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- (71) **Applicant:** SCANIA CV AB [SE/SE]; 151 87 Södertälje (SE).
- (72) **Inventors:** FORSBERG, Jörgen; Vildkattens väg 7, 647 35 Mariefred (SE). LAMADRID, Artiom; Linnégatan 5, 151 44 Södertälje (SE).
- (74) **Agent:** WALLIN, Ulf; Scania CV AB, 151 87 Södertälje (SE).
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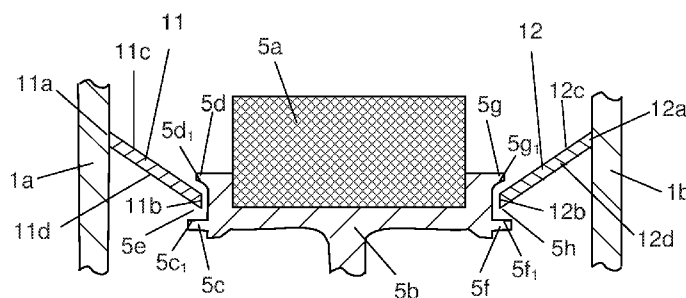
(54) **Title:** ARRANGEMENT FOR DISTRIBUTING OIL IN AN ELECTRIC MACHINE

Fig 2

(57) **Abstract:** The present invention relates to an arrangement for distributing oil in an electrical machine (2). The electrical machine (2) comprises a rotor (5) rotatably arranged around a rotation axis (7), a stator (6) arranged radially outside of the rotor (5), a housing (1) enclosing the rotor (5) and the stator (6), and an oil system supplying oil to the stator windings (6b). The arrangement comprises a guiding member (11, 12) comprising a guiding surface (11c, 11d, 12c, 12d) having an extension between a fixed edge portion (11a, 12a) connected to a wall (1a, 1b) of the housing (1) and a free edge portion (11b, 12b) located close to the rotor (5). The fixed edge portion (11a, 12a) of the guiding surface (11c, 12c) is arranged at a higher height than the free edge portion (11b, 12b) of the guiding surface (11c, 12c) such that the guiding surface (11c, 11d, 12c, 12d) leads oil from the wall (1a, 1b) to a part of the rotor (5) located radially inwardly of the stator windings (6b).

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ARRANGEMENT FOR DISTRIBUTING OIL IN AN ELECTRIC MACHINE

10 BACKGROUND TO THE INVENTION AND PRIOR ART

The present invention relates to an arrangement for distributing oil in an electrical machine according to the preamble of claim 1.

15 Hybrid vehicles usually comprise an electrical machine, which serves as prime mover during running of the vehicle and as generator at times when the vehicle is being braked. The electrical machine is usually situated within a housing or the like. Whether running as prime mover or as generator, the electrical machine is subject to temperature rise. Temperature rise in an electrical machine is substantially confined to
20 specific components, e.g. its stator windings or rotor. Conventional cooling of electrical machines in hybrid vehicles may be performed by air or water led past an external surface of the housing, which encloses the electrical machine. A more effective cooling method is to spray oil on the stator windings of the electrical machine. However, a relatively large part of the oil, which hits the stator windings,
25 bounces away and hits a wall of the housing where it flows downwardly without taking up any heat from the electrical machine.

US 2005/0206251 shows an arrangement for cooling an electrical machine, which is situated in a housing. The electrical machine comprises in a conventional way a stator
30 and a rotor, which is mounted on a rotatable shaft. In this case, oil is used as cooling medium. The oil is led via a duct situated within the rotatable shaft to a location radially internal to the electrical machine. The oil is led thereafter into a radial duct in the hub of the rotor. The radial duct ends with apertures, which lead the oil to two lateral surfaces of the rotor from which the oil is flung radially outwards by the
35 centrifugal force which occurs when the rotor rotates. The oil thereupon comes into contact with protruding portions of the rotor windings and the stator windings.

SUMMARY OF THE INVENTION

5 The object of the invention is to propose an arrangement, which provides a very effective cooling of an electrical machine in a relatively simple way and at low cost.

10 This object is achieved with the arrangement defined in the introduction, which is characterized by the features indicated in the characterising part of claim 1. The arrangement comprises an oil system supplying oil to the stator windings. However, a part of the oil hitting the stator windings bounces away and hits a wall of the housing enclosing the electrical machine. This part of the oil flowing downwardly on the wall until it achieves contact with a guiding member. The guiding member comprises a surface leading the oil from the wall to the rotor. The oil obtains a rotating movement by the rotor and it is thrown radially outwardly by the centrifugal force in a direction
15 towards the stator windings. Consequently, the part of the oil, which leaves the stator windings, can be lead back from the wall of the housing, via the rotor, to the stator windings by means of the guiding member. In this case, substantially all oil supplied to the electrical machine can be used to cool the stator windings in an effective manner. The guiding member may have a simple design and be manufactured to a low cost.
20 The rotor may be arranged on a rotary shaft by a splined connection or arranged on a ring wheel of a planetary gear.

According to an embodiment of the present invention, the free edge portion of the guiding surface comprises drip formations. The free edge portion of the guiding
25 member inclines in relation to a horizontal plane. Thus, there is a risk that the oil entering the free edge portion may form an oil flow downwardly along the free edge portion of the guiding member. The drip formations stop such an oil flow and directs the oil out of the free edge portion and to the rotor. The drip formations may be arranged around the whole free edge portion of the guiding member at constant
30 intervals. The drip formations may be arbitrary irregularities in the edge portion such as recesses or protruding portions.

According to the present invention, the guiding member is annular. An annular guiding member has a simple design and it is easy to manufacture. The guiding member may
35 be manufactured of a sheet metal. The annular guiding member comprises a first guiding surface formed by a radially outer surface of the annular guiding member and

a second guiding surface formed by a radially inner surface of the annular guiding member. It is possible to use the radially outer surface and the radially inner surface of the guiding member as a guiding surfaces and lead the oil out from the wall to the rotor.

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According to an embodiment of the present invention, said part of the rotor comprises an axially protruding portion located radially inwardly of the free edge portion of the guiding member. Such a protruding portion may receive oil and prevent a downwardly directed oil flow past the rotor at the free edge portion of the guiding member.

10 Said axially protruding portion may have radially outer surface located at a constant radial distance from the rotational axis. A surface with such a shape is usually enough for retaining the oil on the rotor.

According to an embodiment of the present invention, said part of the rotor comprises
15 an axially protruding portion located radially outwardly of the free edge portion of the guiding member. Said protruding portion may have a radially outer surface retaining oil, which is used to cool the rotor. Said protruding portion may have a radially inner surface sloping successively radially outwardly towards a free end of the axially protruding portion. The oil retained on the rotor obtains a rotating movement by the
20 rotor. As a consequence, the oil flows radially outwardly by the centrifugal force. The radially inner surface has a shape directing the oil flow towards the stator windings.

According to an embodiment of the present invention, at least one of the axially protruding portions has a free end located in a vertical plane extending through the
25 guiding member. Such a design of the protruding portions may form an axial recess in said part of the rotor, which receives the free edge portion of the guiding member. In this case, it is formed a curved gap between the free edge portion of the guiding member and the surfaces of the axial recess. It is difficult for the oil to pass through such a curved gap without coming in contact with a surface of the rotor.

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According to an embodiment of the present invention, the arrangement comprises two guiding members connected to opposite walls of the housing. The stator windings extend axially out beyond both sides of the stator core. Thus, it is suitable to supply oil to the stator windings on both sides of the stator core. The house may have side walls
35 arranged to enclose the stator winding on both sides of the stator core. In this case, it is suitable to arrange a guiding member on the opposite side walls of the housing.

According to an embodiment of the present invention, the oil system comprises an annular oil channel arranged radially outside of the stator and outlet ducts supplying oil to the stator windings. A pump may direct an oil flow to the annular oil channel.

- 5 The oil may have a positive pressure in the oil channel such that the oil is sprayed out of the outlets duct in a direction towards the stator windings.

BRIEF DESCRIPTION OF THE DRAWINGS

- 10 A preferred embodiment of the invention is described below by way of an example with reference to the attached drawings, on which:

Fig. 1 shows an arrangement for cooling of an electrical machine,

Fig. 2 shows a part of the arrangement more in detail and

- 15 Fig. 3 shows one of the oil guiding members in Fig. 1 in a separate state.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

- 20 Fig. 1 shows a housing 1 enclosing an electrical machine 2 which may be arranged in a hybrid vehicle. A rotatable shaft 3 extends substantially centrally through a first side wall 1a of the housing 1 and a second side wall 1b of the housing 1. At least one of the side walls 1a, 1b is releasably connected to a periphery wall 1c of the housing 1. The shaft 3 is rotatably arranged in relation to the side walls of the housing 1 by means of
- 25 bearings 4. The shaft 3 is driven by a not shown combustion engine of a hybrid vehicle. The electrical machine 2 comprises in a conventional way a rotor 5 and a stator 6. The rotor 5 comprises a rotor core 5a supported by a rotor hub 5b. The rotor hub 5b is fastened on the rotatable shaft 3 by means of a splined connection.
- Alternatively, it may be arranged on a ring wheel of a planetary gear. The rotor 5 and
- 30 the shaft 3 rotates around a common rotation axis 7. The stator 6 comprises a stator core 6a, stator windings 6b mounted on the inside of the periphery wall 1c of the housing 1 and a mantle 6c enclosing the stator core 6b. An annular oil channel 8 is arranged in a radial space between the periphery wall 1c of the housing 1 and the mantle 6c. Oil is supplied to the annular oil channel 8 via an oil conduit 10 by a not
- 35 visible oil pump. The oil is supplied with a positive pressure to the annular oil channel 8. The annular oil channel 8 comprises a number of outlet ducts 9 in the mantle 6c

spraying oil from the annular oil channel 8 in a direction towards the stator windings 6b.

- 5 A first guiding member 11 is connected to an inner surface of the first side wall 1a of the housing and a second guiding member 12 is connected to an inner surface of the second side wall 1b of the housing 1. Fig. 2 shows a part of the guiding members 11, 12 more in detail. Each guiding member 11, 12 comprises a fixed edge portion 11a, 12a connected to the respective side walls 1a, 1b and a free edge portion 11b, 12b located at a distance from the respective side walls 1a, 1b. Each guiding member 11, 12 has an extension between the fixed edge portion 11a, 12a and the free edge portion 11b, 12b. Each guiding member 11, 12 is annular. As a consequence, each guiding member 11, 12 comprises a radially outer surface forming a first guiding surface 11c, 12c and a radially inner surface forming a second guiding surface 11d, 12d.
- 10 In a mounted position, the first guiding surface 11c, 12c forms an upwardly directed surface of an upper half of the guiding member 11, 12 and the second guiding surface 11d, 12d forms an upwardly directed surface of a lower half of the guiding member 11, 12. The first guiding surfaces 11c, 12c receives oil flowing downwardly on a part of the side walls 1a, 1b located at an outer radial position of the fixed edge portions 11a, 12a of the guiding members 11, 12. The second guiding surfaces 11d, 12d form guiding surfaces for oil flowing downwardly on a part of the side walls 1a, 1b located at an inner radial position of the fixed edge portions 11a, 12a of the guiding members 11, 12. The guiding surfaces 11c, d, 12c, d of the guiding members 11, 12 may slope downwardly within an angle range of 30-60 degrees.
- 15 20 25
- 30 The rotor hub 5b comprises on a first side portion a first axially protruding portion 5c and a second axially protruding 5d located at a somewhat outer radial position in relation to the first axially protruding portion 5c. The first protruding portion 5c comprises an outer radial surface 5c₁ arranged at a constant radial distance from the rotation axis 7. The second protruding portion 5d comprises a radial inner curved surface 5d₁ inclining radially outwardly towards a free end of the second protruding portion 5d. The first protruding portion 5c and the second protruding portion 5d form a first annular recess 5e receiving the free edge portion 11b of the first guiding member 11. The rotor hub 5b comprises on an opposite second side portion a third axially protruding portion 5f and a fourth axially protruding 5g located at a somewhat outer radial position in relation to the third axially protruding portion 5f. The third
- 35

protruding portion 5f comprises a radial outer surface 5f₁ arranged at a constant radial distance from the rotation axis 7. The second protruding portion 5g comprises a radial inner curved surface 5g₁ inclined radially outwardly towards a free end of the fourth protruding portion 5g. The third protruding portion 5f and the fourth protruding
5 portion 5g form a second annular recess 5h receiving the free edge portion 12b of the second guiding member 12.

Fig. 3 shows the first guiding member 11 in a separated state. It is here visible that the first guiding surface 11c of the guiding member 11 comprises drip formations at the
10 free edge portion 11b which in this case is designed as drip notches 11e. The drip notches 11e are arranged at substantially constant intervals along the free edge portion 11b. The second guiding surface 11d may have a corresponding design with drip notches 11e at the free end portion 11b. The second member 12 may have a corresponding design with drip formations 11e at the free end portion 12b.

15 During operation of the electrical machine 2, oil is supplied to the annular channel 8. The oil in the annular channel reaches the oil ducts 9 where it is sprayed out towards the stator windings 6b. The oil provides an effective cooling of the stator windings 6b. A part of the oil hitting the stator windings 6b get caught on the stator winding during
20 a period of time. Inevitably, a part of the oil hitting the stator windings will bounce away and hit the inner surface of the side walls 1a, 1b. This part of the oil flows downwardly along the inner surface of the side walls 1a, 1b. The oil hitting the respective side wall 1a, 1b in a position located radially outside of the fixed edge portion 11a, 12a of the guiding members 11, 12 comes in contact with the first surface
25 11c, 12c of the respective guiding members 11, 12 when it flows downwardly along the side walls 1a, 1b. The first surface 11c, 12c leads the oil out from the wall 1a, 1b and in a direction towards the free edge portion 11b, 12b. At the free edge portion 11b, 12b the oil leaves the first guiding surfaces 11c, 12c and enters the recesses 5e, 5g of the rotor 5.

30 Since the free edge portions 11b, 12b are inclined in relation to a horizontal plane, a part of the oil may start to flow downwardly along the free edge portion 11b, 12b. However, this part of the oil will relatively soon reach one of the drip notches 11e which directs the oil out from the free edge portion 11b, 12b and into the recesses 5e,
35 5h of the rotor hub 5b. A vertical plane through a free end of the first protruding portion 5c extends through the first guide member 11. A vertical plane through the free

end of the third protruding portion 5f extends the second guiding member 12. In view of these facts, the oil leaving the free edge portions 11b, 12b of the guiding members 11, 12 will hit a bottom surface of the recesses 5e, 5h or the outer radial surfaces 5c₁, 5f₁ of the protruding portions 5c, 5f. The oil retained on the surfaces of the recesses 5e, 5h obtains a rotating movement by the rotor 5. As a consequence, the oil is pressed radially outwardly by the centrifugal force. The oil reaches the inner radial surfaces 5d₁, 5g₁, which slope radially outwardly towards the free ends of the protruding portions 5d, 5g. The oil leaves the free ends of the protruding portions 5d, 5g in a radially outwardly towards the stator windings 6b.

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However, a part of the oil in the recesses 5e, 5h may fall downwardly into an inner space defined by the guiding members 11, 12. This oil may hit an inner surfaces of the side walls 1a, 1b located between the fixed edge portions 11a, 12a of the guiding members 11, 12. The oil hitting the side walls 1a, 1b flows downwardly and reaches the second guiding surfaces 11d, 12d of the guiding members 11, 12. Alternatively, the oil may hit the second guiding surfaces 11d, 12d directly. The second guiding surfaces 11d, 12d leads the oil towards the free edge portions 11b, 12b. The oil leaves the second guiding surfaces 11d, 12d at the free edge portions 11b, 12b and enters the recesses 5e, 5h of the rotor 5. The oil in the recesses 5e, 5h obtains a rotating movement by the rotor 5. As a consequence, the oil is pressed radially outwardly by the centrifugal force. The oil is directed by the surfaces 5d₁, 5g₁ radially outwardly towards the stator windings 6b. Consequently, also this part of the oil can be used to cool the stator windings 6b.

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25 The invention is in no way limited to the embodiment to which the drawing refers but may be varied freely within the scopes of the claims.

Claims

1. An arrangement for distributing oil in an electrical machine (2), wherein the electrical machine (2) comprises a rotor (5) rotatably arranged around a rotation axis (7), a stator (6) arranged radially outside of the rotor (5), a housing (1) enclosing the rotor (5) and the stator (6), and an oil system supplying oil to the stator windings (6b), wherein the arrangement comprises an annular guiding member (11, 12) comprising a guiding surface (11c, 11d, 12c, 12d) having an extension between a fixed edge portion (11a, 12a) connected to a wall (1a, 1b) of the housing (1) and a free edge portion (11b, 12b) located close to the rotor (5), wherein the fixed edge portion (11a, 12a) of the guiding surface (11c, 12c) is arranged at a higher height than the free edge portion (11b, 12b) of the guiding surface (11c, 12c) such that the guiding surface (11c, 11d, 12c, 12d) leads oil from the wall (1a, 1b) to a part of the rotor (5) located radially inwardly of the stator windings (6b), characterized in that the annular guiding member (11, 12) comprises a first guiding surface (11c, 12c) formed by a radially outer surface of the annular guiding member (11, 12) and a second guiding surface (11d, 12d) formed by a radially inner surface of the annular guiding member (11, 12).
2. An arrangement according to claim 1, characterized in that the free edge portion (11b, 12b) of the guiding surface (11c, 11d, 12c, 12d) comprises drip formations (11e).
3. An arrangement according to any one of the preceding claims, characterized in that said part of the rotor (5) comprises an axially protruding portion (5c, 5f) located radially inwardly of the free edge portion (11b, 12b) of the guiding member (11, 12).
4. An arrangement according to claim 3, characterized in that said axially protruding portion (5c, 5f) has a radially outer surface located at a constant radial distance from the rotational axis (7).
5. An arrangement according to any one of the preceding claims, characterized in that said part of the rotor (5) comprises an axially protruding portion (5d, 5g) located radially outwardly of the free edge portion (11b, 12b) of the guiding member (11, 12).
6. An arrangement according to claim 5, characterized in that said axially protruding portion (5d, 5g) has radially inner surface sloping successively radially outwardly towards an outer end of the axially protruding portion (5c, 5f).

7. An arrangement according to claim 5, characterized in that at least one of the axially protruding portions (5c, 5d, 5f, 5g) has a free end located in a vertical plane extending through the guiding member (11, 12).

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8. An arrangement according to any one of the preceding claims, characterized in that the arrangement comprises two guiding members (11, 12) connected to opposite walls (1a, 1b) of the housing (1).

10 9. An arrangement according to any one of the preceding claims, characterized in that the oil system comprises an annular oil channel (8) arranged radially outside of the stator (5) and outlet ducts (9) supplying oil to the stator windings (6b).

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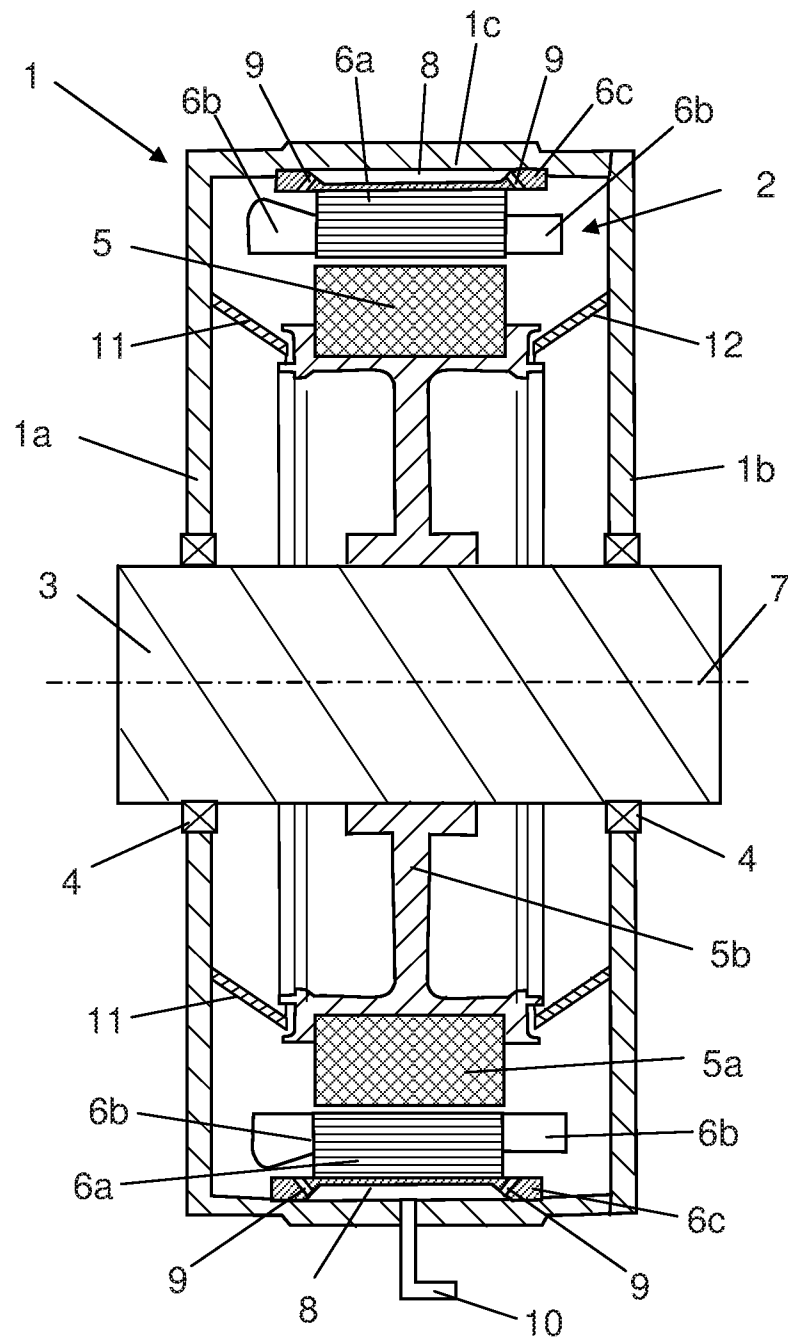


Fig 1

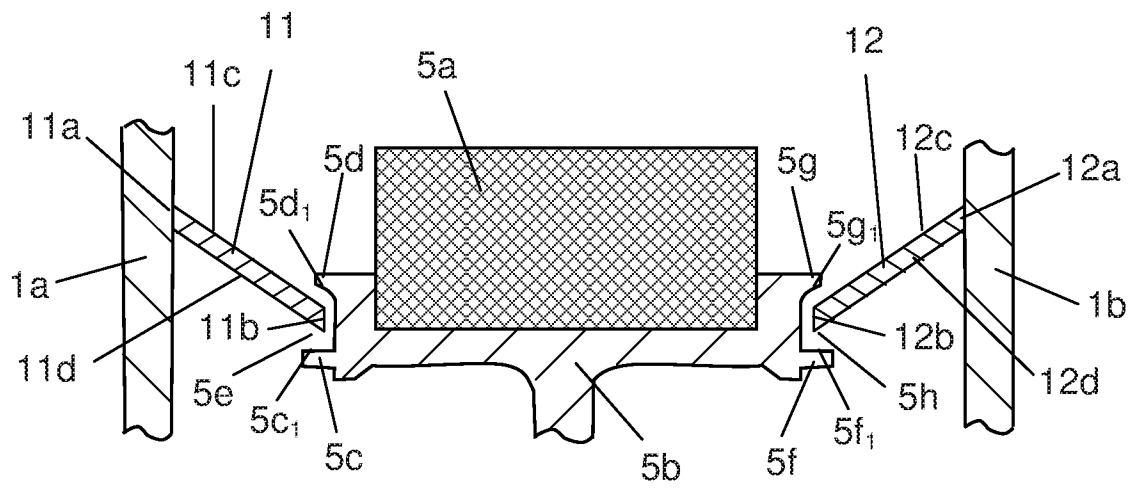


Fig 2

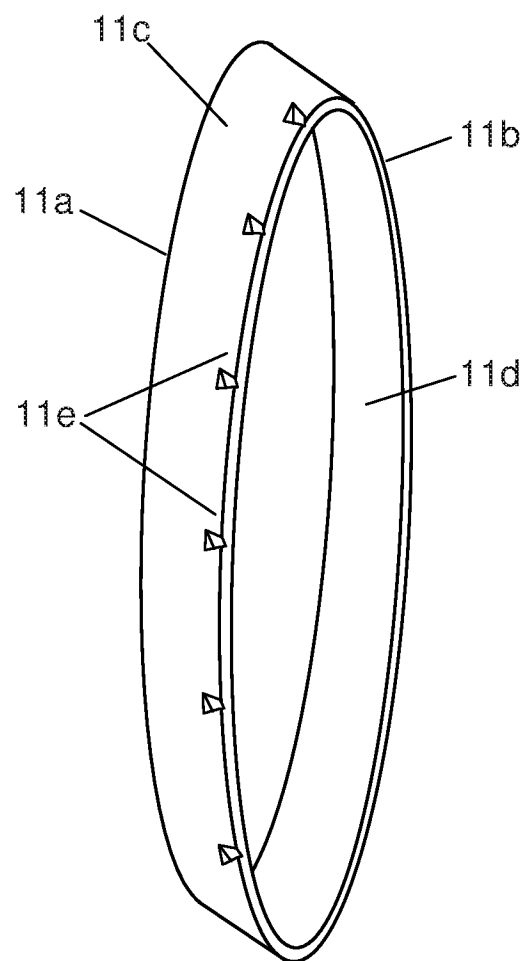


Fig 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050320

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: H02K

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, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20110298318 A1 (BRADFIELD MICHAEL D), 8 December 2011 (2011-12-08); paragraphs [0019]-[0029]; figures 1,3,6,7 --	1-9
A	WO 2012154423 A2 (REMY TECHNOLOGIES LLC ET AL), 15 November 2012 (2012-11-15); paragraphs [0020], [0023], [0025], [0026], [0029], [0030], [0049]; figure 2 --	1-9
A	US 20110298316 A1 (BRADFIELD MICHAEL D), 8 December 2011 (2011-12-08); paragraphs [0027], [0034], [0039]; figure 7B --	1-9



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

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Name and mailing address of the ISA/SE

Patent- och registreringsverket
Box 5055
S-102 42 STOCKHOLM
Facsimile No. + 46 8 666 02 86

Authorized officer

Jonas Holmqvist

Telephone No. + 46 8 782 28 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050320

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Continuation of: second sheet

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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