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(54) Title: A STATOR AND BUSBAR ASSEMBLY FOR AN ELECTRIC SUPERCHARGER

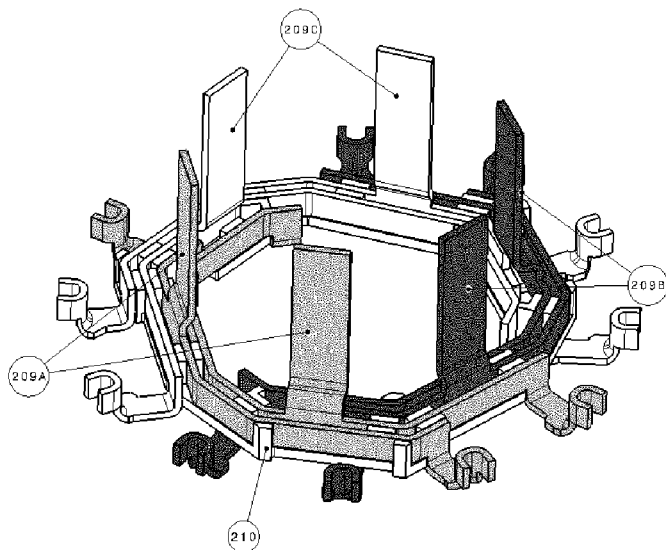


Figure 3b

(57) Abstract: An electric supercharger comprises a switched reluctance motor. The motor includes a stator assembly (201) comprising a plurality of pairs of windings (203A-C), each pair of windings (203A-C) comprising a first winding for forming a first pole and a second winding for forming a second, opposite, pole, each winding having an input termination (205) and an output termination (207). The stator assembly further comprises a plurality of pairs of busbars (209A-C), each pair of busbars being associated with a respective pair of windings (203A-C). Each pair of busbars (209A-C) comprises an input busbar (211) connecting the input terminations (205) of the first and second windings in the respective pair of windings, and an output busbar (213) connecting the output terminations (207) of the first and second windings in the respective pair of windings (203A).



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A STATOR AND BUSBAR ASSEMBLY FOR AN ELECTRIC SUPERCHARGERTechnical Field

5 The present invention relates to an electric supercharger, and particularly an electric supercharger comprising a switched reluctance motor having a stator assembly.

Background of the Invention

10 Figures 1a and 1b show a previously suggested stator assembly for an electric supercharger.

 The electric supercharger (not shown) comprises a switched reluctance motor. The stator assembly 1 of the motor
15 has six windings 3 arranged in three pairs (each pair comprising two windings 3A, 3B, 3C opposite one another for forming opposing poles). Each winding 3 is a coil of wire that is wrapped around a metallic core. Each winding 3 has an input termination 5 and an output termination 7 associated
20 with it. These terminations are connectable to an energising source (not shown in Figure 1a). In the stator assembly of Figures 1a and 1b, the terminations 5, 7 extend directly above each respective winding 3. The terminations 5, 7 are therefore arranged in a ring (formed of twelve terminations,
25 in sequential pairs of input terminations 5 and output terminations 7 above each respective winding 3).

 To control the energising of the windings, the stator assembly comprises a control module (indicated in general terms by reference numeral 9 and shown in Figure 1b). The
30 control module 9 includes a microprocessor (not shown) for determining and controlling the sequence of energising the windings 3, three power control modules 11A, 11B, 11C each being arranged to supply power to one of the pairs of windings

3A, 3B, 3C, and tracking 13 to connect each pair of windings 3A, 3B, 3C, to a respective power control module 11A, 11B, 11C. For the sake of clarity, only elements relating to one pair of windings 3B are shown in Figure 1b (with the exception
5 of all three power control modules 11A-C).

The tracking 13 (shown only in simplified form in Figure 1b) is formed of three PCB layers stacked above one another, each layer being associated with a respective pair of windings 3A-C. Each layer has a first track 15 connecting together the
10 input terminations 5 of a pair of windings, a second track 17 connecting together the output terminations 7 of the same pair of windings, and additional tracks 19 linking the I/O terminals of the respective power module 11A-C with the first and second tracks 15, 17.

15 Such a tracking arrangement is complex and may therefore add cost to the control module. Furthermore, the tiered tracking results multiple layers of PCB and therefore in a relatively thick control module which can be undesirable from a cost perspective and/or from the perspective of the PCB's
20 interaction with surrounding components of the supercharger.

An arrangement that seeks to address the above-mentioned problems is shown in Figure 2 and described in GB2510382 and WO 2014/118557. In that arrangement, the terminations of each pair of windings 103A-C are arranged such that the input
25 terminations 105 for the first and second windings are located adjacent one another and the output terminations 107 of the first and second windings are also located adjacent one another (within each pair of windings, the winding for forming one pole is indicated by the light-coloured wires, and the
30 winding for forming the opposing pole is indicated by dark-coloured wires). By arranging the input terminations for the first and second windings adjacent one another and the output terminations of the first and second windings adjacent one

another, the need for complex layers of tracking is removed. However, the arrangement in Figure 2 has been found to be difficult to efficiently manufacture/assemble. For example, locating and arranging the pairs of terminations in the suggested manner can be complex and has been found not to be well-suited to mass-production. Furthermore, the proximity of the wires of each of the windings, around the perimeter of the stator, may increase the risk of arcing or of other undesirable electrical contact between wires.

The present invention seeks to remove or mitigate at least some of the above-mentioned drawbacks.

Summary of the Invention

According to a first aspect of the invention there is provided an electric supercharger according to CLAIM 1. Providing the pair of busbars associated with each pair of windings, has been found to facilitate relatively easy assembly of the switched reluctance motor, whilst still avoiding the need for complex layers of tracking to connect to a control module.

The input termination is the termination through which current is arranged to flow into the winding. The output termination is the termination through which current is arranged to flow out of the winding. For example there may be a voltage drop from the input termination to the output termination. The input and output terminations may be positive and negative terminations.

The first pole may be a south pole and the second pole may be a north pole (or vice versa). It will be appreciated that the pole formed by each winding is dependent on the direction of the winding and/or the direction of the current flow through the winding.

In principle, the first and second windings could be in any number of different relative positions. However, in more preferable embodiments of the invention, the first and second windings are located opposite one another.

5 The pairs of busbars are preferably substantially identical in shape. Such an arrangement is beneficial from the point of view of the manufacturing/assembly process. The pairs of busbars are preferably substantially identical in their electrical properties. This has been found to be beneficial
10 because it reduces the risk of electrical mis-match between pairs of busbars and simplifies the control of the switched reluctance motor (SRM). The pairs of busbars may be substantially identical (in both shape and in electrical properties).

15 Within each pair of busbars, the input busbar may be different from the output busbar. For example the input and output busbars may be different lengths.

 The stator assembly preferably has a longitudinal axis. The longitudinal axis is typically the axis of rotation of the
20 rotor associated with the stator assembly. The pairs of busbars may be rotationally symmetrical about the longitudinal axis of the stator assembly. Having a rotationally symmetrical arrangement has been found to be beneficial because it simplifies the manufacturing/assembly process
25 (especially for mass-production). The pairs of busbars may have rotational symmetry of order $360/n$ (where n = the number of pairs of windings). For example for a 3-phase motor (having three pairs of windings) the pairs of busbars have rotational symmetry of order 120 degrees.

30 Each input busbar may comprise a tab for forming an electrical connector. Each output busbar may comprise a tab for forming an electrical connector. The tabs may be upwardly extending for providing an electrical connection above the

stator assembly. The tabs are preferably equally spaced around the perimeter of the stator assembly. Such an arrangement has been found to be beneficial from a manufacturing perspective and also provides a simple arrangement for connection to other parts of the SRM (for example to a control module for selectively energising each of the pairs of windings in the stator assembly).

The stator assembly may further comprise a busbar housing. The busbar housing may be arranged to house the plurality of pairs of busbars such that the busbars are electrically insulated from one another. The busbar housing may comprise a series of insulated guide tracks, each guide track being arranged to receive and locate one of the busbars.

Each busbar preferably extends in a substantially circumferential direction to connect the terminations of the respective winding.

The motor is a switched reluctance motor (SRM). The motor may include a control module for controlling the energising of each of the pairs of windings in the stator assembly. For example the control module may selectively energise the pairs of windings to generate a changing, and preferably a rotating, magnetic field. The control module may be arranged to selectively energise more than one pair of windings at any one time. The control module may comprise a plurality of power modules, each power module being arranged to power one of the pairs of windings. The waveform of the signal received by each pair of windings may be the same. The signals received by each pair of windings may be at least partially out of phase with one another.

Each winding is preferably in the form of a coil of wire. The winding may be wrapped around a core.

The windings are preferably arranged in a circle. The windings may be arranged with the first and the second

windings in each pair being diametrically opposite one another.

The input and output terminations for each winding may be on the end of respective input and output wires to/from the winding. The input and output terminations of each winding are preferably located adjacent that winding (for example directly above the winding). The input and output wires of each winding preferably do not extend in a substantially circumferential direction such that the termination is circumferentially remote from its respective winding.

The input terminations for the first and second windings may be located substantially opposite one another. The output terminations for the first and second windings may be located substantially opposite one another.

The terminations may be positioned radially inwardly of the windings.

The stator assembly may comprise a multiplicity of pairs of windings. The stator assembly may comprise three pairs of windings.

According to another aspect of the invention, there is provided a stator assembly for use in an electric supercharger. The stator assembly may be arranged in accordance with CLAIM 13.

According to another aspect of the invention, there is provided a busbar assembly for use in an electric supercharger. The busbar assembly may be arranged in accordance with CLAIM 14.

According to another aspect of the invention, there is provided an internal combustion engine in combination with the electric supercharger as described herein with reference to the first aspect of the invention.

Any features described with reference to one aspect of the invention are equally applicable to any other aspect of the

invention, and vice versa. For example, any features described with reference to the electric supercharger of the first aspect of the invention are equally applicable to the stator assembly of the second aspect of the invention.

5

Description of the Drawings

Various embodiments of the invention will now be described, by way of example only, with reference to the accompanying schematic drawings of which:

10

Figure 1a is a partially exploded perspective view of a previously suggested stator assembly in an electric supercharger;

15

Figure 1b is a schematic plan view of the stator assembly of Figure 1a, also showing a control module;

Figure 2 is a perspective view of a stator assembly in another previously suggested arrangement;

20

Figure 3a shows a partially-exploded view of a stator assembly in an electric supercharger according to a first embodiment of the invention;

Figure 3b shows a perspective view of the pairs of busbars of Figure 3a;

25

Figure 4 is a partially-exploded view of the stator assembly of Figure 3a but with only one pair of busbars shown;

Figure 5 shows the pair of busbars of Figure 4 in isolation;

Figure 6 shows part of stator assembly of Figure 3, but with an upper part of a busbar housing installed.

30

Detailed Description

Figures 1a and 1b show a previously suggested stator assembly in an electric supercharger (not shown). As explained above, the stator assembly comprises a control module including tracking 13 to connect each pair of windings 3A, 3B, 3C, to a respective power control module 11A, 11B, 11C. The tracking 13 (shown in simplified form in Figure 1b) is formed of three PCB layers stacked above one another, each layer being associated with a pair of windings 3A-C. Such a tracking arrangement is complex and may therefore add cost to the stator assembly. Furthermore, the tiered tracking results in a relatively thick PCB which can be undesirable from a cost perspective and/or the PCB's interaction with surrounding components of the supercharger.

Figure 2 shows another previously suggested stator assembly. The stator assembly 101 comprises six windings 103 arranged in a circle. The windings 103 can be divided into pairs of diametrically opposite windings 103A-C, each winding 103 in the pair being arranged to form an opposite pole to the other when energised by a control module. Within each pair of windings, the winding for forming one pole is indicated by the light-coloured wires, and the winding for forming the opposing pole is indicated by dark-coloured wires.

By arranging the input terminations for the first and second windings adjacent one another and the output terminations of the first and second windings adjacent one another, the need for complex layers of tracking is removed (and this has therefore been found to be an improvement over the arrangement in Figures 1a and 1b). However, the arrangement in Figure 2 has been found to be difficult to efficiently manufacture/assemble. For example, locating and arranging the pairs of terminations in the suggested manner can be complex and has been found not to be well-suited to mass-production. Furthermore, the proximity of the wires of

each of the windings, around the perimeter of the stator, may increase the risk of arcing or of other undesirable electrical contact between wires.

Reference will now be made to Figures 3a to 6, which show
5 a stator assembly in an electric supercharger according to a first embodiment of the invention.

Figure 3a is a partially-exploded view of a stator
assembly in an electric supercharger according to a first
embodiment of the invention. The stator assembly comprises a
10 three pairs of windings 203A-203C arranged in a circle. Each
winding has an input termination 205 and an output termination
207 (only those on winding 203A are labelled in Figures 3a for
clarity). The windings in each pair are on diametrically
opposite sides of the circle and are connected in parallel
15 such that the windings form opposite poles.

The stator assembly is part of a switched reluctance motor
(SRM) (not shown) and is arranged such that the pairs of
windings can be selectively energised by a control module (not
shown), to create a rotating magnetic field. The control
20 module comprises a plurality of power modules (not shown),
each power module being arranged to supply power to one of the
pairs of windings.

These features of the stator assembly are known *per se* (in
this respect the assembly is substantially similar to the
25 arrangement shown in Figure 1a). In contrast to known stator
assemblies however, the first embodiment of the invention also
comprises three pairs of busbars 209A-209C, to which reference
will now be made:

The pairs of busbars 209A-C are located in a busbar housing
30 210 located above the windings. Each pair of busbars 209A-C
is associated with a respective pair of windings 103A-c. In
Figures 3a and 3b the different pairs 209A-C are highlighted

by the shading on each pair (209A having light shading, 209B having dark shading, and 209C having no shading).

Each pair of the pairs of busbars is identical, so for the sake of clarity, reference is now made to Figures 4 and 5, which show only one of the busbar pairs 209A. The pair of busbars 209A comprises an input busbar 211 and an output busbar 213. The busbars 211, 213 are shaped to extend around the circumference of the stator assembly and are electrically isolated from one another by the busbar housing 210.

The input busbar 211 connects the input terminations 205 of the two windings in the associated pair of windings 203A, whereas the output busbar 213 connects the output terminations 207 of the two windings in the pair of windings 203A. The connection to the winding terminations is made by crimping and welding the U-shaped connectors 212 on the busbar around the respective termination. Each busbar includes an upwardly extending tab 215 that acts as an electrical connector.

The connector tabs 215 are arranged to be connected to a control module (not shown) for selectively energising the coils. It will be appreciated that by connecting the control module across the two connector tabs 215, the pair of windings 203A are electrically connected in parallel.

The first embodiment of the invention has been found to have several advantages: Firstly, providing busbars to connect the pairs of windings has been found to facilitate relatively easy assembly of the stator assembly (and the switched reluctance motor more generally) as well as avoiding the need for complex layers of tracking to connect to a control module. Secondly, providing identical pairs of busbars is beneficial from the point of view of the manufacturing/assembly process and reduces the risk of electrical mis-match between pairs of busbars. Thirdly, in the first embodiment of the invention the pairs of busbars

have a rotational symmetry of order 120 degrees about the longitudinal axis of the stator assembly (in other words, if the busbars were rotated 120 degrees about this axis, they would look identical). This has also been found to be
5 beneficial because it simplifies the manufacturing/assembly process (especially for mass-production).

Figure 6 shows a busbar assembly for use in the stator assembly of Figures 3a-5. The busbar assembly includes an electrically-insulating upper housing 217 that protects the
10 pairs of busbars. The upper housing includes slots through which the connector tabs 215 protrude and attachment feet 219 for connection to a lower part of the stator assembly.

Whilst the present invention has been described and illustrated with reference to particular embodiments, it will
15 be appreciated by those of ordinary skill in the art that the invention lends itself to many different variations not specifically illustrated herein. Where in the foregoing description, integers or elements are mentioned which have known, obvious or foreseeable equivalents, then such
20 equivalents are herein incorporated as if individually set forth. Reference should be made to the claims for determining the true scope of the present invention, which should be construed so as to encompass any such equivalents. It will also be appreciated by the reader that integers or features of
25 the invention that are described as preferable, advantageous, convenient or the like are optional and do not limit the scope of the independent claims.

Claims

1. An electric supercharger comprising a switched reluctance motor, the switched reluctance motor including

5 a stator assembly comprising a plurality of pairs of windings,

each pair of windings comprising a first winding, for forming a first pole, connected in parallel with a second winding, for forming a second, opposite, pole,

10 each winding having an input termination and an output termination,

characterised in that the stator assembly further comprises a plurality of pairs of busbars, each pair of busbars being associated with a respective pair of windings, and each pair
15 of busbars comprising:

an input busbar connecting the input terminations of the first and second windings in the respective pair of windings, and an output busbar connecting the output terminations of the first and second windings in the respective pair of windings.

20 2. A supercharger according to claim 1, wherein the pairs of busbars are substantially identical.

3. A supercharger according to claim 2, wherein the pairs of
25 busbars are rotationally symmetrical about the longitudinal axis of the stator assembly.

4. A supercharger according to any preceding claim, wherein each input busbar and each output busbar comprises a tab for
30 forming an electrical connection.

5. A supercharger according to claim 4 wherein the tabs are upwardly extending for providing an electrical connection above the stator assembly.

5 6. A supercharger according claim 4 or claim 5, wherein the tabs are equally spaced around the perimeter of the stator assembly.

7. A supercharger according any preceding claim, wherein each
10 busbar extends in a substantially circumferential direction to connect the terminations of the respective winding.

8. A supercharger according to any preceding claim, wherein the windings are arranged with the first and the second
15 windings in each pair being diametrically opposite one another.

9. A supercharger according to any preceding claim, wherein the input and output terminations of each winding are located
20 adjacent that winding.

10. A supercharger according to claim 9 when dependent on claim 8, wherein the input terminations for the first and second windings are located substantially opposite one another, and
25 the output terminations for the first and second windings are located substantially opposite one another.

11. A supercharger according to any preceding claim wherein the motor includes a control module for selectively energising
30 each of the pairs of windings in the stator assembly.

12. A supercharger according to claim 11, wherein the control module comprises a plurality of power modules, each power

module being arranged to supply power to one of the pairs of windings.

13. A stator assembly for use in a switched reluctance motor in an electric supercharger, the stator assembly comprising a plurality of pairs of windings,

each pair of windings comprising a first winding, for forming a first pole, connected in parallel with a second winding, for forming a second, opposite, pole,

each winding having an input termination and an output termination,

characterised in that the stator assembly further comprises a plurality of pairs of busbars, each pair of busbars being associated with a respective pair of windings, and each pair of busbars comprising:

an input busbar connecting the input terminations of the first and second windings in the respective pair of windings, and an output busbar connecting the output terminations of the first and second windings in the respective pair of windings.

14. A busbar assembly for use in the supercharger of claims 1 to 12, the busbar assembly comprising a plurality of pairs of busbars, each pair of busbars being arranged to be associated with a respective pair of windings, and each pair of busbars comprising:

an input busbar for connecting the input terminations of the first and second windings in the respective pair of windings, and an output busbar for connecting the output terminations of the first and second windings in the respective pair of windings.

15. An electric supercharger, stator assembly and busbar assembly as described herein with reference to Figures 3 to 6.

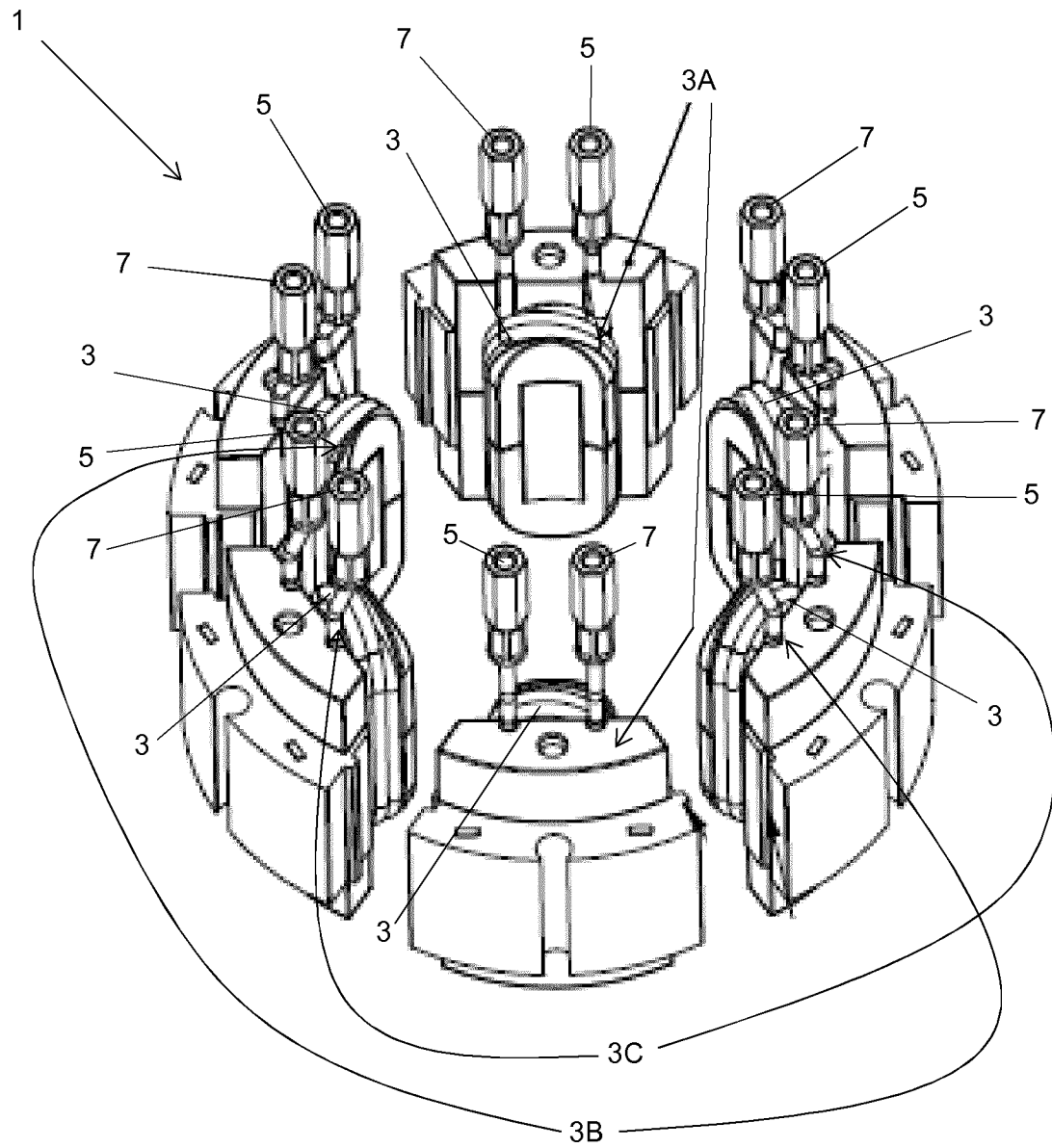


Figure 1a
(Prior art)

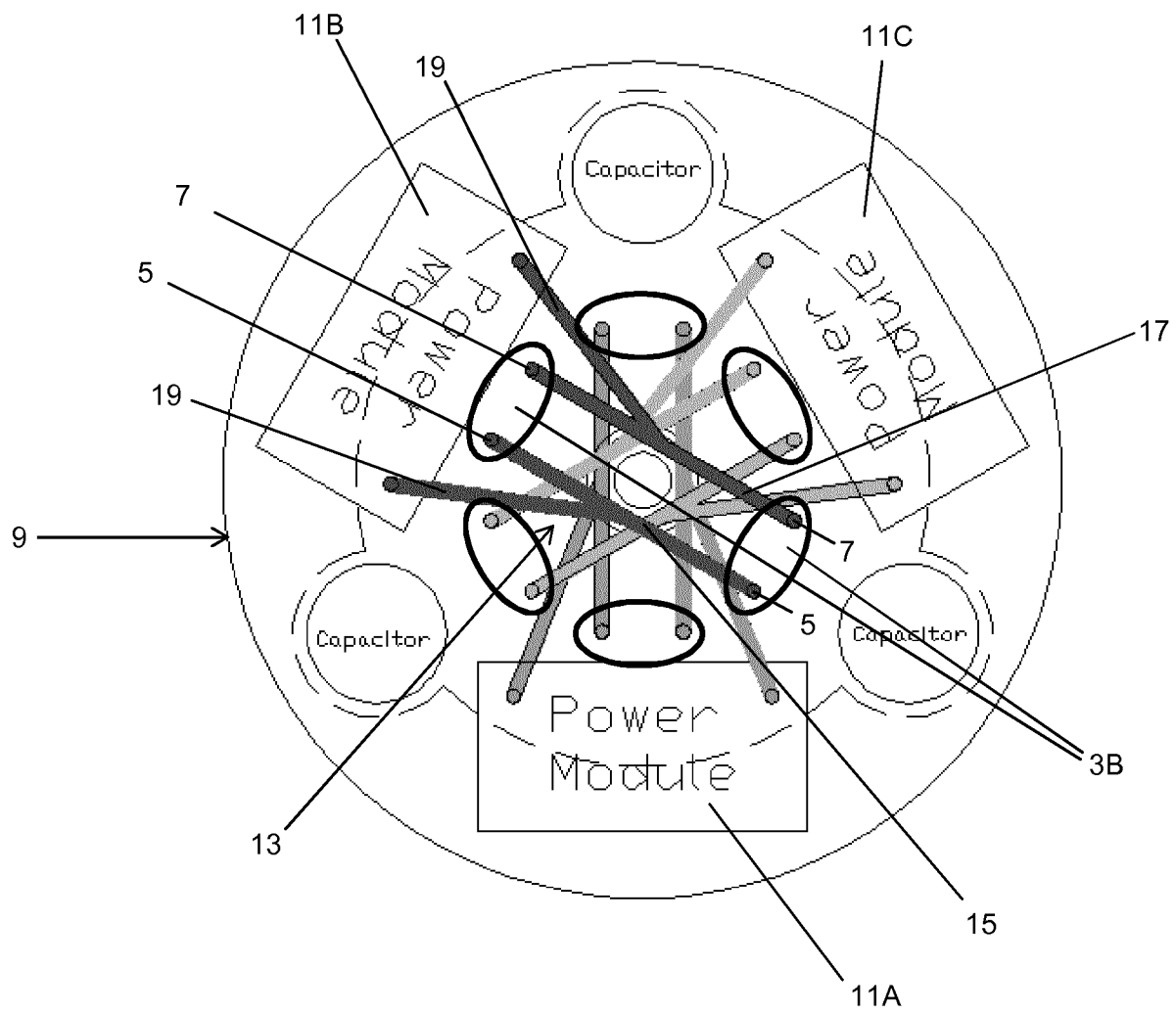


Figure 1b
(Prior art)

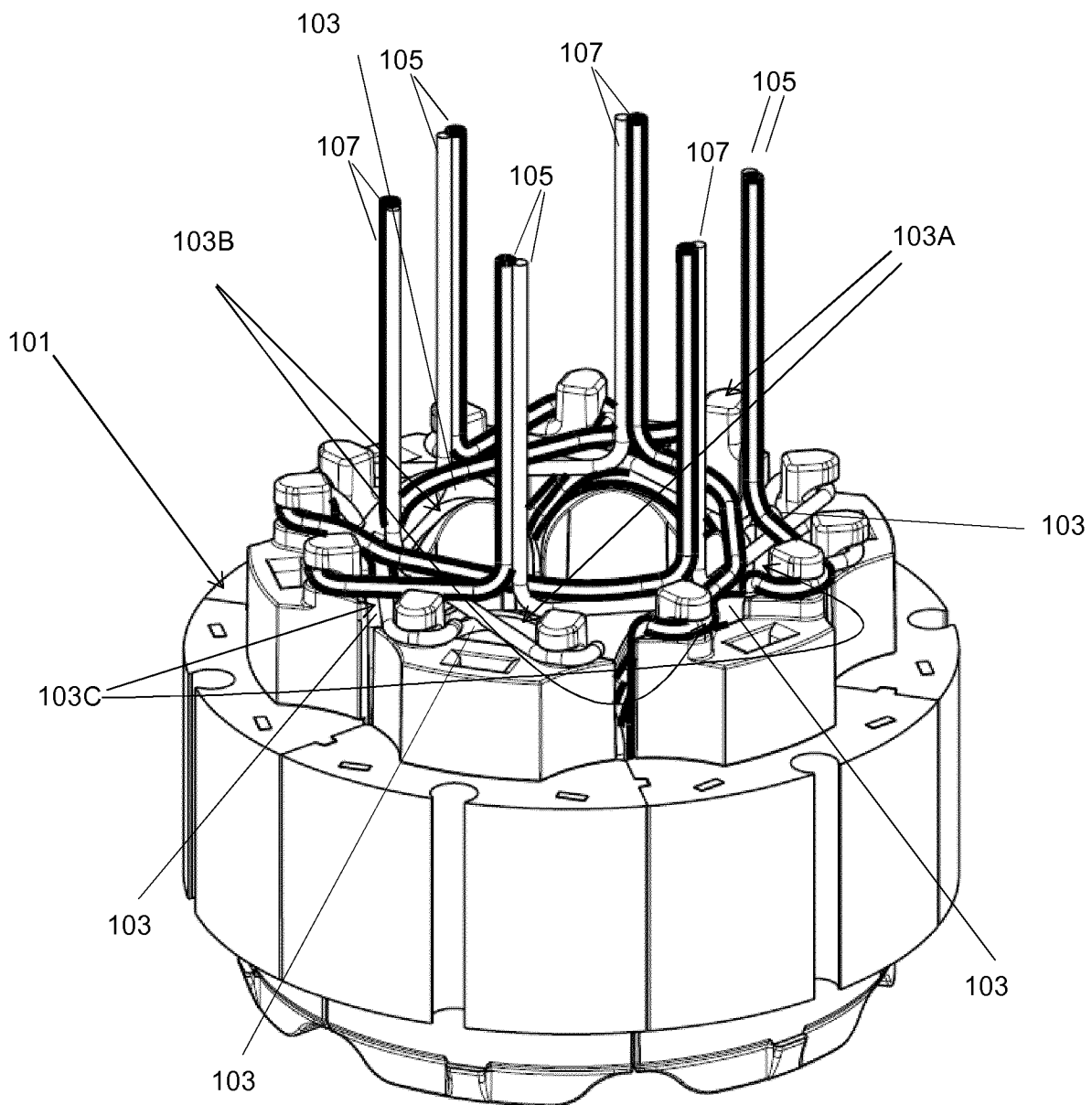


Figure 2
(Prior art)

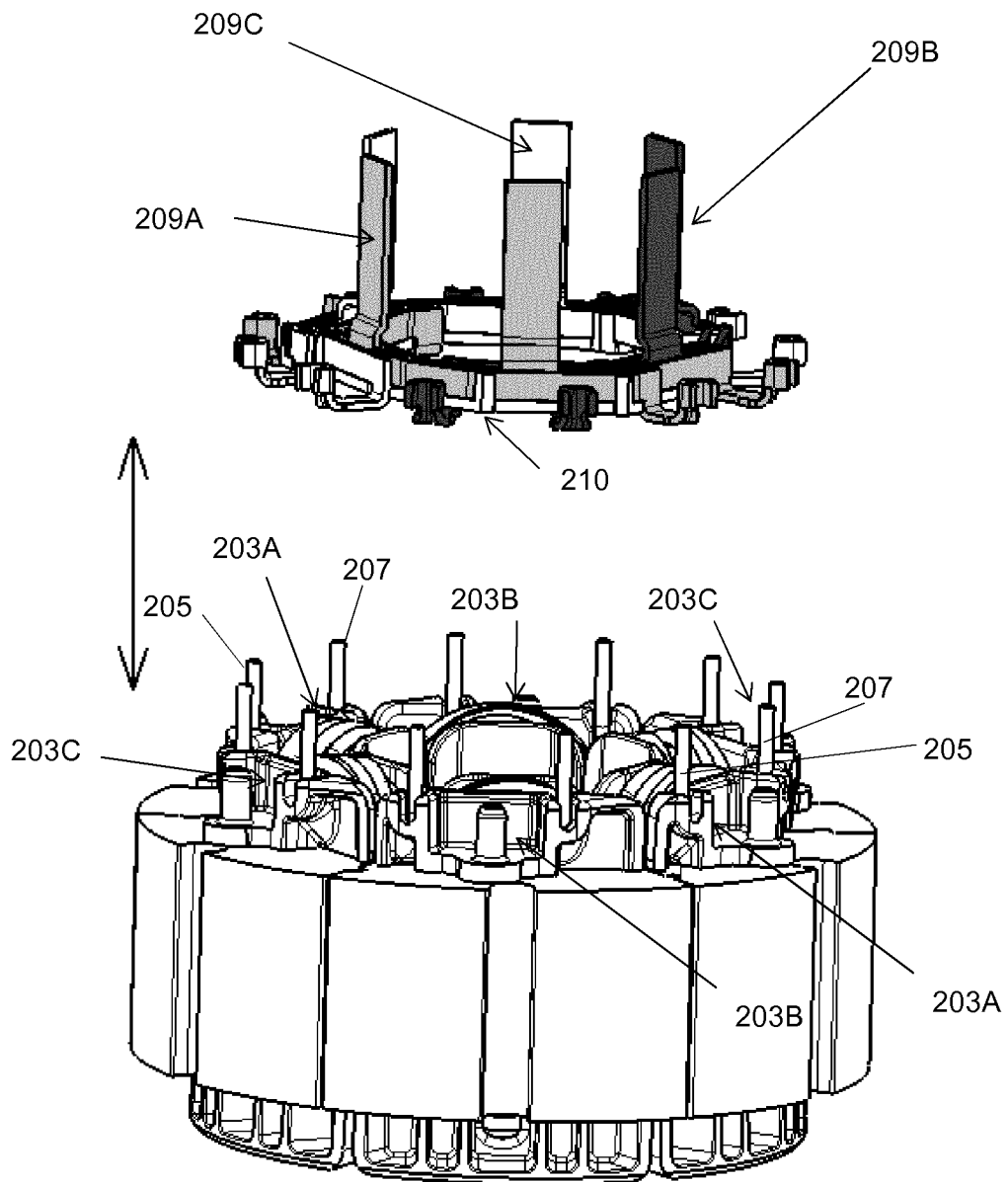


Figure 3a

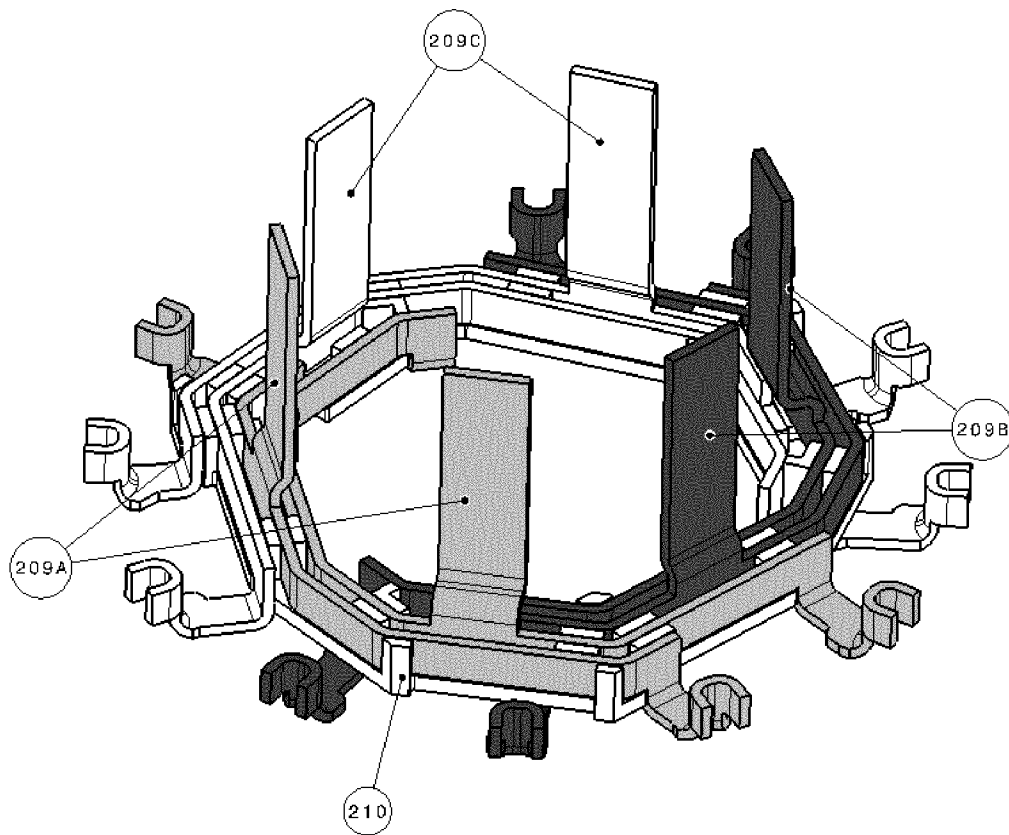


Figure 3b

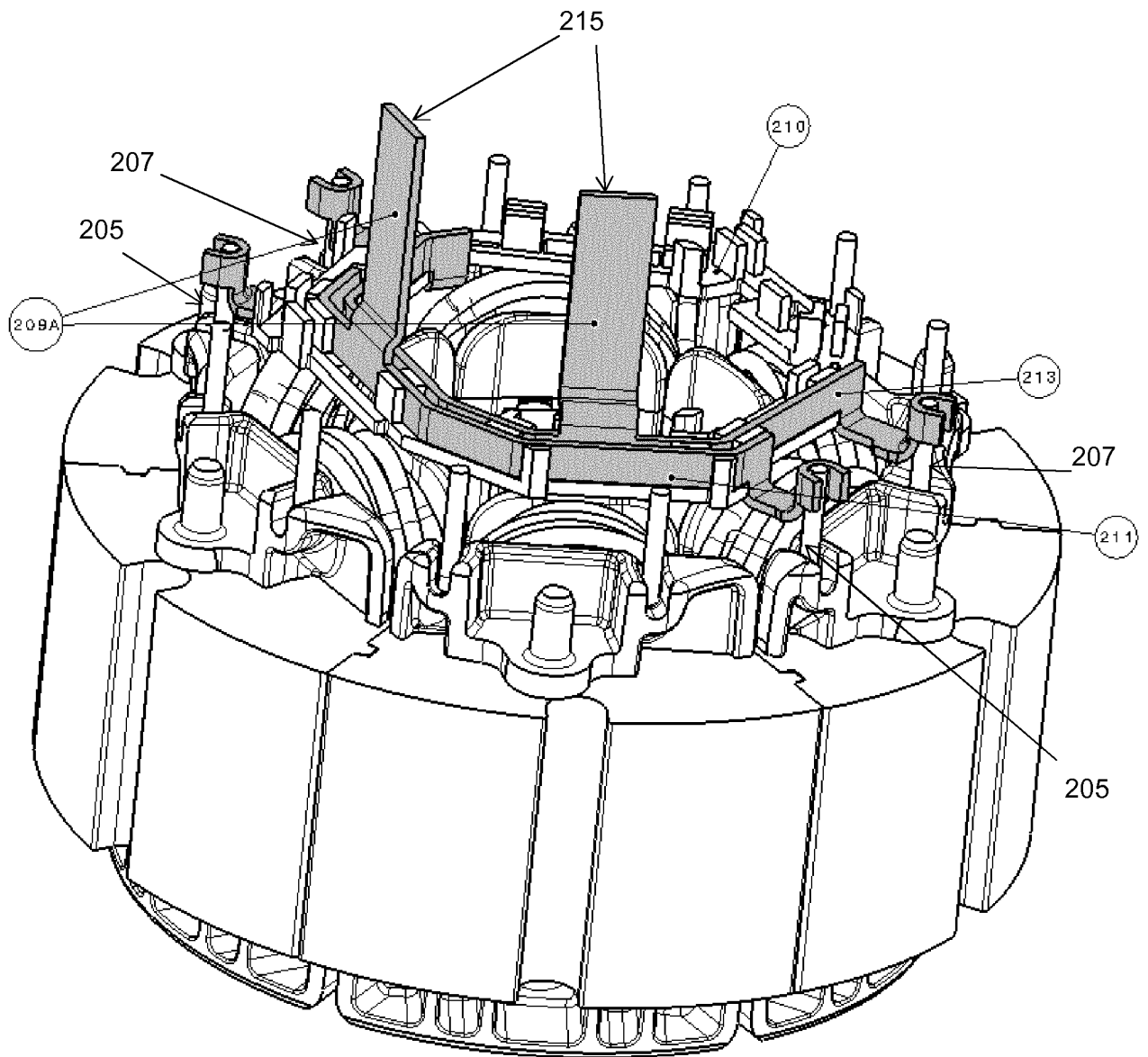


Figure 4

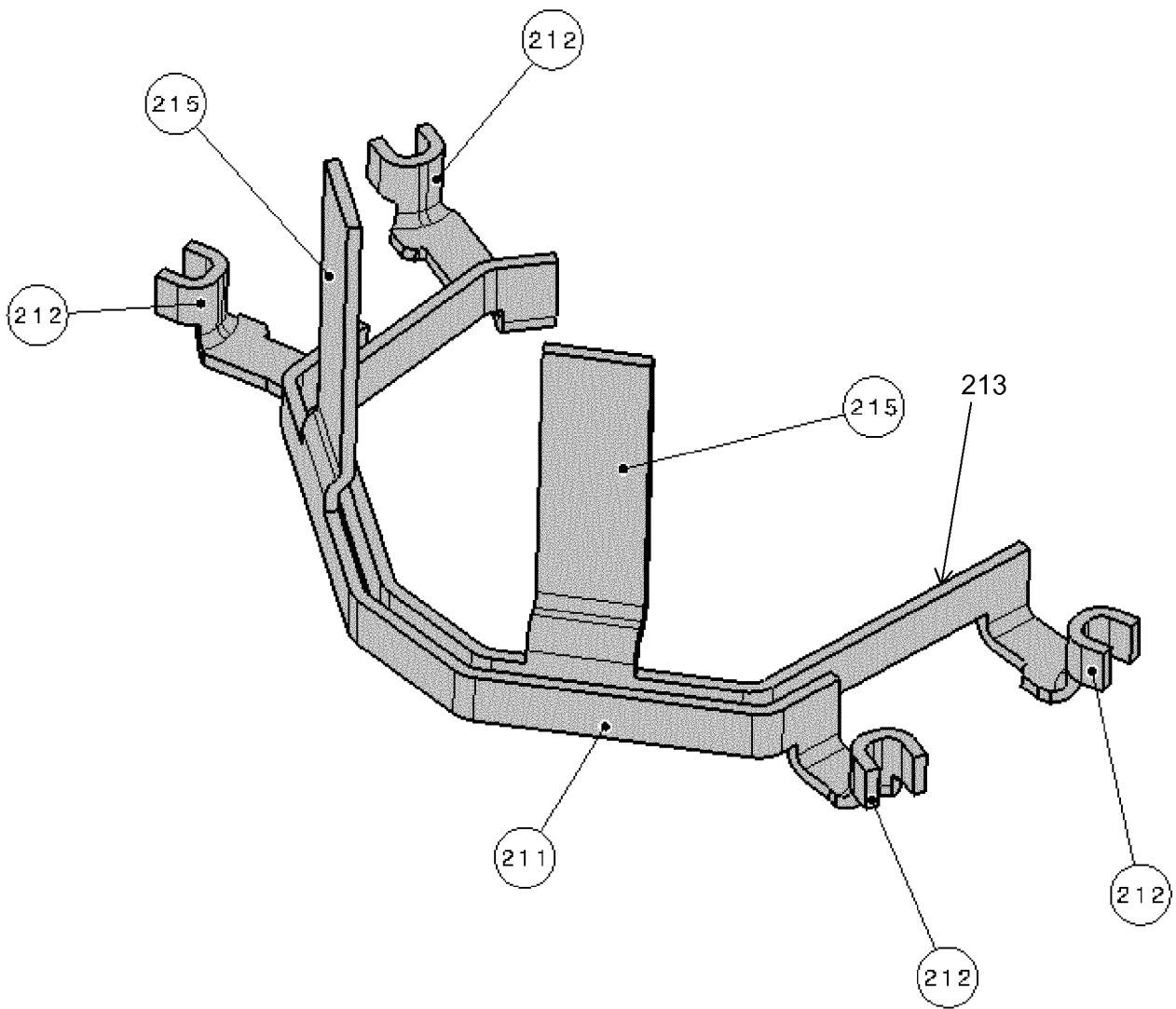


Figure 5

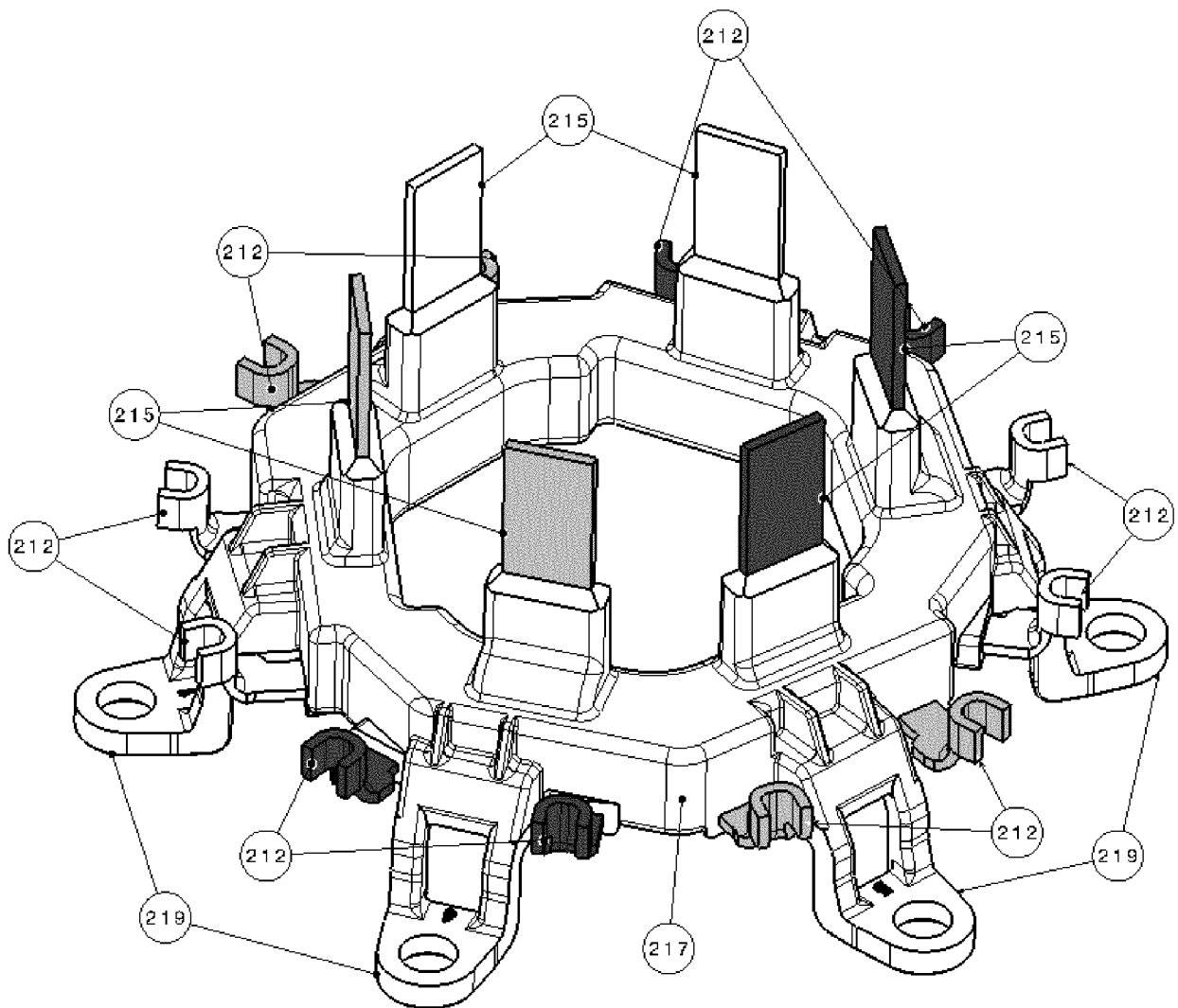


Figure 6

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/077899

A. CLASSIFICATION OF SUBJECT MATTER

INV. H02K3/52 F02B39/10
 ADD. H02K19/10 F02B33/00

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 F02B

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

C. 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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Y	paragraph [0016]; figures 2, 8, 11	1,4,6-13
A		2,3,15
Y	----- WO 2014/118557 A2 (VALEO AIR MAN UK LTD [GB]) 7 August 2014 (2014-08-07) cited in the application	1,4-13
A	figures 2-4 page 1, line 5 - line 7 page 4, line 26 - line 27 page 8, line 15 - line 21 page 10, line 2 - line 7 -----	2,3,14, 15
	-/--	



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

25 January 2017

Date of mailing of the international search report

02/02/2017

Name and mailing address of the ISA/

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Georgopoulos, P

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/077899

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	figures 7-10, 16, 17	5
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Information on patent family members

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