating magnetic field when rotating and a sensing element adapted to detect the magnetic field variations. This sensor unit is characterized in that the sensing element includes a piezoelectric sensor having one end fast with the fixed element and having, on its other end, a magnet radially facing the magnetized ring.

Thanks to the invention, the rotation of the coder element generates magnetic field variations which provoke displacements of the magnet fixed to the piezoelectric sensor. The displacement of the magnet provokes deformations of the piezoelectric sensor and therefore induces the generation, by the piezoelectric sensor, of an electrical current whose electrical characteristics are parameters representing the rotation speed of the rotating element. The piezoelectric sensor is a relatively small component, which can be mounted in a reduced space, allowing to save space to implement other functions, such as sensing data processing components. In addition, the electrical current produced by the piezoelectric sensor can be used to run electronic signal processing functions.

According to further aspects of the invention, which are advantageous but not compulsory, such a sensor unit may incorporate one or several of the following features:

- The sensing element extends in a limited angular sector of an annular gap defined between the rotating element and the fixed element.
- The piezoelectric sensor is connected to an annular printed circuit board fast with the fixed element and centered around the rotation axis of the rotating element.
- The printed circuit board comprises means for processing and transmitting data delivered by the sensing element.
- The printed circuit board includes means to electrically feed the means for processing and transmitting data with an electrical current delivered by the piezoelectric sensor.
- The printed circuit board comprises means to determine, on the basis of an electrical current delivered by the piezoelectric sensor, the rotation speed of the rotating element with respect to the fixed element.
- The magnetized ring is adapted to be mounted on the rotatable ring of a bearing allowing the rotation of the rotatable element with respect to the fixed element.
- The magnet faces the magnetized ring along an axis perpendicular to the rotation axis of the rotatable element.

The invention also concerns a bearing assembly comprising a bearing, in particular a rolling bearing including a fixed ring fast with a fixed element, a rotatable ring fast with a rotatable element, and rolling elements. This bearing assembly is characterized in that it comprises a sensor unit as mentioned above. According to a further optional aspect, the coder element is fixed to the rotatable ring.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be explained in correspondence with annexed figures, as an illustrative example. In the annexed figures:

- Figure 1 is a sectional view, along a longitudinal axis, of a portion of a rolling bearing assembly including a sensor unit according to the invention;
- Figure 2 is a perspective view of a coder element of the sensor unit according to the invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

The rolling bearing assembly A represented on figure 1 is adapted to be mounted on an automotive vehicle, such as a motorcycle.

Assembly A comprises a shaft 2, adapted to be fixed to a non-shown fork of a motorcycle and a hub 4, adapted to be fast in rotation with a non-shown wheel of the motorcycle, so that it rotates with respect to shaft 2 along a longitudinal axis X-X' of shaft 2.

Rotation of hub 4 with respect to shaft 2 is allowed by a rolling bearing 6. Rolling bearing 6 comprises an inner ring 60, an outer ring 62 and rolling elements, such as balls 64. Inner ring 60 is fixed to a sleeve 8, which is mounted on shaft 2. Inner ring 60 is mounted on an outer peripheral surface 80 of sleeve 8 and positioned against a shoulder 82 of sleeve 8, which delimits peripheral surface 80 with respect to a peripheral surface 84, which has a greater outer diameter than peripheral surface 80.

Outer ring 62 is fast in rotation with hub 4 and mounted on an inner peripheral surface 40 of hub 4. An annular gap G extends between surfaces 40 and 84.

Rolling bearing assembly A is equipped with a sensor unit 10, adapted to detect or sense the angular position of hub 4 with respect to shaft 2 in order to determine the rotation speed of hub 4 and the speed of the motorcycle.

Assembly A comprises a coder element 70 formed by a magnetic ring made by assembling permanent magnets 72 of alternated magnetic polarities. Coder element 70 is fast in rotation with outer ring 62 thanks to non-represented fastening means.

Assembly A also comprises a piezoelectric sensing element 90, which is fast with shaft 2 and equipped with a piezoelectric sensor 900. Sensor 900 extends parallel to axis X-X' in idle configuration. Piezoelectric sensor 900 is fixed and connected to a printed circuit board (PCB) 30. PCB 30 has an annular radial shape centered around axis X-X' and extends on an area axially facing coder element 70. At its end opposed to PCB 30, piezoelectric sensor 900 is equipped with a magnet 904 adapted to face, along an axis perpendicular to an axis X-X', the alternated magnetic poles of magnets 72 of coder element 70.

When coder element 70 rotates with respect to sensing element 90, the passage of alternated poles in front of magnet 904 produces an alternating magnetic field which

induces alternative displacements of magnet 904, as shown by double arrow A1 on figure 12.

The subsequent vibrations of piezoelectric sensor 900 permit to sense the magnetic field variations and induce the generation of an electrical current whose electrical characteristics are representative of the rotation speed of coder element 70.

Printed circuit board 30 is equipped with components adapted to process data delivered by sensing element 90. The electrical current delivered by piezoelectric sensor 900 is processed so as to determine the angular position of coder 70 and the rotation speed of hub 4. For example, printed circuit board 30 can comprise microprocessors and memories. Printed circuit board 30 also comprises means to transmit, to a non-shown dashboard of the motorcycle, data delivered by sensing element 90 or calculated by the components of printed circuit board 30, generally parameters representative of the rotation speed of hub 4. To transmit such parameters, printed circuit board 30 can include a non represented radio signals emitter, and an antenna 310 connected to printed circuit board 30. Antenna 310 is housed in a groove 88 realized on surfaces 80 and 84 between stop 86 and an axial end 89 of sleeve 8 close to bearing 6. Antenna 310 extends partially outside a volume delimited by hub 4. This structure avoids blocking of radio signals by hub 4, which is generally metallic and may act as a faraday cage.

The electrical output current of piezoelectric sensor 900 directly or indirectly provides electric energy for operating the processing and transmitting means implemented on printed circuit board 30. Transducers can be used to obtain, from the output current of sensor 900, a direct current to be delivered to the electronic components of printed circuit board 30. Given that the electrical power needs of the electronic components of printed circuit board 30 are relatively low, for example below 10^{-4} W, there is no need for high electrical current generation. The electrical current generated by piezoelectric sensor 900 is therefore sufficient to operate the processing and transmitting means. In other words, the tachymeter bearing formed by rolling bearing 6 and sensor unit 10 is autonomous, as it generates itself the electrical energy needed to process and transmit the data delivered by sensor unit 10.

Besides, the relatively small space occupied by piezoelectric sensing element 90 allows mounting it in a limited angular sector of annular gap G and to improve the compactness of 10 and rolling bearing assembly A, by mounting sensing element 90 on PCB 30.

According to a non-shown alternate embodiment of the invention, inner ring 60 of rolling bearing 6 may be the rotatable ring, while outer ring 62 may be the fixed ring.

The invention can be implemented in any kind of bearing, for instance a rolling bearing, such as a ball bearing, or a plain bearing.

CLAIMS

1. A sensor unit (10) for sensing the rotation speed of a rotatable element (4) with respect to a fixed element (2), comprising:
 - a coder element (70), fast in rotation with the rotatable element (4), formed by a magnetized multipole ring (70) for producing an alternating magnetic field while rotating,
 - a sensing element (90) adapted to detect the magnetic field variations,wherein the sensing element (90) includes a piezoelectric sensor (900) having one end fast with the fixed element (2) and having, on its other end, a magnet (904) facing the magnetized ring (70).
2. Sensor unit according to claim 1, wherein the sensing element (90) extends in a limited angular sector of an annular gap (G) defined between the rotating element (4) and the fixed element (2).
3. Sensor unit according to claim 2, wherein the piezoelectric sensor (900) is connected to an annular printed circuit board (30) fast with the fixed element (2) and centered around the rotation axis (X-X') of the rotatable element (4).
4. Sensor unit according to claim 3, wherein the printed circuit board (30) comprises means for processing and transmitting data delivered by the sensing element (90).
5. Sensor unit according to claim 4, wherein the printed circuit board (30) includes means to electrically feed the means for processing and transmitting data with an electrical current delivered by the piezoelectric sensor (900).
6. Sensor unit according to one of claims 4 and 5, wherein the printed circuit board (30) comprises means to determine, on the basis of an electrical current delivered by the piezoelectric sensor (900), the rotation speed of the rotatable element (4) with respect to the fixed element (2).
7. Sensor unit according to one of the previous claims, wherein the magnetized ring (70) is adapted to be mounted on the rotatable ring (62) of a bearing (6) allowing the rotation of the rotatable element (4) with respect to the fixed element (2).

8. Sensor unit according to one of the previous claims, wherein the magnet (904) faces the magnetized ring (70) along an axis perpendicular to the rotation axis (X-X') of the rotating element (4).

9. Bearing assembly (A) comprising a bearing (6) including a fixed ring (60) fast with a fixed element (2), a rotatable ring (62) fast with a rotatable element (4), and a sensor unit (10) according to one of the previous claims.

10. Bearing assembly according to claim 9, wherein the coder element (70) is fixed to the rotatable ring (62).

11. Bearing assembly (A) according to claim 9 or 10, wherein the bearing (6) further comprises rolling elements (64) located between the fixed ring (60) and the rotatable ring (62).

12. Bearing assembly (A) according to claim 11, wherein the rolling elements (64) are balls which travel along raceways arranged on the fixed ring (60) and the rotatable ring (62).

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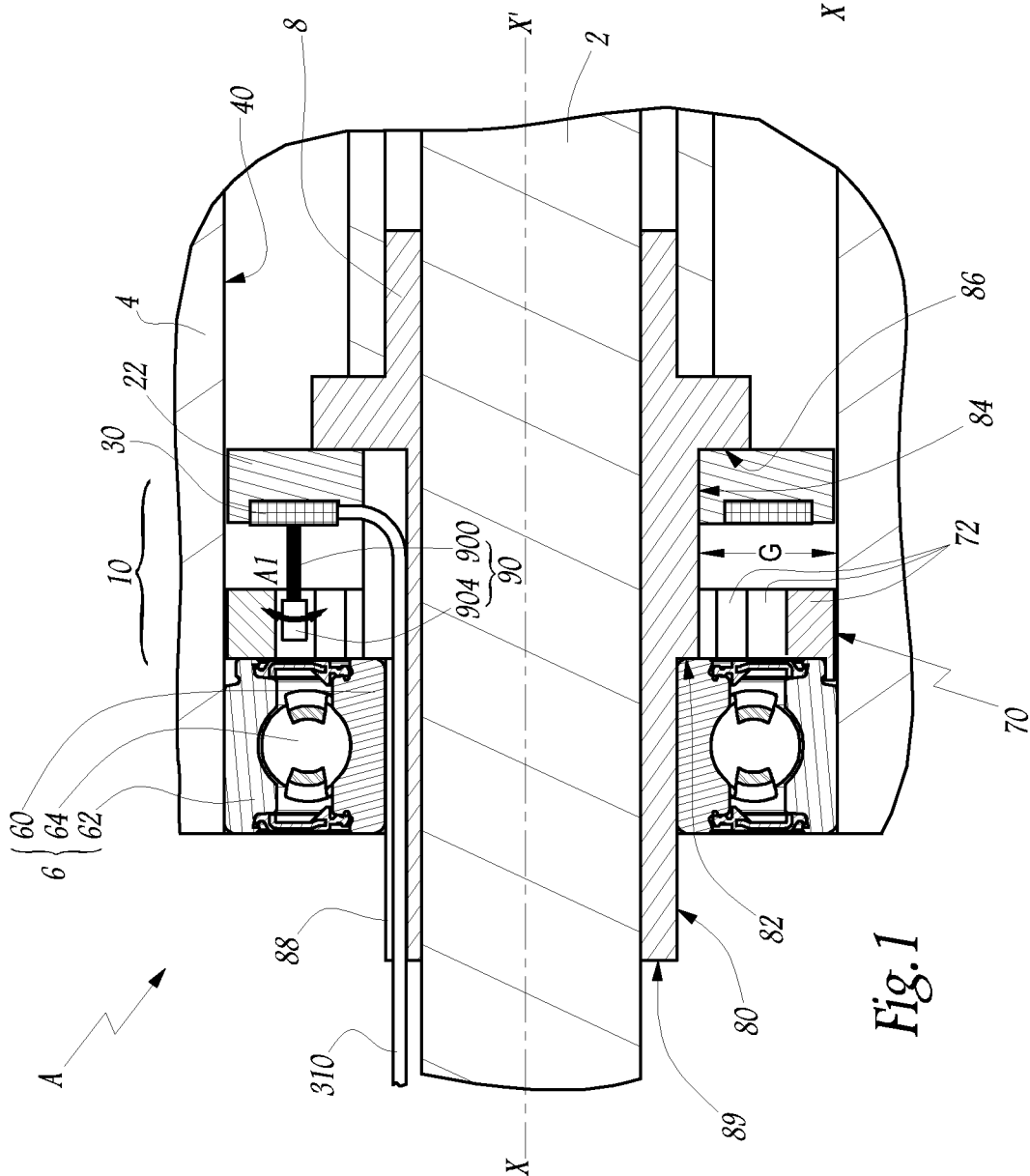


Fig. 1

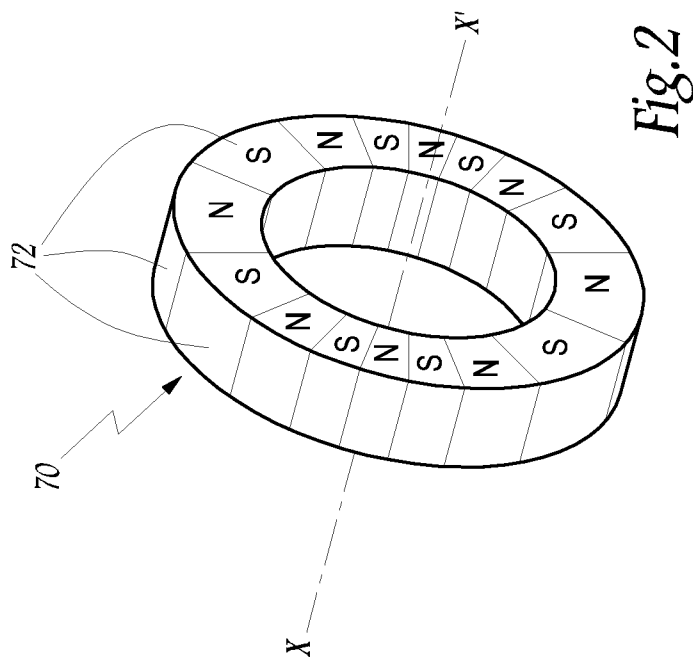


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER

INV. G01P3/487 G01P3/481 G01P3/44
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01P

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2003 189641 A (NEC TOKIN CORP; NEC TOKIN CERAMICS CORP) 4 July 2003 (2003-07-04)	1,2
Y	abstract; figures 1,3,4 -----	1-12
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	abstract; figures 1,6 -----	
Y	DE 20 2004 017906 U1 (HUEBNER ELMASCH GMBH [DE]) 23 March 2006 (2006-03-23)	1-12
	paragraphs [0014] - [0020]; figures 1,2 -----	
Y	US 2005/235513 A1 (NIARFEIX FRANCOIS [FR]) 27 October 2005 (2005-10-27)	2-12
	paragraphs [0042] - [0048], [0063], [0064]; figures 6,11,12 -----	



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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