(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
24 October 2013 (24.10.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/157999 A1

(51) International Patent Classification:
G01P 3/44 (2006.01) *G01P 3/487* (2006.01)
B60T 8/32 (2006.01)

(21) International Application Number:
PCT/SE2012/000055

(22) International Filing Date:
17 April 2012 (17.04.2012)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

WO 2013/157999 A1

(54) Title: A WHEEL SPEED SENSOR ARRANGEMENT

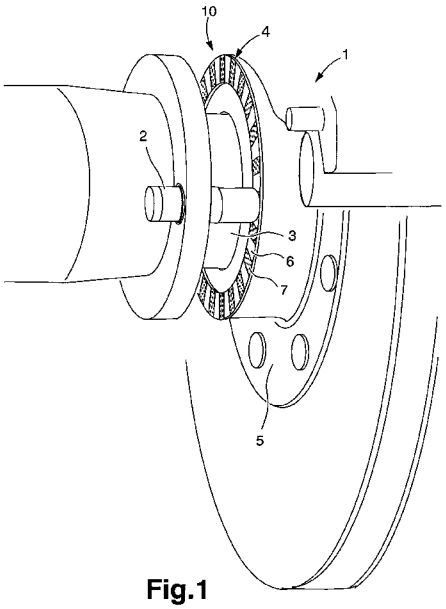


Fig.1

(57) Abstract: The invention relates to a vehicle speed sensor arrangement 1 comprising a stationary sensor 2 placed in front of a rotatable sensor wheel 4. The sensor wheel 4 is concentrically mounted on a rotatable wheel hub 5 wherein the rotatable sensor wheel 4 having a surface facing the stationary sensor 2, the surface having circumferentially arranged alternating magnetic segments 6, 36 and non-magnetic segments 7, 37.

A wheel speed sensor arrangement

TECHNICAL FIELD

The invention relates to a wheel speed sensor arrangement comprising a stationary sensor and a rotating sensor wheel for measuring the individual wheel speed for vehicles such as trucks and personal cars. The stationary sensor is arranged on a wheel axle and placed in front of a rotatable sensor wheel mounted on a likewise rotatable wheel hub.

BACKGROUND OF THE INVENTION

In vehicles such as trucks or personal cars, wheel speed measurements are common. One reason for wishing to determine the wheel speed of a vehicle may be to use the information in regulating the braking force in order to achieve an optimal braking performance. Knowledge of the wheel speed facilitates maintaining of an optimal force on each axle or even on each wheel such that the force may be kept just below the limit where skidding may occur.

Another reason for measuring the wheel speed may be for stability control where information about the wheel speed will be sent to a computer stability system (ESP). Yet another reason for measuring the wheel speed may be to determine if the vehicle moves or is parked, which may be useful in some applications.

Wheel speed sensors comprising a stationary sensor and a rotating sensor wheel are well known in the art. When the sensors are used for brake control, the brake system is dependent on correct information regarding the speed of each individual wheel. The most common approach to get this information is by using a stationary sensor that is mounted somewhere on the wheel axle, which is a non-rotating part, and a corresponding sensor wheel that is mounted on the wheel hub, which is a rotating part. The sensor wheel has varying magnetic properties along its

circumference. The stationary sensor uses a magnetic field to detect the variation in magnetic properties as the sensor wheel rotates and gives an alternating electrical signal to the brake system from which the wheel speed is calculated.

The rotating sensor wheel may be placed on the wheel hub which has the same rotating speed as the wheel to which it is attached. One commonly used rotating sensor arrangement component is a wheel having annularly placed magnetic spokes separated by slots. A signal is sent from the stationary sensor measuring the number of slots passing the stationary sensor. Another commonly used sensor wheel is made from magnetic material and has circumferentially arranged alternating grooves and ridges resulting in a measurable variation in magnetic properties depending on the varying distance between the rotating sensor wheel and the stationary sensor device. A problem with these sensor wheels is that they are highly prone to collect dirt in the slots or grooves between the magnetic spokes or ridges which severely affects the function of the sensor device and the accuracy of the wheel speed measurements. In order to protect the rotatable sensor wheel from dirt or water it may therefore be provided with a protective cover. The cover is made of non-magnetic material so as not to interfere with the signal from the wheel speed sensor system.

For general information the wheel speed sensor is attached to the wheel hub which is concentrically attached to a non-rotating axle such as a wheel axle. More precisely, the wheel hub is journalled on the wheel axle by roller bearings in order to reduce the friction between the fixed wheel axle and the rolling wheel.

Generally, a wheel speed sensor works using an iron cored coil with a magnet attached to one end. When a piece of ferrous metal is moved towards the end of the sensor it changes the shape of the magnetic field in the coil and the changed magnetic field then induces a current to flow in the windings of the coil resulting in a small amount of electricity being generated.

The sensor arrangement can only detect movement of ferrous objects near the stationary sensor so it is typically used for speed sensing, for example as a wheel sensor in an ABS system. The sensor arrangements need to be robust and not to

be affected by dirt. The stationary sensors which are used have a very high signal output making them less sensitive to noise which is ideal for automotive applications.

JP 8-327 638 discloses a wheel speed sensor comprising a stationary sensor and a rotating sensor wheel. The sensor reads off the circumference of the rotating sensor wheel which is equipped with circumferentially separated magnetic elements. The rotating sensor wheel is connected to the wheel and to a cover shielding against intrusion of dirt or water. The cover is provided with an opening and the stationary sensor is directed towards the opening when measuring the wheel speed. One problem with the wheel speed sensor in JP 8-327 638 is that dirt may force its way through the opening into the rotating sensor wheel.

US-B2- 7 350 976 discloses a wheel speed sensor with a cover of a non-magnetic material placed in front of a rotating sensor wheel, or between the sensor wheel and the stationary sensor. Detection of rotational speed as well as the lifetime of the sensor arrangement is taught to be improved and the non-magnetic cover is said to prevent intrusion of dirt and water. However, a major problem with the solution in US-B2- 7 350 976 is that the cover placed in front of the rotating wheel is bulky and takes up too much space which is a considerable disadvantage in vehicle construction where economy of space as well as weight are of utmost importance. Moreover, the part of a vehicle where the wheel speed sensor is mounted is already fully loaded and has very limited available space.

Normally, an amount of dirt is collected from the surroundings because the wheel is subject to a dirty environment. The material collected on the cover has no effect on the sensor or on the measurement of the speed since the cover is non-magnetic.

It would be desirable to provide a wheel speed sensor which can be used in any environment including very dirty environments and environments containing material which may be detrimental to the function of the wheel speed sensor. An example of such an environment may be a mining environment where particles containing iron are present. Additionally it would be optimal if the wheel speed

sensors could be made more weight and space efficient, without sacrificing the protection offered by a cover.

Accordingly, it is an object of the invention to provide a contamination insensitive wheel speed sensor arrangement which may be used in different types of environments including an environment where it will be exposed to iron-containing dirt. It is a further object of the invention to offer such a wheel speed sensor arrangement having reduced space requirements.

SUMMARY OF THE INVENTION

In accordance with the invention, there is now offered an improved vehicle speed sensor arrangement.

The vehicle speed sensor arrangement comprises a stationary sensor placed in front of a rotatable sensor wheel concentrically mounted on a rotatable wheel hub wherein the rotatable sensor wheel has a surface facing the stationary sensor, the surface having circumferentially arranged alternating magnetic segments and non-magnetic segments.

The two different kinds of segments on the rotatable sensor wheel are placed in a contiguous relationship next to each other and preferably form a smooth or substantially smooth surface. In this manner, dirt is prevented from being deposited on the rotating sensor wheel and, in particular, from being accumulated between the magnetic segments of the sensor wheel. Accordingly, there is no risk of dirt deposits on the sensor wheel interfering with the function of the sensor arrangement. Furthermore, a cover placed in front of the rotating sensor wheel is made redundant resulting in a slimmer and more space efficient sensor arrangement than was previously possible to achieve.

An advantage with the proposed speed sensor arrangement is that the rotatable sensor wheel having alternating segments of non-magnetic material makes it possible to place the speed sensor in an environment where iron particles are present. Dirt including iron particles is prevented from accumulating on the annular sensor since there are no cavities in which ferruginous dirt may gather.

The above described vehicle speed sensor arrangement may comprise a rotatable sensor wheel comprising a frame structure having regularly spaced cavities wherein the frame structure is magnetic and the cavities contain a non-magnetic filler material. More in detail, the magnetic frame structure may form the magnetic segments and the filled cavities may form the non-magnetic segments in between the magnetic segments.

Filler material is defined as an evenly distributed and relatively smooth piece with a defined hardness. The shape and size of the filler material are made to completely fit the cavities in which the filler material is placed. The magnetic filler material may, for example, be made of steel. The non-magnetic filler material is preferably made of heat resistant plastic material such as epoxy, melamine etcetera which may be conveniently shaped in a desired form by known methods. Magnetic material may also be any magnetic metal or may be an alloy or a polymer composite providing the alloy or composite contains a sufficient amount of magnetic material. One example may be a polymer composite containing magnetic particulate material dispersed in the polymer composition.

The vehicle speed sensor arrangement may alternatively have a reverse configuration to that described above and may comprise a rotatable sensor wheel comprising a frame structure having regularly spaced cavities wherein the frame structure is non-magnetic. The cavities may then contain a magnetic filler material. The non-magnetic frame structure forms the non-magnetic segments and the filled cavities form the magnetic segments.

To have a frame structure as described above facilitates the possibilities to manufacture the speed sensor arrangement and it also gives a robust and durable construction. A frame structure manufactured in one piece makes a solid arrangement and is durable in a demanding environment.

The vehicle speed arrangement may have segments evenly distributed around the circumference of the rotatable sensor wheel. Accordingly, the magnetic segments may be equidistantly arranged in the circumferential direction of the sensor wheel.

This means that the segments of non-magnetic material separating the magnetic segments are of equal width. Likewise, the non-magnetic segments may be equidistantly arranged in the circumferential direction of the sensor wheel implying that the segments of non-magnetic material separating the magnetic segments are of equal width. The spacing between the magnetic segments may be different from the spacing between the non-magnetic segments, or the magnetic segments may be arranged with the same spacing as the non-magnetic segments. This can alternatively be expressed as the widths of the magnetic segments being different from or equal to the widths of the non-magnetic segments as it is the width of the intervening segments which decide the size of the spacing.

The sensor wheel may be a rotating disc with the magnetic and non-magnetic segments arranged as alternating portions on the radial surface of the disc. In a sensor wheel of this kind, at least one of the non-magnetic segments and the magnetic segments will generally be wedge-shaped to compensate for the increase in circumference which takes place when moving in a radial direction from the centre of the sensor wheel to the periphery thereof. A disc-shaped sensor wheel may either be a circular plate with the magnetic and non-magnetic segments arranged at least at the periphery of the plate. Alternatively, the sensor wheel may be in the form of a ring-shaped disc with a central hole. When the segments are wedge shaped, the width of the segments will vary in the radial direction of the sensor wheel. In such case, the implication of the widths of the non-magnetic and/or magnetic segments being equal in the circumferential direction of the sensor wheel is that the widths are equal when measured at the same radial distance from the centre of the wheel.

In a speed sensor arrangement, the stationary sensor device will be placed in a facing relationship with the segment carrying surface of the disc-shaped sensor wheel such that the variation in electric signal can be registered by the stationary sensor device as the senor wheel rotates in front of the stationary sensor device. Accordingly, in this arrangement the stationary sensor device is placed parallel with the axial direction of the sensor wheel.

The sensor wheel may alternatively be in the form of a rotating cylinder having the alternating magnetic and non-magnetic segments arranged in an axial direction on the radial surface of the cylinder. In an arrangement of this kind, the stationary sensor device is placed perpendicular to the axial direction of the sensor wheel.

The cavities in the sensor wheel frame structure may be constituted of through holes or may be formed as grooves or holes penetrating only through a part of the thickness of the frame structure. In the latter case the surface of the sensor wheel frame structure may be made of a sintered sheet from which material is milled off to get a desired shape with valleys and peaks. The valleys are thereafter filled with a suitable material, which may be magnetic or non-magnetic depending on the properties of the sintered sheet material.

Through holes allow for a simple and hands-on manufacturing process and after the holes have been punched they are filled with magnetic or non-magnetic material as required depending on the properties of the frame structure.

The non-magnetic segments may be constituted of plastic material.
Plastic material is advantageous since it is easy to handle, light-weight and may be shaped and applied by known techniques.

The surface of the rotatable sensor wheel which is facing the stationary sensor may be even without any gaps or irregularities. The surface is preferably smooth in order to further improve the dirt-repelling properties of the rotatable sensor wheel. An even and smooth surface may be accomplished by ascertaining that the segments of the sensor wheel have the same thickness and that they fit perfectly together to produce a contiguous surface without any gaps or other irregularities in which dirt may be accumulated. It is further possible to apply a thin non-magnetic coating such as a thin plastic coating over the surface of the sensor wheel or to produce the wheel by molding a non-magnetic frame structure in which the magnetic material is incorporated such that the magnetic material is enclosed and protected by the non-magnetic material.

Thus, an advantage with the proposed speed sensor arrangement is that the rotatable sensor wheel having alternating segments of non-magnetic material makes it possible to place the speed sensor in an environment where iron particles are present. Dirt including iron particles is prevented from accumulating on the annular sensor since there are no cavities in which it is easy for dirt to gather.

The magnetic material used in this invention is ferromagnetic, which is described as a non-linear magnetic material, and is a permanent magnet, unlike the material which turns magnetic only when placed in an external magnetic field.

Another advantage with the proposed speed sensor arrangement is that there is no need for a separate cover to be mounted in front of the sensor wheel since the sensor wheel has an even surface without any cavities or irregularities. The presence of alternating segments still ascertains that wheel speed may be measured with a conventional stationary sensor. The sensor wheel according to the invention is made in one piece with non-magnetic material used instead of air-filled slots between magnetic elements in the sensor wheel. The proposed speed sensor arrangement therefore has been made more compact than previously known arrangements using separate covers implying that the whole vehicle speed sensor arrangement may be made less bulky and space-consuming than has heretofore been possible.
This is a very important and advantageous feature for a wheel speed sensor device which is used in an area of a vehicle where a great number of components are arranged.

As set out above, the segments may be formed in a frame structure having regularly spaced cavities wherein the frame structure is made from magnetic material and the cavities are filled with non-magnetic material. This option makes it possible to manufacture the sensor wheel practically and is a simple way of realising the invention. The size of the magnetic and non-magnetic segments is either equal or of different sizes in radial and/or the circumference direction. For ease of manufacturing and in order to simplify operation of the sensor arrangement the distance between the segments may preferably be the same. The magnetic material is made of for example steel. The non-magnetic material is

preferably made of heat resistant plastic such as epoxy, melamine etcetera which is convenient to shape in a desired form.

Further, the segments may constitute a frame structure having regularly spaced cavities wherein the frame structure is made from a non-magnetic material and the cavities are filled with a magnetic material. In this case the magnetic pieces may be placed and glued into the correct positions or may be placed in a mold together with the non-magnetic material. Further options for producing the sensor wheel exist, such as injection-molding of magnetic and non-magnetic polymer material. The frame structure may be manufactured using die-casting.

Further, the segments are evenly distributed around the circumference of the rotatable sensor wheel. This is preferred for an easy use of the vehicle speed sensor arrangement and counting of the magnetic segments is facilitated with evenly distributed segments. The stationary sensor may be attached to the end of the wheel axle. The sensor wheel is preferably attached to the hub and the hub may be anchored to the wheel axle via two conically shaped cylinder bearings.

The cavities may be constituted of through holes. This embodiment is comparatively easy to manufacture. Additionally, this feature gives the possibility to easily exchange one type of segment. In some manufacturing cases it may be easier to attach the material in a through hole. This is for instance the case when the sensor wheel is mounted to an annular plate.

As an example the sensor wheel may take the form of a ring wherein the inner diameter d1 of the ring may be 40 - 200 mm, preferable 132 mm. The exterior diameter d2 may be 50 - 300 mm, preferably 146 mm. The distance between the stationary sensor and the sensor wheel may be 0 - 2 mm as an example, preferably as close as possible. The number of slots may be around 100 per revolution on a sensor wheel.

The distance between the stationary sensor and the sensor wheel is important for the function of the measurement. The reading may not function if the distance is too large. If the distance is too small a risk of collision between the components

arises. If clay is gathered between the stationary sensor and the sensor wheel wear may appear.

The non-magnetic material may be constituted of plastic material. Plastic material makes the manufacturing facilitated since plastic has moulding capabilities and can be coloured in suitable colours. Plastic material is enough hardwearing and this is an important feature because the wheel is subject to a dirty environment which also means that for instance gravel will graze the surface of the plastic segments.

The magnetic and non-magnetic segment may be of different width between them. However, all the magnetic segments preferably have the same width in the same vehicle speed sensor arrangement. Also, all the non-magnetic segments preferably have the same width.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention together with the above-mentioned and other objects and advantages may best be understood from the following detailed description of the embodiments, but not restricted to the embodiments, wherein is shown schematically:

Fig. 1 an embodiment of a vehicle speed sensor arrangement,
Fig. 2 a detailed view of a sensor wheel; and
Fig. 3 a further detailed view of a sensor wheel

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

In the drawings, equal or similar elements are referred to by the same reference numerals. The drawings are merely schematic representations, not intended to portray specific parameters of the invention. Moreover, the drawings are intended to depict only typical embodiments of the invention and therefore should not be considered as limiting the scope of the invention.

Fig. 1 shows a vehicle speed sensor arrangement 1 comprising a stationary sensor 2 arranged on a wheel axle 3, more specific on the axle shaft. The stationary sensor 2 is placed in front of a rotatable sensor wheel 4 concentrically mounted on a likewise rotatable wheel hub 5 wherein the sensor wheel 4 has circumferentially alternating segments 6, 7 of magnetic and non-magnetic material. Thus, the wheel hub 5 as well as the stationary sensor 2 are mounted on the axle shaft of the wheel axle 3.

Fig. 2 shows a rotatable sensor wheel 4 comprising a frame structure 8 in the form of an annular plate having regularly spaced cavities 9. The frame structure 8 is in itself made of magnetic material and the cavities 9 contain non-magnetic filler material. The magnetic frame structure 8 forms the magnetic segments 6 and the filled cavities 9 form the non-magnetic segments 7. Preferably, every second segment is magnetic and every second segment is non-magnetic. The surface 10 facing the stationary sensor 2 of the sensor wheel is thus a substantially even surface constituted of circumferentially alternating magnetic segments 6 and non-magnetic segments 7, i.e. the thickness of the rotatable sensor wheel is substantially constant around the annular ring. Iron containing dirt may thus not affect the measurement since dirt cannot be held in the filled cavities.

Fig. 3 shows another sensor arrangement with a rotatable sensor wheel 34 comprising a frame structure 38 having regularly spaced cavities 39. The frame structure 38 is in itself made of non-magnetic material and the cavities 39 contain magnetic filler material. The magnetic frame structure 38 forms the non-magnetic segments 37 and the filled cavities 39 form the magnetic segments 36.

It is proposed that the segments 6, 7, 36, 37 are evenly distributed around the circumference of the rotatable sensor wheel. Equidistantly distributed segments give the advantage that it facilitates the measurement of the speed since the measured distance of each segment is the same. The width w1 of the non-magnetic segments are the same along the surface as well as the width of the magnetic segments w2 of the magnetic segments are the same, even though the width of the different kinds of segments may be different, that is $w1=w2$ or $w1 \neq w2$.

Yet another proposal is that the cavities 9, 39 are constituted of through holes. It gives above all production advantages since punching through holes is a convenient and common way of manufacturing details.

The non-magnetic material may be constituted of plastic material, which is advantageous since plastic is easily formable.

Accordingly, as set out above, the invention provides improved handling possibilities for driving in different environment in mines as well as in other ferriferous environment. The possibilities and flexibility to drive a truck in different surroundings are enhanced by using the described invention. Moreover the invention entails considerably reduced volume compared to a solution with a cover placed in front of the rotatable sensor wheel. Design freedom is also achieved as well as it facilitates the construction of speed measurement arrangements. Although the sensor wheels shown in the figures have radially arranged segments the inventions is also applicable to sensor wheels having axially arranged segments.

CLAIMS

1. A vehicle speed sensor arrangement (1) comprising a stationary sensor (2) placed in front of a rotatable sensor wheel (4) concentrically mounted on a rotatable wheel hub (5) characterized in the rotatable sensor wheel (4) having a surface (10) facing the stationary sensor (2), the surface having circumferentially arranged alternating magnetic segments (6, 36) and non-magnetic segments (7, 37).

2. A vehicle speed arrangement according to claim 1, characterized in that the rotatable sensor wheel (4) comprises a frame structure (8) having regularly spaced cavities (9) wherein the frame structure (8) is magnetic and the cavities (9) contain a non-magnetic filler material and wherein the magnetic frame structure (8) forms the magnetic segments (6) and the filled cavities (9) form the non-magnetic segments (7).

3. A vehicle speed sensor arrangement according to claim 1, characterized in that the rotatable sensor wheel (4) comprises a frame structure (38) having regularly spaced cavities (39) wherein the frame structure (38) is non-magnetic and the cavities (39) contain a magnetic filler material and wherein the non-magnetic frame structure (38) forms the non-magnetic segments (37) and the filled cavities (39) form the magnetic segments (36).

4. A vehicle speed arrangement according to claims 2-3, characterized in that the cavities (9, 39) are constituted of through holes.

5. A vehicle speed arrangement according to claims 2 -3 characterized in that the cavities (9, 39) are formed as grooves and holes penetrating through a part of the thickness of the frame structure.

6. A vehicle speed arrangement according to claims 1-5, characterized in that the non-magnetic segments (7, 37) are constituted of plastic material.

7. A vehicle speed arrangement according to claims 1-6, characterized in that the magnetic segments (6, 36) are equidistantly arranged in the circumferential direction of the sensor wheel (4).

8. A vehicle speed arrangement according to claims 1-7, characterized in that the non-magnetic segments (7, 37) are equidistantly arranged in the circumferential direction of the sensor wheel (4).

9. A vehicle speed arrangement according to claims 1-8, characterized in that surface of the rotatable sensor wheel (4) which is facing the stationary sensor (2) is even without any gaps and irregularities.

10. A vehicle speed arrangement according to claim 1 – 9, characterized in that a thin non-magnetic coating such as a thin plastic coating is applied over the surface (10) of the sensor wheel.

11. A vehicle speed arrangement according to claim 1 – 10, characterized in that the inner diameter d1 of the sensor wheel is 40 - 200 mm and the exterior diameter is 50 - 300 mm.

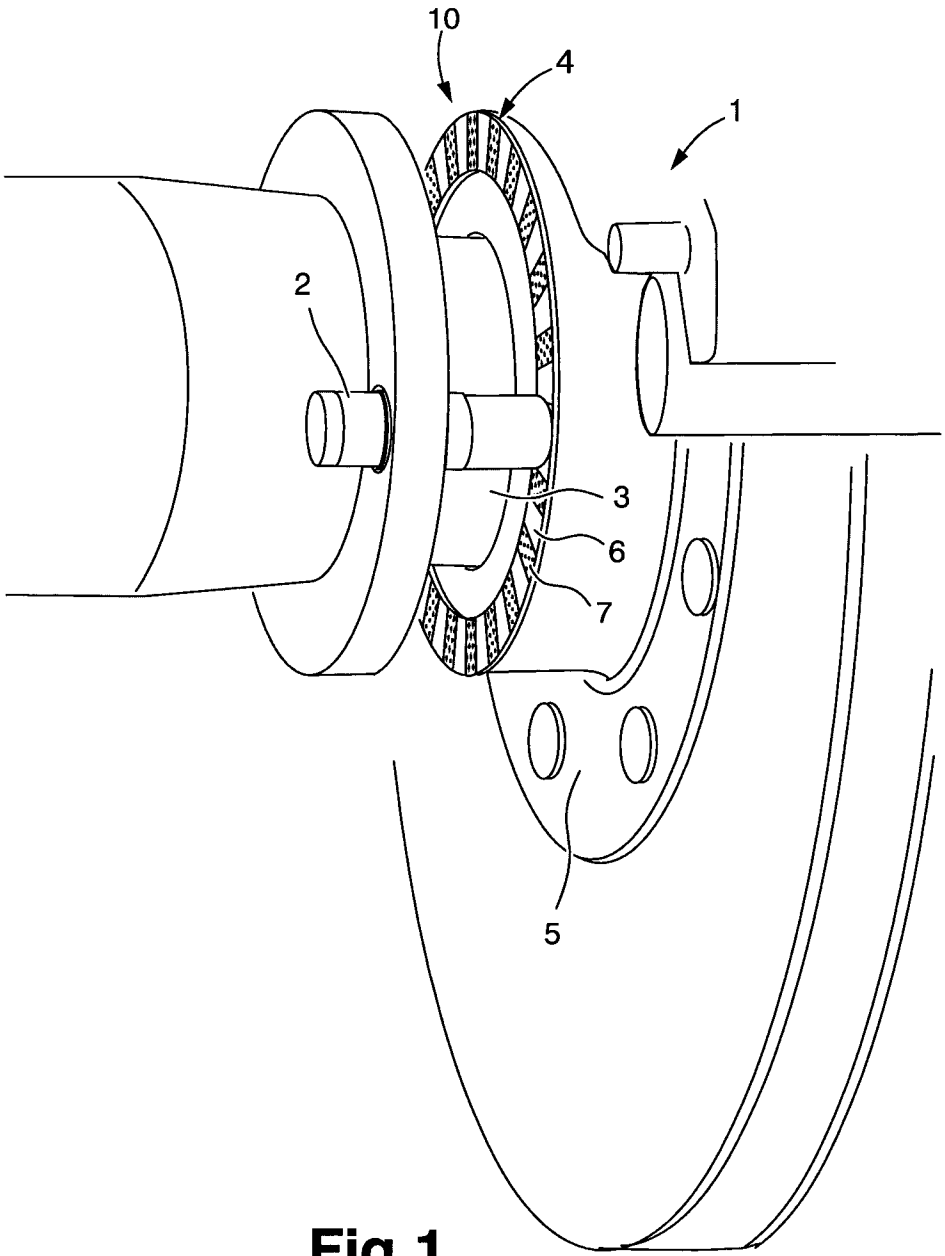


Fig.1

Fig.2

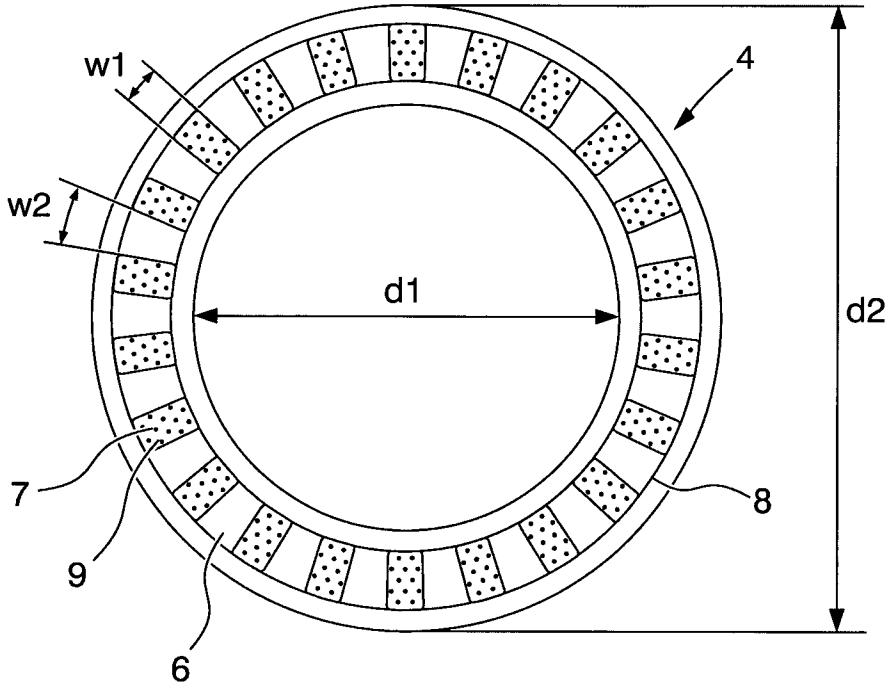
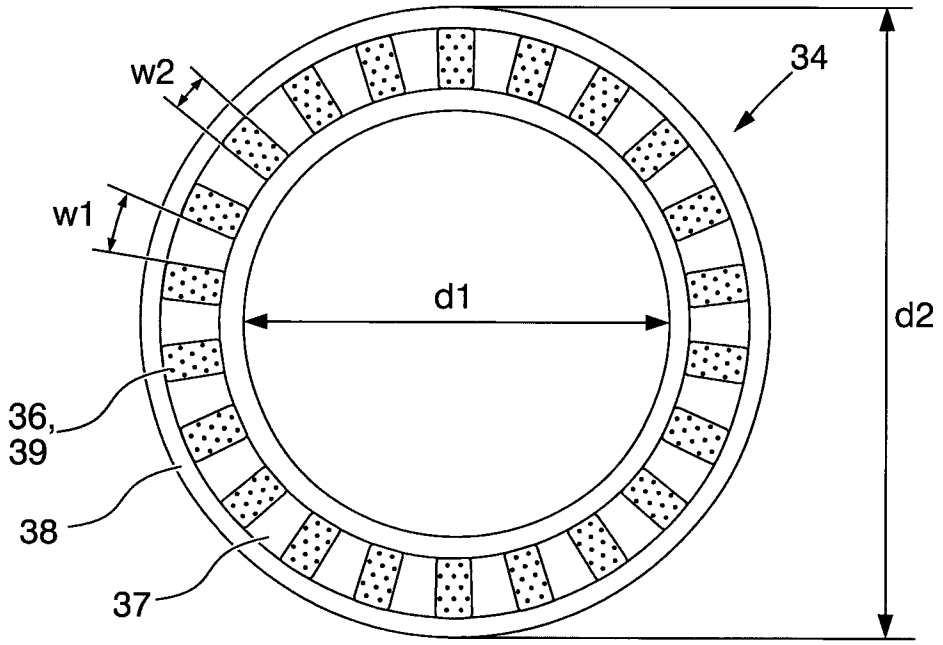


Fig.3



INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2012/000055

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: B60T, G01P

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

SE, DK, FI, NO classes as above

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

EPO-Internal, PAJ, WPI data, COMPENDEX, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 4230043 A1 (KNORR BREMSE AG), 10 March 1994 (1994-03-10); column 1, line 55 - column 1, line 57; column 1, line 68 - column 2, line 4; column 3, line 23 - column 3, line 27; figures 1,3	1, 2, 4-7, 9-11
Y	--	10
X	US 20030122539 A1 (HEIMANN RUDY J ET AL), 3 July 2003 (2003-07-03); paragraph [0059]; figures 14,16,18; claims 6, 11	1, 3, 8
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Y	US 7350976 B2 (OHTSUKI HISASHI ET AL), 18 November 2004 (2004-11-18); column 11, line 33 - column 12, line 11; claims 6, 11	10
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

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

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

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Date of the actual completion of the international search	Date of mailing of the international search report
12-02-2013	12-02-2013

Name and mailing address of the ISA/SE	Authorized officer
Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Anna Lundqvist Telephone No. + 46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2012/000055

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3716787 A1 (HAMMOND P), 13 February 1973 (1973-02-13); column 1, line 30 - column 1, line 47; column 2, line 30 - column 2, line 42; figure 2	1, 3, 8
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X	EP 0557932 A1 (SKF IND SPA), 1 September 1993 (1993-09-01); column 1, line 21 - column 1, line 37; column 2, line 24 - column 2, line 27; figure 3	1
A		2-11
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A	US 20100097054 A1 (KULL BERNHARD ET AL), 22 April 2010 (2010-04-22); whole document	1-11
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International application No.
PCT/SE2012/000055

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International Patent Classification (IPC)

G01P 3/44 (2006.01)
B60T 8/32 (2006.01)
G01P 3/487 (2006.01)

DE	4230043	A1	10/03/1994	NONE			
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