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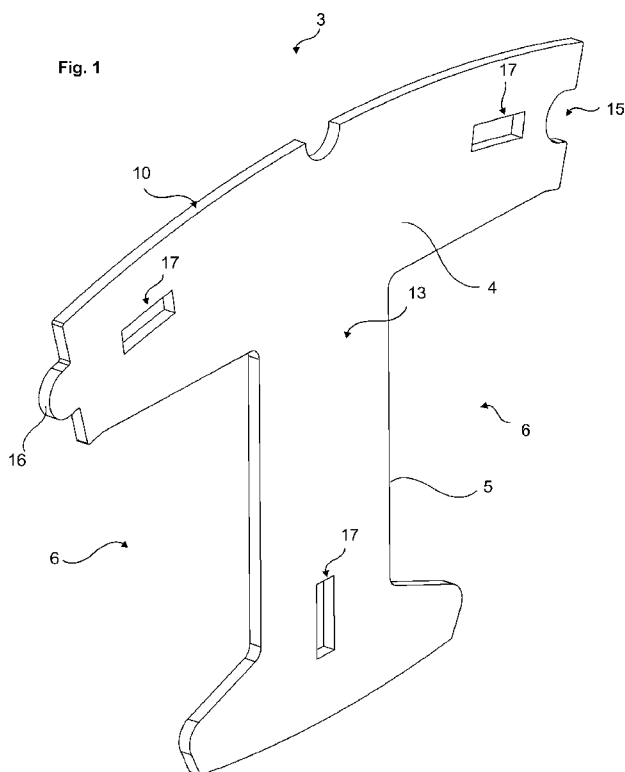
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(54) Title: SEGMENTED STATOR AND METHOD OF MANUFACTURING THE SAME



(57) Abstract: The present invention relates to a segmented stator (1) comprising a plurality of stator segments (2). Each stator segment (2) has a plurality of stacked laminations (3). Each lamination (3) has a yoke (4), a single tooth (5), and winding slots (6) on the tooth (5). In the segmented stator (1) of the present invention, the plurality of stator segments (2) are arranged into a loop in which all the adjacent stator segments (2) are respectively joined to each other by welding joints (7, 8) which are at least partly formed on each of the radially outwardly facing junctions (9) between the adjacent stator segments (2).

**Description****SEGMENTED STATOR AND METHOD OF MANUFACTURING THE SAME**

- [0001] The present invention relates to an electric machine, in particular to an electric motor or a generator which has a segmented stator. The present invention more particularly relates to the segmented stator and the method of manufacturing the same.
- [0002] Electric machines such as electric motors and generators are commonly known. Electric motors can be used both in industrial and domestic applications. For instance, an electric motor can be used to drive the rotating member of a household appliance. An electric motor generally comprises a rotating shaft, a stator, and a rotor which is fixed to the shaft. The stator generally comprises a laminated magnetic core which has a plurality of radially inwardly projecting teeth. The laminated magnetic core of the stator generally comprises a plurality of windings around the teeth for generating a rotating magnetic field. The rotor generally comprises a laminated magnetic core which has a squirrel cage type conductor. The rotor is concentrically disposed into the stator. A small uniform air gap is left between the rotor and the stator.
- [0003] In a commonly known technique the stator lamination and the rotor lamination are stamped from the same sheet metal using a die. A drawback of this technique is that the slots in the stator lamination are difficult to access when the conducting wires are wound around the teeth. Thus, the slots cannot be completely filled with the winding. Such difficulties put a limitation on the power of the electric motor. Another drawback of this technique is that a large amount of waste is produced during the stamping process due to the aforementioned slots and the air gap. The amount of waste is even higher when the rotor is produced from a permanent magnet. The waste generally increases the production cost of the electric machine.
- [0004] In another commonly known technique, the stator is manufactured by assembling a plurality of individual stator segments which are formed by stacking a plurality of laminations, each having a yoke, a single tooth, and winding slots on the single tooth. According to this technique, the stator

segments are respectively provided with windings prior to assembling them. Subsequently, the stator segments having the windings are joined with each other. Thereby, the density of the windings can be increased. Also the aforementioned waste can be significantly reduced. A drawback of this technique is that there are two wire ends per winding which must be connected to the terminal during the assembly process. Due to the large number of wire ends, there is a risk of confusion. Thus, the connection process becomes complicated and time consuming. Moreover, pulling a wire end when performing the connections may cause the other wire ends to tangle and receive damage. Another drawback of this technique is that the plurality stator segments are vulnerable to misalignments and dislocations during the assembly. In general the integrity of the stator is of utmost importance in view of its performance. Thus, the performance of the electric machine is generally degraded when the stator segments are not properly joined.

[0005] An objective of the present invention is to provide a segmented stator, an electric machine having the same, and a method of manufacturing the segmented stator which overcomes at least some of the drawbacks of the prior art and which enables a cost effective production, an easy and reliable assemblage, and an improved performance of the electric machine.

[0006] This objective has been achieved by the segmented stator as defined in claim 1, the electric machine as defined in claim 11, and the manufacturing method as defined in claim 13. Further achievements have been attained by the subject-matters respectively defined in the dependent claims.

[0007] In the segmented stator of the present invention, the plurality of stator segments which have been obtained by stacking the plurality of laminations are subsequently arranged into a loop in which all the adjacent stator segments are respectively joined to each other by forming welding joints that are at least partly formed on each of the radially outwardly facing junctions between the adjacent stator segments. In order to prevent misalignments and dislocations during the welding, the stator segments are held tightly together by applying a uniform radially inward force onto

the periphery of the segmented stator.

- [0008] With the present invention, particularly by virtue of using individual stator segments, the waste of sheet metal can be reduced as much as possible. Thereby, the material costs have been comparatively reduced. With the present invention, particularly by virtue of the welding joints at the radially outwardly facing junctions, the integrity of the segmented stator can be improved and the stator segments can be joined properly while concurrently reducing the losses due to the eddy currents in as much as possible. Thereby, a proper alignment and a precise gap between the segmented stator and the rotor can be safely established and, thus, the consequential loss of the magnetic flux can also be reduced as much as possible.
- [0009] The present invention provides a plurality of alternative techniques for welding the loop of stator segments in order to attain an improved integrity of the segmented stator and reduce the losses due to eddy currents as much as possible.
- [0010] In an embodiment, the adjacent stator segments are welded only vertically along the radially outwardly facing junctions respectively.
- [0011] In an alternative embodiment, the stator segments are alternatively welded only along one or more than one narrow circumferential contour on the radially outwardly facing surface of the yokes. These contours cross the junctions. The thickness of the welding joint along the narrow circumferential contour may range from one to a few laminations.
- [0012] In another embodiment, a peripheral metal sleeve is circumferentially shrink-fitted around the stator segments, in particular onto the radially outward surfaces of the yokes. The welding joints apply a uniform radially inward force onto the periphery of the segmented stator and prevent misalignments/dislocations during the shrink fitting, and thus, the stator segments are held tightly together. The sleeve is preferably made from lamination steel and improves the integrity of the segmented stator.
- [0013] In another alternative embodiment, a peripheral cover is molded over at least the radially outwardly surfaces of the yokes by plastic injection molding operation. The welding joints apply a uniform radially inward force

onto the periphery of the segmented stator and prevent misalignments/dislocations during the plastic injection molding, and thus, the stator segments are held tightly together. The peripheral cover is made from plastic. The plastic peripheral cover improves the integrity of the segmented stators and also provides electrical insulation.

- [0014] In another embodiment, the peripheral cover is molded so as to also enclose the upper and lower surfaces of the outermost laminations respectively.
- [0015] In another embodiment, the winding slots of the teeth are respectively covered with insulating materials such as insulators for protecting the electrical conductor of the windings from damage and preventing any short-circuit.
- [0016] In another embodiment, the insulators are integrally formed with the peripheral cover onto the stator segments by plastic injection molding.
- [0017] In another alternative embodiment, the insulators have a two-piece structure and are installed onto the teeth respectively.
- [0018] In another embodiment, the terminal is integrally molded with the peripheral cover.
- [0019] In another alternative embodiment, the terminal is provided onto the stator segments by sticking, screwing or any other connection method.
- [0020] In another embodiment, the integrity of the segmented stator is improved by grooves and matching tongues which are formed beforehand into the yokes of the laminations.
- [0021] In another embodiment, the integrity of the segmented stator is improved by lock holes which are formed beforehand into the laminations. The lock holes respectively receive locking extensions from the adjacent laminations.
- [0022] In another embodiment, some of the laminations comprise welding grooves for receiving the welding joints. Thereby, the welding joints become flush with the surrounding surface of the yokes. Alternatively, the welding joints can be smoothed.
- [0023] In another embodiment, the plurality of stator segments which are obtained by stacking the plurality of laminations are initially arranged into a

loop, and subsequently joined with each other prior to forming the windings. The joined stator segments are provided with a terminal. Then, an electrical conductor is wound around the tooth in one of the plurality of stator segments, and the winding ends are connected to the terminal. The winding process and connection process are serially continued until all stator segments respectively have their own windings that are connected to the terminal.

- [0024] With the present invention, the winding and connection processes of the windings can be orderly performed. Thereby, the risk of mixing up and tangling the winding ends is eliminated or reduced as much as possible. Moreover as the winding and connection processes are performed successively, the overall manufacturing process is expedited and the labor costs are comparatively reduced. In addition, the risk of damaging the windings during the joining process has been eliminated as the stator segments are joined prior to the provision of the windings.
- [0025] Additional advantages of the segmented stator, the electric machine and the manufacturing method of the present invention will become more apparent with the detailed description of the embodiments with reference to the accompanying drawings in which:
- [0026] Figure 1 – is a perspective view of a lamination according to an embodiment of the present invention;
- [0027] Figure 2 – is a perspective view of a stator segment which is formed by stacking a plurality of laminations according to an embodiment of the present invention;
- [0028] Figure 3 – is a perspective view of a plurality of stator segments which are arranged into a loop according to an embodiment of the present invention;
- [0029] Figure 4 – is a perspective view of a loop of stator segments which are joined to each other by welding joints according to an embodiment of the present invention;
- [0030] Figure 5 – is a perspective view of a loop of stator segments which are joined to each other by welding joints according to another embodiment of the present invention;
- [0031] Figure 6 – is a perspective view of a loop of stator segments which are

joined to each other by a metal sleeve which is shrink fitted around the radially outwards surfaces of the yokes according to another embodiment of the present invention;

[0032] Figure 7 – is a perspective view of a loop of stator segments which are joined to each other by a plastic peripheral cover which is molded onto the radially outwards surfaces of the yokes, the upper surface of the uppermost lamination, and the lower surface of the lowermost lamination according to another embodiment of the present invention.

[0033] The reference signs appearing on the drawings relate to the following technical features.

1. Segmented stator
2. Stator segment
3. Lamination
4. Yoke
5. Tooth
6. Winding slot
7. Welding joint
8. Welding joint
9. Junction
10. Surface
11. Metal sleeve
12. Peripheral cover
13. Surface
14. Terminal
15. Groove
16. Tongue
17. Locking hole

[0034] The segmented stator (1) comprises a plurality of stator segments (2). Each stator segment (2) has a plurality of stacked laminations (3). Each lamination (3) has a yoke (4), a single tooth (5), and winding slots (6) on the tooth (5) (Fig. 1 to 7).

[0035] In the segmented stator (1) of the present invention, the plurality of stator segments (2) are arranged into a loop in which all the adjacent stator

segments (2) are respectively joined to each other by welding joints (7, 8) which are at least partly formed on each of the radially outwardly facing junctions (9) between the adjacent stator segments (2).

- [0036] The present invention also provides an electric machine (not shown), in particular an electric motor (not shown) or a generator (not shown) which comprises the segmented stator (1) according to the present invention. The electric machine also comprises a rotor (not shown) which is concentrically disposed into the segmented stator (1). A small uniform air gap (not shown) is left between the rotor and the segmented stator (1) (Fig. 1 to 7).
- [0037] The present invention also provides a household appliance (not shown) which comprises the electric machine, in particular the electric motor or the generator according to the present invention.
- [0038] In an embodiment, the welding joints (7) extend vertically along the entire radially outwardly facing junctions (9) between the adjacent stator segments (2) (Fig. 1 to 4 and Fig. 6 to 7).
- [0039] In an alternative embodiment, the welding joints (8) extend circumferentially along one or more than one closed contour around the radially outwardly facing surfaces (10) of the yokes (4). The closed contours cross each of the radially outwardly facing junctions (9) between the adjacent stator segments (2) (Fig. 1 to 3 and Fig. 5 to 7).
- [0040] In another embodiment, the segmented stator (1) comprises a peripheral metal sleeve (11) which is circumferentially shrink-fitted by thermal treatment onto the radially outwardly facing surfaces (10) of the yokes (4) of the stator segments (2) in the loop (Fig. 1 to 6).
- [0041] In another alternative embodiment, the segmented stator (1) comprises a peripheral cover (12) made from plastic material which is circumferentially molded by plastic injection molding at least onto the radially outwardly facing surfaces (10) of the yokes (4) of the stator segments (2) in the loop (Fig. 1 to 5 and Fig. 7).
- [0042] In another embodiment, the peripheral cover (12) encloses in addition to the radially outwardly facing surfaces (10) of the yokes (4) also the upper surface (13) of the uppermost lamination (3) and the lower surface of

lowermost lamination (3) (Fig. 1 to 5 and Fig. 7).

- [0043] In another embodiment, the segmented stator (1) further comprises the insulators (not shown) which insulate the winding slots (6) respectively (Fig. 1 to 7).
- [0044] In another embodiment, the insulators are integrally formed with the peripheral cover (12) onto the stator segments (2) by plastic injection molding (Fig. 1 to 5 and Fig. 7).
- [0045] In another alternative embodiment, the insulators (not shown) have a two-piece structure and are clamped around the teeth (5) respectively (Fig. 1 to 7).
- [0046] In another embodiment, the segmented stator (1) further comprises a terminal (14) which is integrally formed with the peripheral cover (12) onto the stator segments (2) by plastic injection molding (Fig. 1 to 5 and Fig. 7).
- [0047] In another alternative embodiment, the terminal (14) is provided onto the stator segments (2) by sticking, screwing or any other connection method (Fig. 1 to 7).
- [0048] In another embodiment, the laminations (3) comprise a groove (15) and a matching tongue (16) which are located at circumferentially opposing ends of the yoke (4). In this embodiment, the laminations (3) also have welding grooves (not shown) for receiving the welding joints (7, 8) (Fig. 1 to 7).
- [0049] In another embodiment, each lamination (3) has one or more than one rectangular shaped locking hole (17) for receiving locking extension from the adjacent lamination (3) (not shown).
- [0050] In another embodiment, each lamination (3) has three locking holes (17) which are rectangular shaped. Two of them are located on the opposing ends of the yoke (4). The third one is located in close proximity to the tip of the tooth (5) (Fig. 1 to 7).
- [0051] In another embodiment, the number of laminations (3) which are stamped is a predetermined multiple of the number of the stator segments (2) so as to reduce the amount of the resulting waste.
- [0052] In another embodiment, after the plurality of stator segments (2) are joined, an electrical conductor (not shown) is wound around the tooth (5) in one of the plurality of stator segments (2), and the winding ends (not

shown) are connected to the terminal (14). The winding operation and the connection operation are successively continued until all stator segments (2) have a winding (not shown) which is connected to the terminal (14).

## Claims

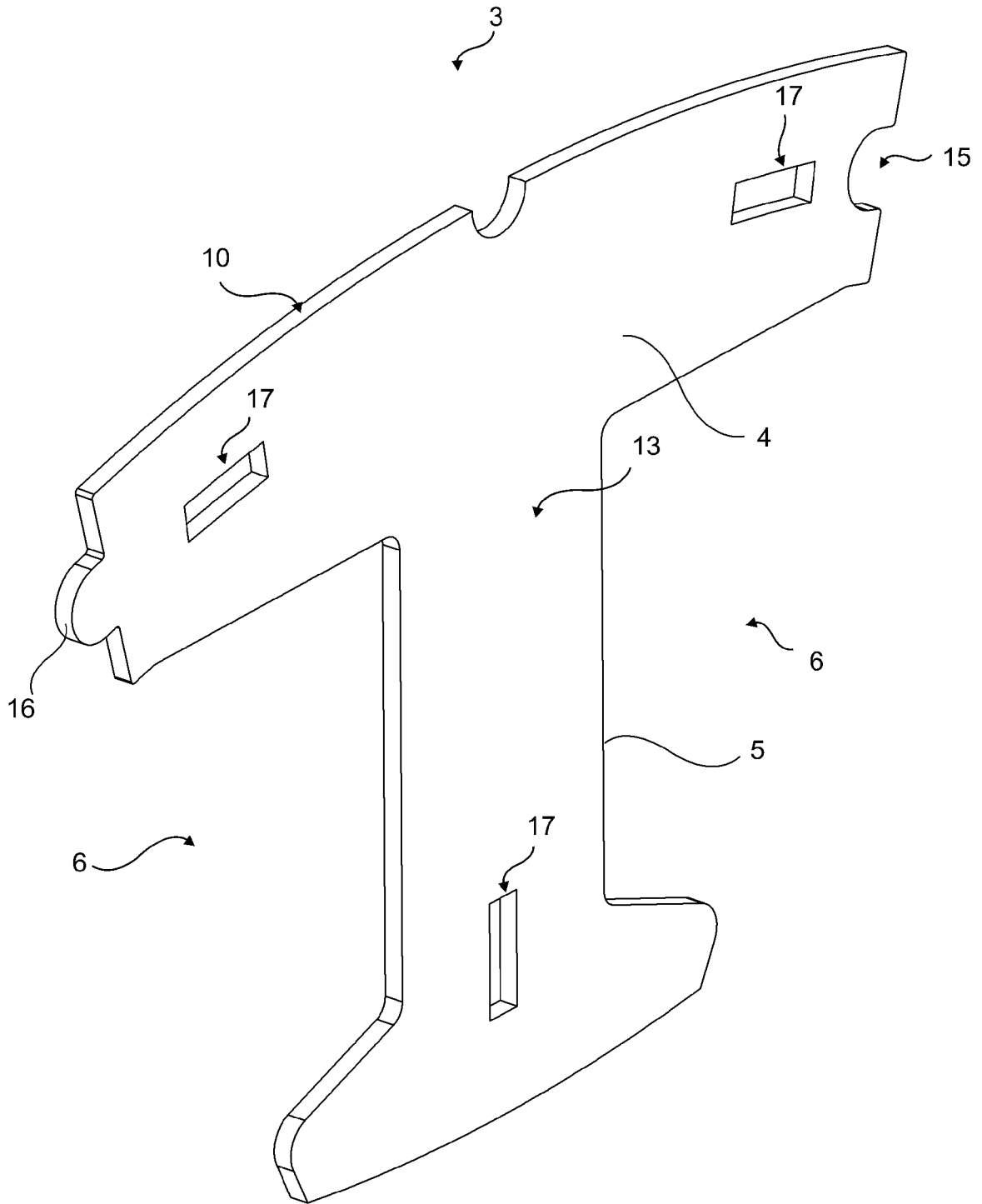
1. A segmented stator (1) comprising a plurality of stator segments (2), wherein each stator segment (2) has a plurality of stacked laminations (3), and wherein each lamination (3) has a yoke (4), a single tooth (5), and winding slots (6) on the tooth (5), **characterized in that** the plurality of stator segments (2) are arranged into a loop in which all the adjacent stator segments (2) are respectively joined to each other by welding joints (7, 8) which are at least partly formed on each of the radially outwardly facing junctions (9) between the adjacent stator segments (2).
2. The segmented stator (1) according to claim 1, **characterized in that** the welding joints (7) extend vertically along the entire radially outwardly facing junctions (9) between the adjacent stator segments (2).
3. The segmented stator (1) according to claim 1 or 2, **characterized in that** the welding joints (8) extend circumferentially along one or more than one closed contour around the radially outwardly facing surfaces (10) of the yokes (4), wherein the closed contours cross each of the radially outwardly facing junctions (9) between the adjacent stator segments (2).
4. The segmented stator (1) according to any one of claims 1 to 3, **characterized in that** a peripheral metal sleeve (11) which is circumferentially shrink-fitted by thermal treatment onto the radially outwardly facing surfaces (10) of the yokes (4) of the stator segments (2) in the loop.
5. The segmented stator (1) according to any one of claims 1 to 4, **characterized in that** a peripheral cover (12) which is circumferentially molded by plastic injection molding at least onto the radially outwardly facing surfaces (10) of the yokes (4) of the stator segments (2) in the loop.
6. The segmented stator (1) according to claim 5, **characterized in that** the peripheral cover (12) encloses in addition to the radially outwardly facing surfaces (10) of the yokes (4) also the upper surface (13) of the uppermost lamination (3), and the lower surface of lowermost lamination (3).
7. The segmented stator (1) according to any one of claims 5 to 6, **characterized in that** the insulators which insulate the winding slots (6) respectively, wherein the insulators are integrally formed with the peripheral cover (12) onto the

- stator segments (2) by plastic injection molding.
8. The segmented stator (1) according to any one of claims 5 to 7, **characterized in that** a terminal (14) which is integrally formed with the peripheral cover (12) onto the stator segments (2) by plastic injection molding.
  9. The segmented stator (1) according to any one of claims 1 to 8, **characterized in that** the laminations (3) comprising a groove (15) and a matching tongue (16) which are located at circumferentially opposing ends of the yoke (4), and at least some of the laminations (3) comprising welding grooves for receiving the welding joints (7, 8).
  10. The segmented stator (1) according to any one of claims 1 to 9, **characterized in that** each lamination (3) comprising one or more than one rectangular shaped locking hole (17) for receiving a matching locking extension from the adjacent lamination (3).
  11. An electric machine, in particular an electric motor or a generator, **characterized in that** the segmented stator (1) according to any one of claims 1 to 10 and a rotor.
  12. A method of manufacturing a segmented stator (1), the method comprising the step of forming a plurality of stator segments (2) by stacking a plurality of laminations (3), each having a yoke (4), a single tooth (5), and winding slots (6) on the tooth (5), **characterized by** further comprising the steps of:
    - arranging the plurality of stator segments (2) into a loop,
    - applying a uniform radially inward force onto the periphery of the stator segments (2) in the loop so as to hold the stator segments (2) tightly together and
    - joining all the adjacent stator segments (2) in the loop respectively to each other by forming welding joints (7, 8) at least partly on each of the radially outwardly facing junctions (9) between the adjacent stator segments (2).
  13. The method according to claim 12, **characterized in that** in the joining step, a metal sleeve (11) is circumferentially shrink-fitted by thermal treatment onto the radially outwardly facing surfaces (10) of the stator segments (2) in the loop after the welding joints (7, 8) are formed.
  14. The method according to claim 12 or 13, **characterized by** further comprising a step of providing an injection mold, wherein in the joining step a peripheral

cover (12) is circumferentially molded onto the radially outward surfaces (10) of the stator segments (2) in the loop by plastic injection molding after the welding joints (7, 8) are formed.

15. The method according to any one of claim 12 to 14, **characterized by** further comprising the steps of:
- providing a terminal (14) and winding, after the joining step, an electrical conductor around the tooth (5) in one of the plurality of stator segments (2) and
  - connecting the winding ends to the terminal (14), wherein the winding step and the connecting step are successively continued until all stators segments (2) have a winding which is connected to the terminal (7).

Fig. 1



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Fig. 2

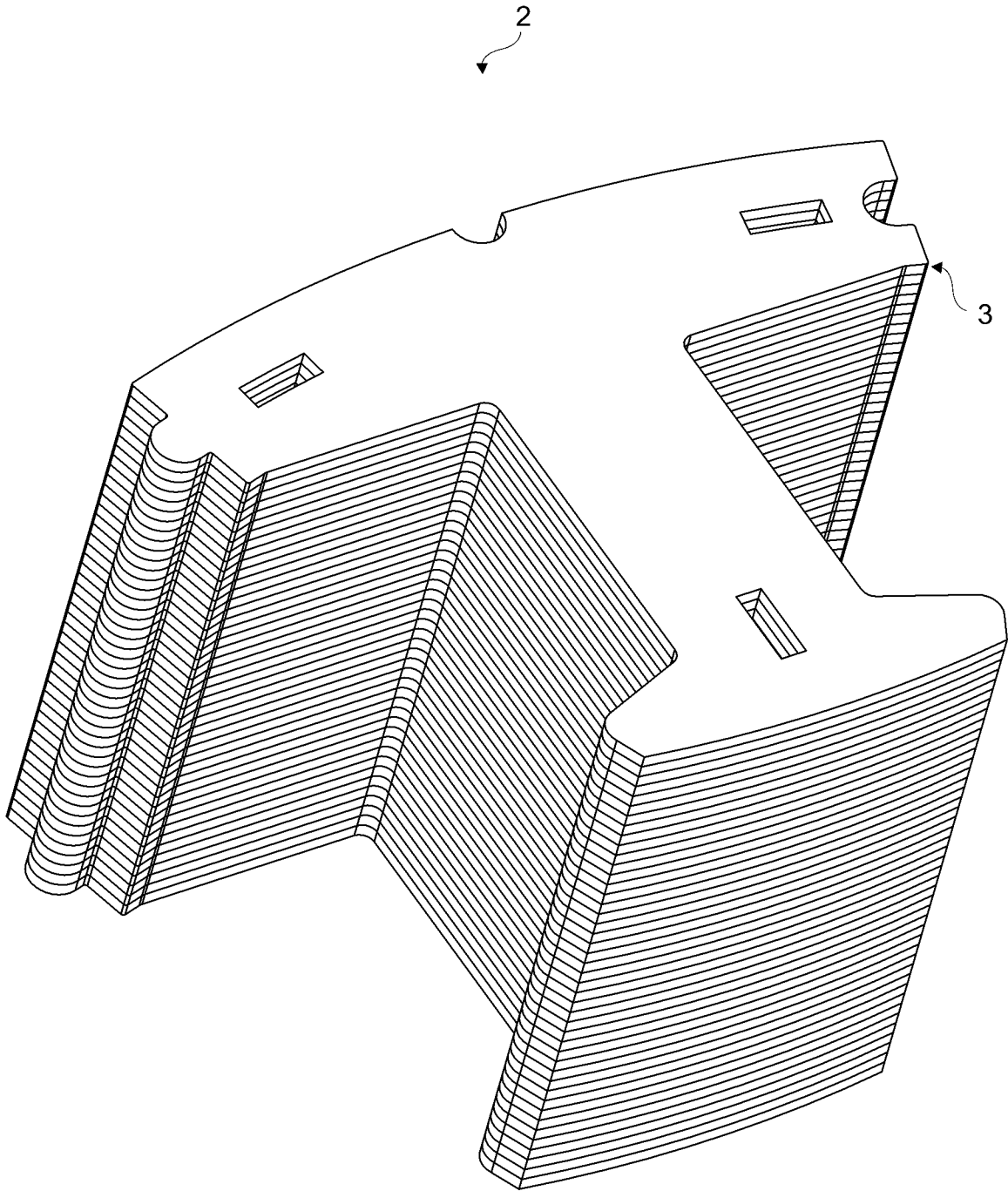


Fig. 3

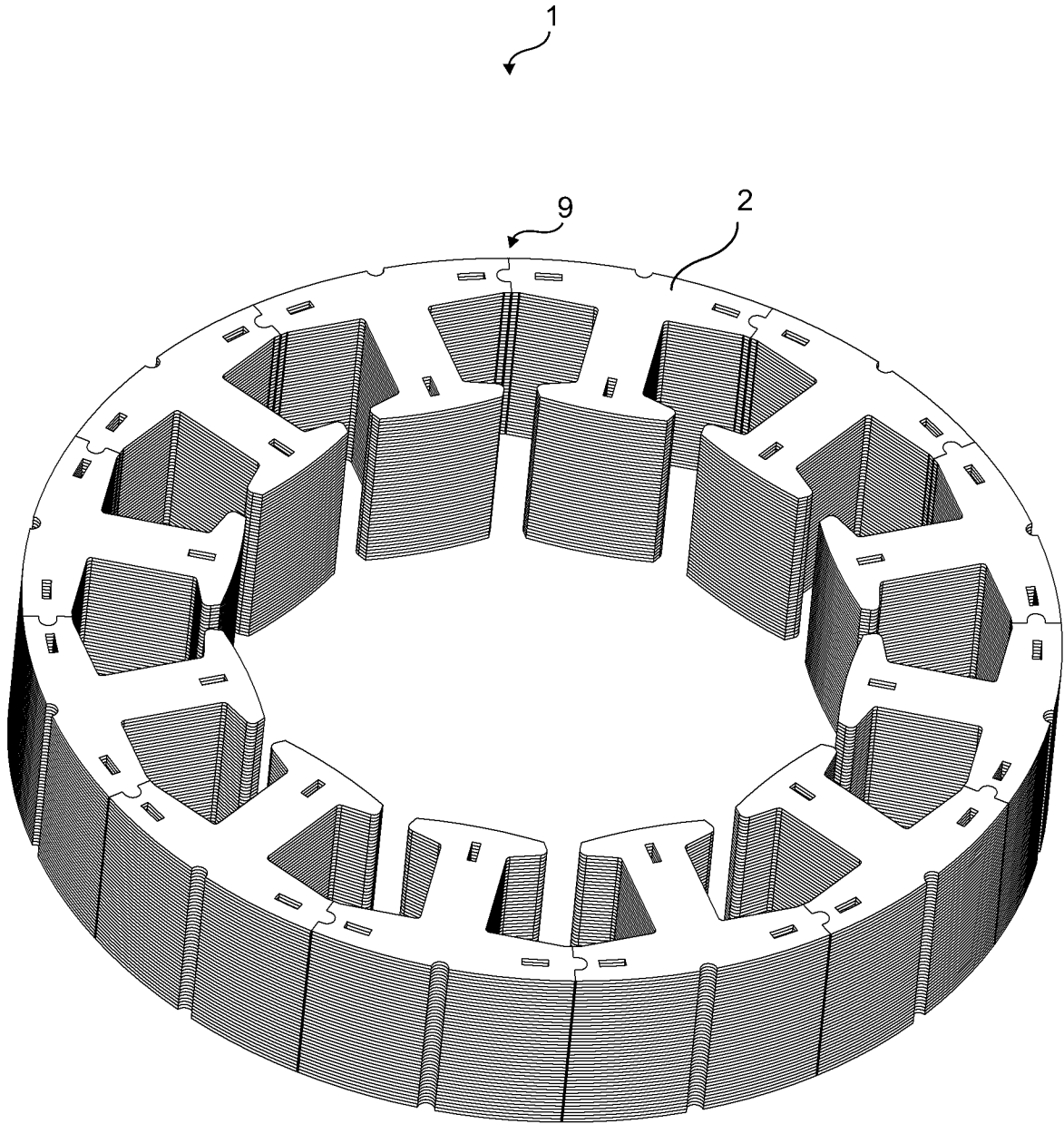


Fig. 4

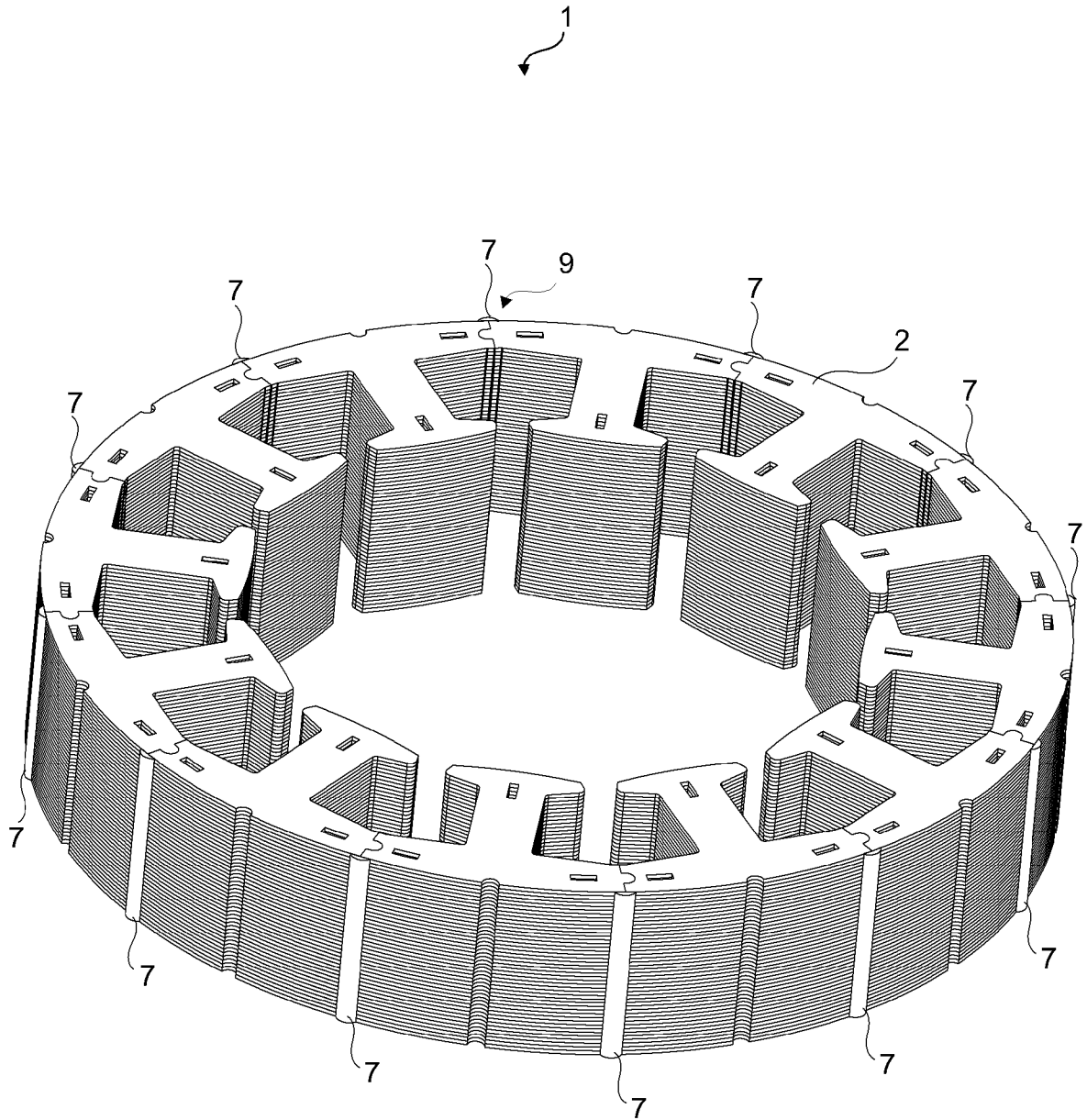


Fig. 5

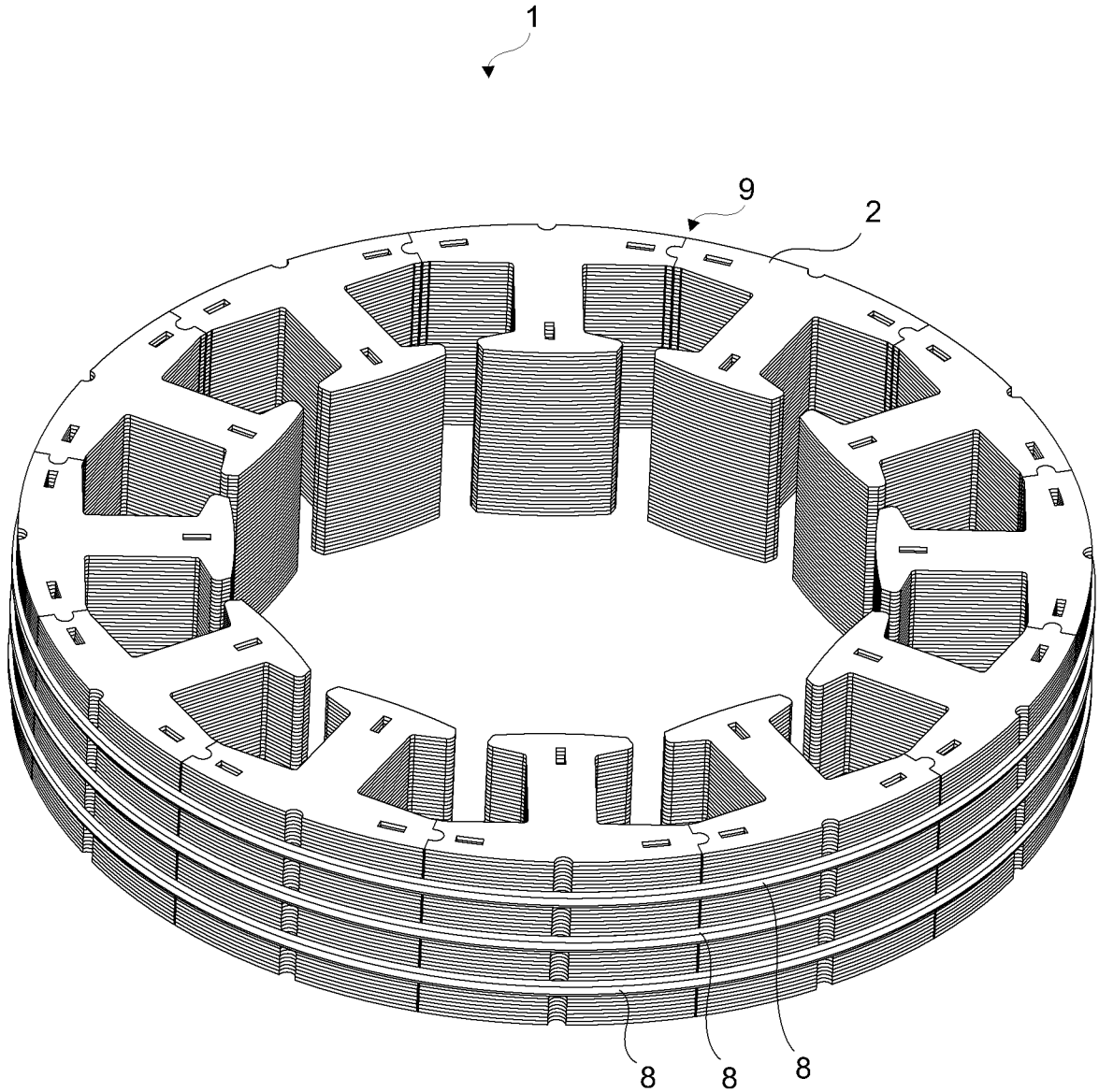


Fig. 6

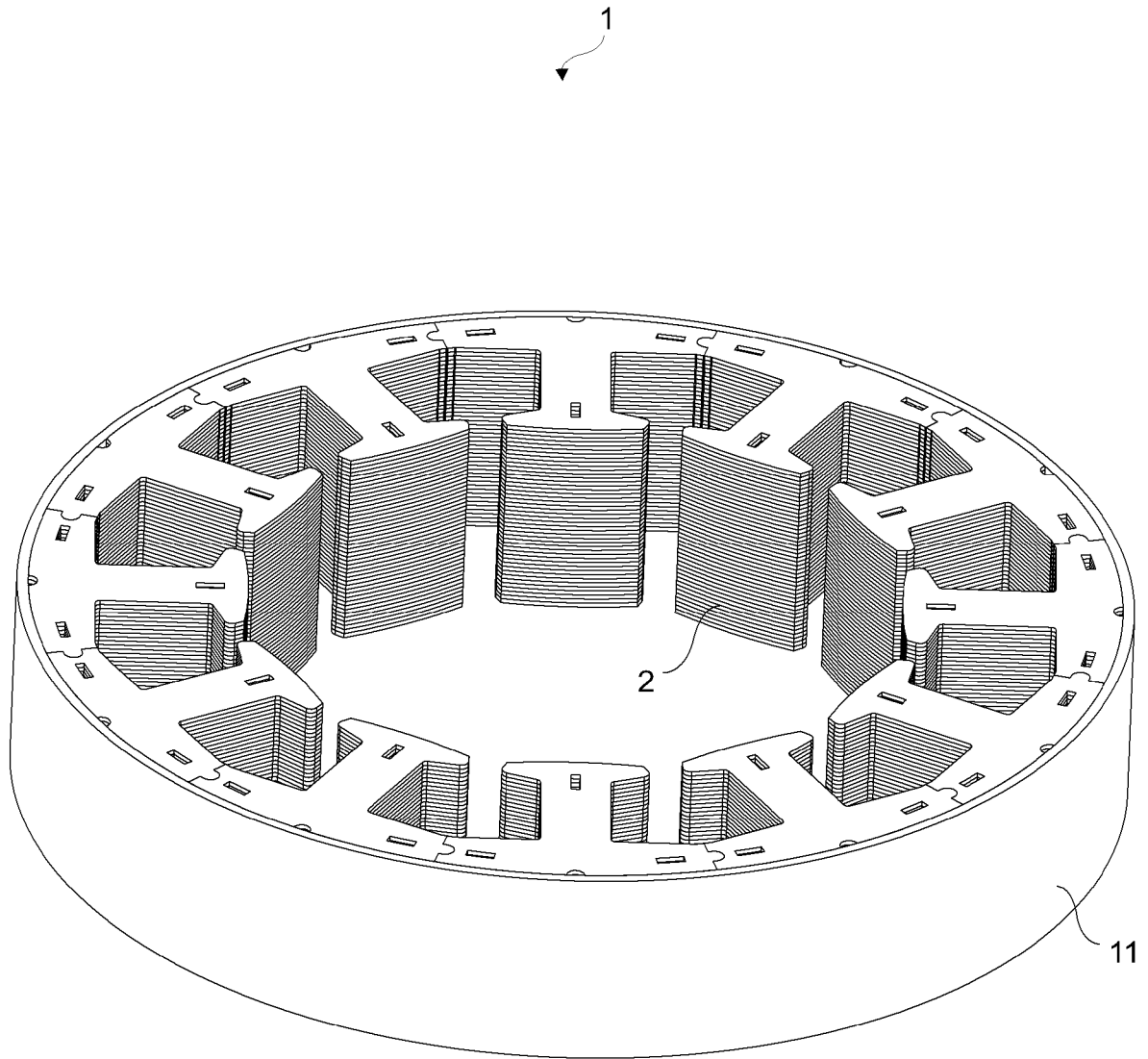
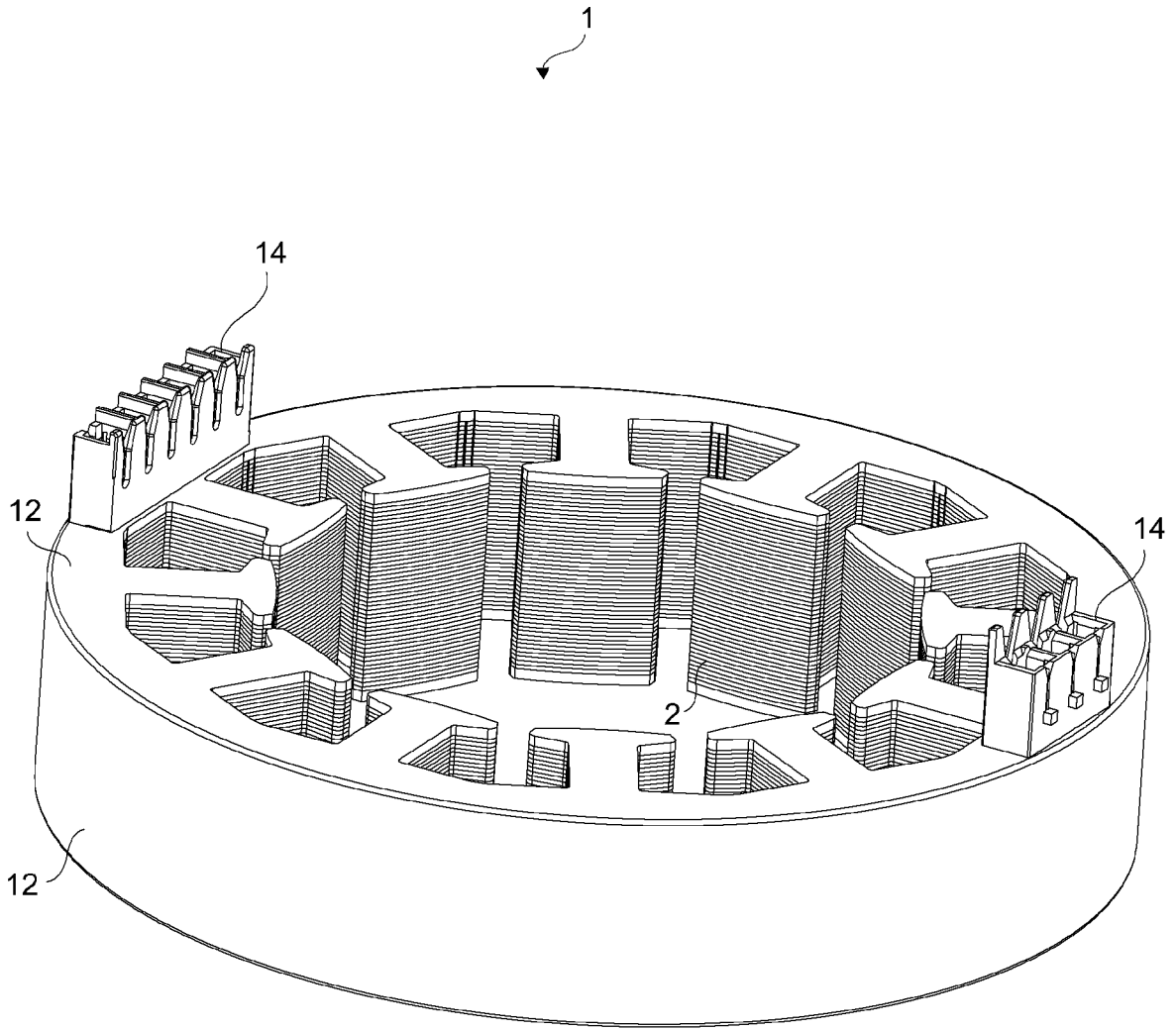


Fig. 7



INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER  
INV. H02K1/14  
ADD. H02K5/08 H02K3/52

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

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Further documents are listed in the continuation of Box C.

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Date of the actual completion of the international search  22 July 2015	Date of mailing of the international search report  04/08/2015
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Ganchev, Martin
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