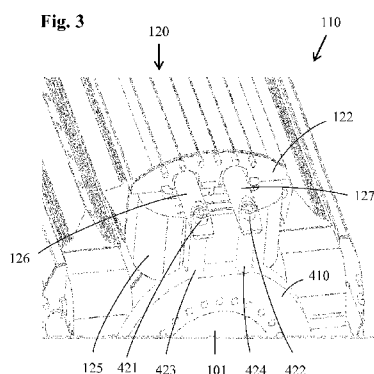
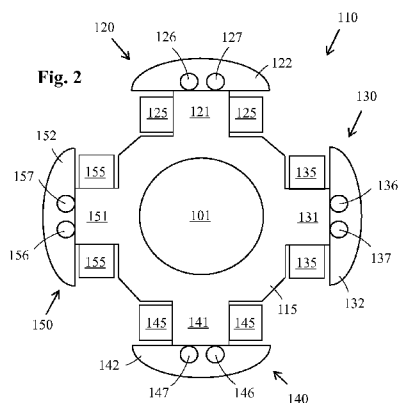




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[Continued on next page]

(54) Title: AN ELECTRIC MACHINE



(57) **Abstract:** An electric machine comprises a rotor being rotatable around a longitudinal centre axis of rotation. The rotor comprises poles (120, 130, 140, 150) distributed at an equal angular distance around a circumference of the rotor. Each pole (120, 130, 140, 150) is formed of a pole body (121, 131, 141, 151) and a pole shoe (122, 132, 142, 152). A rotor winding (125, 135, 145, 155) is wound around each pole body (121, 131, 141, 151). Support beams (126, 127, 136, 137, 146, 147, 156, 157) extend axially through the pole shoe (122, 132, 142, 152) so that each end portion of the support beams (126, 127, 136, 137, 146, 147, 156, 157) extend beyond the axial ends of the pole (120, 130, 140, 150). The support beams (126, 127, 136, 137, 146, 147, 156, 157) support the end portions of the rotor winding (125, 135, 145, 155) in the radial direction against centrifugal forces. The axial outer ends of the support beams (126, 127, 136, 137, 146, 147, 156, 157) are attached with radially extending fastening means (410, 421, 422) based on a compression joint to a shaft (101) of the rotor (100).



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— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

AN ELECTRIC MACHINE

FIELD OF THE INVENTION

The invention relates to an electric machine.

Electric machines i.e. electric motors and electric generators are
5 used in many applications. Electric motors are used to drive different kinds of machines and electric generators are used to produce electric power.

A rotor in an electric machine comprises normally a shaft and poles distributed at an equal angular distance around a circumference of the rotor and extending axially along the rotor. Each pole is formed of a pole body
10 extending radially outwards from the shaft of the rotor and a pole shoe at an outer end of the pole body. The outer curved surface of the pole shoe forms the outer surface of the rotor. A rotor winding is wound around each pole body, the rotor winding comprising two axial straight portions at each side of the pole body and two end portions connecting the axial straight portions at each end of
15 the pole body. Support beams extend axially through the pole shoe so that each end portion of the support beams extend beyond the axial ends of the pole. The support beams keep the pack of sheets in the pole together and support the end portions of the rotor winding in the radial direction against centrifugal forces. The pole body and the pole shoe are formed as one single
20 entity.

The axial end portions of the support beams are subjected to heavy stresses due to centrifugal forces causing the curved end portions of the rotor winding to be pressed against the outer ends of the support beams. The weight of the rotor winding in one pole in a big electric machine can be in the
25 order of several hundred kilograms. The centrifugal forces acting on the ends of the support beams will cause the support beams to bend outwardly. This bending will cause heavy stresses on the support beams at the axial point where the support beams protrude from the pole shoe.

The rotational speed of a big electric machine can be in the order of
30 1500 rpm or more and the diameter of the rotor can be in the order of 0.5 m or more. The centrifugal forces acting on the end portions of the support beams are thus really big.

This means that the support beams have to be manufactured from high strength steel in order to withstand these centrifugal forces. High strength
35 steel is, however, expensive and it is not produced in all parts of the world. It

would be a benefit if steel having lower strength i.e. constructional steel could be used for the support beams.

BRIEF DESCRIPTION OF THE INVENTION

5 An object of the present invention is to achieve an improved electric machine.

The electric machine according to the invention is defined in claim 1.

The electric machine comprises a rotor being rotatable around a longitudinal centre axis of rotation,

10 the rotor comprising axially along the rotor extending poles distributed at an equal angular distance around a circumference of the rotor,

each pole being formed of a radially outwards extending pole body and a pole shoe at an outer end of the pole body, the pole shoe having a curved outer surface forming an outer surface of the rotor,

15 a rotor winding being wound around each pole body, the rotor winding being formed of two axial portions at each side of the pole body and two end portions connecting the axial portions at each axial end of the pole body,

20 support beams extending axially through the pole shoe so that each end portion of the support beams extend beyond the axial (X-X) ends of the pole,

the support beams supporting the end portions of the rotor winding in the radial direction against centrifugal forces.

The electric machine is characterized in that

25 the axial outer ends of the support beams are attached with radially extending fastening means based on a compression joint to a shaft of the rotor.

The use of radially extending fastening means for attaching the axial outer ends of the support beams will reduce the stresses in the support beams considerably compared to a situation where the outer ends of the support beams are free. This inventive arrangement changes the traditional cantilever support beam to a structure supported at both axial ends. This change in structural design will reduce the bending moment and thereby the heavy stresses acting on the support beam. The bending moment acting on the support beam is reduced to about 50% compared to that of a cantilever support beam. The change is naturally depending on the length of the support

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beam, but this reduction of about 50% is achieved in this case when the length of the support beam is in the order of three times the width of the cross section of the support beam. The shear force acting on the support beam is reduced to about 50% compared to that of a cantilever support beam.

5 The support beams in prior art cantilever support arrangements have to be manufactured from high strength steel in order to withstand these high stresses. The inventive arrangement makes it possible to use steel having a lower strength i.e. constructional steel in the support beams.

10 The invention is especially suitable to be used in big electric machines having a shaft height of at least 0.5 m.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

15 Fig. 1 shows a longitudinal cross section of an electric machine,
 Fig. 2 shows a traverse cross section of a rotor of an electric machine,
 Fig. 3 shows an axonometric view of a section of an electric machine according to the invention.

20 DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Fig. 1 shows a longitudinal cross section of an electric machine. The electric machine 300 comprises a longitudinal centre axis X-X, a cylindrical rotor 100 and a cylindrical stator 200 surrounding the rotor 100.

25 The rotor 100 comprises a middle portion 110 provided with a rotor winding (not shown in the figure) and two end portions 102, 103 at each axial X-X end of the middle portion 110. Each end portion 102, 103 of the rotor 100 is rotatably supported on a bearing 104, 105 provided in a bearing house 106, 107, which is supported on a support structure R.

30 The stator 200 comprises a stator core 210 and a stator frame 220 surrounding the stator core 210. The stator frame 220 can be of any construction. The stator core 210 is attached e.g. through welding or through compression joints based on bolts to the stator frame 220 and the stator frame 220 is supported on a support structure R. The stator core 210 is further provided with a stator winding. The figure shows only the winding ends 211A of
35 the stator winding.

There is an air gap G1 between the outer surface of the middle portion 110 of the rotor 100 and the inner surface of the stator core 210.

The electric machine 300 can be an electric motor or an electric generator.

5 Fig. 2 shows a traverse cross section of a rotor of an electric machine. The figure shows the middle portion 110 of the rotor 100 provided with four poles 120, 130, 140, 150 distributed at an equal angular distance around a circumference of the rotor 100 and extending axially X-X along the rotor 100. The shaft 101 passes through the middle portion 110 of the rotor
10 100 and the magnetic core 115 of the rotor 100 is attached to the shaft 101. The poles 120, 130, 140, 150 are part of the magnetic core 115 of the rotor 100.

Each pole 120, 130, 140, 150 is formed of a pole body 121, 131, 141, 151 extending radially outwards from the shaft 101 and a pole shoe 122, 132, 142, 152 at an outer end of the pole body 121, 131, 141, 151. The cross
15 section of the pole shoe 122, 132, 142, 152 has the form of a mushroom cap. The outer curved surface of the pole shoe (122, 132, 142, 152) forms the outer surface of the rotor 100. The pole body 121, 131, 141, 151 and the pole shoe 122, 132, 142, 152 are formed as one single entity together with the magnetic
20 core 115.

A rotor winding 125, 135, 145, 155 is wound around the pole body 121, 131, 141, 151, a lap of the rotor winding 125, 135, 145, 155 is formed of two axial X-X portions at each side of the pole body 121, 131, 141, 151 and two end portions connecting the axial X-X portions at each end of the pole
25 body 121, 131, 141, 151. The rotor winding 125, 135, 145, 155 passes in the axial X-X direction of the rotor 100 along a first side of the pole body 121, 131, 141, 151 and returns back along the opposite second side of the pole body 121, 131, 141, 151. The lower surface of the cup like pole shoe 122, 132, 142, 152 supports the straight portions of the rotor winding 125, 135, 145, 155 in
30 the radial direction against centrifugal forces. The end portions of the rotor winding 125, 135, 145, 155 that passes at the axial X-X end of the pole 120, 130, 140, 150 from one side to the other side of the pole 120, 130, 140, 150 are, however, not supported by the pole shoe 122, 132, 142, 152.

Support beams 126, 127, 136, 137, 146, 147, 156, 157 extend
35 axially X-X through the pole shoe 122, 132, 142, 152 so that each end portion of the support beams 126, 127, 136, 137, 146, 147, 156, 157 extend beyond

the axial X-X ends of the pole 120, 130, 140, 150. The support beams 126, 127, 136, 137, 146, 147, 156, 157 support the curved end portions of the rotor winding 125, 135, 145, 155 in the radial direction against centrifugal forces. The outer ends of the support bars 126, 127, 136, 137, 146, 147, 156, 157 are in prior art solutions free i.e. they are not supported on the rotor 100 in any way.

Each pole 120, 130, 140, 150 is made of sheets, which means that axial support bars passing through the pole 120, 130, 140, 150 are needed in order to keep the package of sheets together. The support beams 126, 127, 136, 137, 146, 147, 156, 157 may be used to hold the package of sheets together. The support beams 126, 127, 136, 137, 146, 147, 156, 157 are in such case attached e.g. by welding from the root to the outermost sheets of the pole 120, 130, 140, 150. Another possibility would be to use a threaded joint and nuts in order to attach the support beams 126, 127, 136, 137, 146, 147, 156, 157 to the outermost sheets of the pole 120, 130, 140, 150.

Fig. 3 shows an axonometric view of a section of an electric machine according to the invention. The section shows one pole 120 of the rotor 100. The outer ends of the support bars 126, 127 are attached with radially extending fastening means 410, 421, 422, 423, 424 to the shaft 110. The fastening means 410, 421, 422 comprises a ring member 410, bushings 423, 424 and fastening bolts 421, 422. The ring member 410 is attached to the shaft 101. Each of the bushings 423, 424 extend radially between an axial X-X outer end of each support beam 126, 127, 136, 137, 146, 147, 156, 157 and an outer perimeter of the ring member 410. Each of the fastening bolts 421, 422 extend radially through the axially X-X outer end of the support beam 126, 127, 136, 137, 146, 147, 156, 157 and further through the bushing 423, 424 to a threaded hole in the ring member 410. Each outer end of each support beam 421, 422 becomes attached to the shaft 101 through the bushing 423, 424 and the fastening bolt 421, 422.

The ring member 410 is advantageously also used as the balancing ring for the rotor of the electric machine. The balancing ring may be provided with holes at the perimeter of the ring. Some of the holes can then be filled with bars in order to balance the rotor of the electric machine.

The cross section of the support beams 126, 127, 136, 137, 146, 147, 156, 157 for the portion being inside the poles 120, 130, 140, 150 and the portion being outside the poles 120, 130, 130, 150 could be the same or

different. The cross section of the support beams 126, 127, 136, 137, 146, 147, 156, 157 is in the figures circular throughout the axial X-X length of the support beams 126, 127, 136, 137, 146, 147, 156, 157. The cross section of the of support beams 126, 127, 136, 137, 146, 147, 156, 157 could be of any
5 form e.g. rectangular or polygonal or elliptical or partly circular or curved with a straight portion.

The fastening means 410, 421, 422, 423, 424 consists in the figure of a ring member 410, radial bushings 423, 424 and radial fastening bolts 421, 422. The axial outer ends of the support beams 126, 127, 136, 137, 146, 147, 156, 157 could instead be attached with radial fastening bolts 421, 422 passing
10 directly to the middle portion 110 of the rotor 100. Bushings 423, 424 might not be necessary in such a case.

It is advantageous to use radial fastening bolts 421, 422 instead of axial fastening bolts. The ring member 410 can be made smaller when radial bolts 421, 422 are used. Radial bolts 421, 422 can withstand greater radial
15 forces compared to axial bolts.

Figure 2 shows four poles 120, 130, 140, 150, but the electric machine could naturally have any number of poles. The poles 120, 130, 140, 150 are formed as an integral part of the magnetic core 115 of the rotor 100.
20 The shaft 101, 102, 103 is formed of a middle portion 101 passing within the middle portion 110 of the rotor and of the end portions 102, 103 at opposite ends of the middle portion 101 of the shaft. The magnetic core 115 is attached to the middle portion 101 of the shaft 101, 102, 103.

The salient rotor 100 could be of any type i.e. the invention is not
25 limited to the salient rotor 100 shown in the figures.

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

CLAIMS

1. An electric machine comprising a rotor (100) being rotatable around a longitudinal centre axis (X-X) of rotation,

the rotor (100) comprising axially (X-X) along the rotor (100) extending poles (120, 130, 140, 150) distributed at an equal angular distance around a circumference of the rotor (100),

each pole (120, 130, 140, 150) being formed of a radially outwards extending pole body (121, 131, 141, 151) and a pole shoe (122, 132, 142, 152) at an outer end of the pole body (121, 131, 141, 151), the pole shoe (122, 132, 142, 152) having a curved outer surface forming an outer surface of the rotor (100),

a rotor winding (125, 135, 145, 155) being wound around each pole body (121, 131, 141, 151), the rotor winding (125, 135, 145, 155) being formed of two axial (X-X) portions at each side of the pole body (121, 131, 141, 151) and two end portions connecting the axial (X-X) portions at each axial (X-X) end of the pole body (121, 131, 141, 151),

support beams (126, 127, 136, 137, 146, 147, 156, 157) extending axially (X-X) through the pole shoe (122, 132, 142, 152) so that each end portion of the support beams (126, 127, 136, 137, 146, 147, 156, 157) extend beyond the axial (X-X) ends of the pole (120, 130, 140, 150),

the support beams (126, 127, 136, 137, 146, 147, 156, 157) supporting the end portions of the rotor winding (125, 135, 145, 155) in the radial direction against centrifugal forces,

characterized in that

the axial outer ends of the support beams (126, 127, 136, 137, 146, 147, 156, 157) are attached with radially extending fastening means (410, 421, 422) based on a compression joint to a shaft (101, 102, 103) of the rotor (100).

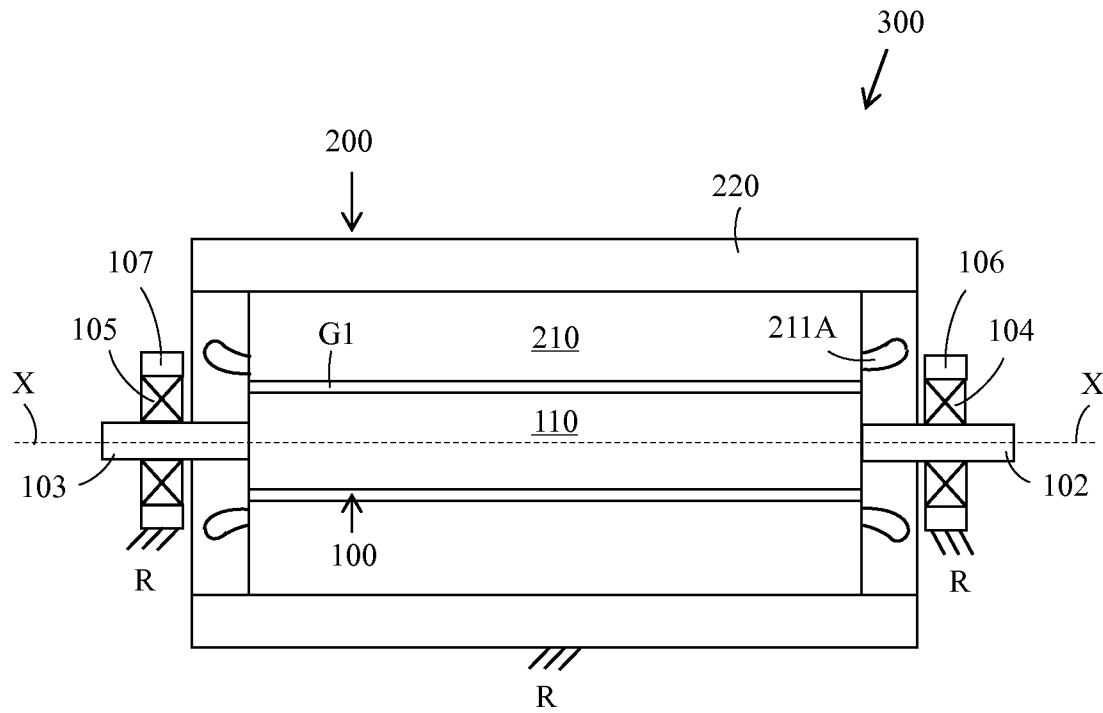
2. An electric machine according to claim 1, **characterized** in that the fastening means (410, 421, 422) comprises a ring member (410) attached to the shaft (101, 102, 103), a bushing (423, 424) extending radially between each axial (X-X) outer end of each support beam (126, 127, 136, 137, 146, 147, 156, 157) and an outer perimeter of the ring member (410), a fastening bolt (421, 422) extending radially through the axially (X-X) outer end of each support beam (126, 127, 136, 137, 146, 147, 156, 157) and further through the bushing (423, 424) to threaded holes in the ring member (410), whereby the

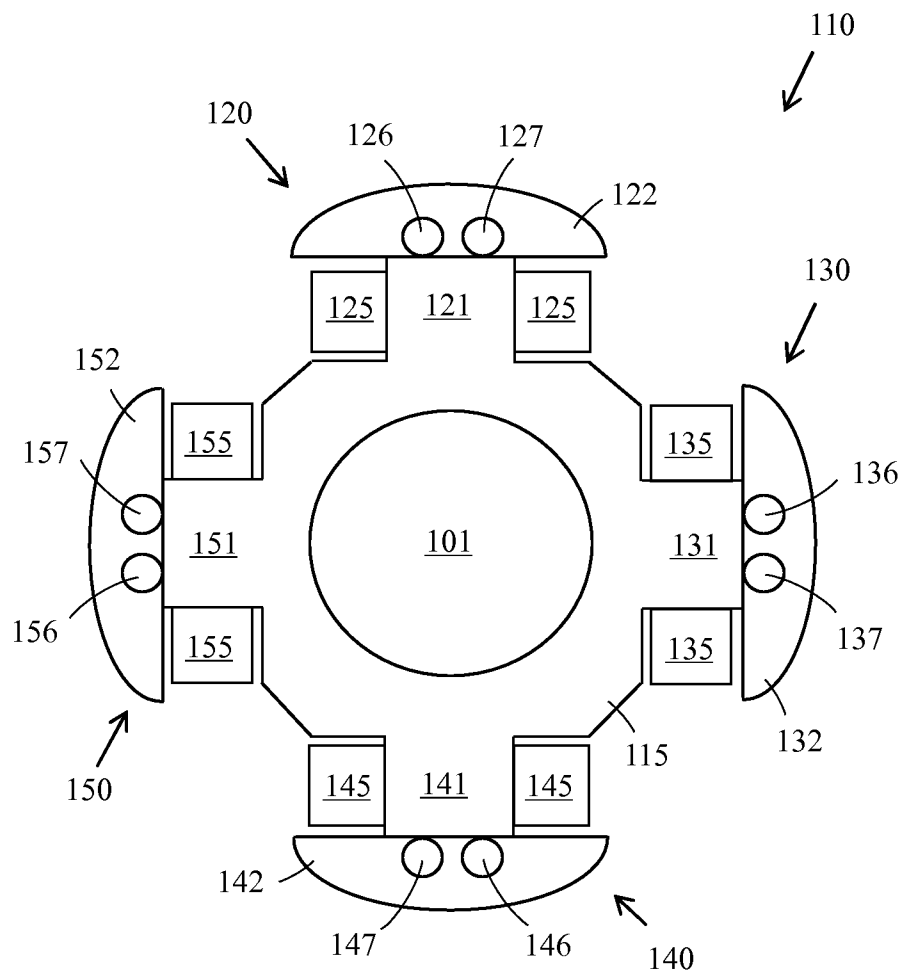
outer ends of the support beams (421, 422) become attached through the fastening bolts (421, 422) to the shaft (101, 102, 103) of the rotor (100).

3. An electric machine according to claim 1 or 2, **characterized** in that the ring member (410) is the balancing ring of the electric machine.

5 4. An electric machine according to any of claims 1 to 3, **characterized** in that the electric machine has a shaft height of at least 0.5 m.

5. An electric machine according to any of claims 1 to 4, **characterized** in that the support beams (126, 127, 136, 137, 146, 147, 156, 157) are made from constructional steel.

**Fig. 1**

**Fig. 2**

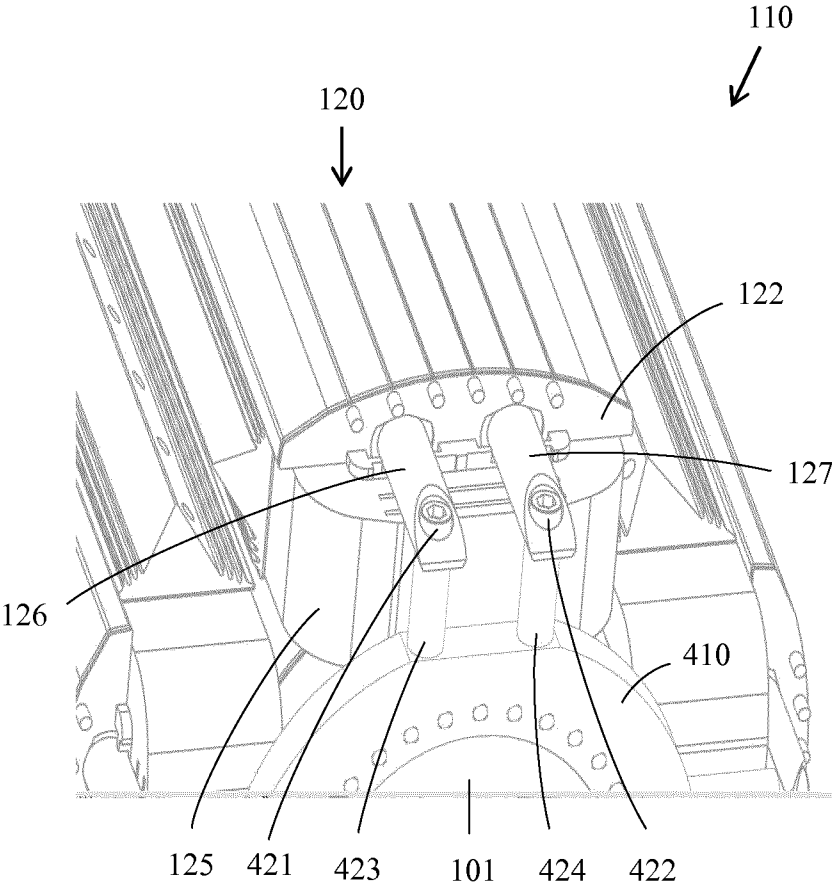


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/069476

A. CLASSIFICATION OF SUBJECT MATTER
INV. H02K3/52
ADD. H02K1/24

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)
H02K

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 practicable, 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 2005 318709 A (NISHISHIBA DENKI KK) 10 November 2005 (2005-11-10)	1,4,5
Y	Paragraphs 2, 6, 10, 13, 20-22; figures 1,4	2,3
Y	----- DE 10 2007 008771 A1 (SIEMENS AG [DE]) 28 August 2008 (2008-08-28) Paragraph 39; figure 7 -----	2,3



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

"E" earlier application or patent but published on or after the international filing date

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"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

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/069476

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2005318709 A	10-11-2005	NONE	
DE 102007008771 A1	28-08-2008	NONE	